# CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

# PENINSULAR BIGHORN SHEEP 2017-18 ANNUAL REPORT


*This report presents information on the status, distribution, and management of Peninsular bighorn sheep from 1 June 2017 to 31 May 2018*

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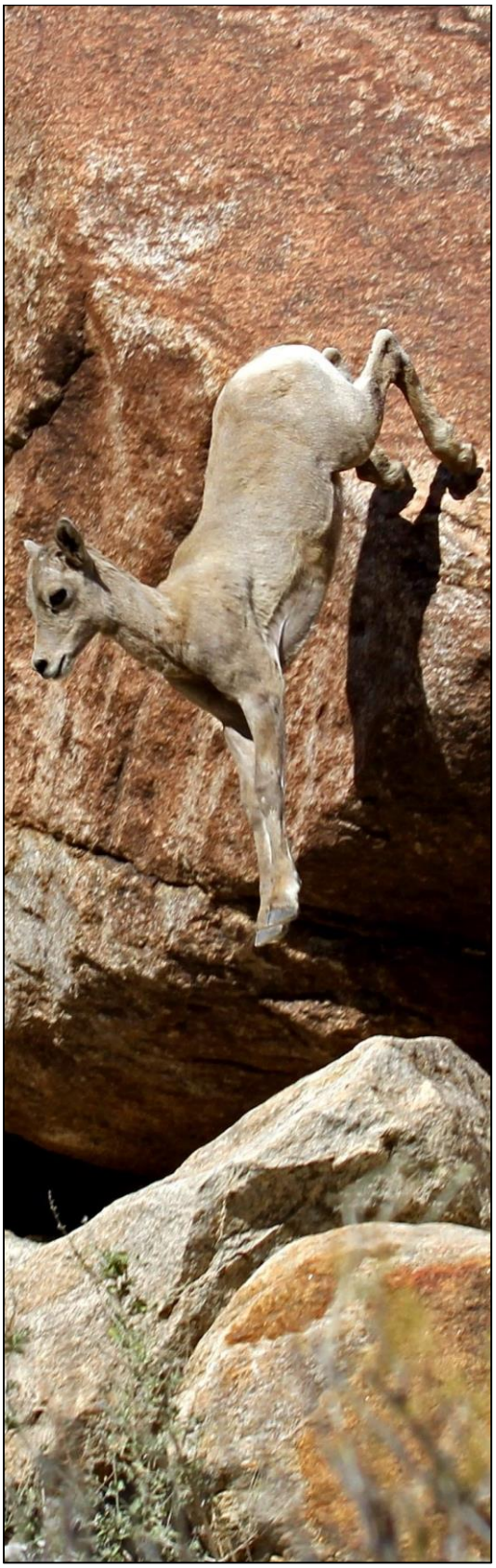

Photo by Jeff Young

# California Department of Fish and Wildlife
# Peninsular Bighorn Sheep Annual Report
# 2017-18
# Table of Contents




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## 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). In 1998, the U.S. Fish and Wildlife Service (USFWS) listed Peninsular bighorn sheep as a federally endangered population segment (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) carry 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 ewe (female sheep) population estimate was 552 with greater than 25 ewes 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).

This report covers a 12-month period from 1 June 2017 to 31 May 2018 and summarizes data collected from 9 recovery regions within the Peninsular Ranges. 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).

In order to obtain accurate estimates of ewe abundance, it is necessary to maintain radio-collars on at least 25% of the ewes within each of the 9 recovery regions. However, given that the Peninsular sheep recovery program lacks dedicated funding, securing necessary funding for radio-collars and capture activities has been, and continues to be difficult. Based on current funding availability, CDFW tentatively plans on a fall 2019 capture to increase the number of radio-collars within the CoC, VM, and CC recovery regions. Captures in the remaining 6 recovery regions may occur if additional funding is secured.

At the beginning of the reporting period, there were 123 active radio-collared ewes, representing approximately 22% of the ewe population range-wide. During fall 2017, an additional 36 ewes were captured and deployed with radio-collars in the SJM (8 ewes), NSRM (10 ewes), SSRM (4 ewes), VM (2 ewes), and CC (12 ewes) recovery regions. Over the reporting period, 22 radio-collared sheep died (20 ewes and 2 rams) and 24 radio-collars (23 ewes and 1 ram) became nonfunctional. At the end of the reporting period, there were 116 active radio-collared ewes, representing approximately 21% of the ewe population range-wide. Presently, the percentage of radio-collared ewes is adequate for the SJM (31%), NSRM (61%),

SSRM (26%), NSYM (38%) and SSYM (31%) recovery regions. Conversely, the percentage of radio-collared ewes for the CSRM (18%), CoC (7%), VM (19%) and CC (12%) are below the recommended minimum of 25% for each recovery region.

From 1992 to 2016, on average, 11% of all active radio-collared sheep died each year with predation accounting for 6%, nonpredation accounting for 3%, and unknown causes accounting for 2%. Over the reporting period, a higher than average percentage (13.4%) of active radio-collared sheep died of which 9.8% was attributed to predation, 1.8% was attributed to nonpredation, and 1.8% was due to unknown causes. With respect to the age category of bighorn sheep killed by lions (n = 16), 56% were old (≥9 years old), 31% were middle-aged (≥ 4 and ≤ 8 years old), and 13% were young (≤ 3 years old). Predation risk was highest from January through May.

For this reporting period, average range-wide survival of radio-collared ewes was 89.5%. Average percent survival by recovery region from highest to lowest was NSYM and SSYM (100%), SSRM (95%), CSRM and SJM (94%), NSRM (90%), VM (80%), CC (74%), and CoC (63%). While the low survival rate in CoC is of concern, the low statistic may partially be due to the extremely low percentage of radio-collared ewes within this recovery region.

Due to concerns of pneumonia in lambs, CDFW monitored lamb survival (survival to ~ 3 to 4 months) and recruitment (survival to 1 year) in several recovery regions. In 2017, the lowest lamb recruitment in the Peninsular Ranges was in the NSRM with only 4% of lambs surviving through their first year. Lamb recruitment was below 30% in the CSRM's Urban sub-ewe group (19%), CoC (24%), and in CC's In-Ko-Pah ewe group (26%). Persistently low recruitment rates below 30% may pose a significant obstacle in population recovery (Cassirer et al. 2013). Contagious Ecthyma (CE), a viral skin disease, was observed in lambs, as well as adult bighorn sheep, in the Tierra Blanca and In-Ko-Pah ewe groups (CC), the Lizard Wash ewe group (VM), the Palm Canyon ewe group (NSYM), and the Urban sub-ewe group (CSRM). The virus typically resolves on its own within 1 to 2 months; however, CE may decrease the chances of survival for lambs that already have pneumonia.

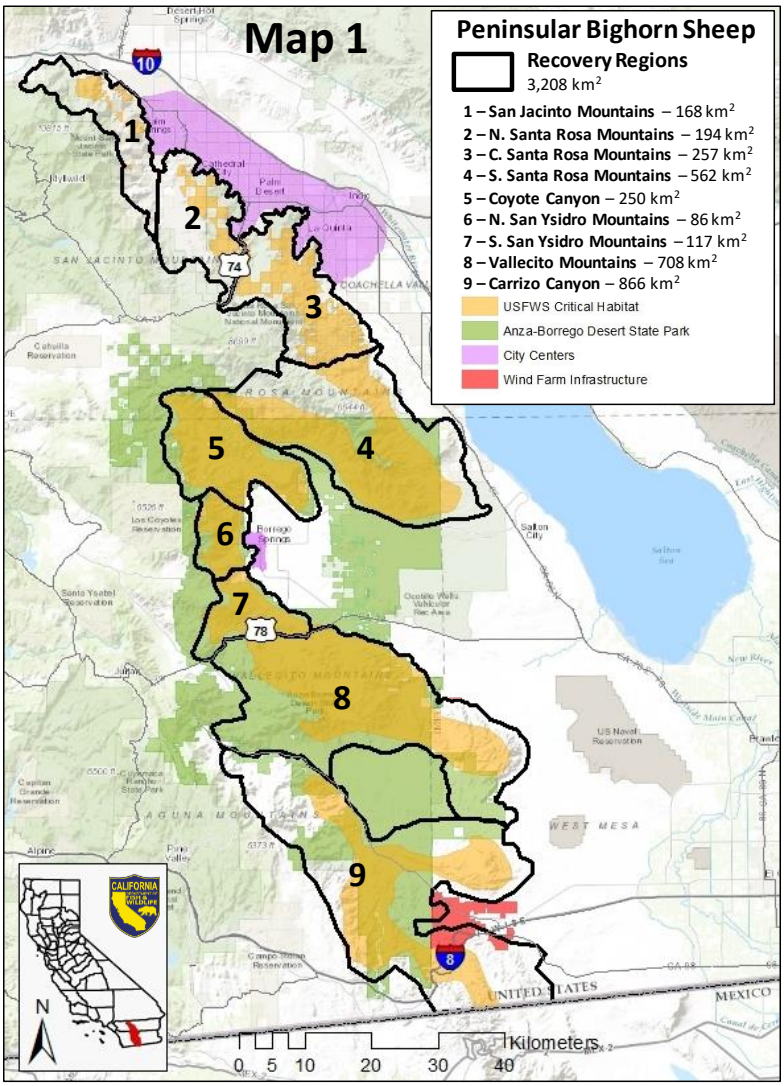
Since 2009, CDFW has deployed GPS radio-collars on female bighorn sheep to understand ewe group structure and seasonal movements within the Peninsular Ranges. Thus far, there have been 19 ewe groups identified within the Peninsular Ranges. The number of ewe groups within each recovery region are: SJM = 1, NSRM = 1, CSRM = 2, SSRM = 3, CoC = 2, NSYM = 1, SSYM = 1, VM = 4, and CC = 4. There is a great amount of substructuring within each ewe group and movement between adjacent ewe groups is common when roads are not present. Movements among recovery regions were common between the CSRM and SSRM, and between CoC and the NSYM. A few radio-collared ewes in the VM cross Highway 78 at Sentenac Canyon during the fall months and enter the SSYM. Additionally, regular seasonal movements by a radio-collared ewe were documented between the VM and CC recovery regions. The Jacumba ewe group in the CC recovery region move across the US-Mexico border on a seasonal basis. While no radio-collared sheep were documented moving between the NSRM and CSRM during this reporting period, 2 ewes and 1 ram were hit and killed by vehicles while attempting to cross Highway 74 between the NSRM and CSRM recovery regions. 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 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.

## BACKGROUND

This report summarizes capture activities, radio-collar monitoring, disease surveillance, and cause-specific mortality investigations 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 12-month period from 1 June 2017 to 31 May 2018.




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 group 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 the internet. A Cessna 185 fixed-wing aircraft was used to conduct aerial telemetry monitoring twice a month, or when availability allowed. Flights were conducted to monitor radio-collared sheep status (alive/dead).

## 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 allows us to monitor distribution and movement patterns, adult survivorship, cause-specific mortality, and health status.

At the beginning of the reporting period (1 June 2017), the 9 recovery regions contained 128 (123F, 5M) active radio-collared bighorn sheep (Table 1). Over the reporting period, an additional 36 ewes were captured and deployed with radio-collars, 22 radio-collared sheep died (20F, 2M) and 24 radio-collars (23F, 1M) became nonfunctional (censored). At the

end of the reporting period (31 May 2018), there were 118 (116F, 2M) active radio-collared bighorn sheep. Range-wide, approximately 22% of the estimated ewe population was radio-collared at the beginning of the reporting period compared to 21% at the end of the reporting period (based on 2016 generalized ewe population survey estimate of 552). Presently, the percentage of radio-collared ewes is adequate for the SJM (31%), NSRM (61%), SSRM (26%), NSYM (38%) and SSYM (31%) recovery regions. Conversely, the percentage of radio-collared ewes for the CSRM (18%), CoC (7%), VM (19%) and CC (12%) are below the recommended minimum of 25% for each recovery region.

Table 1. Distribution and numbers of active radio-collared female (F) and male (M) bighorn sheep within the 9 recovery regions starting on 1 June 2017 and ending on 31 May 2018. The estimated percentage of females radio-collared (% F Collared) at the end of May 2018 is based on the generalized ewe abundance estimate of 552 obtained from the 2016 helicopter survey. Additions is based on the number of new bighorn sheep captured in November 2017 and not including bighorn sheep that were recaptured and thus already accounted for at the beginning of the reporting period (6/1/2017). Mortalities are the number of bighorn sheep that died during the reporting period. Censored is the number of bighorn sheep that wore radio-collars that became nonfunctional during the reporting period.

| 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 |
| 6/1/2017 | 8 | 1 | 10 | 0 | 18 | 0 | 15 | 1 | 8 | 0 | 11 | 0 | 11 | 0 | 27 | 2 | 15 | 1 | 123 | 5 | 128 |
| additions | 8 | | 10 | | | | 4 | | | | | | | | 2 | | 12 | | 36 | | 36 |
| mortalities | 1 | | 2 | | 1 | | 1 | | 3 | | | | | | 5 | 1 | 7 | 1 | 20 | 2 | 22 |
| censored | 5 | | 1 | | 5 | | 4 | 1 | 2 | | | | 2 | | 4 | | | | 23 | 1 | 24 |
| 5/31/2018 | 10 | 1 | 17 | 0 | 12 | 0 | 14 | 0 | 3 | 0 | 11 | 0 | 9 | 0 | 20 | 1 | 20 | 0 | 116 | 2 | 118 |
| % F Collared | 31% | | 61% | | 18% | | 26% | | 7% | | 38% | | 31% | | 20% | | 12% | | 21% | | |

**CAPTURE AND RADIO-COLLARING**

During this reporting period, CDFW managed capture activities while experienced capture specialists from Leading Edge Aviation carried out helicopter captures. Captures were conducted between 1 and 4 November 2017 on State and Federal Lands throughout the Peninsular Ranges within eastern San Diego, western Imperial and western Riverside counties. Recovery regions where captures occurred included the SJM, NSRM, SSRM, VM, and CC. Helicopter capture was funded through Federal Wildlife Restoration Act Grant G1798018 (CDFW Region 6) and CDFW Big Game Fund Account while Federal Wildlife Restoration Act Grant G1798020 (CDFW Region 5) and USFWS funding were used to purchase radio-collars.

VHF, solar GPS store-on-board (GPS collars), and Iridium satellite radio-collars (satellite collars) were fitted to adult ewes in the targeted recovery regions in order to: 1) maintain collars on approximately 25-30% of the ewe population for mark-resight population estimation, 2) define temporal and spatial movement patterns, 3) define ewe group structure and distribution, 4) determine causes of mortality, and 5) health screening.

All bighorn sheep were captured by helicopter net-gun and field processed by Leading Edge Aviation capture specialists. Field processing sheep included collecting blood and nasal swabs for health screening, assessing body condition, estimating age, placing radio-collars and ear-tags, and photographing each sheep. CDFW biologists (Region 5) and Wildlife Investigation Lab (WIL) support personnel managed a base camp near each capture zone for radio communications, coordinating capture activities, assigning radio-collars, and processing and storing biological samples.

During the 4 days of capture, 42 ewes were fitted with radio-collars of which 6 were VHF radio-collared ewes that were recaptured and fitted with new radio-collars (Table 2). Of the 42 ewes captured, 29 were deployed with satellite collars, 9

with solar GPS collars, and 4 with VHF collars. All radio-collared ewes were fitted with unique combinations of colored radio-collars and ear tags to facilitate individual identification.

Table 2. Number and type of radio-collars deployed on ewes by recovery region and area. Numbers in parenthesis represent the number of ewes that were recaptured and refitted with new radio-collars.

| Recovery Region | Area | Satellite | Solar GPS | VHF | No. Collars Deployed |
|---|---|---|---|---|---|
| 1 | San Jacinto Mtns. | 8 | | | 8 |
| 2 | N. Santa Rosa Mtns. | 10 (3) | | (1) | 10 (4) |
| 4 | S. Santa Rosa Mtns. | 4 (1) | | | 4 (1) |
| 8 | Vallecito Mtns. | 1 (1) | 1 | | 2 (1) |
| 9 | Tierra Blanca Mtns. | | 3 | 1 | 4 |
| 9 | Carrizo Gorge | 1 | 2 | 2 | 5 |
| 9 | In-Ko-Pah Gorge | | 3 | | 3 |
| **Grand Total** | | **29** | **9** | **4** | **42** |

The average age of captured ewes was 5 years and all were in fair to good condition. No injuries to sheep occurred during the capture. CDFW fixed-wing aerial monitoring flights were conducted 4 days and 2 weeks post-capture and confirmed all radio-collared ewes were alive. Furthermore, ground monitoring of radio-collared bighorn sheep and monitoring of satellite-collared sheep via the Internet confirmed all bighorn sheep were alive 3-weeks post capture.

**CAUSE-SPECIFIC MORTALITY**

Between 1 June 2017 and 31 May 2018 there were 22 (20F, 2M) radio-collared sheep mortalities (Table 3). Mortalities by recovery region were SJM = 1F, NSRM = 2F, CSRM = 1F, SSRM = 1F, CoC = 3F, VM = 6 (5F, 1M), and CC = 8 (7F, 1M). 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%. Over the reporting period, a much higher percentage of active radio-collared sheep died (13.4%) of which 9.8% was attributed to predation, 1.8% was attributed to nonpredation, and 1.8% was due to unknown causes.

Table 3. Cause of death for 22 radio-collared bighorn sheep by recovery region within the Peninsular Ranges of Southern California from 1 June 2017 to 31 May 2018.

| Region | Animal ID | Sex | Age | Mortality Date | Mortality Cause |
|---|---|---|---|---|---|
| SJM | 482 | F | 3 | 2/7/2018 | Probable lion |
| NSRM | 451 | F | 7 | 12/3/2017 | Dystocia |
| NSRM | 475 | F | 3 | 1/24/2018 | Possible coyote |
| CSRM | 353 | F | 7 | 4/30/2018 | Drown in Coachella Canal |
| SSRM | 438 | F | 8 | 11/30/2017 | Probable lion |
| CoC | 347 | F | 8 | 3/12/2018 | Probable lion |
| CoC | 450 | F | 7 | 3/16/2018 | Possible lion |
| CoC | 448 | F | 9 | 4/4/2018 | Possible lion |
| VM | 177 | F | 18 | 10/25/2017 | Possible lion |
| VM | 345 | F | 14 | 12/10/2017 | Lion |
| VM | 373 | M | 10 | 1/9/2018 | Lion |
| VM | 372 | F | 10 | 2/3/2018 | Possible lion |
| VM | 461 | F | 6 | 2/5/2018 | Lion |
| VM | 376 | F | 8 | 3/2/2018 | Probable lion |
| CC | 333 | F | 7 | 6/21/2017 | Unknown |
| CC | 292 | F | 12 | 8/23/2017 | Possible lion |
| CC | 227 | F | 10 | 9/30/2017 | Probable lion |
| CC | 337 | M | 9 | 10/1/2017 | Unknown |
| CC | 336 | F | 13 | 3/24/2018 | Possible lion |
| CC | 459 | F | 10 | 3/30/2018 | Possible lion |
| CC | 455 | F | 6 | 4/20/2018 | Unknown |
| CC | 233 | F | 13 | 5/16/2018 | Unknown nonpredation |

The long-term data indicates that predation risk increases from November through May with the peak in December and is lowest in June and July. For this reporting period, predation risk did not increase significantly until January with the peak in March and with no mortalities due to predation in May (Figure 1). Similar to the long-term trend, predation risk was lowest in June and July.

The average age of radio-collared sheep alive at the end of the reporting period was 8.6 years with a range between 2 and 16 years (n = 118). The average age of radio-collared sheep that died during the reporting period was 9 years with a range between 3 and 18 years (n = 22). With respect to the age category of bighorn sheep killed by lions (n = 16), 56% were old (≥9 years old), 31% were middle-aged (≥ 4 and ≤ 8 years old), and 13% were young (≤ 3 years old).

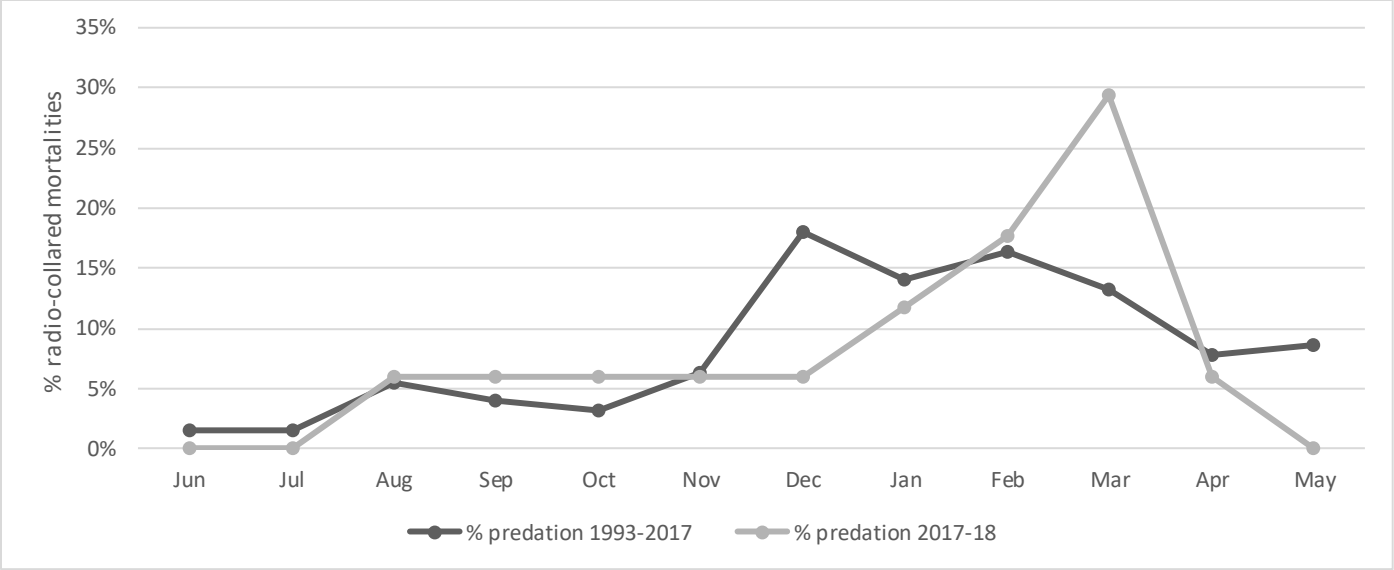



Figure 1. Average monthly percentage of radio-collared sheep mortalities due to predation from 1993 to 31 May 2017 (n = 128) compared to current reporting period from 1 June 2017 to 31 May 2018 (n = 16).

***Coyote Canyon Mortalities (Recovery Region 5)***

Over the reporting period, CoC recovery region lost the highest percentage of radio-collared sheep (37%) with all 3 deaths attributed to predation (Table 3). There are two ewe groups within this recovery region with 2 deaths in the Coyote Mountain ewe group and 1 death in the Collins Valley ewe group.

Coyote Mountain Ewe 347 was 8 years old, pregnant, and in fair condition when killed by a lion in Box Canyon in Anza-Borrego Desert State Park (ABDSP) in March of 2018. Ewe 450 was 7 years old and in fair condition when killed by a lion the following month within the same area of ABDSP as Ewe 347.

Ewe 448 was the only active radio-collar remaining within the Collins Valley ewe group. The ewe was 9 years old and in poor condition when killed by a lion in the upper reaches of Salvador Canyon (ABDSP) in April 2018. The bony cores of both horns of Ewe 448 were necrotic due to chronic sinusitis and this condition may have been a contributing factor in her death.

***Carrizo Canyon Mortalities (Recovery Region 9)***

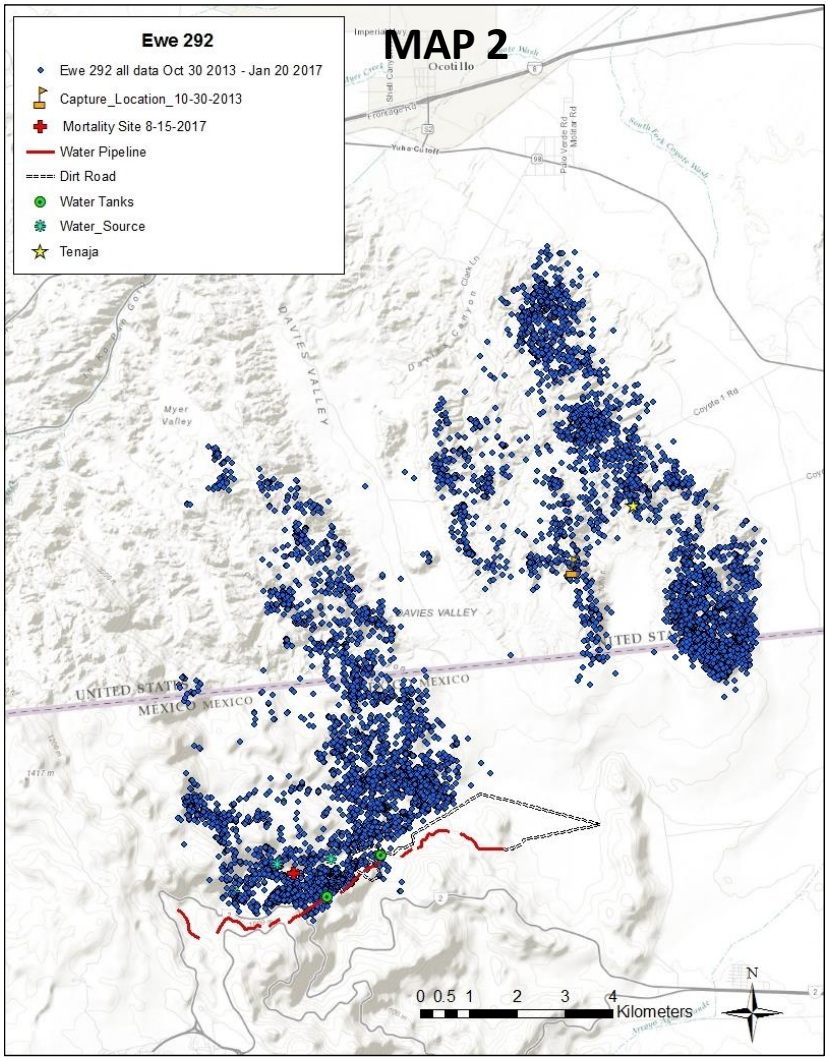
Carrizo Canyon recovery region lost the second highest percentage of radio-collared sheep (29%) with 4 deaths attributed to predation and the cause of another 4 deaths unknown (Table 3). There are 4 ewe groups within this recovery region with 3 deaths in the Tierra Blanca ewe group, 2 deaths in the Carrizo Canyon ewe group, 2 deaths in the In-Ko-Pah ewe group, and 1 death in the Jacumba ewe group.

In the Tierra Blanca ewe group, Ewes 333 and 336, and Ram 337 died during the reporting period. In June of 2017, 6-year-old Ewe 333 died west of Canebrake community on privately owned land. The cause of death could not be determined due to the amount of time between death and investigation. Ewe 336 was 13 years old and in fair condition when killed by a lion in the mountains to the northwest of Agua Caliente County Park (ACCP) in March 2018. Ram 337 was captured in the Tierra Blanca Mountains but was found dead, of unknown cause, in Carrizo Canyon in October 2017. The year prior to his death, the ram was observed at ACCP with a swollen jaw but was otherwise acting normally. Two months prior to his death, the ram no longer had a swollen jaw but did have a severe case of Contagious ecthyma (Photo 1). During the mortality investigation, it was noted that the ram had osteomyelitis of the right mandible. Whether this condition precipitated or contributed to the cause of death is not known due to the amount of time between time of death and investigation.

In the Carrizo Canyon ewe group, 2 ewes died during the reporting period. Ewe 459 was 10 years old when killed by a lion on the east side of Carrizo Canyon in March of 2018: her health at the time of death was unknown. Ewe 455 was 6 years old at the time of her death northwest of Mortero Palms. The health of this ewe prior to death was unknown; furthermore, due to the length of time between her death and investigation, the cause of death was listed as unknown.

Photo 1. Ram 337 at Agua Caliente County Park campground on 8/2/2017 with contagious ecthyma.

In the In-Ko-Pah ewe group, 2 ewes died during the reporting period. Ewe 227 was 9 years old and in fair condition when killed by a lion within the Interstate 8 Island. Since 2009, 6 of 13 radio-collared deaths have been due to lion predation; however, this was the first lion predation within the Island created by the divergence of the eastbound and westbound lanes of Interstate 8. Ewe 233 was first fitted with a GPS collar in 2009 when she was estimated to be 4 years old. While Ewe 233 was documented to have a lamb each spring, in 2015 she successfully raised twins. In the months prior to her death, she was often observed moving stiffly, would occasionally cough, and did not appear to be pregnant. Subsequently, the ewe died in May of 2018 north of Mountain Springs. Her death was not due to predation; however, the exact cause could not be determined but was likely due to age-related disease.




In the Jacumba ewe group, 1 ewe died during the reporting period. The Jacumba ewe group typically spends each winter and spring within the Jacumba Wilderness in the United States and each summer and fall within a canyon just north of Highway 2 in Mexico. During a telemetry flight on 9/2/2017, the GPS collar on Ewe 292 was detected on mortality mode within the canyon alongside Highway 2 in Mexico. It took a month to plan and collaborate with the wildlife officials in Mexico (Profepa Delagacion Baja California) before the mortality could be investigated. Due to the length of time between death and investigation, lion predation could not be confirmed and thus was listed as "possible" lion predation. Ewe 292 was deployed with a store-on-board solar GPS collar in October of 2013. Due to the remote areas that this ewe inhabited, data from her GPS collar had only been obtained once in 2014 and once in 2015. We are grateful for the cooperation and assistance from the wildlife officials in Mexico; otherwise, it would have not been possible to obtain the GPS location data stored on the radio-collar between 2015 and 2017. These location data are vital to our understanding of bighorn sheep movement between the United States and Mexico (Map 2).

***Vallecito Mountains Mortalities (Recovery Region 8)***

The VM recovery region lost the third highest percentage of radio-collared sheep (19%) with all 6 deaths attributed to predation (Table 3). There are 4 ewe groups within this recovery region with 2 deaths in the Lizard Wash ewe group, 2 deaths in the Sunset ewe group, 2 deaths in the Vallecito Mountains ewe group, and no deaths in the Fish Creek Mountains ewe group.

In the Lizard Wash ewe group, 1 ewe and 1 ram died during the reporting period. In January 2018, 10-year-old Ram 373 was killed by a lion on a peak east of Lizard Canyon. The ram was in poor health at the time of his death as evidenced by 3 infected molars resulting in osteomyelitis of the left mandible. One month later, 10-year-old Ewe 372 was killed by a lion a few miles to the southeast in Bighorn Canyon: the health of the ewe was unknown at the time of her death.

In the Sunset ewe group, 2 ewes died during the reporting period. Ewe 345 was 13 years old and had chronic sinusitis when killed by a lion on the west side of Sunset Mountain in December of 2017. Ewe 376 was 9 years old and her health status unknown when killed by a lion in March 2018 in the mountains east of Harper Canyon.

In the Vallecito Mountains ewe group, 2 ewes died during the reporting period. Ewe 177 was first captured in 2003 and estimated to be at least 4 years old since she had all her permanent incisor teeth. CDFW lost track of her whereabouts when her VHF collar went nonfunctional in February 2014. In November 2014, Ewe 177 was opportunistically recaptured and deployed with a new VHF radio-collar. The ewe was last observed in fair condition in January 2017 in Lycium Wash. Minimally, Ewe 177 was 18 years old when she was killed by a lion in October 2017 near the North Fork of Fish Creek Wash: her advanced age may have made her more vulnerable to predation. Ewe 461 was 6 years old, in poor condition (based on examination of bone marrow) and pregnant when she was killed by a lion in February 2018 on the lower slopes west of June Wash (Whale Peak).

***Northern Santa Rosa Mountains Mortalities (Recovery Region 2)***

The NSRM recovery region lost the fourth highest percentage of radio-collared ewes (10%) with 1 death attributed to predation and 1 death attributed to nonpredation (Table 3). Ewe 451 was born in captivity at the Bighorn Institute (BI) in Palm Desert and released, at 6 years old, in April 2016 into Bradley Canyon. At the request of BI, the ewe was recaptured to replace a malfunctioning VHF collar during CDFW's November 2017 capture. Unfortunately, Ewe 451 died 1 month post-capture. BI investigated this mortality and reported the cause of death as due to apparent dystocia. Ewe 475 was 3 years old when possibly killed by coyotes in Magnesia Canyon in January 2018. The mortality investigation occurred within 2 days of the death; however, coyotes had already consumed, disarticulated, and carried off skeletal remains making it difficult to assess if the ewe (and possibly her lamb) had been killed or scavenged by coyotes. GPS data, and evidence at the site, indicated that the ewe and her lamb had stayed in a small area on the slope above the mortality site for 3 days prior to death. Lack of movement for an extended period may indicate that either the ewe or the lamb was sick or injured—likely making them more vulnerable to predation.

***San Jacinto Mountains Mortality (Recovery Region 1)***

The SJM recovery region lost 6% of radio-collared ewes with 1 death attributed to predation. Ewe 475 was 3 years old and in fair condition when killed by a lion in February 2018 on a north-facing cliff of Chino Canyon. A 2-week-old lamb stayed near the mortality site for several days and approached the investigators 3 times during the investigation. Based on the lamb's behavior, it was assumed the lamb belonged to Ewe 475.

***Central Santa Rosa Mountains Mortality (Recovery Region 3)***

The CSRM recovery region lost 5% of radio-collared ewes with 1 death due to drowning. Ewe 353 was 7 years old, pregnant, and in extremely poor condition when she drowned in the Coachella Valley Canal at PGA West in April 2018. The ewe was captured and radio-collared in 2014, and observed in good to fair condition up until the spring of 2017. Over the summer and fall, the ewe lost body fat and condition despite often foraging on the rich grasses of the golf course

communities. Ewe 353 was last observed by CDFW on 3/26/18 on the slopes above PGA West and noted as in medium to poor condition, with patches of hair missing from her right side, and udders only half-developed. According to GPS location data, Ewe 353 entered PGA West on the morning of 4/29/18 and slowly worked her way north, entering the south end of SilverRock Golf Course by 1331 hours. A temporary fence at the toe-of-the-slope at SilverRock is ineffective in preventing sheep from entering SilverRock from the south via PGA West. Two hours prior to sunset on 4/29/2018, the ewe crossed a canal bridge at the south end of SilverRock near the temporary fence. At 2139 hours (two hours past sunset), the ewe was at the far north end of the golf course attempting to access the mountain slopes. Unable to access the slopes, the ewe turned around and followed the fence line south. At midnight, she was back at the south end of SilverRock where she spent the remainder of the night on the golf course between the canal and the fence (Satellite Image 1). On 4/30/18, the ewe once again headed south into PGA West. The last GPS location was obtained at 1557 hours on 4/30/18 near the canal at the north end of PGA West. Because the GPS collar obtains locations every hour, it was assumed she fell into the canal after 1557 hours and prior to 1657 hours on 4/30/18. The ewe was found dead at the terminus of the canal at Lake Cahuilla on 5/4/18. A necropsy was performed at the California Animal Health and Food Safety laboratory (CAHFS) in San Bernardino on 5/14/18. Lab results found that the ewe had bacterial meningitis probably due to a traumatic penetrating wound to the head. It is plausible that due to the meningitis, the ewe became disoriented and fell into the canal.


Satellite Image 1. Unable to access escape terrain on the slopes above SilverRock, ewe 353 spent the night of 4/29/18 on the SilverRock golf course between the fence and the canal (Red dots highlighted by black arrows). Blue line = temporary fence, Orange line = CVWD fence.

***Southern Santa Rosa Mountains Mortality (Region 4)***

The SSRM recovery region lost 5% of radio-collared ewes with 1 death attributed to predation. Ewe 438 was 7 years old and in fair condition when killed by a lion south of Rattlesnake Spring in November 2017.

***Non-collared Mortalities (Range-wide)***

During the reporting period, there were 21 non-collared bighorn sheep deaths reported (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 public or other organizations. Because these mortalities are found by chance alone or typically near urban centers, they are not necessarily representative of the overall sheep population. Lambs with pneumonia have been documented in every recovery region; however, the majority of deaths are documented in urban areas because lambs are more visible and easily found in comparison to lamb deaths in very remote areas.

Table 4. Cause of death for 21 non-collared bighorn sheep by recovery region within the Peninsular Ranges of Southern California from 1 June 2017 to 31 May 2018. Sheep/vehicle collisions on Highway 74 were investigated and/or reported by Bighorn Institute and all other mortalities were investigated by CDFW.

| Region | Location | date | Age | sex | cause |
|---|---|---|---|---|---|
| NSRM/CSRM | Highway 74 | 7/28/2017 | Adult | M | Killed by vehicle |
| NSRM/CSRM | Highway 74 | 2/28/2018 | Adult | F | Killed by vehicle |
| NSRM/CSRM | Highway 74 | 3/31/2018 | Adult | F | Killed by vehicle |
| CSRM | PGA West - La Quinta | 6/19/2017 | Lamb | F | Bronchopneumonia |
| CSRM | PGA West - La Quinta | 6/20/2017 | Lamb | F | Bronchopneumonia |
| CSRM | PGA West - La Quinta | 6/24/2017 | Lamb | M | [a]Presumptive bronchopneumonia |
| CSRM | PGA West - La Quinta | 6/29/2017 | Lamb | F | Bronchopneumonia |
| CSRM | PGA West - La Quinta | 7/11/2017 | [b]Lamb | F | bronchopneumonia |
| CSRM | LC County Park - La Quinta | 7/12/2017 | Lamb | M | [a]Presumptive bronchopneumonia |
| CSRM | Tradition - La Quinta | 9/3/2017 | Adult | M | [a]Presumptive oleander poisoning |
| CSRM | PGA West - La Quinta | 12/23/2017 | Lamb | F | Presumptive drowning |
| CoC | Lower Willows | 8/1/2017 | Yearling | F | Coyote predation (confirmed) |
| NSYM | Borrego-Palm Canyon | 7/12/2017 | Lamb | M | [a]Presumptive bronchopneumonia |
| NSYM | Borrego-Palm Canyon | 8/11/2017 | Adult | M | [c]Cardio-respiratory failure |
| NSYM | S22 (Montezuma Grade) | 3/13/2018 | Adult | M | Killed by vehicle |
| SSYM | S3 (Yaqui Pass) | 10/13/2017 | Adult | M | Killed by vehicle |
| Carrizo | Interstate 8 (east-bound) | 6/7/2017 | Lamb | F | Killed by vehicle |
| Carrizo | Canebrake | 6/10/2017 | Lamb | F | Bronchopneumonia |
| Carrizo | Interstate 8 (east-bound) | 9/21/2017 | Adult | F | Killed by vehicle |
| Carrizo | Interstate 8 (east-bound) | 3/20/2018 | Adult | F | Killed by vehicle |
| Carrizo | Agua Caliente County Park | 5/21/2018 | Lamb | M | Coyote predation (confirmed) |

[a]Lab tests not conducted/cause based on physical evidence
[b]Lamb of radio-collared ewe 349
[c]Compatible of an acute toxicity of the heart.

**EWE SURVIVAL**

Population viability is most sensitive to changes in ewe survival (Ruben et al. 2002); therefore, it is important to document ewe survival 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. During this reporting period, average percent range-wide survival of radio-collared ewes was 89.5 ± 5 (annual Kaplan-Meir survival rates reported as mean percent survival ± 95% Confidence Interval). Average percent survival by recovery region from highest to lowest was the following: NSYM and SSYM 100 ± 0, SSRM 95 ± 11, CSRM 94 ± 11, SJM 94 ± 12, NSRM 90 ± 13, VM 80 ± 8, CC 74 ± 16, and CoC 63 ± 33. While the low survival rate in CoC is of concern, the low statistic may partially be due to the extremely low percentage of radio-collared ewes within this recovery region.

**LAMB SURVIVAL AND RECRUITMENT**

Outside of all-age outbreaks of disease, lamb survival is considered the best demographic indicator of the health 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 5). Because rates of survival can

vary, consistent monitoring is essential to examine long-term trends in lamb survival within each ewe group. Additionally during this reporting period, lamb recruitment and survival data were obtained in the SJM and the Tierra Blanca ewe group (recovery region 9) and lamb recruitment data for the NSRM (not shown in Table 5). In the SJM, 2017 lamb recruitment was 35% and 2018 lamb survival was 67%. In the Tierra Blanca ewe group, 2017 lamb recruitment was 42% and 2018 lamb survival was only 19%. In 2017, the lowest lamb recruitment in the Peninsular Ranges was in the NSRM with only 4% of lambs surviving through their first year. Moreover, lamb recruitment in 2017 was below 30% in the Urban ewe group (19%), CoC (24%), and in IKP-CC (26%) recovery regions (Table 5). Lamb survival in 2018 was extremely high in the Urban ewe group (83%) despite clinical signs of pneumonia and Contagious ecthyma (CE) within the ewe group. The only ewe groups with lamb survival below 30% were the SSYM (22%) and the Tierra Blanca (19%). Details concerning respiratory disease in lambs can be found in the CDFW 2015 Annual Report and the CDFW 2016-17 Annual Report.

Table 5. Index of lamb survival to ~3 to 4 months old (Survival) and recruitment of lambs to yearlings (Recruited) from 2008 – 2018 in CoC, NSYM, SSYM, IKP ewe group in CC, Urban ewe group in CSRM and Wild ewe group in CSRM.

| 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]41% | 24% | 77% | 34% | 83% | 32% | [b] | 26% | 77% | 19% | 61% | [b] |
| 2018 | 31% | | 33% | | 22% | | 41% | | 83% | | 38% | |

[a]Lamb:ewe ratio obtained from ABDSP 2017 annual sheep count for CoC
[b]Not enough observation data were obtained for lamb:ewe ratios.
*Observation data were not collected.

During the reporting period, CE was observed in lambs, as well as adult bighorn sheep, in the Tierra Blanca and In-Ko-Pah ewe groups (recovery region 9), the Lizard Wash ewe group (recovery region 8), the Palm Canyon ewe group (recovery region 6), and the Urban sub-ewe group in recovery region 3 (Map 3). CE is a viral skin disease (Parapoxvirus) that mainly occurs in sheep and goats and is transmitted by direct contact (Jessup and Boyce 1993). Infected sheep typically develop scabby, dark, cauliflower appearing skin lesions around the nose and muzzle: other areas lesions can be found are the eyes, lower extremities, and udders. The virus typically resolves on its own within 1 to 2 months with no long-term harmful effects to the animal; however, death may result if secondary complications, such as bacterial infections develop (Wilson and McFarlane 2012). Lesions are painful and severely infected lambs may refuse to nurse resulting in starvation and death. CE is typically observed in bighorn sheep populations that are overpopulated or when other stressors are present (Jessup and Boyce 1993) and once CE enters a herd it is difficult to eradicate. Vaccines or natural immunity following an outbreak are not effective in preventing future outbreaks; however, in subsequent outbreaks lesions are usually less severe (Higgs 1996, Lloyd 2000).

In early August 2017, CE was observed in the Tierra Blanca ewe group within the CC recovery region (Photo 1). The majority of bighorn sheep with clinical signs of CE were rams (57%), ewes (55%) and yearlings (33%) with only 17% of lambs affected. CE was observed throughout August and September with no lesions observed in October. CE lesions on lambs were minimal and did not appear to impair their ability to forage or suckle; concurrently, few lambs showed signs of pneumonia. Lamb recruitment for 2017 within the Tierra Blanca ewe group was 42%.

Ewe 371 spends the majority of her time within the Lizard Wash Ewe group in the VM recovery region; however, during the summer months, the ewe travels 28 km south and joins the Tierra Blanca ewe group. Ewe 371 was observed with a mild case of CE while with the Tierra Blanca ewe group in August 2017. The ewe returned to Lizard Wash in September;

then, in November, a small group of ewes and yearlings were observed with CE in the Lizard Wash ewe group. Lamb survival and recruitment is not monitored in the VM recovery region so it is unknown if CE contributed to or resulted in the deaths of any lambs.

In March 2018, several lambs and ewes, including 4 radio-collared ewes and 2 of their lambs, were observed with clinical signs of CE in Borrego-Palm Canyon (NSYM recovery region). CE lesions on ewes were mild; in contrast, lambs had numerous, large lesions on their muzzles and above their hooves. Concurrently, most lambs in Borrego-Palm canyon, including some of the lambs with CE, had clinical signs of pneumonia. Ewe 308's lamb had pneumonia and a severe case of CE and did not survive (Photo 2). In contrast, ewe 310's lamb had a mild case of CE, showed no signs of pneumonia, and survived. Lamb survival for 2018 in the NSYM was 33%.

At the end of May 2018, clinical signs of CE were observed in 5 of 24 lambs (21%) at PGA West golf community (Urban sub-ewe group in the CSRM recovery region). Two female and 3 male lambs had CE; however, 1 of the male lambs also showed signs of pneumonia. Lamb survival for 2018 within the urban sub-ewe group was 83%. CE was not observed in the wild sub-ewe groups in the CSRM; however, clinical signs of mild cases of CE are difficult to observe unless viewed at close-range, which is not possible with the wild CSRM ewe groups.

In the In-Ko-Pah ewe group (CC recovery region), ewe 454's lamb was observed with CE in May 2018. No other lambs or ewes were observed with CE; however, it is not possible to view this group at close range and only severe cases of CE were likely detected. Concurrently, some lambs were observed with clinical signs of pneumonia. Lamb survival for 2018 in the In-Ko-Pah ewe group was 41%.

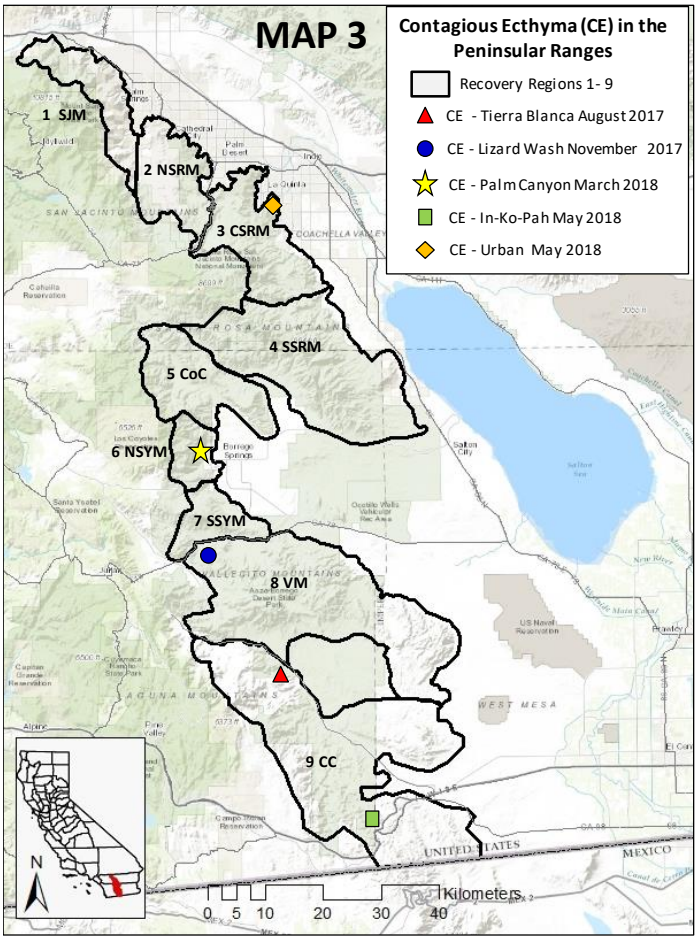




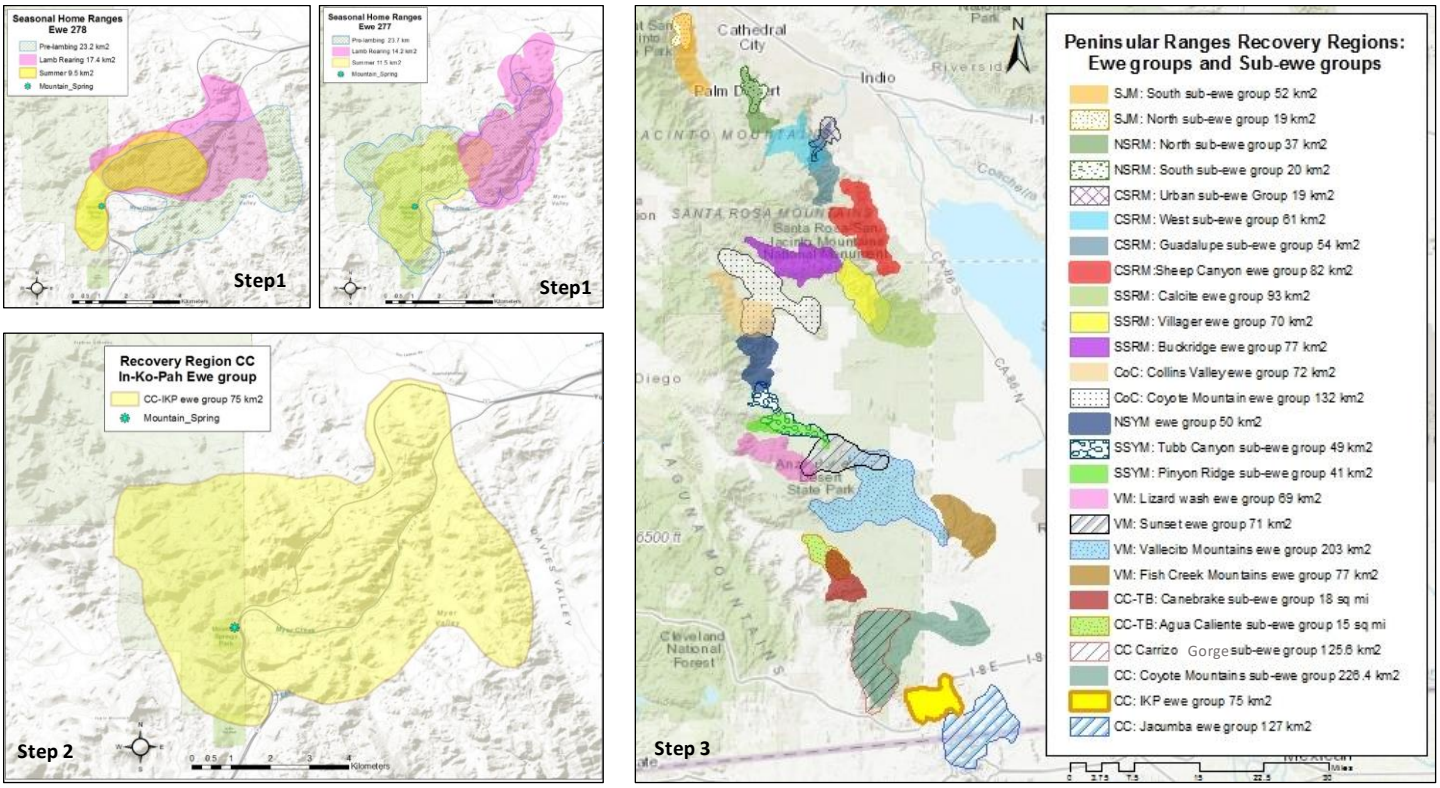
Photo 2. Ewe 308's male lamb as seen in March 2018 with severe CE lesions on the muzzle and right eye. Also, the lamb had pneumonia and diarrhea. The lamb died in April.

**DISTRIBUTION AND MOVEMENT**

Since 2009, CDFW has deployed GPS collars on bighorn sheep range-wide in order to build a foundation of knowledge concerning distribution, movement, and ewe group structure within the Peninsular Ranges (Map Series 4). Each individual ewe's GPS location data is analyzed and grouped by summer (1 June – August 31), prelambing (1 September – 31 December), and lamb-rearing (1 January – 30 May) seasons. All ewes with similar seasonal patterns of habitat use are grouped together into a ewe group and, if appropriate, those individuals displaying distinct patterns of habitat use into sub-ewe groups. As we build a foundation of knowledge concerning ewe group structure, data will be analyzed and compared among ewe groups rather than among recovery regions. While all ewe groups have the same basic requirements for food, water, and safety from predators, each ewe group's geographic location dictates each ewe group's specific needs. If the quality and quantity of vegetation is sparse and water sources are limited, then the area used by a ewe group (home range) will be large in comparison to a

ewe group with an abundance of vegetation and water sources in close proximity. Home ranges are dynamic and can expand or contract among seasons and among years depending on weather conditions that drive quality and quantity of vegetation and water availability. Anthropogenic activities can also influence the size and shape of home ranges as well as connectivity among home ranges. Presently, there are 19 ewe groups identified in the Peninsular Ranges; additionally, within almost every ewe group, several sub-ewe groups have been identified (Map Series 4).

CDFW is currently in the process of compiling and analyzing all GPS data in order to describe ewe group structure, distribution, movement, seasonal habitat use, lambing and nursery habitat, abundance, and carrying capacity within the Peninsular Ranges. Furthermore, knowledge gained from these data will be used to help predict changes in seasonal movement patterns and habitat requirements in an increasingly dry climate. An overview of distribution, movement, and annual homerange use for each ewe group in the Peninsular Ranges can be found in the CDFW 2016-17 Annual Report. This report will only update any changes in distribution and movement patterns of current GPS-collared ewes from 1 June 2017 to May 31 2018.



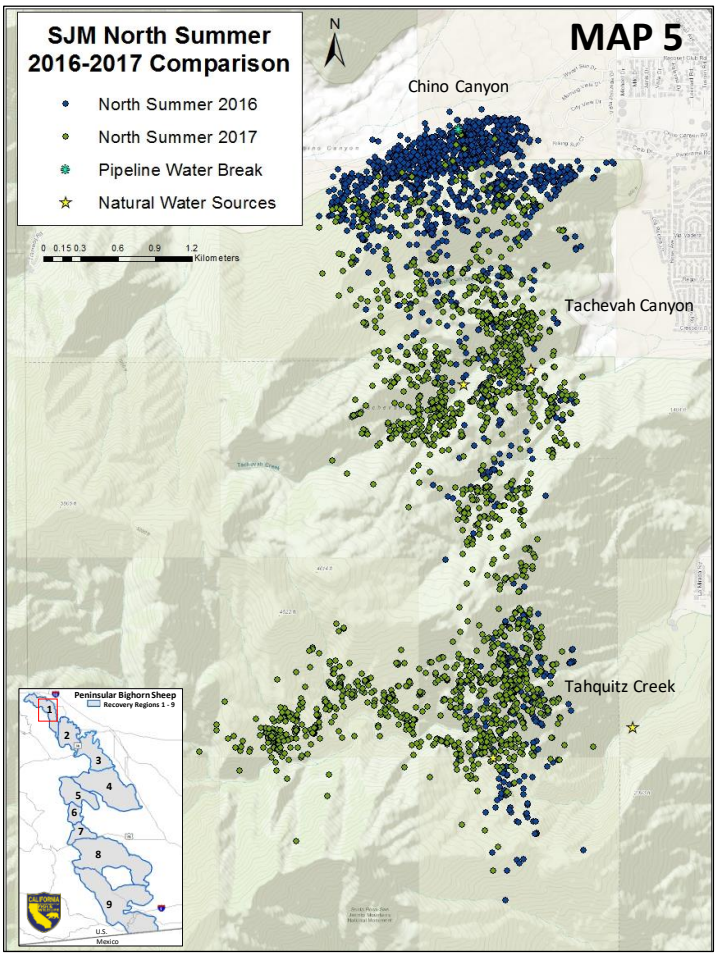

**Map Series 4**. Diagram depicting the process of assessing ewe group structure. Step 1) each ewe's location data is mapped by pre-lambing, lambing, and summer seasons. Step 2) all ewes with similar seasonal patterns of use (particularly during the summer and lamb-rearing seasons) are pooled together to define the boundaries of a ewe group. Step 3) Ewe group structure: the relationship within and among ewe groups are assessed for changes over time in ewe group size, movements and connectivity within and among ewe groups.

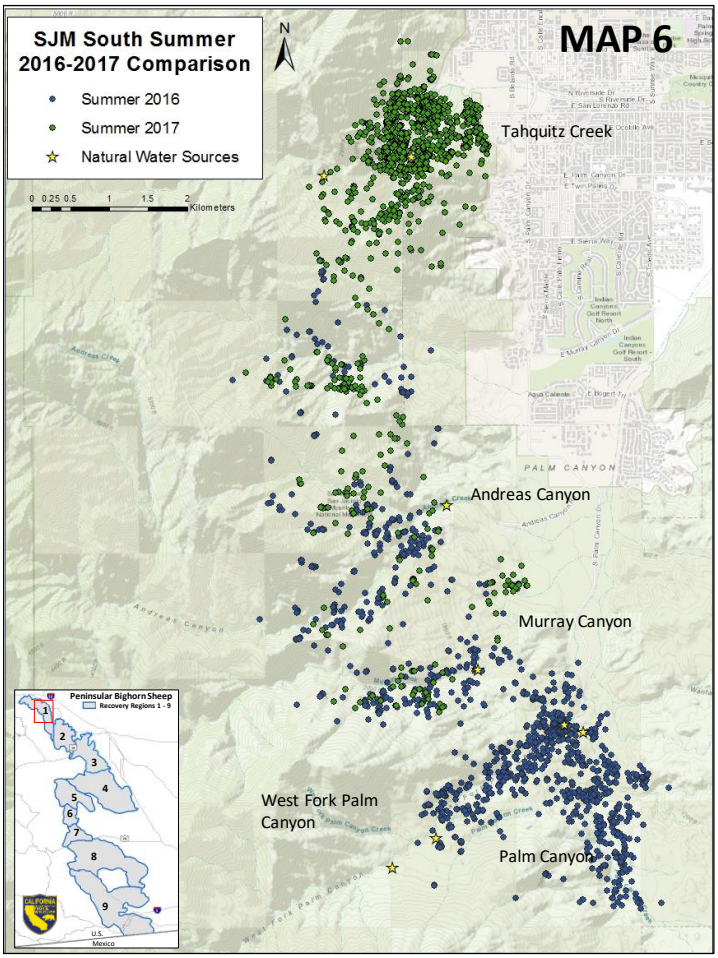
### *San Jacinto Mountains*

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 use different water sources during the summer months located at the north and south ends of the region. 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 (Map Series 4). The western boundary is at approximately 1200 m elevation and extends 4 km to the eastern boundary of the urban interface at approximately 180 m elevation.

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 using natural water sources in Tachevah and Tahquitz Canyons (Map 5). The break in the pipeline was repaired in September 2016. As a result, during summer 2017, the north sub-ewe group concentrated use at the higher elevation natural water sources in Tachevah and Tahquitz Canyons. During summer 2016, the south sub-ewe group's radio-collared ewes concentrated at Palm Canyon and the West Fork of Palm Canyon (Map 6).

In contrast, during summer 2017, the same radio-collared ewes concentrated at lower elevations within Tahquitz Canyon with occasional use in Murray and Andreas Canyons and no use at Palm Canyon (Map 6).



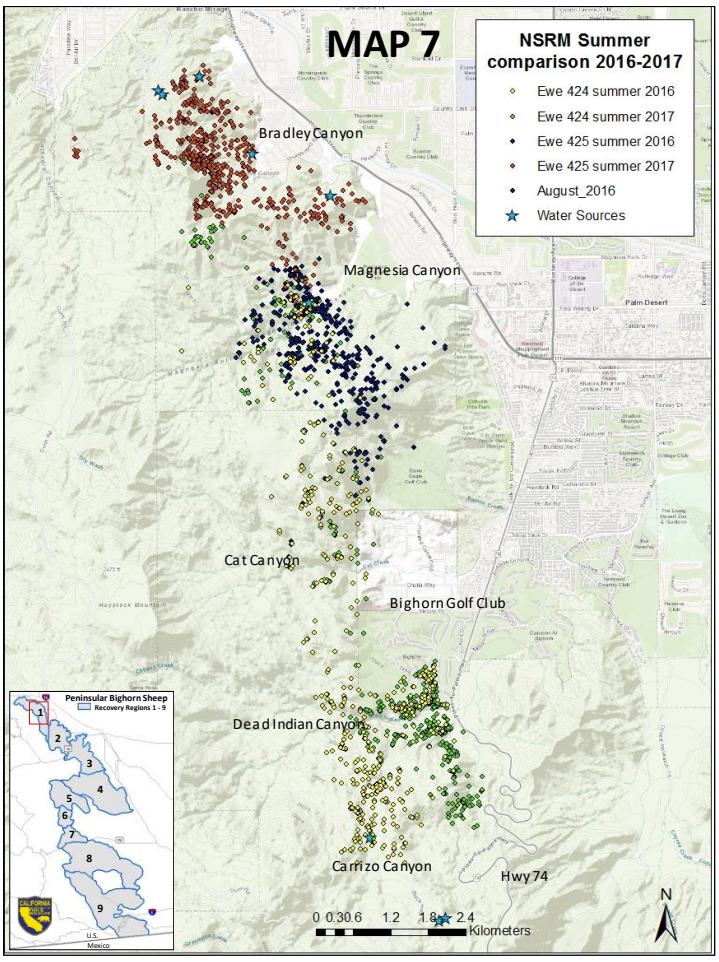

***Northern Santa Rosa Mountains***

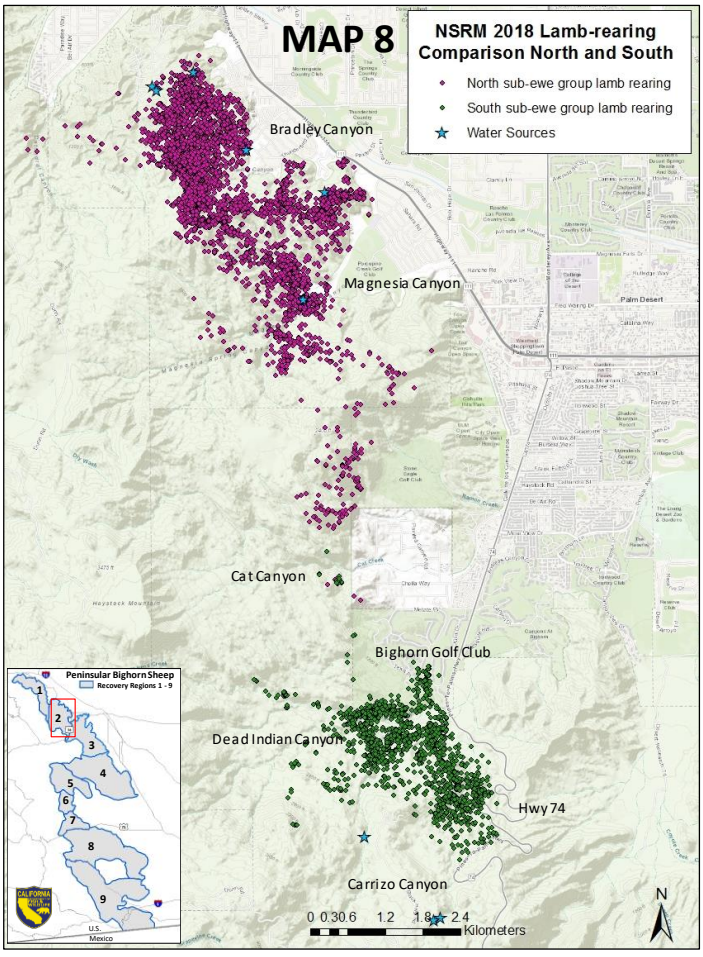
Currently, the NSRM contains 1 ewe group consisting of 2 sub-ewe groups (north and south) that in general use different lamb-rearing areas and different water sources during the summer months located at the north and south ends of the region. The overall ewe group home range size is 41.5 km$^2$ and extends 14 km from Cathedral Canyon in the north to Highway 74 in the south (Map Series 4). During this reporting period, there was no movement across Highway 74 into the CSRM.

In November 2017, 13 ewes were deployed with satellite collars in the NSRM (3 ewes were recaptures). Prior to the capture there were only 2 active GPS-collared ewes in the NSRM; therefore, comparisons between 2016 and 2017 summer use is comprised of a small sample size (Map 7). In 2016, Ewe 425 only used the area surrounding Magnesia springs during the summer months; in contrast, in 2017, summer use switched to Bradley Canyon with only occasional use at Magnesia Spring. Representing the south sub-ewe group, Ewe 424's core summer use area in 2016 was south of the Bighorn Golf Club course in Palm Desert with occasional movement north to Magnesia Spring. Ewe 424 repeated the same pattern of use in summer 2017; however, more time was spent on the slopes above and within the golf course. Based on bighorn sheep behavior in other urban areas, the south ewe group will continue to spend more time within the Bighorn Golf Club community.

The north sub-ewe group's 2018 lamb-rearing habitat (represented by 10 satellite-collared ewes) was centered at Bradley Canyon with some use at Magnesia Canyon (Map 8). None of the north sub-ewe group radio-collared ewes moved south of Cat Canyon during the lamb-rearing season. The south sub-ewe group's 2018 lamb-rearing habitat was centered at

Dead Indian and Carrizo Canyons with no movement north of Cat Canyon. During the 2017 lamb-rearing season, Ewe 424 moved north into Magnesia and Bradley and returned to the south several times; however, in 2018 the ewe remained in the south for the extent of lamb-rearing season.



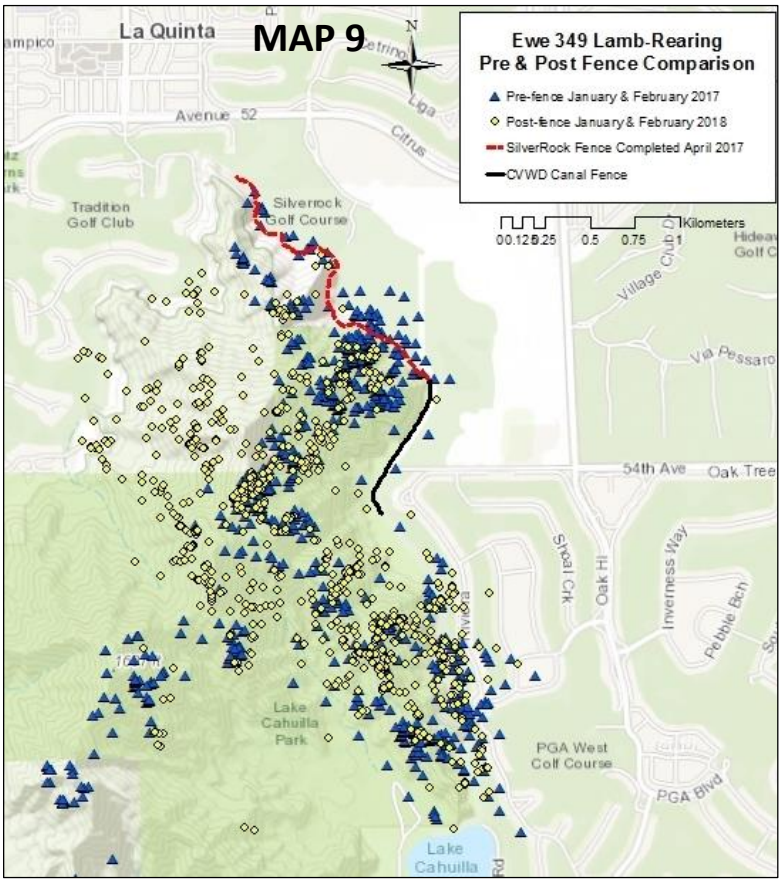




***Central Santa Rosa Mountains***

Currently, the CSRM has 2 ewe groups: the Sheep Canyon ewe group and the La Quinta ewe group, which consists of 3 sub-ewe groups - West, Guadalupe, and Urban (Map Series 4). The Sheep Canyon ewe group's home range is 82 $km^2$. Within the La Quinta ewe group, the West sub-ewe group's home range is 61 $km^2$, the Guadalupe sub-ewe group's home range is 54 $km^2$, and the Urban sub-ewe group's home range is 19 $km^2$. Based on GPS location data, the West sub-ewe group and Guadalupe sub-ewe group have not utilized the urban landscape for water or forage and thus are referred to as "wild" sub-ewe groups.

Seasonal use by GPS-collared ewes has not changed since the last reporting period (refer to CDFW 2016-17 Annual Report for details) with the exception of the Urban sub-ewe group. 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 (Map 9). While this measure has decreased the volume of sheep use on the SilverRock golf course, sheep can still enter the course from the south via PGA West golf community. Presently, there is only 1 functioning GPS-collared ewe in the urban ewe group; therefore, comparison of landscape use 1 year before (pre-fence) and 1 year after (post-fence) fence construction is based on the GPS location data of Ewe 349. One year pre-fence, 67% of annual GPS data was in the mountains above the golf communities, 17% at PGA West, 14% at SilverRock, and only 2% of annual use at Tradition. One year post-fence, approximately the same percentage (68%) of annual GPS data was in the mountains above the golf communities, PGA West increased to 28%, SilverRock decreased to only 1%, and Tradition increased to 3% of annual use. The percentage of

time Ewe 349 spent annually within all golf communities combined pre-fence (33%) and post-fence (32%) virtually remained unchanged—only the location within the urban landscape changed from SilverRock to PGA West. Comparison of pre and post-fence GPS data by month demonstrates the importance of steep mountainous terrain not only year-round but particularly during the first 2 months of lamb-rearing season (Figure 2 & Map 9). However, Ewe 349's post-fence use of mountainous terrain did decrease by 26% and 22% respectively in March and April compared to pre-fence use for the same months. Likely, this change is due to ewe 349's increased habituation to the urban environment, resulting in loss of natural fear for her lamb's safety during the lamb-rearing months. A fence at the base of the mountains is necessary to exclude sheep from the communities of PGA West and Tradition while ensuring full access to native habitat in the mountains above. A fence that would also exclude presently occupied essential sheep habitat in the mountains above the urban area would not be in the best interest for long-term survival of both the urban and wild sub-ewe groups in the CSRM.



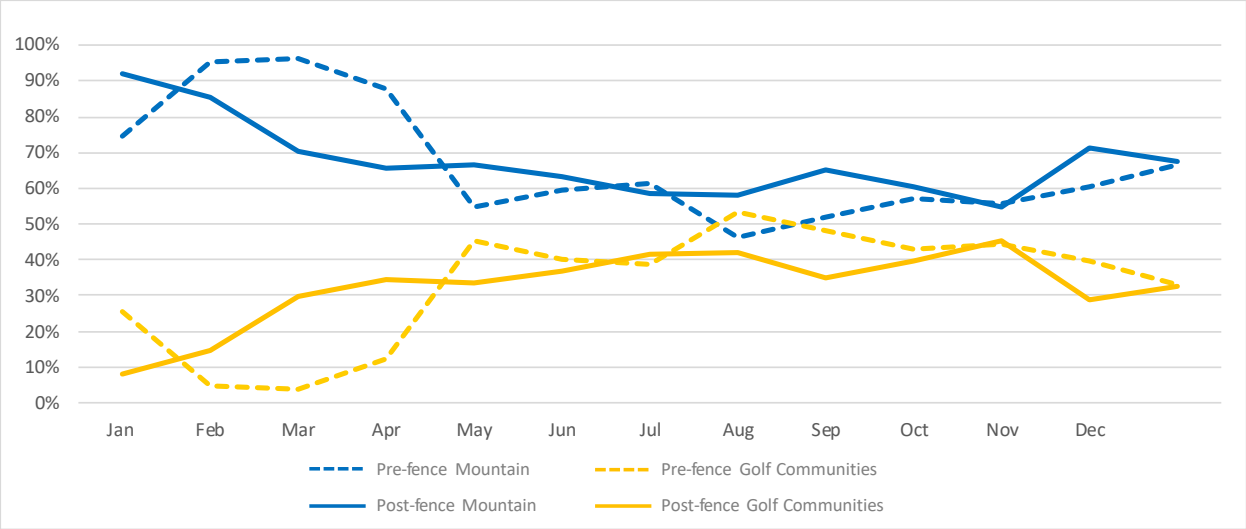



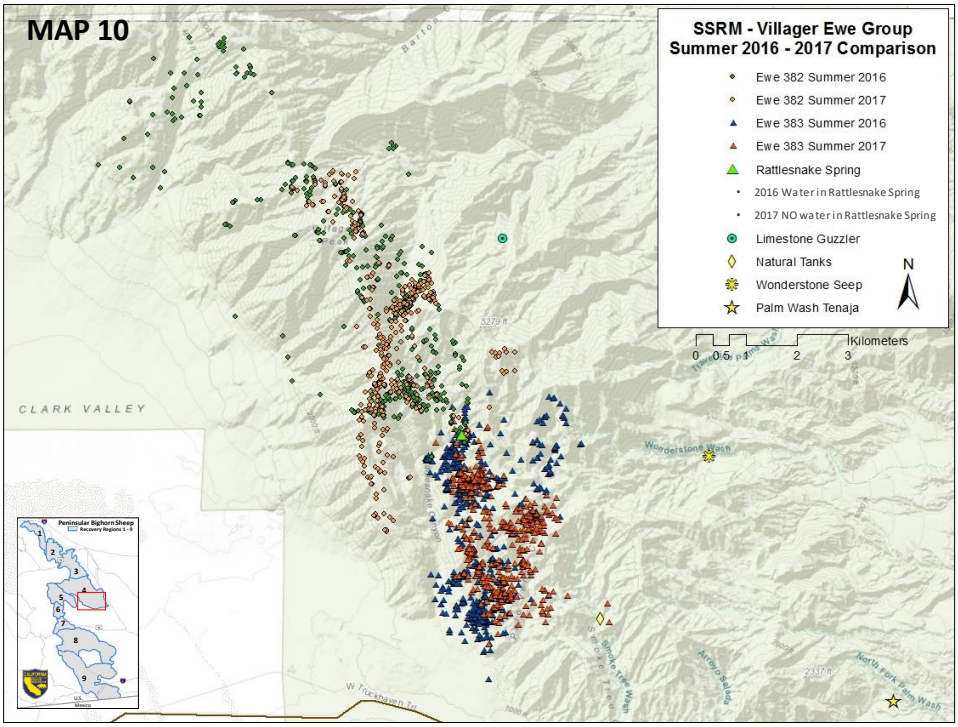

Figure 2. Percentage of GPS location data by month for ewe 349 1 year prior (Pre-fence) and 1 year after (Post-fence) construction of a temporary fence at the base of the mountain at SilverRock Golf Course. Pre-fence period = 1 May 2016 through 30 April 2017 (n = 11164). Post-fence period = 1 May 2017 through 30 April 2018 (n = 5625). Mountain = all GPS data in mountains surrounding urban area. Golf Communities = All GPS data in PGA West, Tradition, and SilverRock golf courses combined.

***Southern Santa Rosa Mountains***

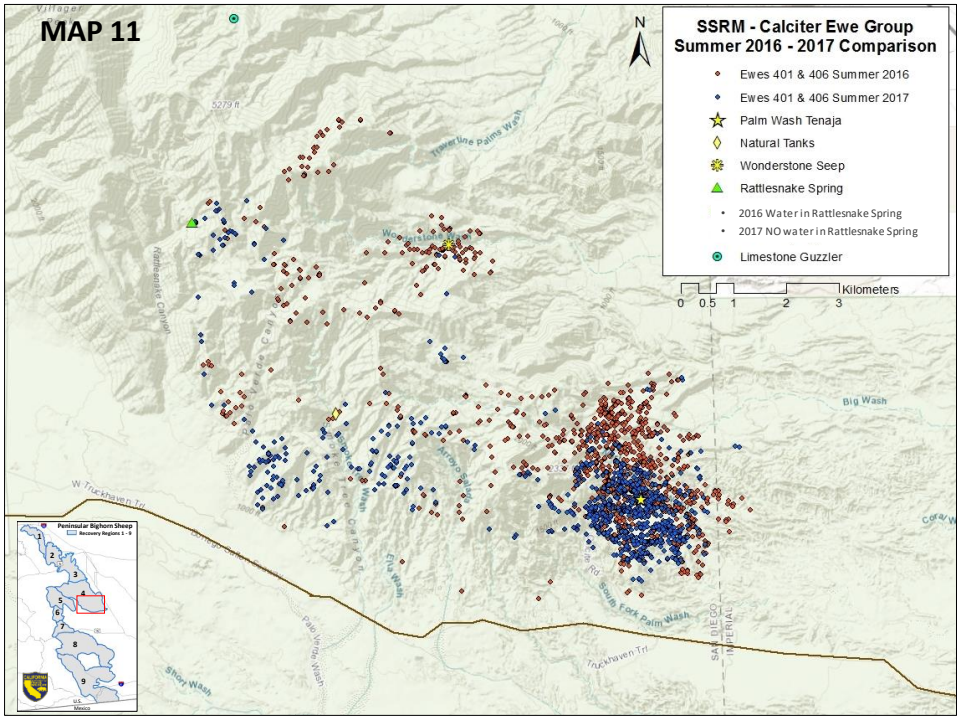
Current GPS location data have identified 3 ewe groups in the SSRM (Map Series 4). The Buck Ridge ewe group's home range, located in the northwest corner of the recovery region, is 77 km$^2$ and is 19 km long from west to east and 7 km wide from north to south. The Villager ewe group's home range is 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.

Presently, there are 7 known water sources available in the SSRM. Unfortunately, in recent years water availability and reliability has not been consistent likely due to the long-term effects of drought. Rattlesnake Spring used to be a reliable water source for the Villager ewe group; however, in 2017, the spring dried up during the hottest part of the summer. Interestingly, despite the lack of reliable water in 2017, the Villager ewe group did not significantly change their pattern of habitat use or move to another water source such as Limestone Guzzler. In both 2016 and 2017, Ewe 383's summer home range was on the southeast side of Rattlesnake Canyon (Map 10). However, in response to the lack of water in 2017, Ewe 383 used a smaller area at slightly higher elevations to the south of Rattlesnake Spring. Furthermore, in 2016, 40% of all summer GPS locations were within 1 km of Rattlesnake Spring compared to 29% in 2017. Similarly, Ewe 382 remained on the northwest side of Rattlesnake Canyon in both 2016 and 2017 but used a smaller area at higher elevations in 2017 (Map 10). Additionally, in 2016, 17% of Ewe 382's summer GPS locations were within 1 km of Rattlesnake Spring compared to only 4% in 2017. Despite the lack of water in 2017, all radio-collared ewes in the Villager ewe group survived through the summer months.

**MAP 10**




**MAP 11**




The Calcite ewe group's main source of water is Palm Wash Tenaja with occasional use at Wonderstone Seep, Natural Rock Tanks, and Rattlesnake Spring (Map 11). Unfortunately, Palm Wash Tenaja is no longer a reliable water source as it often dries up before the end of each summer. In 2016, 42% of all summer GPS locations were within 1 km of Palm Wash Tenaja, 6% at Wonderstone Seep and 1% each at Natural Rock Tanks and Rattlesnake Spring. In 2017, 66% of all summer GPS locations were within 1 km of Palm Wash Tenaja, only 0.2% at Wonderstone Seep and 2% each at Natural Rock Tanks and Rattlesnake Spring. Despite the lack of consistent water in 2017, all radio-collared ewes in the Calcite ewe group survived through the summer months.

***Coyote Canyon***

There are 2 ewe groups within this recovery 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 Series 4). 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 Collins Valley ewe group is 72 km$^2$ and extends 16 km from Salvador Canyon in the north to Henderson Canyon in the south. For an overview of ewe group structure within this region, refer to CDFW 2016-17 Annual Report.

The recovery region lost a significant number of radio-collared ewes to mortality (3) and nonfunctioning collars (2) during this reporting period. There were no noteworthy changes in habitat use or movements based on the 2 remaining GPS-collared ewes and 1 VHF-collared ewe in the Coyote Mountain ewe group. Because there were no GPS-collared ewes within the Collins Valley ewe group during this reporting period, current information on habitat use is lacking.

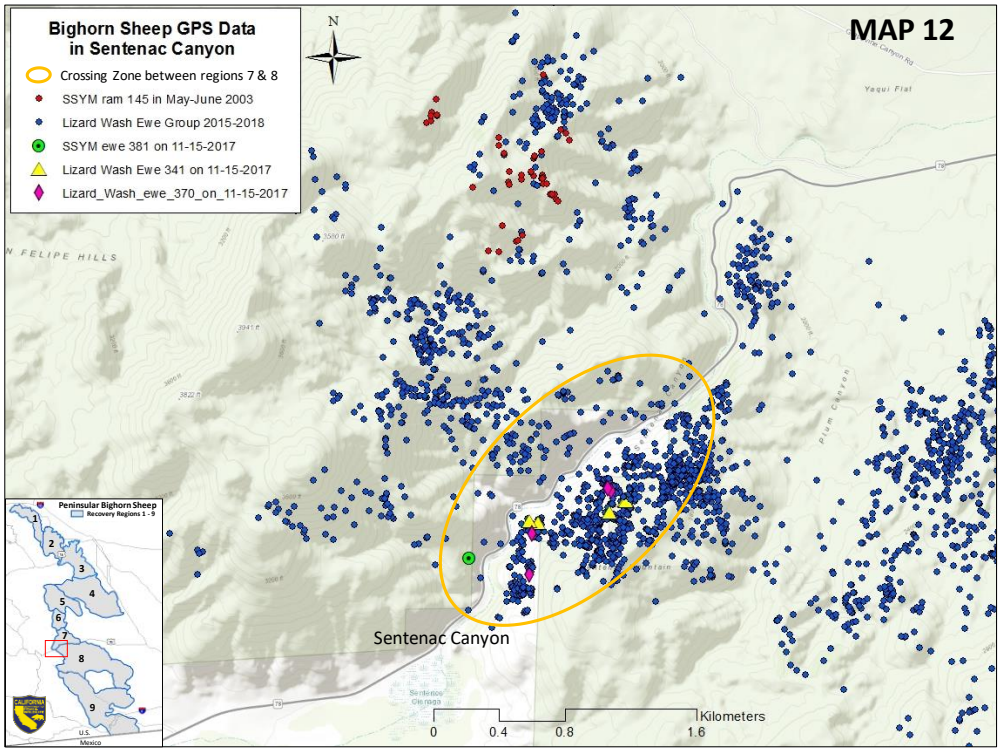
***Northern San Ysidro Mountains***

The NSYM ewe group's overall home range is 50 km$^2$ and extends 13 km from Henderson Canyon in the north to County Road S22 (Map Series 4). The majority of radio-collared ewes spend all 3 seasons within the area surrounding Borrego-Palm Canyon. A second subset of ewes spend the majority of their time between Hellhole Canyon and the slopes above County Road S22 just north of Tubb Canyon; however, these ewes also use Borrego-Palm Canyon during the summer and/or lamb-rearing seasons.

There were no changes in habitat use and movement patterns for this reporting period. For an overview of ewe group structure within this region, refer to CDFW 2016-17 Annual Report.

***Southern San Ysidro Mountains***

The SSYM contains 1 ewe group consisting of 2 sub-ewe groups that share the same area for lamb-rearing, but then use different areas during the summer months. 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 Tubb Canyon sub-ewe group encompasses 49 km$^2$ and the Pinyon Ridge sub-ewe group encompasses 41 km$^2$ (Map Series 4). For an overview of ewe group structure within this region, refer to CDFW 2016-17 Annual Report.




Due to lack of any GPS-collared ewes during this reporting period, habitat use for the reporting period could not be thoroughly assessed. Based on observation data of 9 VHF-collared ewes, sub-ewe group structuring and habitat use was similar to previous years. All 9 VHF-collared ewes used the south slopes of Pinyon Ridge during the lamb-rearing season. Five radio-collared ewes moved to the Tubb Canyon area during the summer months while 4 remained on the south slopes of Pinyon Ridge. Noteworthy: in November 2017, Ewe 381 and 5 other ewes were observed at the southeast end of Grapevine Mountain just above Highway 78 through Sentenac Canyon. There is not much GPS data showing use of Grapevine Mountain by members of the SSYM ewe group with the exception of Ram 145 in 2002 (Map 12). Because Ewe 381 does not wear a GPS collar, it is not known how much time the ewe spends in the Grapevine Mountain area. The Lizard Wash ewe group, in the Vallecito Mountains, crosses Highway 78 in Sentenac Canyon and uses Grapevine Canyon regularly. In fact, 2 GPS-collared Lizard Wash ewes were observed on the east side of Sentenac Canyon

on the same day as SSYM ewe 381 (Map 12). It is possible the CE outbreak in 2017-18 was spread north via the connection formed by Sentenac Canyon between the Lizard Wash and SSYM ewe groups.

***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 Series 4). Ewe group home range size from smallest to largest is Lizard Wash 69 $km^2$, Sunset 71 $km^2$, Fish Creek Mountains (FCM) 77 $km^2$, and Vallecito 203 $km^2$. According to the most recent GPS location data available, patterns of habitat use have not changed significantly in the Vallecito and Fish Creek Mountains ewe groups despite the lack of reliable water sources in the past few years. Currently, there are no GPS-collared ewes in the Sunset ewe group and VHF-collared ewes are not monitored on a frequent basis. For an overview of ewe group structure within this region, refer to CDFW 2016-17 Annual Report.

The Lizard Wash ewe group's home range extends 16 km from Grapevine Mountain to Nolina Wash and is 6 km in width from the east side of Highway 78 to the ridgeline of the North Pinyon Mountains. A few Lizard Wash radio-collared ewes have moved to Sunset Mountain for 3 to 4 days during the lambing season but typically, Nolina Wash defines the eastern boundary. Presently, the patterns of habitat use and movement for GPS-collared ewes in the Lizard Wash ewe group have not changed with the exception of Ewe 371. Based on direct observations, VHF-collared Ewe 371 spends the majority of the year with the Lizard Wash ewe group; however, each year in late summer/early fall the ewe travels 28 km south and joins the Tierra Blanca ewe group in the Carrizo Canyon recovery region. This was the first documented movement by a radio-collared ewe from the Vallecito to Carrizo recovery region. In August 2017, Ewe 371 was observed at Agua Caliente County Park and was among one of the sheep with CE. It is not known if Ewe 371 still had an active case of CE when she returned to Lizard Wash at some point in September. In order to understand the connectivity between the two recovery regions, Ewe 371 was recaptured in November 2017 and deployed with a satellite collar—all equipment used in the capture was disinfected to prevent spread of disease. According to satellite data, Ewe 371 remained in the Lizard Wash ewe group until the end of this reporting period but will likely move south during summer 2018.

***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 Series 4). The Tierra Blanca ewe group consists of 2 sub-ewe groups, Agua Caliente and Canebrake, with an overall home range that 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 (Map Series 4). The Carrizo Canyon ewe group consists of 2 sub-ewe groups, Carrizo Gorge and Coyote Mountains, with a combined home range of 236 $km^2$. The home range extends 26 km in length from the west side of Carrizo Canyon to the east side of the Coyote Mountains and is 20 km in width from the mouth of Carrizo Canyon to Tule Canyon near Interstate 8. The In-Ko-Pah 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 eastbound and westbound lanes of Interstate 8. Lastly, 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 is 13 km wide from west to east.

In November 2017, new solar GPS collars were deployed in the Tierra Blanca, Carrizo, and In-Ko-Pah ewe groups. There were no changes in habitat use and movement patterns for data collected during this reporting period. For an overview of ewe group structure within this region, refer to CDFW 2016-17 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 the following: 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 by recovery region are listed below.

***San Jacinto Mountains and Northern and Central Santa Rosa Mountains***

A. *Habitat Loss and Fragmentation* - 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, 112 acres of essential sheep habitat is being lost in the Chino Cone area due to development of the Desert Palisades subdivision.

B. *Disease* - Disease is a major concern within the NSRM due to high lamb losses over the past few years. Also of concern, it the increasing number of bighorn sheep using the urban environment at Bighorn Golf Club Course in Palm Desert.

C. *Urban Use* - Since 2012, a growing number of sheep have foraged daily at the golf courses at PGA West, SilverRock, the Quarry, and Tradition. 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. While the fence has significantly decreased the volume of bighorn sheep on the golf course, sheep can still enter SilverRock from the south via PGA West; therefore, it cannot be categorized as an exclusion fence. Once sheep enter the golf course they are at higher risk for injury or predation as the fence blocks their access to escape terrain as demonstrated by Ewe 353 (refer to Page 8 & 9).

   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 at the urban interface to exclude bighorn sheep from golf courses and residential areas in La Quinta would be an important step toward preventing urban-related mortalities and enhancing 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. A fence constructed at the base of the mountain at PGA West would prevent sheep from entering both PGA West and SilverRock while allowing full access to all native habitat on the mountain slopes above the community. However, the "Over the Ridge" alternative fence proposed by Coachella Valley Conservation Commission (CVCC) would also eliminate over 100 acres of essential sheep habitat as well as lamb-rearing habitat on the slopes above PGA West. Therefore, the "Over the Ridge" alternative fence cannot be considered a mitigation tool that will enhance or protect essential bighorn sheep habitat as recommended in the bighorn sheep recovery plan (USFWS 2000).

D. *Human Disturbance* - 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 are 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. 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. Three official trails in La Quinta Cove bisect essential lambing and lamb-rearing habitat: Bear Creek trail, Boo Hoff Trail, and Cove to Lake Trail. Kiosks located at the La Quinta Cove trailheads do not provide clear information as to where dogs and bikes are and are not allowed, nor do they provide information concerning bighorn sheep. 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, lambing and nursery habitat, and foraging 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 (Section II.D.1.2.2.1 a-f.). Deployment of enforcement personnel during peak use periods to educate the public, monitor compliance with trail rules, and enforce rules against violations would provide an immediate benefit to bighorn sheep. 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.

E. *Vehicle Collisions* - Highway 74 continues to impede sheep movement between the NSRM and CSRM and each year more sheep are struck and killed by vehicles while attempting to cross the highway. In May 2018, Caltrans installed 2 flashing warning signs at the upper and lower limits of an identified sheep-crossing zone. The efficacy of the new signs will be tested during the peak road-kill months of August, September and April. Future increases in the traffic load on Highway 74 may eventually cut off any movement between the NSRM and CSRM. The recovery plan for bighorn sheep in the Peninsular Ranges Section II.B.2 (USFWS 2000), states that in order for down listing 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."

F. *Domestic Livestock* – In the area surrounding Blaisdell Canyon, domestic sheep and goats that are not properly fenced have the potential to spread disease to the wild sheep population.

***Southern Santa Rosa Mountains***

A. *Habitat Loss and Degradation* - Gold mine exploration is occurring or being proposed within sheep habitat in the Wonderstone Wash area in the eastern portion of this recovery region.

B. *Water depletion* - In the recent past, there were numerous reliable natural water sources for sheep in the SSRM. However, due to long-term drought conditions, most natural springs and tenajas now dry up in the latter portion of the summer. Until recently, Rattlesnake Spring located in the central portion of the recovery region served as an important water source; however, during the summer of 2017 the spring went dry for the first time recorded. If drought conditions continue, natural water sources may no longer meet the needs of sheep within this recovery region.

C. *Human Disturbance* – Off-road vehicle (OHV) use in essential sheep habitat continues to pose an impact to bighorn sheep. Incursions by OHV's in the desert washes and alluvial fans within and adjacent to the boundaries of ABDSP is ongoing. Administration of essential sheep habitat by federal and state land management agencies does not guarantee protection, and regular patrols by enforcement personnel are needed to curb OHV incursions.

***Coyote Canyon***

A. *Water Access* - 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.

B. *Habitat degradation* - The non-native plant species tamarisk (*Tamarix, ssp*.) has been identified as a serious threat to bighorn sheep recovery (USFWS 2000: I.D.5). Tamarisk can deplete surface water sources and outcompete native riparian plant species that sheep depend on as high-quality forage during the summer and fall months. In 1973, ABDSP took the lead in removing tamarisk from riparian areas; and by 2000, the majority of tamarisk had been eliminated within the state park and Coyote Canyon. Until recently, ABDSP resource crews 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 surface water and high-quality sheep habitat.

C. *Disease* - In this recovery region, disease continues to be a threat to lamb survival and CDFW continues to monitor for possible increases in disease occurrence.

***Northern San Ysidro Mountains***

A. *Urban Use* - An increase in urban use of the DeAnza Villas and golf course community by sheep continues to pose a threat in this recovery region. The development poses a threat to the health and survival of sheep 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) vehicle collisions and drowning in pools or ponds, and 4) increased predation at the urban interface. Removal of all oleander bushes from the residential area would be a first step in helping to prevent unnecessary deaths.

B. *Vehicle Collisions* - Movement across County Road S22 continues to pose a risk to bighorn sheep in this recovery region. 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.

C. *Disease* – Pneumonia in lambs continues to result in low lamb survival and recruitment within this recovery region.

D. *Human Disturbance* - In Borrego-Palm Canyon (BPC), the on-set of disease in lambs has occurred at the same time that park visitation numbers soar within the canyon. Inconsistency in PBC trail maintenance has led to visitors becoming lost, ending up off-trail, or following the creek bed to areas where sheep often congregate. Sick lambs need to drink often and will spend a significant amount of time near water. Visitors approaching and photographing sick lambs may decrease their chances of survival or impede movement to and from water sources and high-quality streamside forage. 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 bighorn sheep within the canyon. The continued presence of park personnel during the lamb-rearing season along with regular trail maintenance will provide significant benefits to bighorn sheep within BPC.

   CDFW and Park staff has encountered drone users within BPC and has documented ewes and lambs running from drones. With recreational use of drones on the rise, a solution to this type of disturbance will need to be addressed.

   In recent years, sheep in BPC have increased their use of the water source adjacent to the BPC trailhead parking lot during August. If this trend continues, closure of the trailhead parking lot, posting of signs, and increased enforcement patrols will be necessary to reduce human disturbance.

***Southern San Ysidro Mountains***

A. *Vehicle Collisions* - County Road S3 between Pinyon Ridge and Yaqui Ridge bisects the SSYM ewe group. On Highway 78, both The Narrows and Sentenac Canyon serve as movement corridors between the SSYM and VM recovery regions. Sheep are most often struck and killed by vehicles during the early spring when ewes are moving between lambing and nursery grounds. Unfortunately, this coincides with an increase in traffic during peak visitation to ABDSP and Ocotillo Wells State Vehicular Recreational Area. Reduced speed limits at common sheep-crossing locations and placement of flashing warning signs could help reduce sheep deaths.

B. *Water Access and Depletion* - 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 must be addressed by ABDSP and CDFW in order to ensure future access to water for sheep.

***Vallecito Mountains***

A. *Habitat Loss* - The Fish Creek Mountains (FCM) ewe group resides largely outside the protection of federal (BLM) and state (ABDSP) wilderness areas and thus is vulnerable to habitat loss and fragmentation. Such 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.

B. *Maintaining Water Sources* - 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 been insufficient rain to fill most of the guzzlers. Currently, ABDSP and CDFW are working together to come up with a long-term maintenance plan for guzzlers and access to water sources throughout the State Park in order to assure year-round water availability.

***Carrizo Canyon***

A. *Vehicle Collisions* - Since 2012, there have been 14 documented cases of sheep killed (including 3 radio-collared ewes) by vehicles on Interstate 8. The section of the Interstate through the In-Ko-Pah Gorge 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. Coordination between state and federal wildlife and transportation agencies will be necessary to address the on-going loss of sheep due to vehicles. Improvements necessary to reduce sheep deaths may include signage, barrier and directional fencing, and overpass structures.

B. *Disease* - 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 again indicate *M.ovi.* CDFW will continue to monitor disease among these ewe groups.

C. *Domestic Livestock* - In December 2017, CDFW received a report of 4 domestic goats within habitat used by the In-Ko-Pah ewe group near Mountain Springs. Domestic goats and sheep can potentially spread disease to the wild sheep population. Multiple attempts were made to find the goats and on January 3, 2018, a CDFW biologist found and killed 3 domestic goats near Devils Canyon. To date, no other goats have been sighted within the recovery area and the In-Ko-Pah ewe group has been carefully monitored for signs of disease outbreak.

D. *Water Access and depletion* - Mountain Springs is an important source of water for sheep in the IKP ewe group. Mountain Springs 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 depend on the water sources at Agua Caliente County Park (ACCP). 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 is another important water source for the Tierra Blanca ewe group; however, the canyon resides within private property. Presently, Tamarisk (*Tamarix* spp.) is outcompeting native plant species and blocking access to water sources within the canyon. 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.

E. *Habitat Loss and Fragmentation* - Since 2009, GPS data have 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 Interstate-8 Island, which lies between the eastbound and westbound lanes, and is accessed from the interstate. Jeep activities in Devils Canyon may restrict free movement of sheep to and from their lamb-rearing habitat within the Interstate 8 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 Springs, Myer Valley access from eastbound 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 further development of energy projects within or adjacent to these areas, combined with disturbance by border security activities, will have significant adverse impacts on this ewe group.

**FUTURE ACTIONS**

Program activities for 2018/2019 include monitoring radio-collared sheep via fixed-wing flights and ground telemetry to detect and investigate mortalities, obtain ground observations to assess group composition, health and disease, lamb:ewe and yearling:ewe ratios, and collect location and movement data within recovery regions 4 through 9. In addition, a bighorn sheep capture during fall 2019 will be undertaken to fit new radio-collars on sheep and to undertake health screening. Priority recovery regions for radio-collaring will be CoC, VM, and CC. Captures in the remaining 6 recovery regions may occur if additional funding is secured. Additionally, CDFW will update 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 collaborates on recovery.

**ACKNOWLEDGMENTS**

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**PUBLIC OUTREACH**

March 4, 2018: Presentation by J. Colby at Canebrake community titled “Bighorn Sheep in the Tierra Blanca Mountains”.

March 19, 2018: Presentation by J. Colby for ABDSP Visitor Center Staff titled “Desert Bighorn Sheep in Borrego-Palm Canyon”.

June 16, 2018: Two presentations by J. Colby for ABDSP Sheep Count Volunteers titled “Desert Bighorn Sheep in the Peninsular Ranges” and “Sheep Identification”.

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