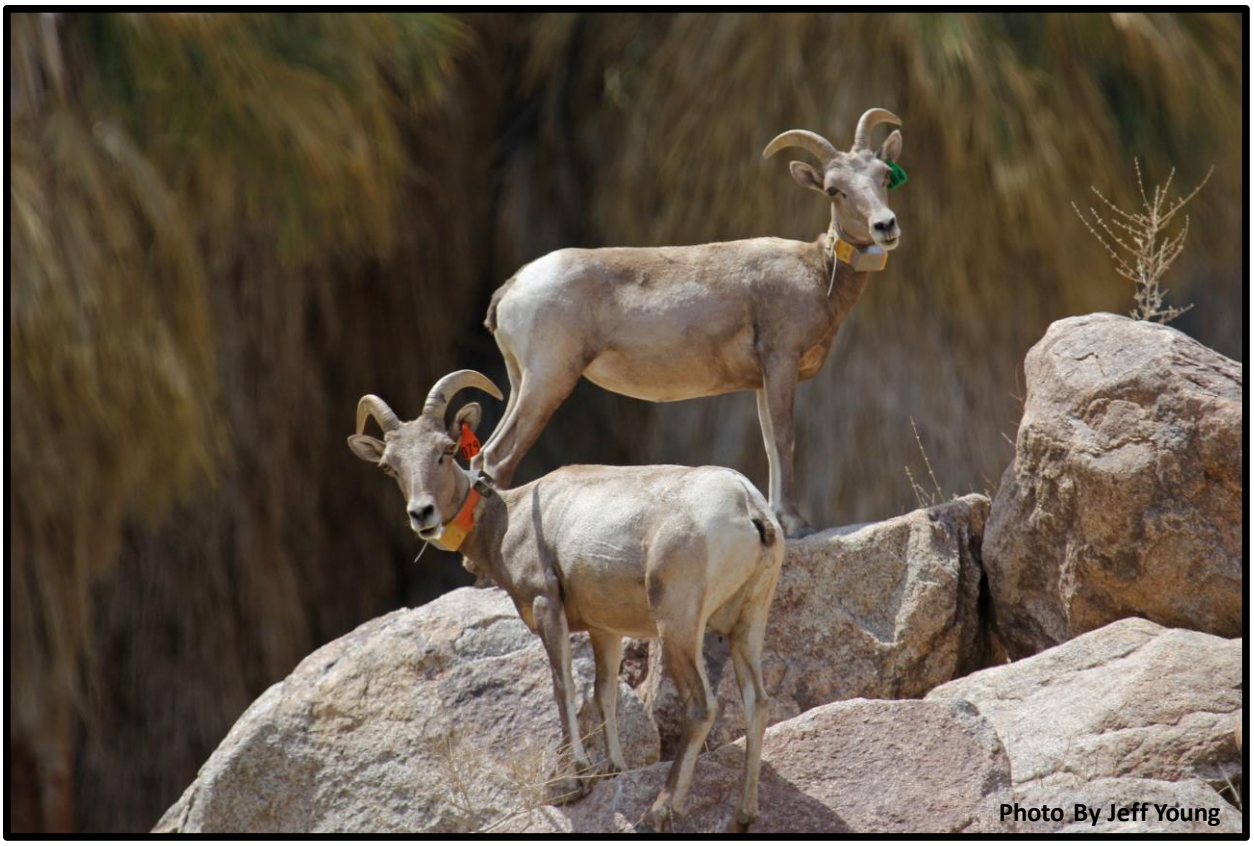
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

PENINSULAR BIGHORN SHEEP 2016-17 ANNUAL REPORT



This report presents information on the status, distribution, and management of peninsular bighorn sheep from 1 January 2016 to 31 May 2017

Authors

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South Coast Region

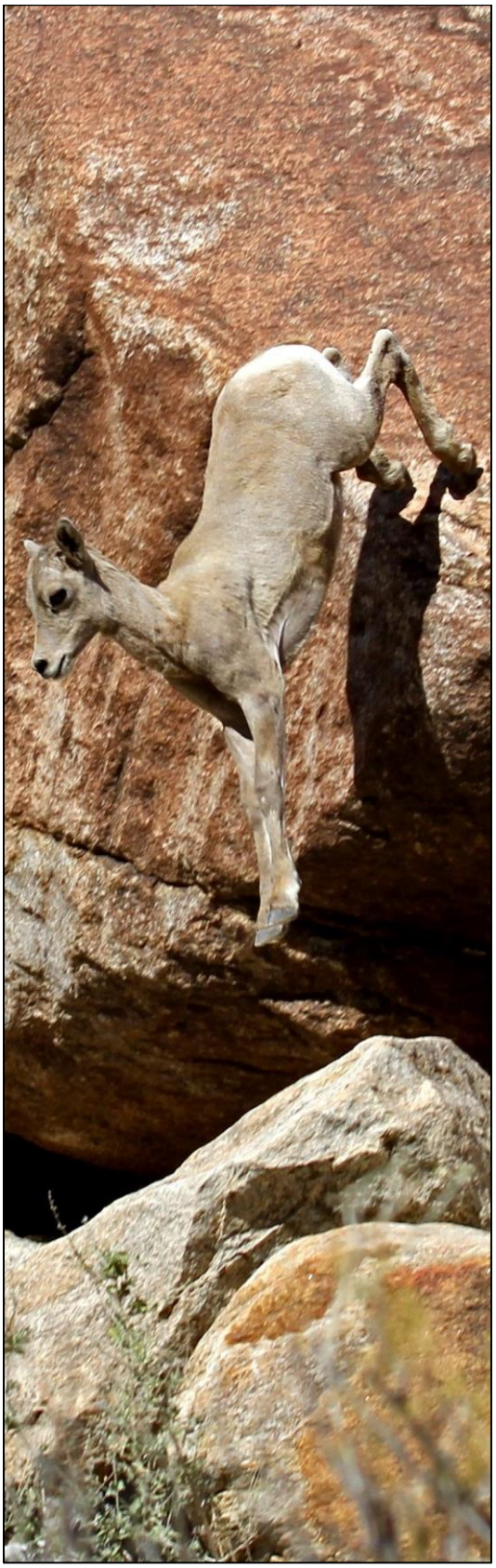

Photo by Jeff Young

California Department of Fish and Wildlife
Peninsular Bighorn Sheep Annual Report
2016-17
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CDFW 2016 Helicopter Survey - Photo by Christine Thompson

EXECUTIVE SUMMARY

Desert bighorn sheep (*Ovis canadensis nelsoni*) inhabit the desert slopes of the Peninsular Ranges of southern California and extend into the mountains of Baja California in Mexico. The population within the Peninsular Ranges was listed as threatened in 1971 under the California Endangered Species Act. In 1974, the population was estimated at 1,171 (Weaver 1975) but by 1996 the rangewide population estimate had declined to only 276 adult sheep (USFWS 2000). Peninsular bighorn sheep were listed by the U.S. Fish and Wildlife Service (USFWS) as a federally endangered population segment in 1998 (63 FR 13134). Reasons for this listing were: 1) habitat fragmentation, degradation, and habitat loss by urban and commercial development; 2) disease; 3) predation coinciding with low population numbers; 4) human disturbance; 5) insufficient lamb recruitment; 6) nonnative toxic plants; and 7) prolonged drought (USFWS 2000). The California Department of Fish and Wildlife (CDFW) carries out population recovery under USFWS Endangered Species Recovery Permit TE163017-1. Presently, the population of desert bighorn sheep in the Peninsular Ranges is stable based on the 2016 CDFW survey estimate of 884 adult bighorn sheep. The range-wide female population estimate was 552 with greater than 25 adult female bighorn sheep within each of the 9 recovery regions. As such, 2016 marked year 1 of 6 in meeting criterion 1 in section II.B.2 for downlisting peninsular bighorn sheep from endangered to threatened status (USFWS 2000).

In order for CDFW to estimate ewe (female) abundance, it is necessary to maintain radio-collars on at least 25% of the ewes within each of the 9 recovery regions. At the beginning of the reporting period (1 January 2016), there were 162 active radio-collared ewes, representing approximately 29% of the ewe population range-wide. At the end of the reporting period (30 May 2017), there were 124 active radio-collared ewes, representing approximately 22% of the ewe population range-wide. Over the reporting period, 20% of radio-collars were lost due to mortality and 3% were lost due to radio-collar failure. A bighorn sheep capture is planned for fall 2017 in order to increase the percentage of radio-collared ewes in preparation for the 2018 survey population estimate.

From 1992 to 2016, on average, 11% of all active radio-collared sheep died each year. In 2016, 12% of all active radio-collared sheep died of which 9% was attributed to predation, 2% unknown causes, and 1% due to vehicle collision. Predation risk was highest in January followed by February and March. Poor health may have been a contributing factor in 47% of all radio-collared sheep mortalities. The highest number of radio-collared mortalities occurred in the Carrizo Canyon (CC) recovery region followed by the Southern Santa Rosa Mountains (SSRM). The San Jacinto Mountains (SJM) had the fewest radio-collared mortalities and the Northern Santa Rosa Mountains (NSRM) had no radio-collared mortalities over the reporting period. In 2016, average rangewide survival of radio-collared ewes was 88%. Survival was highest in the SJM and NSRM and lowest in the SSRM and Southern San Ysidro Mountain Ranges (SSYM). Sheep deaths due to vehicle collisions have increased over the past several years on Highway 74 in the Santa Rosa Mountains and on

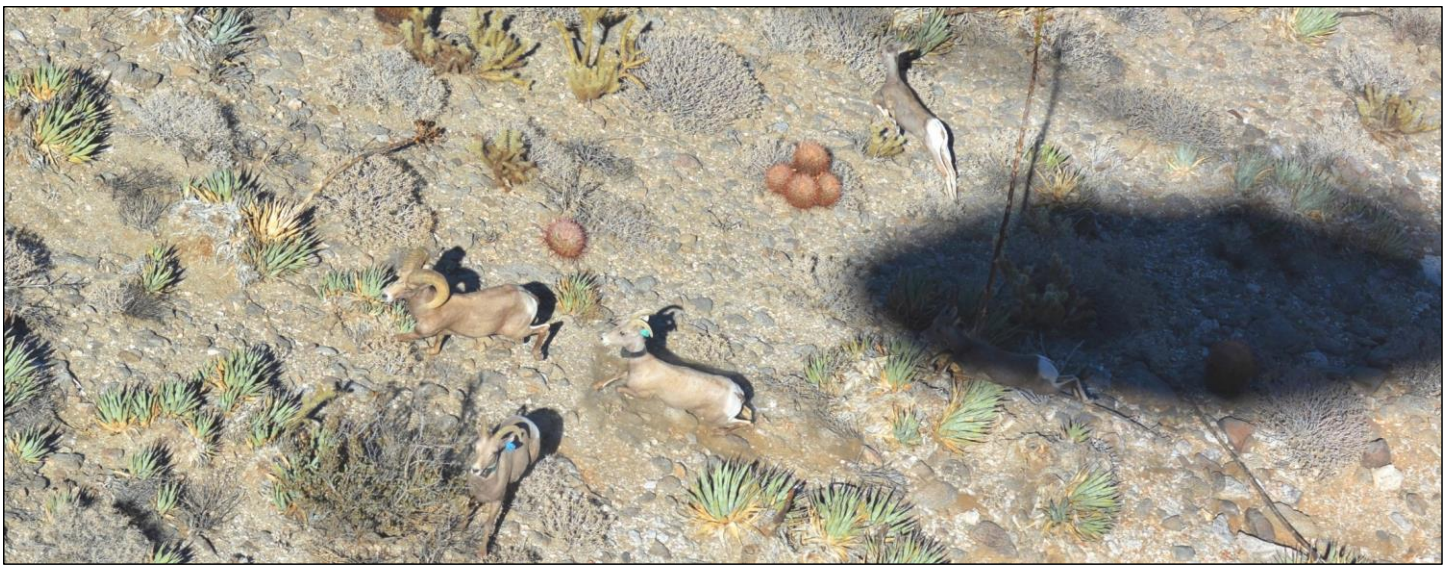
Interstate 8 in the Jacumba Mountains. During the reporting period, the majority of sheep killed by vehicles on Highway 74 were rams whereas the majority of sheep killed on Interstate 8 were ewes.

Due to concerns of pneumonia in lambs, CDFW monitored lamb survival and recruitment in several recovery regions. In 2016, lamb recruitment rates in all recovery regions were higher compared to past years. However, while recruitment rates are encouraging, evidence suggests that once pneumonia is introduced within a population, healthy periods are of short duration and persistently low recruitment rates below 30% may pose a significant obstacle in population recovery (Cassirer et al. 2013).

Since 2009, CDFW has deployed GPS radio-collars on female bighorn sheep to understand ewe group structure and seasonal movements within the Peninsular Ranges. Thus far, there have been 19 ewe groups identified within the Peninsular Ranges. The number of ewe groups within each recovery region are: SJM = 1, NSRM = 1, Central Santa Rosa Mountains (CSRM) = 2, SSRM = 3, Coyote Canyon (CoC) = 2, Northern San Ysidro Mountains (NSYM) = 1, SSYM = 1, Vallecito Mountains (VM) = 4, and CC = 4. There is a great amount of substructuring within each ewe groups and movement between adjacent ewe groups is common when roads are not present. In 2016, movements among recovery regions were common between the CSRM and SSRM and between CoC and the NSYM. Regular seasonal movements by a radio-collared ewe were documented between the VM and CC recovery regions for the first time. In addition, a radio-collared NSRM ewe crossed Highway 74 into the CSRM briefly before returning to the NSRM. No movements were documented between the SJM and the NSRM.

Presently, there is substantial genetic variation and gene flow among bighorn sheep populations within the Peninsular Ranges and across the US-Mexico Border indicating functional connectivity (Buchalski et al. 2015). However, as traffic levels continue to increase connectivity will be lost. Other concerns that may hinder recovery efforts are disease, the loss of natural water sources, reduction and fragmentation of sheep habitat, habitat modification due to invasive nonnative plants, sheep use of urban areas, and human disturbance of essential sheep habitat especially around the urban centers. Yet, even in more remote regions renewable energy projects, completion of the US-Mexico border fence, mining, and human activities (border enforcement and off-road vehicles) may alter, discourage, or restrict sheep movement and habitat use of important resources.

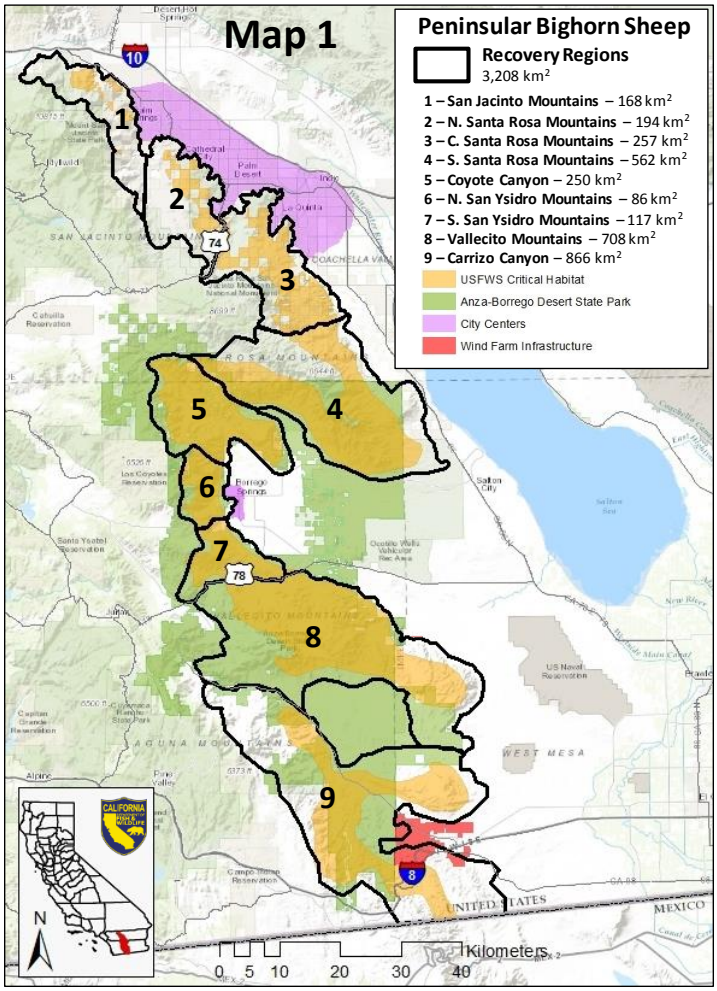
Continued efforts by CDFW to monitor sheep health, habitat use, and movements throughout the range will provide federal, state, and local governmental agencies information to make land and public use decisions that allow for the health and long-term survival of peninsular bighorn sheep.



Helicopter Shadow – CDFW 2016 Survey – Photo by Christine Thompson

BACKGROUND

This report summarizes the fall range-wide helicopter population survey, radio-collar monitoring, disease surveillance, and cause specific mortality investigation undertaken by the California Department of Fish and Wildlife (CDFW) of bighorn sheep in the Peninsular Mountain Ranges of southern California. Bighorn sheep inhabiting the Peninsular Ranges are a federally listed endangered species and thus CDFW carries out population monitoring and recovery under U.S. Fish and Wildlife Service (USFWS) Endangered Species Permit TE163017-1. This report covers a 17-month period from 1 January 2016 through 31 May 2017 rather than the typical calendar year of previous annual reports in order to transition to a new reporting period. All subsequent annual reports will cover a 12-month period starting 1 June of one year and ending 31 May the following year.



The Peninsular Mountain Ranges contain 9 designated bighorn sheep recovery regions occupying portions of southern Riverside, western Imperial and eastern San Diego Counties (Map 1). The 9 recovery regions are: 1) San Jacinto Mountains (SJM), 2) Northern Santa Rosa Mountains (NSRM), 3) Central Santa Rosa Mountains (CSRM), 4) Southern Santa Rosa Mountains (SSRM), 5) Coyote Canyon (CoC), 6) Northern San Ysidro Mountains (NSYM), 7) Southern San Ysidro Mountains (SSYM), 8) Vallecito Mountains (VM), and 9) Carrizo Canyon (CC).

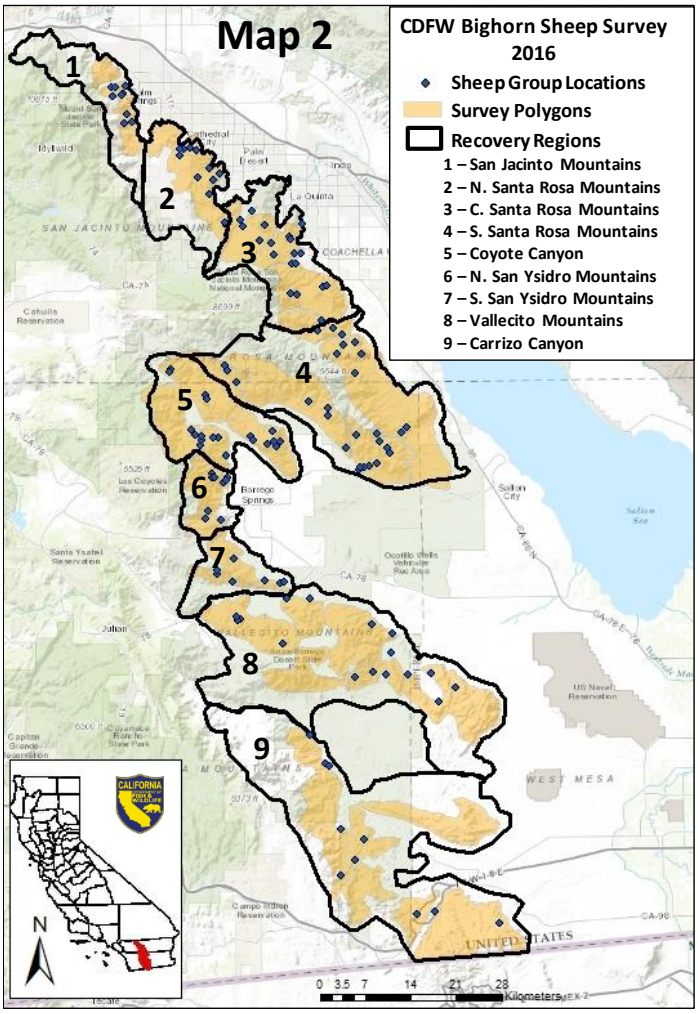
CDFW monitored all Very High Frequency (VHF) and Global Positioning System (GPS) radio-collared sheep range-wide using a combination of ground, satellite, remote-download, and aerial telemetry monitoring. Ground monitoring efforts focused on: 1) radio-collared sheep status (alive/dead), 2) mortality investigations, 3) observations of sheep composition, health, and status, and 4) spatial and temporal movements. Satellite-collared sheep in the SJM, CSRM, SSRM, and VM were monitored every 5 to 10 days with the Iridium Satellite Network that delivers messages and location data via email. A Cessna 185 fixed-wing aircraft was used to conduct aerial telemetry monitoring 1 to 2 times per month, or when availability allowed. Flights were used to monitor radio-collared sheep status, obtain location estimates, and download GPS data. The Bighorn Institute (BI) conducted ground monitoring in the SJM, NSRM, and the northern portion of the CSRM for their own research purposes and provided CDFW with a summary report of their findings for 2016.

POPULATION SIZE AND ESTIMATION

Bighorn sheep helicopter surveys were conducted in the Peninsular Ranges of San Diego, Riverside and Imperial Counties during November 7-15, 2016. Surveys were conducted from the south side of Chino Canyon in the San Jacinto Mountains to the Jacumba Mountains at the U.S. border with Mexico. Twenty-six of 27 predetermined polygons were surveyed; however, polygon 26 within the CC recovery region was not flown due to time constraints (Map 2). Locations of all observed bighorn sheep and flight paths were recorded with a GPS unit. All sheep groups observed were photographed using a digital camera with stabilizing lens. Surveys were coordinated and funded by CDFW. The California Department of Parks and Recreation (CDPR) and the Bureau of Land Management (BLM) provided logistical support.

Based on the number of bighorn sheep observed, mark/resight population estimates (point estimate ± 95% confidence interval) for each recovery region were generated using Chapman's (1951) modification of the Peterson estimator (Seber

1982). The range-wide population estimates were generalized and derived by adding the point estimates of each recovery region. A secondary estimate using the simultaneous double-count method (Graham and Bell 1989) was employed to estimate the minimum number of bighorn sheep present within the surveyed areas. Lastly, for each recovery region, a lamb:ewe ratio (number of lambs divided by the number of ewes observed) and a yearling:ewe ratio (number of female and male yearlings divided by the number of ewes observed) was calculated as an indicator of lamb survival (lamb:ewe ratio) and recruitment (yearling:ewe ratio).



A total of 588 bighorn sheep (including lambs) were observed in 125 groups during 47.88 rotor hours of actual survey time resulting in an overall Catch per Unit Effort (CPUE) of 12.28 sheep per rotor hour (Table 1). Ninety-two (87F, 5M) radio-collared bighorn sheep were seen out of 149 (141F, 8M) present in the range, for an overall observation rate of 62 percent. The overall lamb:ewe ratio was 38% and the overall yearling:ewe ratio was 36% (Table 1).

The generalized range-wide population estimate for adult bighorn sheep was 884 (yearlings, adult males and females, but excluding lambs) and individual recovery region estimates were: SJM 56 ± 14, NSRM 37 ± 14, CSRM 119 ± 19, SSRM 83 ± 17, CoC 69 ± 14, NSYM 59 ± 18, SSYM 42 ± 10, VM 163 ± 50, and CC 256 ± 191. A secondary estimate was generated resulting in an overall range-wide minimum estimate of 752 (lambs, yearlings, and adult males and females) within the surveyed areas.

Table 1. 2016 helicopter survey summary of the number of sheep observed, helicopter flight hours, number of sheep observed per flight hour (CPUE), and lamb:ewe and yearling:ewe ratios in each recovery region.

Region	Adults females	Adult Males	Yearling Females	Yearling Males	Lambs	Total Counted	Flight hours	CPUE	Lamb:Ewe Ratios	Yearling:Ewe Ratios
SJM	21	15	2	5	11	**54**	2.03	27	0.52	0.33
NSRM	14	3	2	2	6	**27**	2.57	11	0.43	0.29
CSRM	46	41	9	6	24	**126**	7.82	16	0.52	0.33
SSRM	36	19	6	4	9	**74**	6.1	12	0.25	0.28
CoC	28	15	9	6	13	**71**	6.59	11	0.46	0.54
NSYM	18	17	1	3	7	**46**	2.9	16	0.39	0.22
SSYM	19	8	3	2	6	**38**	2.17	18	0.32	0.26
VM	39	22	11	4	11	**87**	9.45	9	0.28	0.38
CC	29	13	10	4	9	**65**	8.25	8	0.31	0.48
Total	**250**	**153**	**53**	**36**	**96**	**588**	**47.88**	**12**	**0.38**	**0.36**

The generalized range-wide population estimate for female bighorn sheep was 552 (adults and yearlings) and individual recovery region estimates were: SJM 32 ± 9, NSRM 28 ± 10, CSR M 65 ± 10, SSRM 54 ± 11, CoC 45 ± 9, NSYM 29 ± 7, SSYM 29 ± 6, VM 101 ± 28, and CC 169 ± 53.

Based on the 2016 survey results, and on field observation collected throughout the year, we are confident that each recovery region contains greater than 25 adult female bighorn sheep. As such, 2016 marked year 1 of 6 in meeting criterion 1 in section II.B.2 for downlisting peninsular bighorn sheep from endangered to threatened status (USFWS 2000).

RADIO-COLLAR STATUS

As recommended in the recovery plan for peninsular bighorn sheep (USFWS 2000), CDFW maintains, to the extent possible, active radio-collars on approximately 25-30% of all ewes (female sheep) in each recovery region. The emphasis is placed on radio-collaring ewes because they are the reproductive base of the population. Maintaining at least 25% radio-collared ewes is important for generating reliable mark-resight population estimates based on helicopter surveys. Maintaining a representative sample of radio-collared sheep within the population not only allows us to track population trends, but helps to determine distribution and movement patterns, adult survivorship, causes-specific mortality, and monitor health status and disease. At the beginning of the reporting period (1 January 2016), the 9 recovery regions contained 171 (162F, 9M) active radio-collars (Table 2). At the end of the reporting period (31 May 2017), there were 130 (124F, 6M) active radio-collars (Table 2). Approximately 29% of the estimated female bighorn sheep population was radio-collared at the beginning of the reporting period compared to 22% at the end of the reporting period (based on 2016 overall ewe population survey estimate).

Table 2. Distribution and numbers of active radio-collared female (F) and male (M) bighorn sheep within the 9 recovery regions starting on January 1, 2016 and ending on May 31, 2017. The estimated percentage of females radio-collared (% F Collared) at the end of May 2017 is based on the ewe abundance estimates obtained from the 2016 helicopter survey.

Category	SJM		NSRM		CSRM		SSRM		CoC		NSYM		SSYM		VM		CC		Subtotal		Grand
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	Total
1/1/2016	11	2	11	0	21	0	23	1	12	0	13	0	14	0	32	3	25	3	162	9	171
mortalities	1				2		7		3		2		3		4	1	10	1	32	2	34
censored	2	1	1		1		1		1										6	1	7
5/31/2017	8	1	10	0	18	0	15	1	8	0	11	0	11	0	28	2	15	2	124	6	130
% F Collared	25%		36%		28%		28%		18%		38%		38%		28%		9%		22%		

CAUSE-SPECIFIC MORTALITY AND SURVIVAL

Between 1 January 2016 and 31 May 2017 there were 34 (32F, 2M) radio-collared sheep mortalities (Tables 2 & 3). Mortalities by recovery region were SJM = 1F, CSRM = 2F, SSRM = 7F, CoC = 3F, NSYM = 2F, SSYM = 3F, VM = 5 (4F, 1M), and CC = 11 (10F, 1M) (Table 3). On average, 11% of all active radio-collared sheep die each year with predation (hereafter includes possible lion, probable lion and lion predation combined) accounting for 6%, nonpredation (includes disease, injury, capture related, and vehicle collisions) accounting for 3%, and unknown causes accounting for 2%. In 2016, 12% of all active radio-collared sheep died of which 9% was attributed to predation, 2% unknown causes, and 1% due to vehicle collision. In the first 5 months of 2017, 9% of all active radio-collared sheep died of which 7% was attributed to predation, 1% unknown causes, and 1% due to vehicle collision. The long-term data indicates that predation risk is highest from November through May with the peak in December and predation risk is lowest in June and July. Similarly, for this reporting period, predation risk was highest in January followed by February and March.

For the 17-month reporting period, 47% of sheep mortalities showed signs of poor health of which 15% had either a tooth abscess or mandible infection and 12% showed signs of chronic sinusitis. The average age of radio-collared sheep alive at the end of the reporting period was 8 years with a range between 3 and 18 years (n = 127). The average age of radio-

collared sheep that had no signs of disease prior to death was 6 years with a range between 3 and 10 years (n = 15). In contrast, the average age of radio-collared sheep that were in poor health prior to death was 10 with a range between 5 and 16 years (n = 16).

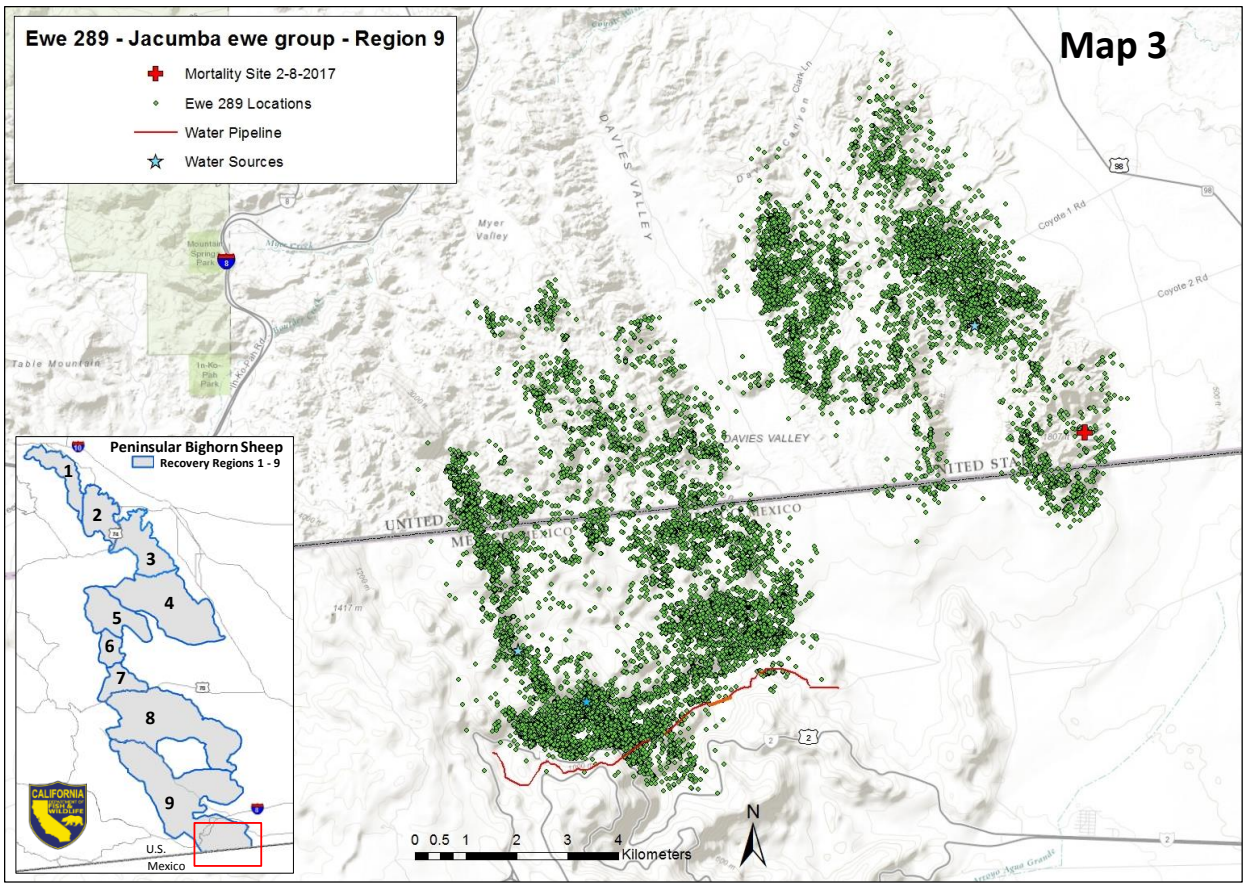
Table 3. Cause of death for 34 radio-collared bighorn sheep by recovery region and ewe group within the Peninsular Ranges of Southern California from 1 January 2016 to 31 May 2017. Carrizo = Carrizo ewe group, IKP = In-Ko-Pah ewe group, and TB = Tierra Blanca ewe group all within the Carrizo Canyon Recovery Region.

Region (Ewe Group)	General Area	Sheep ID	Age (years)	Sex	Mortality Date	Cause of Death
SJM	Tahquitz Creek	*237	14	F	*2/8/2017	Unknown
CSRM	Martinez Canyon	412	8	F	1/31/2016	Possible lion predation
CSRM	Devil Canyon	414	6	F	2/18/2017	Probable lion predation
SSRM	Wonderstone Wsh	405	11	F	1/16/2016	Possible coyote predation
SSRM	Wonderstone Wsh	385	8	F	1/25/2016	Unknown
SSRM	Big Wash	407	11	F	2/25/2016	Probable lion predation
SSRM	Big Wash	384	3	F	3/8/2016	Probable lion predation
SSRM	Wonderstone Wsh	386	10	F	12/11/2016	Possible lion predation
SSRM	Smoke Tree Wash	442	8	F	2/15/2017	Unknown
SSRM	Big Wash	404	10	F	2/28/2017	Lion predation
Coyote	N. Henderson Cyn	449	3	F	1/13/2016	Lion predation
Coyote	N. Henderson Cyn	392	7	F	1/1/2017	Possible lion predation
Coyote	Coyote Creek	393	7	F	1/17/2017	Probable coyote predation
NSYM	Dry Canyon	317	4	F	4/17/2016	Unknown
NSYM	S. Henderson Cyn	311	5	F	12/3/2016	Probable lion predation
SSYM	Tubb Canyon	444	8	F	8/15/2016	Possible lion predation
SSYM	Dry Canyon	378	16	F	9/30/2016	Unknown
SSYM	Yaqui Ridge	380	8	F	11/22/2016	Unknown
Vallecito	Sunset Wash	374	7	F	3/6/2016	Lion predation
Vallecito	Upper Flats	367	6	M	8/28/2016	Possible lion predation
Vallecito	Sunset Wash	344	5	F	11/29/2016	Probable lion predation
Vallecito	Split Mountain	319	9	F	1/20/2017	Probable lion predation
Vallecito	Fish Creek Wash	321	6	F	1/29/2017	Possible lion predation
Carrizo (TB)	Rockhouse Canyon	334	7	F	5/5/2016	Probable lion predation
Carrizo	Tule Canyon	331	14	F	2/12/2016	Probable lion predation
Carrizo	Jojoba Wash	303	12	M	3/23/2016	Probable lion predation
Carrizo	Rockhouse Canyon	301	8	F	1/21/2017	Lion predation
Carrizo	Volcanic Hills	297	10	F	5/12/2017	Probable lion predation
Carrizo (IKP)	Devils Canyon	226	15	F	2/9/2016	Probable lion predation
Carrizo (IKP)	Devils Canyon	232	10	F	3/14/2016	Probable lion predation
Carrizo (IKP)	Interstate 8 (EB)	277	6	F	5/16/2016	Vehicle Collision
Carrizo (IKP)	Myer Creek	282	10	F	1/9/2017	Probable lion predation
Carrizo (IKP)	Interstate 8 (WB)	225	10	F	2/2/2017	Vehicle Collision
Carrizo (Jac)	US/Mexico Border	289	6	F	2/8/2017	Probable lion predation

* Bighorn Institute radio-collared ewe; they were unable to investigate therefore cause is unknown and date of death is only a rough estimate.

Over the 17-month reporting period, CC recovery region lost the highest percentage of radio-collar sheep (39%) with 9 deaths attributed to predation and 2 deaths due to vehicle collisions (Table 3). Of the 9 deaths attributed to predation, 5 sheep were known to be in poor health prior to their deaths. Poor health conditions found that may have resulted in an increased risk of predation were osteoarthritis (ewe 232 & 331), chronic sinusitis (ewe 226), and missing incisors (ram 303). The condition of ewe 297 was not known at time of death; however, in past years the ewe was observed with a thick nasal discharge. The remaining 4 ewes attributed to predation were in medium to good condition at the time of death.

Additionally, lamb remains were found at the predation sites of ewes 226 and 334. Ewe 289 was the first documented sheep killed by a mountain lion within the Jacumba ewe group. This ewe was fitted with a solar GPS collar in October of 2013 that provided detailed location data up until the time of her death in February 2017 (Map 3). The area ewe 289 was killed was only 600 m from the US/Mexico border and in an extreme desert environment that was 12 km due east from higher elevation habitat more typically inhabited by mountain lions. Ewe 225 was struck and killed by a vehicle on the westbound lanes of Interstate 8 (Map 5). This ewe was first radio-collared in 2009 and was never observed pregnant, lactating, or seen with a lamb in 7.5 years of observations. A field necropsy was performed and the ewe was found to be in good health at the time of her death, all organs were normal appearing but she lacked a uterus. Ewe 277 was struck and killed on the eastbound lanes of interstate 8 (Map 5). Nine days prior to her death, the ewe was observed searching for her lamb. According to GPS data, ewe 277 crossed the Interstate 6 times in the 13 days prior to her death.



The SSRM lost the second highest percentage of radio-collared sheep (29%) with 5 deaths attributed to predation and the cause of 2 deaths unknown (Table 3). In both cases where the cause was listed as unknown, disease may have been a contributing factor. For instance, examination of the skeletal remains of ewe 385 revealed a bone infection (osteomyelitis) in the mandible (jawbone) and ewe 442 had severe chronic sinusitis. Of the 5 deaths attributed to predation, 2 were older ewes with severe chronic sinusitis (ewes 386 & 407) and ewe 404 was blind in the left eye which may have made her more vulnerable to predation. The legs, hooves, and skin of a newborn lamb were found at the carcass site of ewe 404. The condition of ewe 405 was unknown; however, GPS data indicate she was moving normally up to the time of her death. There was evidence that indicated coyotes had possibly killed ewe 405: a rarely documented event for adult bighorn sheep in the Peninsular Ranges.

Coyote Canyon lost the third highest percentage of radio-collared sheep (25%) with 2 deaths (ewes 449 & 392) attributed to lion predation and 1 death (ewe 393) attributed to coyote predation (Table 3). Ewe 449 was young and in fair condition (based on bone marrow) prior to her death. The condition of ewe 392 was not known. Ewe 393 was the second documented case of probable coyote predation for the reporting period. Based on fresh tracks, ewe 393 and 2 other adult ewes were half-way across a 1.8-kilometer flat and sandy wash when coyotes started chasing them. Ewe 393 was turned

back into the middle of the wash where she was killed by the coyotes. Unfortunately, the ewe's health status was not known prior to her death.

The SSYM lost the fourth highest percentage of radio-collared sheep (21%) with 1 death attributed to predation and the cause of 2 deaths unknown (Table 3). However, disease was likely a contributing factor for both unknown cases. Both ewes 378 and 380 were observed to be in extremely poor health in the months prior to their deaths. Additionally, examination of the skeletal remains of ewe 378 revealed severe chronic sinusitis and osteomyelitis of the mandible. Ewe 444 was one of the few sheep killed by a lion during the hot summer months; however, the ewe was killed along a stream in a riparian area that was fairly close to cooler mountainous terrain. The health status of ewe 444 at the time of her death was not known.

The NSYM lost 15% of active radio-collars to mortalities with 1 death attributed to predation and the cause of 1 death unknown (Table 3). Ewe 311 was young when killed by a mountain lion; however, she had been observed coughing on several occasions the year prior to her death. While the cause of death could not be determined for ewe 317, the skeletal remains were found 50 meters below County Road S22 and may have been due to a vehicle strike.

The VM lost 14% of active radio-collars to mortalities with all 5 deaths attributed to predation (Table 3). Of the 5 deaths attributed to predation, 3 sheep were known to be in poor health prior to their deaths. Ram 367 had osteomyelitis of the mandible, ewe 344 was observed in extremely poor health 7 days prior to being killed by a lion, and ewe 319 was in fair condition but blind in the right eye, which may have increased her risk of predation. Ewe 374 was in fair condition when she was killed by a lion and an approximately 2-week-old lamb carcass was found at the mortality site. The condition of ewe 321 was not known prior to her death and no signs of disease were detected during the mortality investigation.

The CSRM lost 10% of active radio-collars to mortalities with both deaths attributed to lion predation (Table 3). The skeletal remains of ewe 412 revealed osteomyelitis of the mandible. Ewe 414 was observed pregnant and in good condition 9 days prior to being killed by a lion.

The SJM had 1 death during the reporting period that constituted a loss of 8% of active radio-collars. Ewe 237 was radio-collared and monitored by the BI. The mortality could not be investigated due to steep terrain and thus the cause of death was listed as unknown.

The NSRM was the only recovery region that did not experience a radio-collared sheep mortality during the reporting period.

Because population viability is most sensitive to changes in ewe survival (Ruben et al. 2002), it is important to document ewe survival statistics within the Peninsular Ranges. Ewe survival rates vary by recovery region, year and month and the reliability of survival rates is influenced by the percentage of radio-collared sheep within each recovery region at any point in time. In 2016 (not including the first 5 months of 2017), average rangewide survival of radio-collared ewes was 88% ± 5%. Survival was highest in the SJM and NSRM and lowest in the SSRM and SSYM (Table 4). Over the past 5 years (2012-2016), the SJM has maintained the highest ewe survival rates followed by the NSRM. Due to lack of radio-collared sheep, survival statistics were not collected in 2014 and 2015 in the SSYM and not until 2016 in the SSRM. Regardless of the lack of data to discern a trend in these regions, the overall low

Table 4. Annual Kaplan-Meir survival rates (modified to allow for staggered entry of new animals) for female bighorn sheep in each recovery region from 2012 to 2016. Survival rates are reported as percent survival ± 95% confidence interval. *no data collected.

Region	2012	2013	2014	2015	2016	Average
SJM	**100** ± 0	**100** ± 0	**100** ± 0	**100** ± 0	**100** ± 0	**100** ± 0
NSRM	**100** ± 0	**100** ± 0	**83** ± 29	**80** ± 35	**100** ± 0	**94** ± 8
CSRM	**89** ± 21	**88** ± 23	**83** ± 29	**92** ± 16	**95** ± 9	**91** ± 7
SSRM	*	*	*	*	**78** ± 17	**78** ± 17
CoC	**86** ± 18	**75** ± 24	**100** ± 0	**67** ± 37	**92** ± 16	**83** ± 11
NSYM	**73** ± 26	**100** ± 0	**100** ± 0	**100** ± 0	**85** ± 20	**88** ± 10
SSYM	**90** ± 19	**67** ± 31	*	*	**79** ± 21	**76** ± 14
VM	**100** ± 0	**100** ± 0	**100** ± 0	**90** ± 13	**94** ± 8	**93** ± 8
CC	**100** ± 0	**67** ± 24	**94** ± 12	**89** ± 11	**80** ± 16	**86** ± 7

survival rates are of concern. The downward trend in survivorship in CC and the low 5-year average in CoC is of concern (Table 4).

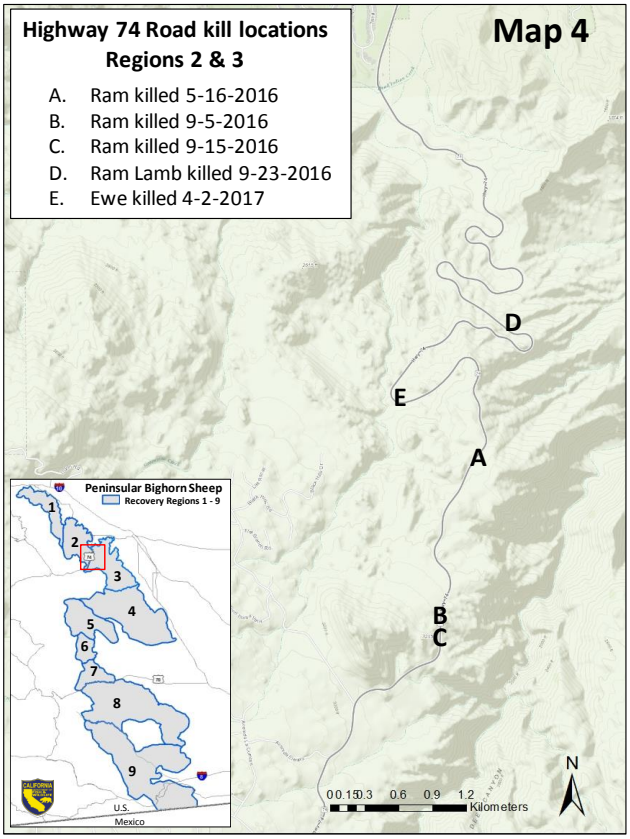
Documentation and mortality investigations of non-collared sheep deaths and/or injuries were undertaken when discovered by CDFW personnel during field monitoring or reported by the general public and government agencies. Because these mortalities are found by chance alone or typically near urban centers, they are not necessarily representative of the overall sheep population. During the 17-month reporting period, there were 26 (10F, 16M) non-collared bighorn sheep deaths reported (Table 5). The majority of deaths (42%) were due to vehicle collisions, 23% were due to predation, another 23% were due to pneumonia in lambs, and 12% were due to nonpredation causes.

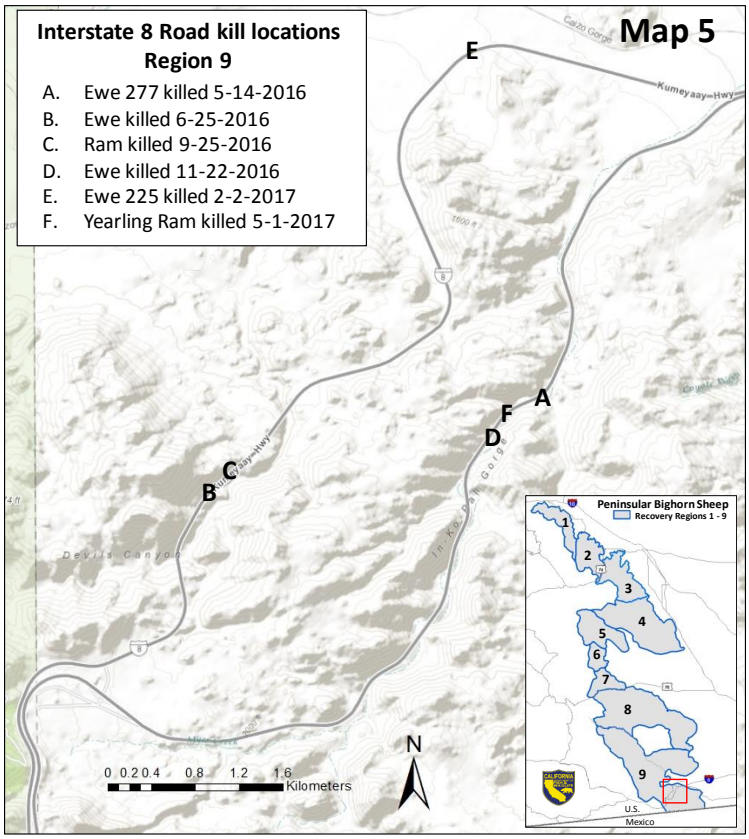
Table 5. Cause of death for 26 bighorn sheep by recovery region and ewe group within the Peninsular Ranges of Southern California from 1 January 2016 to 31 May, 2017. Sheep/vehicle collisions on Highway 74 were investigated/reported by Bighorn Institute and all other mortalities were investigated by CDFW.

Region (Ewe Group)	General Area	Age Estimate	Sex	Mortality Date	Cause of Death
NSRM/CSRM	Highway 74	2 yrs	M	5/16/2016	Vehicle Collision
NSRM/CSRM	Highway 74	8 yrs	M	9/5/2016	Vehicle Collision
NSRM/CSRM	Highway 74	9 yrs	M	9/15/2016	Vehicle Collision
NSRM/CSRM	Highway 74	8 mo	M	9/23/2016	Vehicle Collision
NSRM/CSRM	Highway 74	Adult	F	4/22/2017	Vehicle Collision
CSRM	PGA West	[a]15 wks	M	5/6/2016	Pneumonia
CSRM	PGA West	12 wks	M	5/10/2016	Pneumonia
CSRM	SilverRock	12 wks	F	5/15/2016	Pneumonia
CSRM	SilverRock	[b]17 wks	F	5/18/2016	Pneumonia
CSRM	SilverRock	17 wks	F	5/19/2016	Pneumonia
CSRM	La Quinta Cove	[c]12 wks	M	4/25/2017	Pneumonia
NSYM	Hellhole Canyon	16 wks	M	6/10/2016	Pneumonia
NSYM	Borrego-Palm Cyn	2.9 yrs	F	1/31/2017	Probable lion predation
Vallecito	Nolina Wash	8 yrs	M	4/24/2016	Possible lion predation
Vallecito	Pinyon Wash	10 yrs	M	6/1/2016	Nonpredation
Vallecito	Sentenac Canyon	14 yrs	F	7/12/2016	Nonpredation
Vallecito	Hapaha Flats	11 yrs	M	12/14/2016	Lion predation
Carrizo (TB)	Highway S2	12 yrs	M	5/24/2016	Vehicle Collision
Carrizo (TB)	Agua Caliente	24 wks	M	8/22/2016	Probable lion predation
Carrizo (TB)	Agua Caliente	12 yrs	F	8/22/2016	Probable lion predation
Carrizo (IKP)	Interstate 8 (EB)	7 yrs	M	1/27/2016	Vehicle Collision
Carrizo (IKP)	Devils Canyon	4 yrs	F	2/23/2016	Lion predation
Carrizo (IKP)	Interstate 8 (WB)	Adult	F	6/25/2016	Vehicle Collision
Carrizo (IKP)	Interstate 8 (WB)	6 yrs	M	9/25/2016	Vehicle Collision
Carrizo (IKP)	Interstate 8 (EB)	1.8 yrs	F	11/21/2016	Vehicle Collision
Carrizo (IKP)	Interstate 8 (EB)	1.3	M	5/1/2017	Vehicle Collision

[a] Lamb of radio-collared ewe 350
[b] Lamb of radio-collared ewe 349
[c] Possibly the lamb of radio-collared ewe 352

Sheep deaths due to vehicle collisions have increased over the past several years on Highway 74 between the CSRM and NSRM and on Interstate 8 in CC recovery region. On Highway 74, September 2016 was the deadliest month for rams during the reporting period, likely due to movement into adjacent ewe groups during the breeding season (Map 4). Ewes fared better than rams on Highway 74 with only 1 ewe killed in April 2017 during the lamb-rearing season (Map 4). In contrast, on Interstate 8 during the reporting period, there were only 2 ram deaths due to vehicle collision compared to 4 ewes of





which 2 were radio-collared (Map 5). Interstate 8 bisects the In-Ko-Pah ewe group's core lamb-rearing habitat and radio-collared ewes have been documented to cross the Interstate several times a day as they move between foraging habitat and nursery grounds within the island created by the divergence of the west and eastbound lanes.

LAMB SURVIVAL AND RECRUITMENT

Outside of all-age outbreaks of disease, lamb survival is considered the best demographic indicator of the health status of bighorn sheep populations (Cassirer et al. 2017). Due to concerns of disease in lambs, CDFW initiated monitoring of lamb survival (survival to ~ 3 to 4 months) and recruitment (survival to 1 year) in CoC, NSYM and SSYM in 2008. Lamb monitoring was extended into the In-Ko-Pah (IKP) ewe group (within CC) in 2010 and in the CSRM in 2015. Lamb:ewe ratios and yearling:ewe ratios, based on group observations, are used as indices of lamb survival and recruitment. Poor lamb survival to approximately 4 months of age is considered the most sensitive indicator of pneumonia-induced mortality in lambs (Cassirer et al. 2017). Furthermore, persistently low recruitment below 30% may pose a significant obstacle in population recovery (Cassirer et al. 2013). Clinical signs of lamb pneumonia have been documented in all recovery regions; however, rates of lamb survival and recruitment have varied by ewe group, season, and year (Table 6). Because rates of survival can vary, consistent monitoring activities are essential in order to examine long-term trends in lamb survival within each ewe group. In 2016, lamb recruitment in CoC, NSYM, and SSYM was much higher than in the previous 8 years (Table 6); nonetheless, chronically low recruitment in these recovery regions remains a concern. Details concerning respiratory disease in lambs can be found in the CDFW 2015 Annual Report.

Central Santa Rosa Mountains: Presently, 3 sub-ewe groups have been identified in the mountains above the city of La Quinta; 2 sub-ewe groups do not forage within the urban landscape (hereafter referred to as "wild" sheep) while the third sub-ewe group regularly forages at golf courses and the golf communities (hereafter referred to as "urban" sheep). Lamb recruitment in the wild sub-ewe groups has been stable and above 30% from 2014 to 2016 (Table 6). In contrast, lamb recruitment in the urban sub-ewe group has vacillated from a low of 11% in 2015 to 67% in 2016. Despite higher recruitment in 2016, all 15 urban lambs were observed with clinical signs of pneumonia early in the lamb-rearing season. In May, 5 urban lambs (3F, 2M) between the ages of 12 and 17 weeks died. CDFW transported all dead lambs to the California Animal Health and Food Safety Lab (CAHFS) in San Bernardino. Lab results indicated that all 5 lambs died of

bronchopneumonia with the main bacterial infectious agent identified as *Mycoplasma ovipneumoninae* (*M.ovi*). The remaining 10 urban lambs were able to recover from pneumonia over the summer months. While the 2016 recruitment rate within the urban ewe group is encouraging, evidence suggests that once pneumonia is introduced within a population, healthy periods are of short duration (Cassirer et al. 2013). In 2017, Lamb survival to 3 months was 77% in the urban ewe group and slightly lower in the wild (61%) ewe group. In April, a 3-month-old male lamb was found dead alongside an illegal trail within nursery habitat in La Quinta Cove; an area that is shared by both the urban and wild sub-ewe groups. Lab results indicted the lamb died of bronchopneumonia with the main bacterial infectious agent identified as *M.ovi.*

Table 6. Index of lamb survival to 3 months old (Survival) and recruitment of lambs to yearlings (Recruited) from 2008 – 2017 in CoC, NSYM, SSYM, IKP ewe group in CC, Urban ewe group in CSRM and Wild ewe group in CSRM. Three-month lamb survival was calculated from lamb:ewe ratios from group observations obtained from May-June of the year lambs were born and matched with yearling:ewe ratios (recruited) from January - June of the following year. For example in 2016 in NSYM, 66% of lambs survived to 3 months old (Survival), and 43% survived to yearlings (Recruited).

Year	CoC		NSYM		SSYM		IKP-CC		Urban CSRM		Wild CSRM	
	Survival	Recruited	Survival	Recruited	Survival	Recruited	Survival	Recruited	Survival	Recruited	Survival	Recruited
2008	66%	21%	43%	21%	64%	29%	*	*	*	*	*	*
2009	51%	31%	30%	24%	41%	18%	*	*	*	*	*	*
2010	37%	24%	14%	19%	61%	28%	79%	39%	*	*	*	*
2011	56%	4%	21%	3%	58%	17%	63%	20%	*	*	*	*
2012	36%	7%	13%	13%	63%	38%	70%	45%	*	*	*	*
2013	26%	7%	7%	18%	93%	*	51%	26%	*	*	*	*
2014	25%	22%	38%	34%	*	27%	10%	8%	*	35%	*	38%
2015	35%	27%	19%	11%	47%	23%	86%	35%	53%	11%	66%	36%
2016	73%	52%	66%	43%	94%	42%	75%	33%	86%	67%	65%	43%
2017	a		77%		83%		a		77%		61%	

[a]Not enough observation data were obtained for 3-month lamb:ewe ratios.

* Observation data were not collected.

Coyote Canyon: Lamb recruitment rates had been chronically below 30% in 7 of the past 8 years (Table 6). In 2016, lamb survival to 3 months was much higher at 73% with 52% of lambs recruited to yearlings. There were not enough observations obtained from January through May of 2017 to estimate 3-month lamb survival but lamb disease remains a concern within this recovery region.

Northern San Ysidro Mountains: In 2016, lamb survival (66%) and recruitment (43%) was much higher than in the previous 8 years (Table 6). Prior to 2016, clinical signs of respiratory disease were typically observed when lambs were about 2 months of age. In 2016, clinical signs of respiratory disease were not observed until lambs were over 3 months of age: possibly the timing of onset of respiratory disease affects the outcome. In 2017, survival to 3 months was once again high at 77% with minimal clinical signs of disease observed; nonetheless, this ewe group remains of great concern with respect to respiratory disease.

Southern San Ysidro Mountains: In 2016, very few lambs were observed sick and lamb survival and recruitment rates were much improved at 94% and 42% respectively (Table 6). In 2017, lamb survival was again high at 83% with no lambs observed sick prior to 3 months of age. Within the SSYM ewe group, 2 sets of twins were observed: one set of twins belonged to radio-collared ewe 446 and the other set belonged to a young non-collared ewe. While lamb recruitment in 2016 was higher than the previous 8 years, chronically low lamb recruitment rates in conjunction with a low average annual ewe survival rate of 76% (Table 4) may indicate a declining region.

Carrizo Canyon: There are 4 ewe groups within the CC recovery region: Tierra Blanca, Carrizo, In-Ko-Pah (IKP), and Jacumba. While group observations were obtained in all 4 ewe groups, lamb survival and recruitment ratios are only reported for the IKP ewe group which had been consistently monitored from 2010 through 2016 (Table 6). Starting in 2014 there was an observed increase in the number of lambs with severe symptoms of respiratory disease resulting in only 8% of lambs surviving through their first year. The IKP ewe group has followed the same pattern seen in other ewe groups with respiratory disease, decreasing or chronically low lamb survival and recruitment interspersed occasionally with high

recruitment rates. Following this general pattern, in 2015, lamb survival (86%) and recruitment (35%) ratios rebounded; then in 2016, lamb survival (75%) was slightly lower and recruitment dropped to 33%. Unfortunately, lamb survival to 3 months was not obtained in 2017.

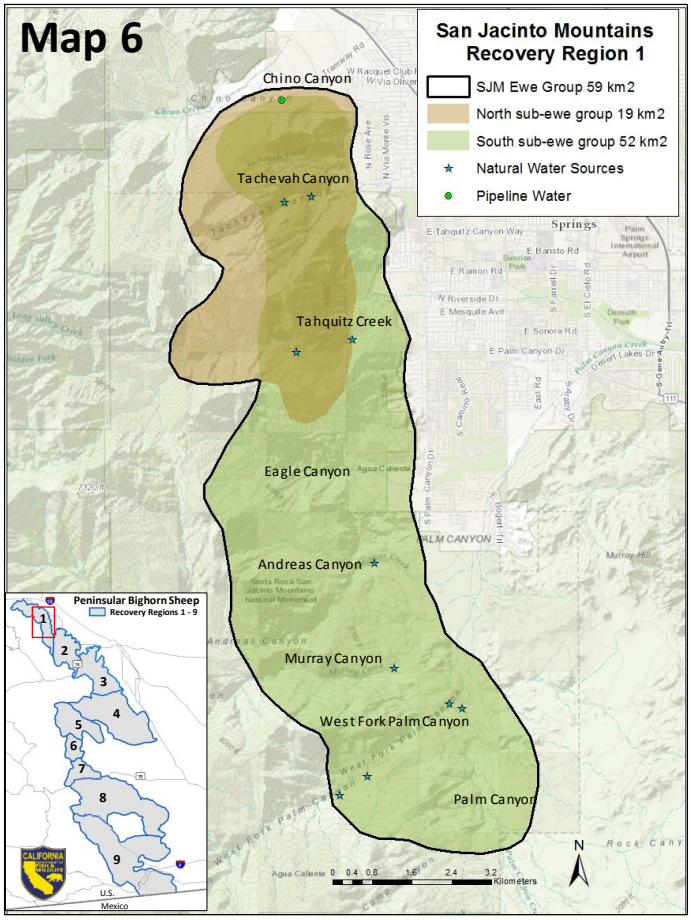
Respiratory disease has been observed in the Tierra Blanca, Carrizo, and Jacumba ewe groups. In the Tierra Blanca ewe group, there has been an increasing number of lambs with mild symptoms of respiratory disease observed each year since monitoring efforts began in 2015. In the Jacumba ewe group, clinical signs of respiratory disease have not been observed; however, observations have been limited due to their remote location and because this ewe group moves into Mexico during the second half of the lambing-rearing season.

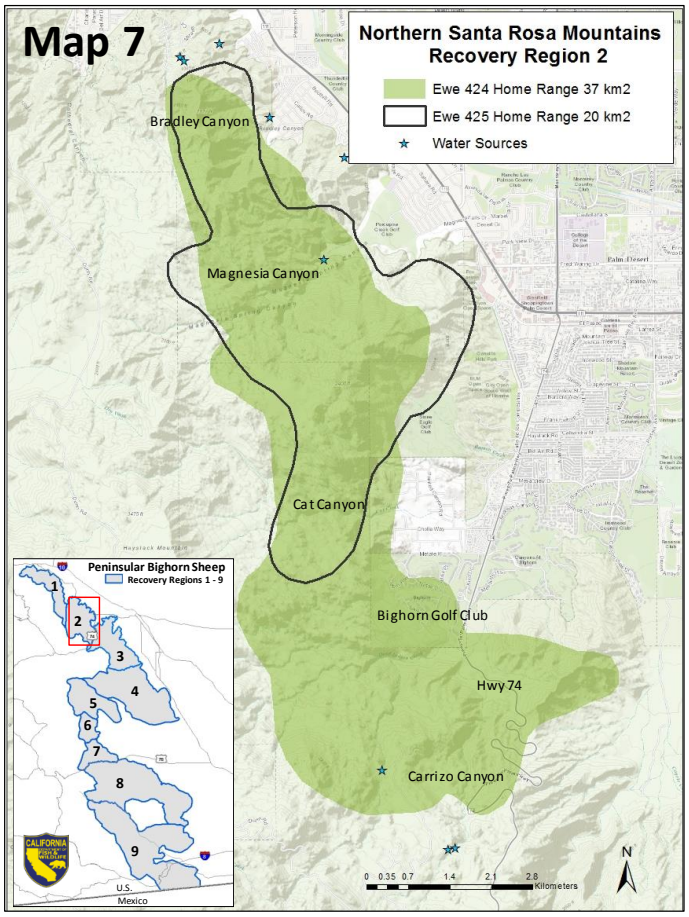
DISTRIBUTION AND MOVEMENT

San Jacinto Mountains: Currently, the SJM contains 1 ewe group consisting of 2 sub-ewe groups (north and south) that share some lamb-rearing areas but in general used different water sources located at the north and south ends of the region (Map 6). Based on current GPS data, the overall ewe group home range size is 59 km^2 and extends 16 km from the south side of Chino Canyon in the north to Palm Canyon at the southern end. The western boundary is at approximately 1200m elevation and extends 4 km to the eastern boundary of the urban interface at approximately 180m elevation. In 2016, the overall home range size for the north sub-ewe group was 19 km^2 compared to 52 km^2 for the south sub-ewe group. A water pipeline break along the Tramway Road in Chino Canyon allowed the north sub-ewe group to remain in Chino Canyon through summer 2016 rather than moving to natural water sources in Tachevah and Tahquitz Canyons. The break in the pipeline was repaired in September 2016.

Presently, none of the sheep captured and radio-collared in 2015 has moved to the north side of Chino Canyon (capture activities were not conducted on the north side of Chino Canyon). According to information provided by BI, in mid-March a young ram was spotted and photographed near the property of a residence on the north side of Chino Canyon. Then in September, BI received reports of a group of rams, ewes, and lambs in the residential community of Little Tuscany located on the south side of Chino Canyon in Palm Springs. There has been no movement documented between the SJM and NSRM by GPS-collared sheep.

Northern Santa Rosa Mountains: Presently, there are only 2 ewes with GPS collars in the NSRM. Due to this small data set, information concerning present ewe group structure is tentative. Current GPS data are suggestive of one ewe group

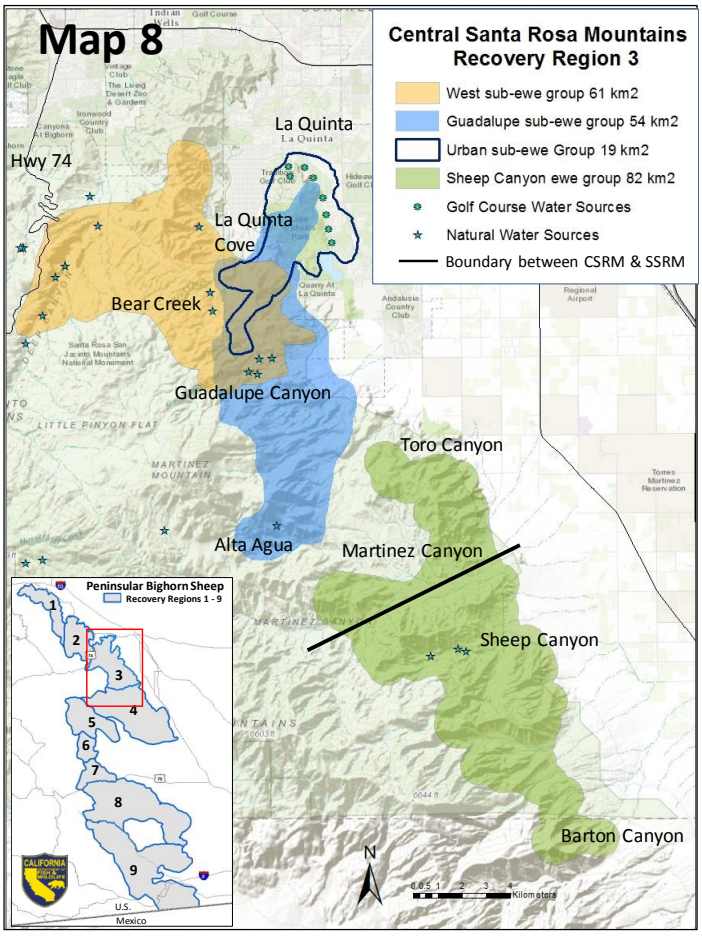




consisting of 2 patterns of habitat use (Map 7). Ewes 424's home range was 37 km^2 and extended 13 km from Bradley Canyon in the north to Highway 74 at the southern boundary. Ewe 425's home range was much smaller at 20 km^2 and extended from Bradley Canyon in the north to Cat Canyon in the south. The average home range width for both ewes was approximately 4 km with the western boundary at approximately 900m elevation and the eastern boundary at approximately 120m elevation at the urban interface. Both ewes shared the same lamb-rearing areas in Bradley and Magnesia Canyons and the same water source in Magnesia Canyon; however, ewe 424 spent the majority of the summer and the prelambing season in the south NSRM whereas ewe 425 remained in the north NSRM year-round. From July through December 2016, ewe 424 frequently foraged at the Bighorn Golf Club course in Palm Desert. Ewe 424 made an atypical movement in March when she crossed Highway 74 and spent two days on the east side of the Highway before returning to the NSRM.

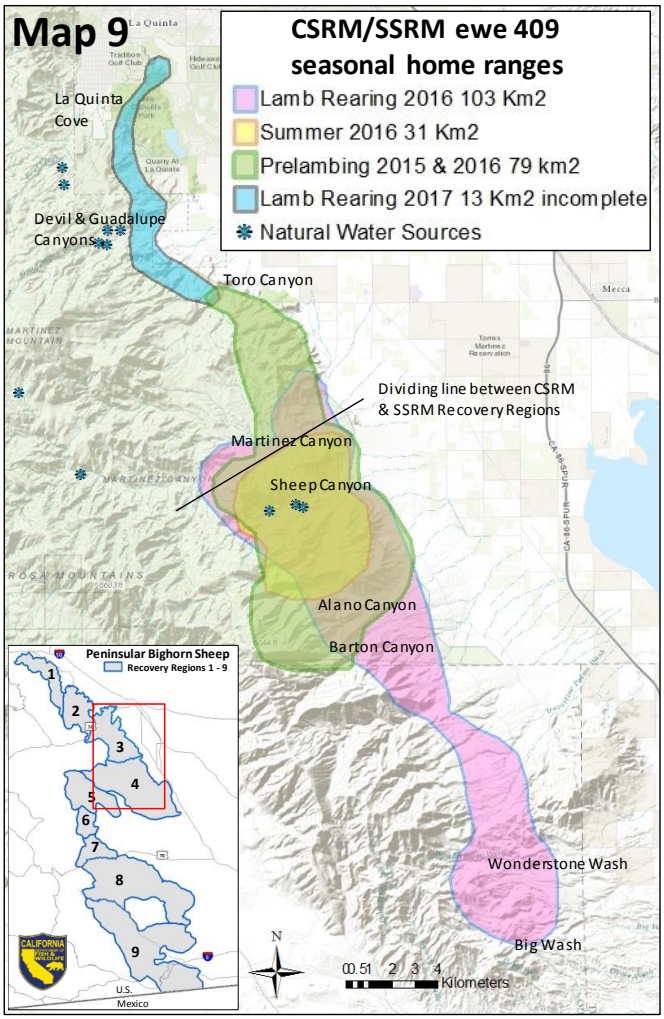
In order to understand current ewe group structure and movement within this recovery region, CDFW will capture and fit an additional 10 ewes with satellite GPS collars in November 2017.

Central Santa Rosa Mountains: This region has extensive ewe group sub-structuring that is very dynamic from one year to the next. Presently, data from GPS-collared ewes have identified 2 ewe groups: the La Quinta ewe group consists of 3 sub-ewe groups (West, Guadalupe, and Urban) and the Sheep Canyon ewe group that lies between the CSRM and SSRM recovery regions (Map 8). The West sub-ewe group's home range is the largest of the sub-ewe groups at 61 km^2. Typically, ewe groups' home ranges are much longer from north to south than from east to west: the West sub-ewe group is an exception with a length of 12 km from east to west and a width of 7 km from north to south. The western boundary abuts highway 74 and acts as a barrier to free sheep movement: thus far, none of the GPS-collared ewes have crossed the highway. The Guadalupe sub-ewe group's home range is 54 km^2 and extends 16 km from the Mountains above the SilverRock Golf Course in the north to Alta Agua Canyon at the southern boundary. The western boundary is at approximately 1160m elevation and extends 6 km to the eastern boundary at approximately 120m elevation near the desert floor. Thus far, the West and Guadalupe sub-ewe groups have not utilized the urban landscape for water or forage and are referred to as "wild" sub-ewe groups. The Urban sub-ewe group's home range is the smallest at 19 km^2 and resides at the lowest elevations relative to the wild sub-ewe groups. It is only 9 km long from north to south and 4 km wide from east to west and is bounded by golf communities on the west, north, and east sides. It is the newest group within the CSRM and most likely formed from ewes that splintered off from the West and Guadalupe sub-ewe groups. These "urban ewes" have become habituated to the urban environment and their movement patterns and behavior contrast strongly with those of their wild neighbors (refer to details in CDFW 2015 Annual Report).

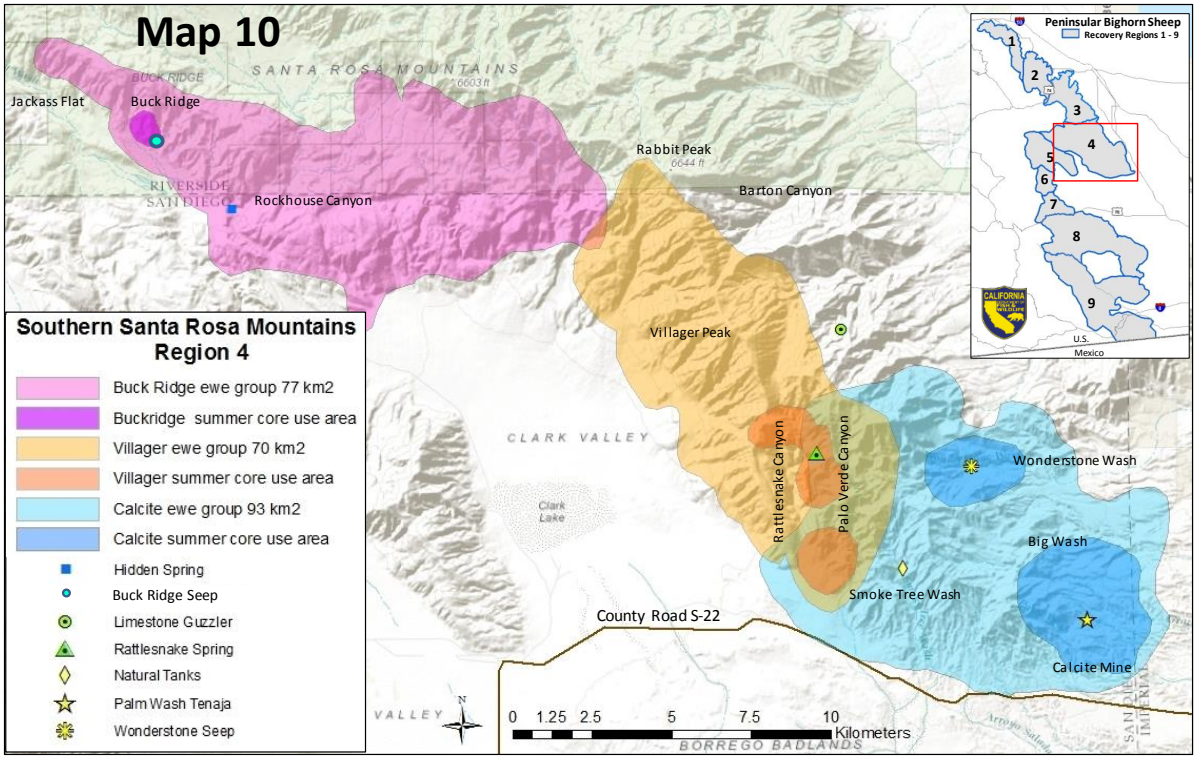


The Sheep Canyon ewe group's home range is 82 km^2 and extends 19 km from Toro Canyon in the north to Barton Canyon in the south (Map 8). The western boundary is at approximately 980m elevation and extends 8 km to the eastern boundary at approximately 120m elevation. It is considered a separate ewe group because it does not share summer or lamb-rearing areas with the West, Urban, or Guadalupe sub-ewe groups according to GPS data collected thus far. The core use area of the ewe group's home range falls through the dividing line between the CSRM and the SSRM recovery regions (Map 8).

A few GPS-collared ewes do not fit neatly into any of the patterns of habitat use within the CSRM and are considered "bridge" ewes. Bridge ewes split their time between 2 or more different ewe groups or sub-ewe groups and often bridge the social and physical discontinuities or gaps between ewe groups within a region or across regions. As an example, ewe 409's home range bridges the gap between the sub-ewe groups in the north CSRM with the Sheep Canyon ewe group and the Calcite ewe group in the SSRM (Map 9). Furthermore, ewe 409 has the largest home range compared to any other ewe documented thus far in the Peninsular Ranges. The overall home range encompassed approximately 150 km^2 and was 42 km long from north to south and 8 km wide from east to west. In 2016, ewe 409's lamb-rearing home range was 103 km^2 with the core use area between Martinez and Sheep Canyons. At the beginning of April, the ewe travelled 20 km to the south and spent time between Wonderstone and Big Wash in the SSRM recovery region before returning to the Sheep Canyon ewe group at the end of April. The summer home range was 31 km^2 with 2 core use areas in Sheep Canyon and the north side of Alano Canyon. Prelambing home range extended from Toro Canyon in the north to Barton Canyon in the south and was 79 km^2. Contrary to the lamb-rearing pattern of 2016, in 2017, ewe 409 moved north and joined the Guadalupe sub-ewe group in Devil Canyon.



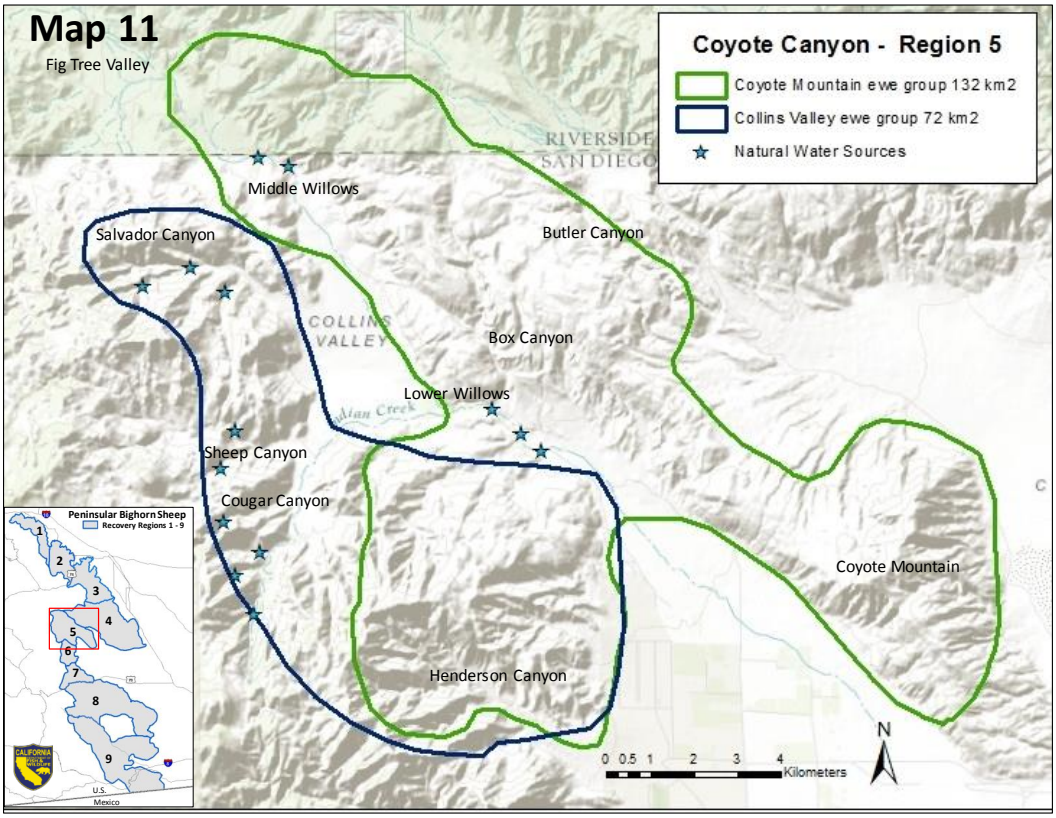
Southern Santa Rosa Mountains: Current GPS location data have identified 3 ewe groups in the SSRM (Map 10). The Buck Ridge ewe group's home range, located in the northwest corner of the recovery region, is 77 km^2 and is 19 km long from west to east and 7 km wide from north to south. The



Villager ewe group's home range is 70 km^2 and is 16 km long from north to south and 6 km wide from west to east. The Calcite ewe group's home range is 93 km^2 and is 13 km long from west to east and 10 km wide from north to south. The Villager and Calcite ewe groups' home ranges overlap in Palo Verde Canyon; however, they use separate lamb-rearing areas and different water sources during the summer months.

Presently, there are 7 known water sources available in the SSRM (Map 10). Unfortunately, in recent years water availability and reliability has not been consistent likely due to the effects of long-term drought conditions. The Calcite ewe group's main water sources are Palm Wash tinaja and Wonderstone seep with occasional use at Natural Rock Tanks. The Villager ewe group's main source of water has been Rattlesnake Spring; however, when water is not available at the spring, the sheep move 3.5 km due south to an area with no known water source. Presently, neither the Villager nor Calcite radio-collared ewes have used the Limestone Guzzler. A small seep has been identified within the Buck Ridge ewe group's core summer use area. Hidden spring, in Rockhouse Canyon, was rarely used as a water source in summer 2016.

Coyote Canyon: There are 2 ewe groups within this region with a fair amount of ewe group sub-structuring most likely due to the multitude of water sources in numerous canyons throughout the region (Map 11). The Coyote Mountain ewe group is 132 km^2 and extends 23 km from Fig Tree Valley in the northwest to almost the terminus of Coyote Mountain to

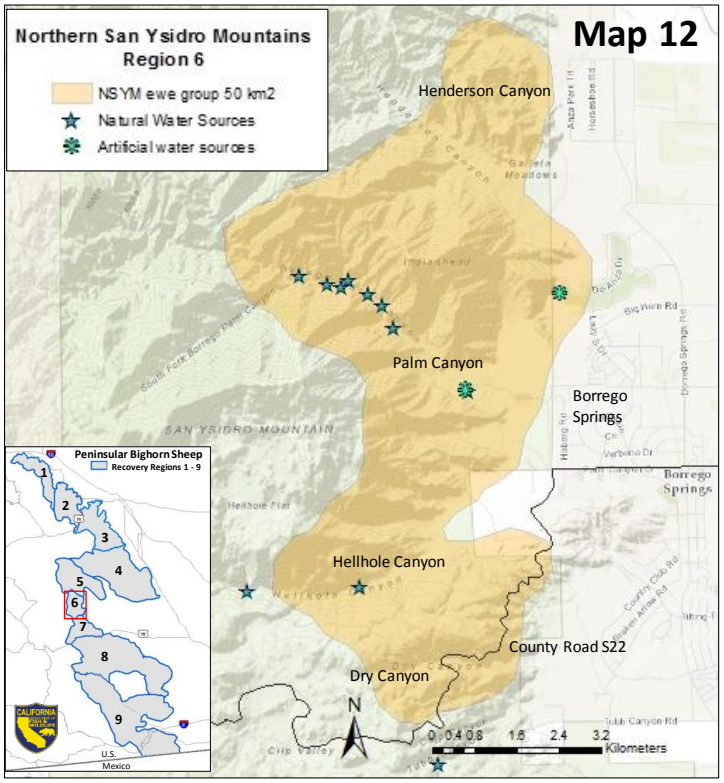


the southeast. The home range is 10 km wide and extends from Henderson Canyon in the southwest to Butler Canyon in northeast. The Coyote Mountain ewe group splits into 2 sub-ewe groups during the summer when some ewes move northwest to Middle Willows while others move to Box Canyon and Lower Willows. The ewes in Middle Willows often remain in the area throughout the prelambing season whereas the ewes in Lower Willows move into the mountains north of Henderson Canyon. The Collins Valley ewe group is 72 km^2 and extends 16 km from Salvador Canyon in the north to Henderson Canyon in the south. The home range is 8 km wide and extends from Cougar Canyon in the west to Coyote Creek to the east. The Collins Valley ewe group spends summer months in Salvador, Sheep, and Cougar Canyons with occasional use at Lower Willows. While both ewe groups use the area just north of Henderson Canyon during the prelambing season, the Coyote Mountain ewe group moves to coyote peak during the lamb-rearing season while the Collins Valley ewe group remains in the mountains on the west side of Coyote Creek.

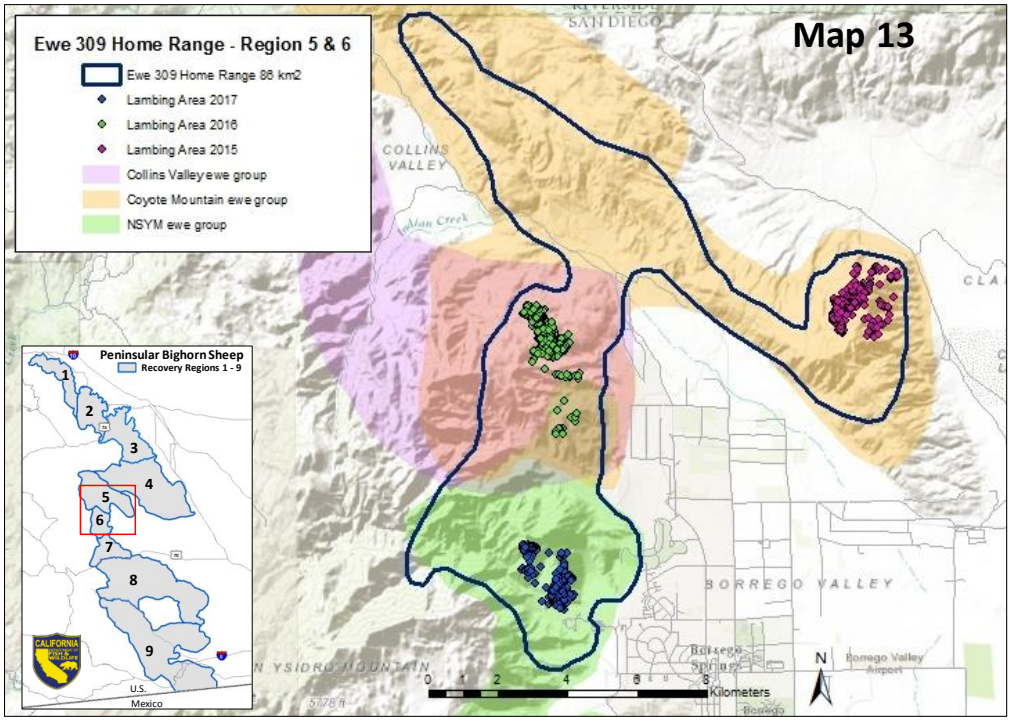
Northern San Ysidro Mountains: The NSYM ewe group's overall home range is 50 km^2 and extends 13 km from Henderson Canyon in the north to Dry Canyon in the south (Map 12). The western boundary is at approximately 980 m elevation and

extends 7 km to the eastern boundary at approximately 240 m elevation in Borrego Springs. The majority of radio-collared ewes (Palm Canyon core ewe group) spend all 3 seasons within the area surrounding Borrego-Palm Canyon (BPC). A second subset of ewes spend the majority of their time between Hellhole Canyon and the slopes above Highway S22 just north of Tubb Canyon; however, these same ewes also use Palm Canyon during the summer and/or lamb-rearing seasons.

During the fall of 2009, NSYM sheep began shifting prelambing habitat use from areas surrounding the creek within BPC to foraging at the DeAnza Country Club golf course and surrounding homes. Since 2009, the general trend has been an increase in the spatial and temporal use (number of days, hours per day, and area used) by rams, ewes, and lambs within the development.

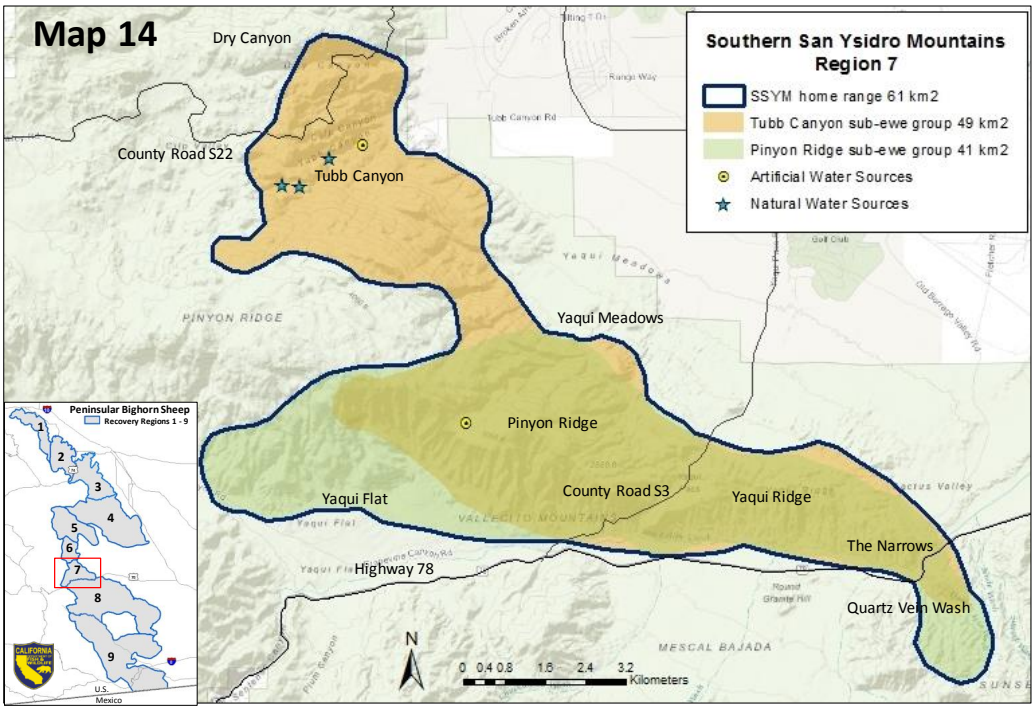


There is a subset of ewes, referred to as bridge ewes, which move between ewe groups and do not appear to have high site fidelity relative to their cohorts. For example, ewe 309, unlike the majority of adult ewes, does not stay with the same ewe group or sub-ewe group each lamb-rearing season (Map 13). Because the majority of ewe 309's time is spent in BPC (6 to 7 months), she is considered a NSYM ewe; however, her overall home range spans 3 ewe groups (Coyote Mountains, Collins Valley, and NSYM ewe groups). Ewe 446 is an example of a ewe that bridges the gap between the NSYM and the SSYM to the south. In 2016, ewe 446 and her lamb stayed with the Palm Canyon ewe group throughout the lamb-rearing season. In 2017, the ewe moved out of the NSYM, crossed Highway S22, and joined the SSYM ewe nursery group on the south-facing slopes of Pinyon Ridge where she was observed with 2-week-old twins.

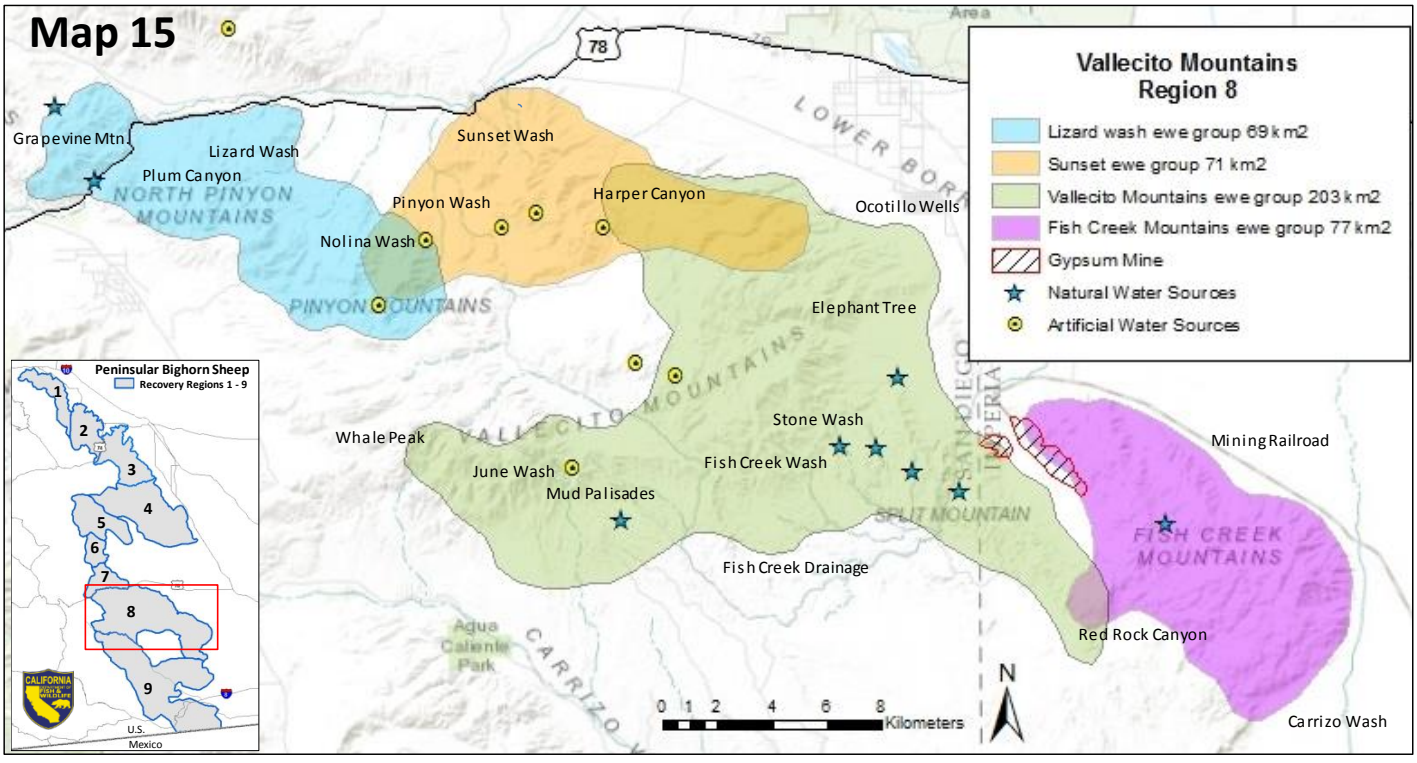


Southern San Ysidro Mountains: Currently, the SSYM contains 1 ewe group consisting of 2 sub-ewe groups that share the same lamb-rearing area but use different areas during the summer months (Map 14). The SSYM overall home range is 61 km^2 and extends 16 km from Dry Canyon in the northwest to the Narrows along Highway 78 in the southeast. The southwestern boundary of the home range is at Yaqui Flat in Grapevine Canyon and extends 5 km to the northeast to Yaqui Meadows. The Tubb Canyon sub-ewe group encompasses 49 km^2 and the Pinyon Ridge sub-ewe group encompasses 41 km^2. Both sub-ewe groups converge on the south-facing slopes of Pinyon Ridge and Yaqui ridge during the peak of lamb-rearing season. County road S3 bisects lamb-rearing habitat and ewes and their lambs cross the road on a regular

basis. As summer approaches, the Tubb Canyon sub-ewe group heads northwest and spends the summer and the first half of the prelambing season in the Tubb Canyon area. In contrast, the Pinyon Ridge sub-ewe group remains on Pinyon and Yaqui Ridges year-round.



Vallecito Mountains: There are 4 ewe groups that have been identified in the Vallecito Mountains; Lizard Wash, Sunset, Vallecito, and Fish Creek Mountains ewe groups (Map 15). The Lizard Wash ewe group's home range is 69 km^2 and extends 16 km in length from Grapevine Mountain to Nolina Wash and 6 km in width from the south side of Highway 78 to the ridgeline of the North Pinyon Mountains. During the summer months, ewes spend the majority of their time between Plum Canyon and Lizard Wash and only occasionally access water at San Felipe Creek along Highway 78. In fact, one of the GPS-collared ewes did not access any known water sources in 2016. While sheep sightings in the Grapevine Mountains have been rare, GPS-collared ewes inhabit the area from late August through October. Ewe 371 was captured in the Lizard Wash area in November 2015 and fitted with a VHF radio-collar. In September of 2016, the ewe was observed at the Agua Caliente County Park Campground within the CC recovery region — a distance of 28 km. This is the first documented movement by a radio-collared ewe from the VM to CC recovery region. Ewe 371 was observed back in Lizard Wash in October 2016.

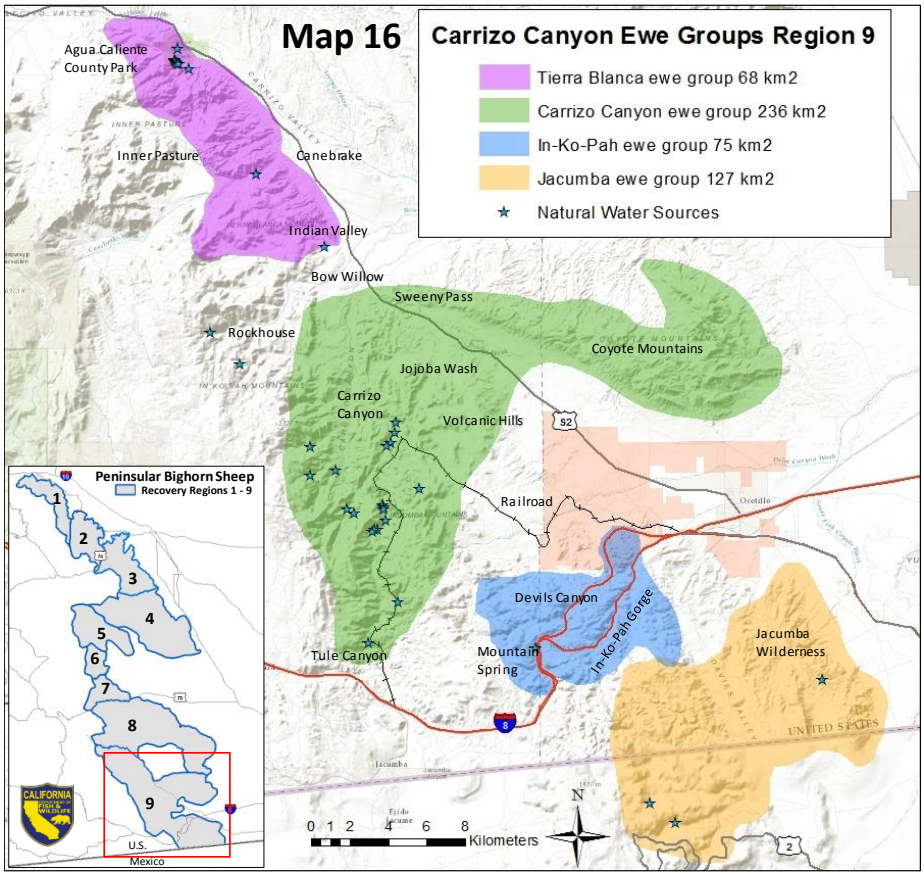


The Sunset ewe group's home range encompasses approximately 71 km^2 and extends 10 km from Nolina Wash in the west to Harper Canyon in the east (Map 15). It is bound by Highway 78 in the north and extends 7 km to Harper Flats at the southern boundary. Presently, there are 7 VHF-collared ewes in this area and no functioning GPS collars. Our understanding of the Sunset ewe group is based on GPS data collected from 2010 to 2012 and on observation data, remote camera data and from VHF-collared sheep. There are no natural water sources within this area and sheep are dependent upon water provided by 4 guzzlers on and surrounding Sunset Peak.

The Vallecito ewe group's home range is 203 km^2 and extends 22 km from the southern slopes of Whale Peak in the west to the Split Mountain area in the east (Map 15). The northern boundary extends 14 km in width from Harper Canyon to Fish Creek Wash drainage. The Vallecito ewe group consists of 3 sub-ewe groups; Elephant Tree, June Wash, and Split Mountain. The Elephant Tree sub-ewe group's core use areas are within the alluvial fan of Elephant Tree and in the mountains to the west and north of the Elephant Tree area. The June Wash sub-ewe group's core use areas are on the slopes between June Wash and the Mud Palisades. The Split Mountain sub-ewe group's core use areas are around Stone Wash and the eastern side of Split Mountain down to Red Rock Canyon.

The Fish Creek Mountains (FCM) ewe group's home range is 77 km^2 and extends 14 km in length from the Gypsum Quarry in the north to Carrizo Wash in the south and 8 km in width from Red Rock Canyon to the Mining Railroad (Map 15). There are only a few known water sources within a north/south trending canyon at the northeast end of their home range. In summer 2016, the lower tinaja was checked and found to be dry; however, current satellite data show this canyon to be the most heavily used during the summer months.

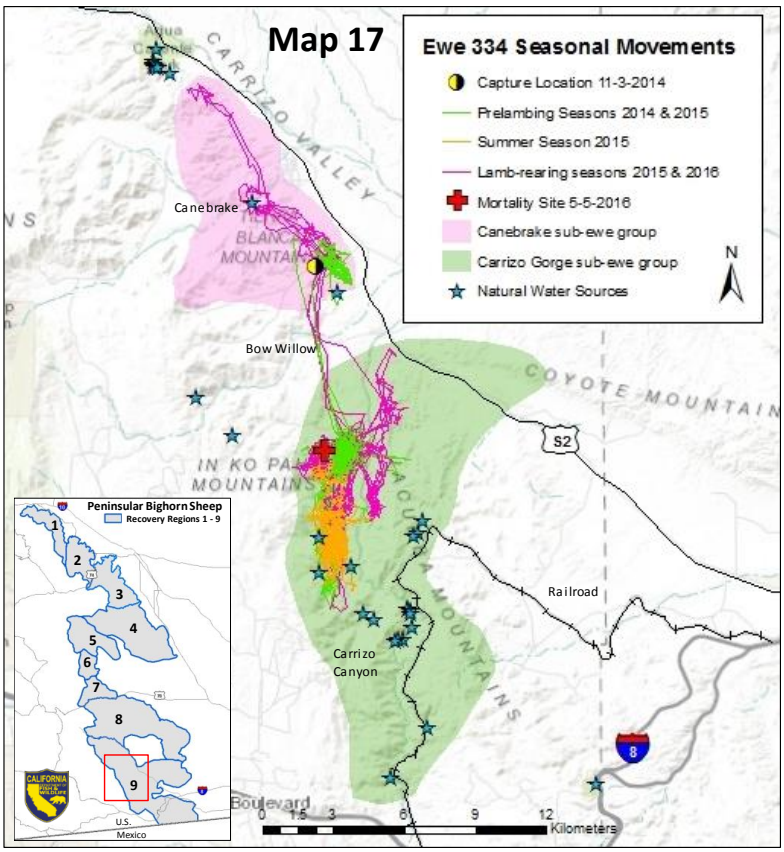
Carrizo Canyon: There are 4 ewe groups that have been identified in CC recovery region; the Tierra Blanca, Carrizo Canyon, In-Ko-Pah, and Jacumba ewe groups (Map 16). The Carrizo Canyon and the In-Ko-Pah ewe groups have been well documented based on data collected from GPS-collared sheep from 2009 to present. Two additional ewe groups have been identified based on GPS data collected from sheep captured in November 2013 within the Jacumba Wilderness (Jacumba ewe group) south of Interstate 8 and the Tierra Blanca Mountains (Tierra Blanca ewe group) north of Carrizo Canyon.



The Tierra Blanca ewe group's overall home range encompasses 68 km^2 and is 16 km in length from the northeast end of the Sawtooth Mountains to the south side of Indian Valley and 6 km in width from the Inner Pasture to County Road S2 (Map 16). The Tierra Blanca ewe group consists of 2 sub-ewe groups; Agua Caliente and Canebrake. The Agua Caliente sub-ewe group's core use area is in the northern half of the Tierra Blanca Mountains. The sub-ewe group obtains water during the summer from the springs surrounding Agua Caliente County Park. In comparison, the Canebrake sub-ewe group's core use area is in the southern half of the Tierra Blanca Mountains. The sub-ewe group obtains water during the summer months exclusively at Canebrake Canyon.

The Carrizo Canyon ewe group's overall home range is 236 km^2 and extends 26 km in length from the west side of Carrizo Canyon to the east side of the Coyote Mountains and 20 km in width from the mouth of Carrizo Canyon to Tule Canyon near Interstate 8 (Map 16). The Carrizo Canyon ewe group consists of 2 sub-ewe groups: Coyote Mountains and Carrizo Gorge. The Carrizo Gorge sub-ewe group remains in the area surrounding Carrizo Canyon year-round whereas the Coyote Mountains sub-ewe group moves east across County Road S2 into the Coyote Mountains during the lamb-rearing season. Both sub-ewe groups spend the summer months near water sources within Carrizo Canyon and its tributaries.

Until recently, there had been no documented regular seasonal movement between the Tierra Blanca and Carrizo Canyon ewe groups. Ewe 334 (captured in November 2014 in the Tierra Blanca Mountains) moved between the Canebrake sub-ewe group and the Carrizo Gorge sub-ewe group several times each year during the prelambing and lamb-rearing seasons until her death in May 2016 (Map 17).



The In-Ko-Pah (IKP) ewe group's home range encompasses 75 km^2 in the areas surrounding Mountain Springs, Devils Canyon, In-Ko-Pah Gorge, and within the island created by the divergence of the east and westbound lanes of Interstate 8 (Map 16). The Jacumba ewe group's home range encompasses 127 km^2 and extends 16 km from the Jacumba Wilderness in the United States to Highway 2 in Mexico and 13 km wide from west to east (Map 16). Data collection and observations are problematic since these ewes spend summers and a portion of lamb rearing and prelambing seasons within Mexico. Detailed information concerning the IKP and Jacumba ewe groups can be found in the CDFW 2014 Annual Report.

THREATS TO RECOVERY

Section II.D.1.1-1.4 of the Peninsular Ranges bighorn sheep recovery plan (USFWS 2000) describes a series of interim and long-term actions that, if implemented, would eliminate or significantly reduce threats to population recovery. Actions described in the plan address a broad range of known and potential threats to recovery. These threats (generally described) include but may not be limited to: 1) habitat loss and fragmentation; 2) loss of habitat connectivity; 3) loss of habitat quality due to natural (fire) and human causes (introduction of exotic/toxic vegetation); 4) loss, reduction or diversion of water sources; 4) use of the urban interface; 5) livestock grazing; 6) road and highway crossing; and 7) human activities known or found to be directly or indirectly detrimental to sheep. Because bighorn sheep in the Peninsular Ranges reside in a network of state, federal, private, and tribal government lands which lie adjacent to large human urban populations, reaching recovery goals and assuring long-term protections for sheep will require an understanding of and commitment to eliminating threats within and among recovery regions. Identified threats as described in the Peninsular Ranges recovery plan are detailed below by recovery region.

San Jacinto Mountains, and Northern and Central Santa Rosa Mountains - *Threats and concerns – habitat loss and fragmentation, urban use, disease, human disturbance, vehicle collisions, and domestic livestock***.** Urban development and human disturbance within and adjacent to sheep habitat continue to be a major concern within these 3 recovery regions. In the SJM, the first few homes have been built in the Desert Palisades subdivision on 112 acres of essential sheep habitat in the Chino Cone area. Connectivity across Chino Canyon is restricted by the Tramway road, fencing, and human activities. In the area surrounding Blaisdell Canyon, domestic sheep and goats that are not properly fenced or allowed to run loose can potentially spread disease to the wild sheep population.

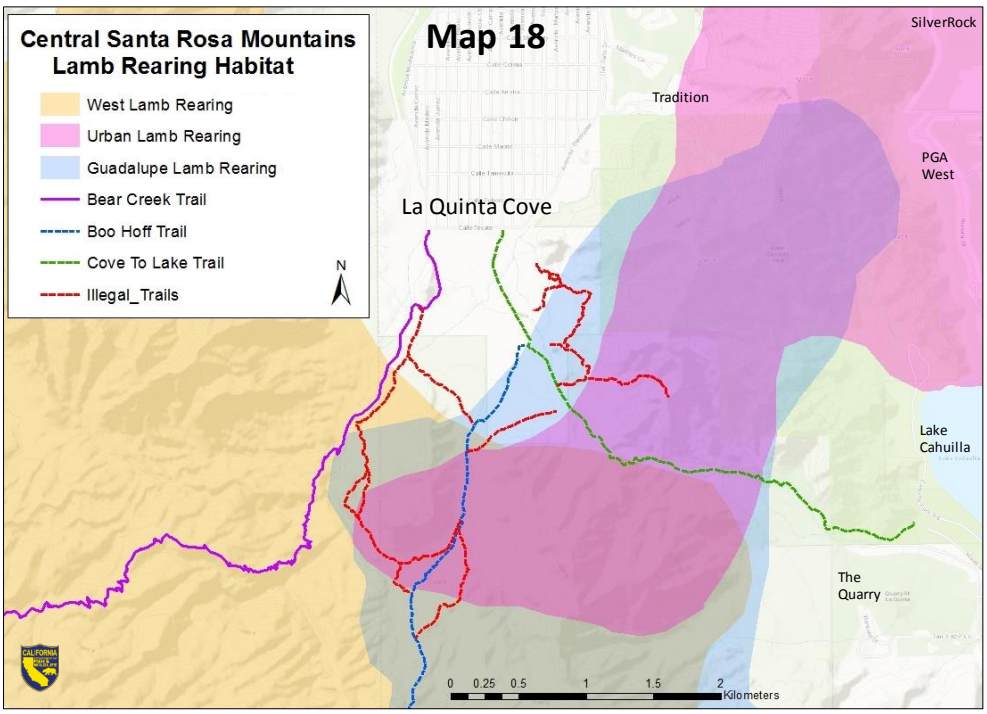
Highway 74 impedes sheep movement between the NSRM and CSRM and each year more sheep are struck and killed by vehicles while attempting to cross the highway (Table 7). Caltrans agreed to place 2 flashing warning signs along the highway at key sheep-crossing zones. The signs need to be installed soon as August and September are the peak months that rams are typically killed while crossing the highway. Future increases in the traffic load on this stretch of the highway may eventually cut off any movement between the NSRM and CSRM. According to the recovery plan for bighorn sheep in the Peninsular Ranges section II.B.2 (USFWS 2000), in order for downlisting criterion 2 to be met "connectivity among all portions of habitat must be established and assured through land management commitments, such that bighorn sheep are able to move freely throughout all habitat."

Table 7. Documented road-killed bighorn sheep within the Peninsular Ranges. Incidents that occur along highways near major urban centers, such as Highway 74, are more likely to be reported; whereas sheep hit and killed in more remote areas (County Roads S2, S22, S3) at lower speeds are often not reported or the information is not relayed to CDFW. Data for road-killed sheep on Highway 74 and Jefferson were provided by Bighorn Institute. ‡Data are from January to May 2017. *No data are available on Interstate 8 prior to 2012.

Road	Year												Total by road
	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	‡2017	
Highway 74		2	2	1	1	1	1	1	3	4	4	1	**21**
Interstate 8	*	*	*	*	*	*	1		[a]1	2	[b]5	[c]2	**11**
County Rd S22		[d]1			[e]4		2						**7**
Highway 78		2	[f]1										**3**
County Rd S3	1			[g]1		[h]2							**4**
Jefferson Street										1			**1**
County Rd S2											1		**1**
Total by year	**1**	**5**	**3**	**2**	**5**	**3**	**4**	**1**	**4**	**7**	**10**	**3**	**48**

[a]Ewe 284 killed on 3/27/2014; [b]Ewe 277 killed on 5/14/2016; and [c]Ewe 225 killed on 2/2/2017
[d]Ewe 184 killed on 12/14/2007; [e]Lamb of ewe 137 killed on 2/9/2010
[f]Ewe 164 killed on 2/16/2008
[g]Ewe167 killed on 3/7/2009; and [h]Ewe 201 killed on 1/26/2011

Human disturbance in areas identified as essential sheep habitat continues to be a major concern within these 3 recovery regions. According to the bighorn sheep recovery Plan (USFWS 2000), "essential habitat comprises those areas believed to be necessary for a self-sustaining bighorn population with a high probability for long-term survival (recovery) in the Peninsular Ranges of the United States. Essential habitat, therefore, consists of those physical and biological resources (space, food, water, cover) needed for: 1) normal behavior with protection from disturbance, and 2) individual/population growth and movement." Protection of essential habitat and reduction or elimination of detrimental human activities within bighorn sheep habitat is listed as recovery actions in sections II.D.1.1.1-1.2.2. In the CSRM, La Quinta Cove has become a popular destination for recreational users and several popular trails pass through essential sheep habitat (Map 18). The West, Urban, and Guadalupe sub-ewe groups use the La Quinta Cove area during all seasons but particularly during the lambing and lamb-rearing seasons that coincides with the most popular time for recreational users. There are 3 official trails in La Quinta Cove that bisect essential lambing and lamb-rearing habitat: Bear



Creek trail, Boo Hoff Trail, and the Cove to Lake Trail. The new kiosks located at the La Quinta Cove trailhead do not provide clear information as to where dogs and bikes are and are not allowed, nor do they provide information concerning bighorn sheep. The public disregards rules restricting dogs, especially on the Cove to Lake Trail. Furthermore, there has been a proliferation of illegal trails (social trails) that are often used by mountain bikers and hikers in areas that have been identified as sheep escape terrain, movement corridors, and lambing and nursery habitat. In order to reduce or eliminate human disturbance the recovery plan recommends that land management agencies, scientific organizations, and user groups develop and implement a trails management program (II.D.1.2.2.1 a-f.). The management action that would have an immediate impact on protecting bighorn sheep would be the deployment of enforcement personnel during peak use periods to educate the public, monitor compliance with trail rules, and enforce rules against violations. In order to achieve this goal, CDFW, city, state, and federal agencies need to work together to clarify, define, and strengthen regulations in an area that is undeniably essential for the continued health and viability of bighorn sheep within the Santa Rosa Mountains.

Since 2012, a growing number of sheep have foraged at PGA West, SilverRock, and Tradition Golf Courses on a daily basis. In April 2017, the City of La Quinta completed construction on a temporary sheep exclusion fence along the base of the mountains at SilverRock golf course. However, this is only a first step, as sheep can still enter the golf course from Tradition to the north and PGA West to the south. Furthermore, since fence installation at SilverRock, sheep have increased their use of Tradition, the Quarry, Lake Cahuilla County Park and the adjacent Riverside County Sheriff shooting range and have significantly increased their use at PGA West. If an exclusion fence is not built at the base of the mountains of the areas listed above, the number of urban related deaths will continue to increase. Since 2012, 3 rams and 1 lamb have drowned in the Coachella Canal, 1 ram and 2 lambs have been rescued from the canal, 1 ram has died from oleander poisoning, and 1 ram was struck and killed on Jefferson Avenue. In the past few years, 9 lambs have died of pneumonia within the golf communities of La Quinta. While disease in lambs is found range-wide, disease can rapidly spread among sheep that concentrate within the golf course communities (refer to section on Respiratory Disease in CDFW 2015 Annual Report).

Fencing at the urban interface is identified as a site-specific recovery action for the Santa Rosa Mountains south of Highway 74 in Section II.D.1.2 of the recovery plan (USFWS 2000). Construction of fencing to exclude bighorn sheep from golf courses and residential areas in La Quinta would be an important step toward preventing urban related mortalities and enhance efforts toward conservation of sheep in the CSRM. For example, the exclusion fence built in Rancho Mirage in 2002 has eliminated urban-related bighorn sheep deaths. Other potential actions, such as the capture and removal of sheep from the golf course communities would not be feasible. Ewes teach their lambs where to obtain food and water and once a pattern of use (home range) is established, it is maintained from one cohort to the next. Sheep are capable of traveling great distances over a short period and would easily find their way back to their original home range. Furthermore, because disease has been identified within the urban ewe group, removal of these sheep to another area would facilitate the spread of disease to other areas of the range.

Southern Santa Rosa Mountains - *Threats and concerns – habitat loss and degradation, depleting water sources, human disturbance (off-road vehicles), disease, and predation.* Gold mine exploration is taking place within sheep habitat in the Wonderstone Wash area in the eastern portion of this recovery region. Sheep habitat within the boundaries of Anza Borrego Desert State Park (ABDSP) does not guarantee protection due to incursions by off-road vehicles in washes that are presently not often patrolled by the State Park.

In the past, there have been numerous reliable sources of water for sheep in the SSRM. Recently, some natural springs and tinajas have dried up in the latter portion of the summer. If drought conditions continue these water sources may no longer meet the needs of sheep within this recovery region. Recently radio-collared sheep within the SSRM and placement of more cameras at springs will help determine whether water enhancement projects may be warranted.

Coyote Canyon - *Threats and concerns – water source accessibility, disease, predation, and human disturbance.* Coyote Canyon, in ABDSP, is closed between Lower Willows and Middle Willows from June 1 through September 30 in order to protect the watering rights of bighorn sheep. However, Coyote Creek is a dynamic system and sheep have recently been accessing water at or below the closure gate where it is more open and escape terrain is closer. Moving the closure gate below second crossing may help to ensure that sheep can obtain water in a safe location without human disturbance.

The non-native plant species tamarisk (*Tamarix, ssp*.) has been identified as a serious threat to bighorn sheep recovery (USFWS 2000: I.D.5). This is mainly due to the plants ability to outcompete native riparian plant species such as mesquite (*Prosopis glandulosa*) and catclaw acacia (*Acacia greggii*) that sheep depend on as high quality forage during the summer and fall months. In 1973, ABDSP took the lead in tamarisk removal from riparian areas; and by 2000, had eliminated the majority of tamarisk within the state park and Coyote Canyon. Until recently, ABDSP resource crew pulled tamarisk seedlings from Middle and Lower Willows in Coyote Canyon on an annual basis in order to prevent tamarisk re-infestations. Middle and Lower Willows in Coyote Canyon are essential sheep habitat and maintenance level tamarisk removal needs to be continued in order to prevent the loss of high quality sheep habitat.

Disease in this recovery region continues to be a threat and CDFW will continue to monitor for possible increases in disease occurrence. Typically, sheep that live within recovery regions with perennial streams and extensive riparian areas (CoC, NSYM, and CC) have higher predation rates than sheep living in areas without perennial streams. Sick lambs will often stay near water sources, which in turn increase their risk of predation. Furthermore, in past years, CDFW has documented on 5 occasions ewes standing guard over their dead lambs (deaths due to pneumonia) for up to 3 days; in 2 of these cases, the ewes were killed by a mountain lion. Ravens at the lamb carcass site may alert predators to the ewe's location: dead lambs are now removed when found near a ewe.

Northern San Ysidro Mountains - *Threats and concerns – urban use, vehicle collision, disease, predation, and human disturbance.* An increase in urban use by sheep within this recovery region continues to be a concern as sheep become habituated and increase their use each year at the DeAnza Villas and golf course community. The development poses a threat to the health and survival of sheep in this recovery region due to the following: 1) possible ingestion of poisonous ornamental plants such as oleander, 2) facilitation of the spread of disease due to sheep concentrating on the golf course, 3) accidents such as vehicle collisions and drowning in pools or ponds, 4) drinking contaminated water, and 5) increased predation at the urban interface. CDFW continues to examine the feasibility of installing barrier fencing along the boundary of ABDSP and DeAnza Villas along with public and agency support and funding sources for such an effort.

Another threat to sheep within this recovery region is movement across County Highway S22. One of the most frequently crossed sections of this road is between mile marker 13 and 14.5, with several past sheep deaths documented at a specific point just below mile marker 14. CDFW continues to examine the feasibility of placing warning lights and signs at locations along stretches of S22 to reduce this risk.

In recent years, most water sources within Borrego-Palm Canyon (BPC) dry up and sheep now rely on the pupfish pond adjacent to the trailhead parking lot. If this trend continues, placement of another water source closer to the slopes and away from the trailhead parking lot may allow sheep to access water without being disturbed, while still allowing visitors to access the trailhead parking area.

Pneumonia in lambs continues to be a major concern within this recover region. Sick lambs need to drink often and will spend a significant amount of time near the creek in BPC. Lamb disease occurs at the same time park visitation numbers soar within the canyon. The BPC trail is not regularly maintained and visitors often become lost and end up off-trail following the creek bed where sheep often congregate. Visitors approaching and photographing sick lambs may decrease their chances of survival or impede movement to and from water sources and high quality forage alongside the stream. During the record-breaking crowds of the wildflower "super bloom" in spring 2017, ABDSP Visitor Center Staff did a spectacular job educating, controlling and preventing the crowds from disturbing ewes and lambs that were foraging on the blooming flowers within the canyon. Park visitors enjoyed the opportunity to view sheep without disturbing them and to learn about sheep behavior and ecology. Sheep in BPC now face a new human disturbance—drones. CDFW and Park staff has encountered use of drones within BPC and has documented ewes and lambs running away from drones. While ABDSP does not allow drones within the park, other public lands that lack regulations or enforcement may encounter similar disturbances to sheep.

Southern San Ysidro Mountains - *Threats and concerns – vehicle collision, maintaining water sources, disease, and predation.* County Highway S3 between Pinyon Ridge and Yaqui Ridge bisects the SSYM ewe group. Highway 78, at the Narrows, serves as a movement corridor between the SSYM and VM. Sheep are most often struck and killed on both

sections of these roads during the early spring when ewes are moving between the lambing and nursery grounds. Unfortunately, this coincides with an increase in traffic during the peak of visitation to ABDSP and the Ocotillo Wells Off-Road Recreation Park. Reducing the speed limit at common sheep-crossing locations and placement of flashing warning signs may help reduce sheep deaths.

Natural springs within upper Tubb Canyon in ABDSP that were accessible for a few years following a fire in 2012 have now filled in with vegetation. Accessibility, water depletion, and regular maintenance of springs and guzzlers within this recovery region need to be addressed by ABDSP and CDFW in order to ensure future access to water for sheep.

Vallecito Mountains - *Threats and concerns - maintaining water sources, habitat loss, human disturbance, and disease.* The Fish Creek Mountains (FCM) ewe group resides largely outside the protection of BLM wilderness and wilderness areas within ABDSP and thus is vulnerable to habitat loss and fragmentation. Sources of habitat loss and fragmentation may result from continued expansion of a gypsum mine at the northern portion of the FCM ewe group's home range, and off-road vehicle use and target shooting on BLM lands on the eastern edge of the FCM.

Numerous tinajas in the FCM have been dry for the past few years. If drought conditions continue these water sources may no longer meet the needs of sheep within FCM and water enhancement projects may be warranted. For over 30 years, ABDSP has maintained numerous guzzlers within the VM and sheep have become dependent upon their use. Due to drought conditions, there has not been enough rain to fill some guzzlers. In 2015, ABDSP trained volunteers to check the condition of guzzlers; however, a long-term cooperative ABDSP and CDFW maintenance program with dedicated funding should be considered to assure year round water availability.

Carrizo Canyon - *Threats and concerns – vehicle collisions, habitat loss and fragmentation, disease, water accessibility, human disturbance, and domestic livestock.* In the past few years, there has been an increase in the number of sick lambs observed in 3 of 4 ewe groups (Tierra Blanca, IKP, and Carrizo). In June of 2015, a dead lamb was found in Carrizo Canyon and lab results identified *Mycoplasma ovipneumoniae* (*M.ovi*) as the likely causative pathogen. In June 2017, a dead lamb was discovered in Canebrake Canyon in the Tierra Blanca Mountains and preliminary lab results indicate *M.ovi.* CDFW will continue to monitor disease among these ewe groups.

Since 2012, there have been 11 documented cases of sheep killed (including 3 radio-collared ewes) by vehicles on Interstate 8 (Table 7). This section of the Interstate bisects the seasonal movement pathway of both rams and ewes. As Interstate traffic continues to increase each year, seasonal movement pathways will eventually be cut off. CDFW staff continues to recommend that USFWS and renewable energy project proponents implement vehicle strike hazard reduction (funnel and barrier fencing and signage) and habitat improvement measures required to offset impacts from energy developments in bighorn sheep habitat in CC. Ultimately, overpass structures and directional fencing are the only effective structures that will allow movement over the freeway while preventing sheep access to the roadway along the I-8 In-Ko-Pah Gorge corridor.

Water availability and access to water is a growing concern. Mountain Spring is an important source of water for sheep in the IKP ewe group. Mountain Spring is on San Diego County Park land and adjacent to the westbound lanes of Interstate 8. While vehicle access to the spring is restricted from the Interstate, the spring can be accessed via a jeep trail from the west. This road is ungated and allows unrestricted public and vehicle access to the spring. Placement of a gate is needed to protect the watering rights of bighorn sheep. Sheep within the Tierra Blanca ewe group are dependent on the water sources at Agua Caliente County Park (ACCP) and Canebrake Canyon. The campground at ACCP is closed to the public during the summer allowing sheep free access to the springs. Campground construction and maintenance activities should be minimized during this time. While Oleander bushes (*Nerium oleander*) in the campground were removed in 2013, regular inspection and prompt removal of resprouts should be undertaken in order to prevent sheep deaths due to oleander poisoning. Canebrake Canyon provides an important water source for sheep. The upper canyon is being choked by tamarisk (*Tamarix* spp.) which may eventually prevent access to water and out-compete important native plant species. Additionally, some residences within the community of Canebrake have oleander bushes in their yards that are easily accessible to sheep foraging in the canyon. CDFW highly encourages removal of non-native and poisonous plants from privately owned properties within essential sheep habitat.

Since 2009, GPS data identified areas within CC that are important sheep habitat and movement corridors. Sheep in CC face increasing challenges posed by renewable energy developments, access road construction and maintenance related to border security, as well as human disturbance. Presently, target shooting is allowed on BLM land within the I-8 island and is accessed via the Mountain Springs exit. Jeep activities in Devils Canyon may restrict free movement of sheep to and from their lamb-rearing habitat within the island. Border security activity throughout the recovery region is intensive with regular vehicle patrols, foot patrols, and helicopter flights both night and day within lamb-rearing habitat and movement corridors in designated wilderness areas. The following areas are considered important sheep movement corridors that have been impacted by unauthorized roads; Bow Willow Canyon, Rockhouse Canyon, Sweeney Canyon, Jojoba Wash, the Volcanic Hills, Devils Canyon, the jeep road to Mountain Spring, Myer Valley access from east-bound Interstate 8, Davies Canyon and Valley, and the eastern Jacumba Mountains.

The Jacumba ewe group is dependent on resources both within the US and Mexico. A fence along the US-Mexico border would prohibit movement to, and use of, prelambing and lamb rearing habitat and summer water sources. Furthermore, lamb-rearing habitat in the east Jacumba Mountains is not within USFWS designated critical sheep habitat and any further energy projects development within or adjacent to the these areas combined with disturbance by border security activities may have significant adverse impacts on this ewe group.

FUTURE ACTIONS

Program activities for 2017/2018 include monitoring radio-collared sheep to detect and investigate mortalities, obtain ground observations to assess group composition, health and disease, lamb:ewe and yearling:ewe ratios, and collecting location and movement data. In addition, a capture is planned for fall 2017 to replace radio-collars in the SJM and increase the number of radio-collars in the NSRM, SSRM, VM, and CC recovery regions. In the fall of 2018, a helicopter survey will be conducted to estimate the range-wide bighorn sheep population. Additionally, CDFW will update rangewide population structure, distribution, and movement based on GPS data collection. CDFW personnel involved in peninsular sheep recovery will coordinate with federal, state, local and NGO recovery program partners on recovery.

CDFW Helicopter Survey 2016 – Photo by Tim Glenner

Photo by Jeff Young

GLOSSARY

Bridge ewe: A ewe that has a pattern of habitat use that varies significantly from the majority of ewes within a ewe group or sub-ewe group. Unlike its cohorts, a bridge ewe does not use the same lamb-rearing habitat each season (lacks site fidelity). Bridge ewes split their time between two or more different ewe groups or sub-ewe groups and often bridge the social and physical discontinuities or gaps between ewe groups within a region or across regions.

Catch per Unit Effort (CPUE): is the total number of sheep observed (catch) during a helicopter survey divided by the time spent searching (unit effort) for sheep during the survey. This number can be used as an indirect measure (or index) of sheep abundance.

Confidence Interval: In statistics, a confidence interval is used to express the precision and uncertainty associated with a particular sampling method (http://stattrek.com/estimation/estimation-in-statistics.aspx). In this report, all population point estimates are reported with 95% confidence intervals (95% CI). Short confidence intervals indicate high reliability in the estimate and longer intervals indicate lower reliability in the estimate.

Ewe: Female adult bighorn sheep. Adults are ≥ 2 years old.

Ewe Group: A group of ewes that share the same spatial and temporal patterns of habitat use particularly during the lambing-rearing and summer seasons.

GPS collar: refer to radio-collar

GPS location data: Information collected by a GPS (Global Positioning System) radio-collar. Basic information collected by GPS-collared sheep in the Peninsular Ranges are location coordinates every 2 to 3 hours, date, time and elevation.

Home Range: The area used by a ewe or group of ewes over a specified period such as lamb rearing, prelambing, summer seasons or annually. GPS location data, for each ewe and ewe group, were used to created home range boundaries using ArcMap 10.

Lamb: male and female bighorn sheep < 1 year old.

Lamb:ewe ratio: refer to lamb survival.

Lambing habitat: The area used by a ewe to give birth.

Lamb-rearing habitat: The area used by a ewe or group of ewes to raise their lambs particularly during the first five months postpartum.

Lamb-rearing season: For each individual ewe, lamb-rearing season begins once her lamb is born and extends until the lamb is weaned at approximately 5 to 6 months. Ewes typically give birth between January and May but can give birth earlier or later. In this report, Lamb-rearing season is defined from 1 January to 30 May.

Lamb recruitment: Survival of lambs through their first year of life and are thus "recruited" into the adult sheep population. Yearling:ewe ratios are used as a rough indicator of lamb recruitment and are based on the number of yearlings and ewes observed during field observations or during a survey (yearlings ÷ ewes × 100). Example: if 7 yearlings and 20 ewes are observed in a group (7 ÷ 20 × 100 = 35) then lamb recruitment is approximately 35%.

Lamb survival: Survival of lambs through their first 3 to 4 months of life. Lamb:ewe ratios are used as a rough indicator of lamb survival and are based on the number of lambs and ewes observed during field observations or during a survey (lambs ÷ ewes × 100). Example: if 10 lambs and 20 ewes are observed in a group (10 ÷ 20 × 100 = 50) then lamb survival is approximately 50%.

Mark/resight population estimate: A well-established and repeatable *statistical* method of objectively *estimating* a wildlife population. It is not possible to find and count every sheep in such a vast area as the peninsular ranges and therefore a representative sample of the population is counted within defined areas (polygons) using a helicopter and crew and the population size is estimated based on the sample. The simple mark/resight formula is the following: Population estimate = $(n_1 \times n_2) \div m_2$. Example of a simple mark/resight estimate: First, a representative sample of 60 sheep from the population were captured, marked using radio-collars (n_1), and released. At a later date, a second representative sample of 100 sheep were counted (n_2) of which 30 were wearing radio-collars (resight = m_2). By plugging the numbers into the formula (60 × 100) ÷ 30 = 200, the estimated population is 200. The basic assumption of the mark-resight estimator is that the proportion of marked animals observed during the second sample (30/60 = 0.50) is the same as that in the population at large (100/200 = 0.50). CDFW uses Chapman's (1951) modification of the Peterson estimator (Seber 1982) to generate mark/resight population estimates (N): $N = [(n_1+1)(n_2+1)/(m_2+1)]-1$, where n_1 is the number of collared animals in the sampling area, n_2 is the total number of animals observed, and m_2 is the number of collared animals observed in the sampling area. Confidence intervals (95%) were calculated as $N \pm 1.96$ (variance of $N)^{0.5}$, with the variance defined as: variance $= [(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)]/[(m_2+1)^2(m_2+2)]$ (Seber 1982).

Nursery Area/habitat: The area used by a ewe group during the first few months of lamb-rearing season.

Point estimate: In statistics, estimation refers to the process by which one makes inferences about a population, based on information obtained from a sample. A point estimate of a population parameter is a single value of a statistic. For example, the sample mean (average) is a point estimate of the population mean (http://stattrek.com/estimation/estimation-in-statistics.aspx).

Polygon: a predetermined geographic boundary that the helicopter survey team must remain within while searching for bighorn sheep.

Predation: A general term used to describe when a predator, such as a mountain lion or coyote, kills and consumes a bighorn sheep. Strict criteria are used to classify whether a sheep's death is due to predation, probable predation, possible predation, or not due to predation (nonpredation) based on the type and strength of the evidence found during the mortality site investigation.

Prelambing season: In this report, prelambing season is defined from 1 September to 31 December.

Ram: Male adult bighorn sheep. Adults are ≥ 2 years old.

Radio-collar: a collar with attached radio telemetry technology that is placed around a bighorn sheep's neck in order to monitor a sheep's movements. Radio-collar is a general term that includes 3 types of telemetry systems used by CDFW on bighorn sheep in the Peninsular Ranges: VHF, GPS, and Satellite telemetry technology.

- **VHF collar**: a Very High Frequency (VHF) collar emits a unique radio signal (or channel) that is detected with a handheld radio receiver and antenna. A sheep's location can only be obtained by a researcher tracking and locating the sheep from the ground, or by estimating the location from the ground or air.
- **GPS collar:** a Global Positioning System (GPS) collar receives and stores location data (store-on-board) from a satellite system. Because location data are stored on the collar, it requires a researcher to be in clear sight of the sheep in order to remotely connect with the GPS collar and transmit the data to a handheld device.
- **Satellite collar:** a Global Positioning System (GPS) collar receives and stores location data using a satellite system. Location data are transmitted to a data portal every 1 to 3 days and can be retrieved via email.

Satellite collar: refer to radio-collar.

Simultaneous double-count method: A method of estimating a population that does not rely on "marked" animals. There are no confidence intervals produced with this method and thus no measure of reliability.

Sinusitis: A bacterial infection of the frontal or cornual sinus cavity of bighorn sheep. Long-term infection (**chronic sinusitis**) can often result in necrosis (bone or tissue death) to the frontal bone, horn core and horn sheath. The cause of the disease is not known; however, in peninsular bighorn sheep a secondary infection caused by a cactus spine penetrating the sinus cavity is suspected as one possible cause.

Sub-ewe Group: Within each ewe group there is some sub-structuring, or variations in patterns of use by a subset of ewes. For example, a sub-ewe group may spend all or a portion of lamb-rearing season with another ewe group but the two groups will split and spend summer and prelambing seasons in a different areas. In other words, sub-ewe groups share areas in common with other sub-ewe or ewe groups but their overall temporal and spatial patterns of use differ from the other groups.

Summer season: In this report, summer season is defined from 1 June to 31 August.

VHF collar: refer to radio-collar

Yearling: A male or female bighorn sheep that is ≥ 1 year old and < 2 years old.

Yearling:ewe ratio: refer to lamb recruitment.

CDFW 2016 Helicopter Survey - Photo by Tim Glenner

CDFW 2016 Helicopter Survey - Photo by Christine Thompson

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