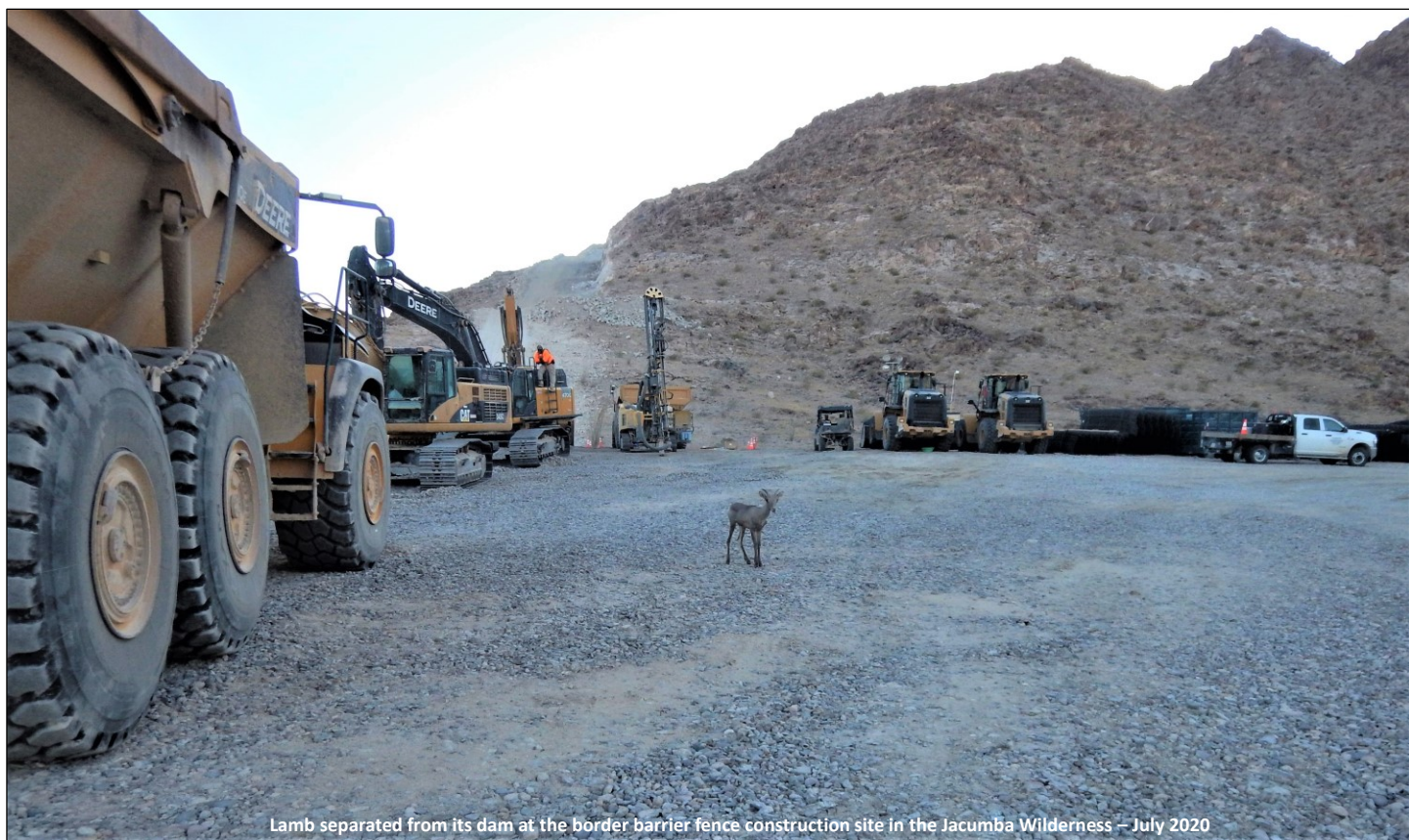# CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
PENINSULAR BIGHORN SHEEP ANNUAL REPORT
1 June 2020 - 31 May 2021

Lamb separated from its dam at the border barrier fence construction site in the Jacumba Wilderness – July 2020

This report presents information on the status, distribution, and management of Peninsular bighorn sheep from 1 June 2020 to 31 May 2021

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South Coast Region & Inland Deserts Region

Photo by Jeff Young

California Department of Fish and Wildlife Peninsular Bighorn Sheep 2020-21 Annual Report

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Photo 1. View of Skull Valley in the Jacumba Wilderness looking east towards the border wall construction staging area and access road in July 2020. Lat: 32.630494° Long: -115.954621°

EXECUTIVE SUMMARY

Peninsular 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 range-wide population estimate had declined to only 277 adult bighorn sheep (USFWS 2000). Peninsular bighorn sheep (PBS) 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 caused by urban and commercial development; 2) disease; 3) predation coinciding with low population numbers; 4) human disturbance; 5) insufficient lamb recruitment; 6) invasive and toxic nonnative plants; and 7) prolonged drought (USFWS 2000).

Sustainable management and conservation of PBS hinges on reliable and consistent population estimates. Unfortunately, the current population status of PBS is unknown. The last range-wide population survey, conducted in 2016, estimated a stable population of 884 Peninsular bighorn sheep. Population surveys were not conducted in 2018 or 2020 due to lack of helicopter availability and/or funding limitations. Therefore, it is unknown whether the range-wide population has remained stable, increased, or decreased since the 2016 surveys. Scientifically based population surveys are costly and without a dedicated funding source it will not be possible to determine if recovery goals are being met.

Maintaining a representative sample of 25% to 30% radio-collared bighorn sheep in each recovery region is important for generating reliable mark-resight population estimates and accurately tracking trends in distribution and movement patterns, adult survivorship, cause-specific mortality, and overall health status. Unfortunately, due to on-going funding shortages, only 13% of the estimated range-wide ewe (female) population was radio-collared at the beginning of the current reporting period (June 1, 2020 – May 31, 2021) and 18% at the end of the reporting period (based on 2016 generalized ewe population survey estimate of 552). Therefore, all descriptive statistics presented for the current reporting period may not fully represent the greater PBS population. Consistent funding for every recovery region is needed before information on population status and dynamics can be accurately assessed.

For the current reporting period, 14% of all active radio-collared bighorn sheep died with predation accounting for 7%, nonpredation 4%, urban related 2%, and unknown causes 1%. Most bighorn deaths due to mountain lion predation occurred in the southern portion of the Peninsular Ranges. Climate change took a toll on bighorn sheep with over half the deaths categorized as nonpredation due to lack of water during the summer months. Radio-collared deaths attributed to the urban environment were all due to vehicle collisions on Interstate 8 during the lamb-rearing season. Also, there were a record 34 reports of non-collared bighorn sheep deaths. The leading cause of non-collared bighorn deaths was due to
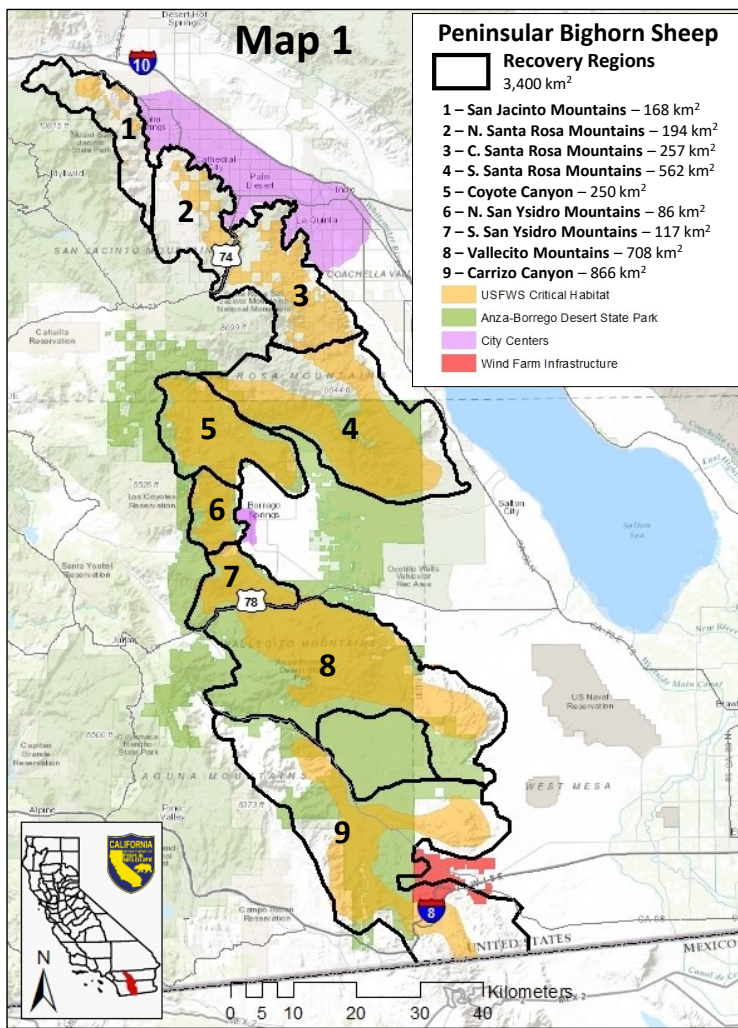
the urban environment with the majority of the deaths due to vehicle collisions on Interstate 8 followed by Highway 74, and 3 death due to drowning in the Coachella Canal.

Average survival of radio-collared ewes was 92% in the San Jacinto Mountains, 95% in the North Santa Rosa Mountains, and 89% in the Central Santa Rosa Mountains. Survival rates for the remainder of the recovery regions could not be calculated due to small sample size of radio-collared ewes.

Respiratory disease in lambs has been a persistent problem in all recovery regions of the Peninsular Ranges. 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). In 2020, recruitment indices were well below 30% in the Tierra Blanca ewe group (10%), San Jacinto Mountains (11%), North Santa Rosa Mountains (16%), North San Ysidro Mountains (17%), and the Wild sub-ewe groups in the Central Santa Rosa Mountains (22%). In contrast, lamb recruitment was above 30% in the Urban sub-ewe group in the Central Santa Rosa Mountains and the In-Ko-Pah ewe group (52%). In general, long-term trends in survival and recruitment in the Peninsular Ranges has demonstrated that lamb survival indices below 65% portends recruitment indices below 30%. As such, recruitment in 2021 is predicted to be poor since lamb survival indices in 2021 were all well below 65%. Unfortunately, 2020 recruitment and 2021 survival indices for Coyote Canyon and the South San Ysidro Mountains could not be obtained due to the low number of radio-collared ewes in these recovery regions during the reporting period.

Since 2009, California Department of Fish and Wildlife has deployed Global Positioning System (GPS) radio-collars on female bighorn sheep to understand ewe group structure and seasonal movements within the Peninsular Ranges. Thus far, 19 ewe groups and/or sub-ewe groups have been identified within the Peninsular Ranges. Movement between ewe groups is common except between recovery regions 1 and 2 and between 8 and 9. During the current reporting period, 2 ewes with GPS collars were documented moving from recovery region 1 into recovery region 2 on several occasions. And in 2018, data from a GPS-collared ewe documented the round-trip route between recovery regions 8 and 9. Occurrence data demonstrates that PBS have shifted their habitat use to both higher and lower elevations outside of the revised 2009 critical habitat designation most notably in recovery regions 4, 8 and 9. Based on documented structural changes to vegetation mainly at lower elevations but also at the higher elevations over the past 30 years (Hanston et al. 2021) concurrent with changes in habitat use by PBS since listing, USFWS critical habitat designation should be re-analyzed and adjusted to ensure that corridors and habitat currently occupied and unoccupied will be available in a changing climate. Research is needed to understand how climate change influences the health, survival, distribution, and abundance of PBS throughout the Peninsular Ranges in order to guide management decisions for recovery efforts.

Presently, there is substantial genetic variation and gene flow among bighorn sheep populations within the Peninsular Ranges and across the U.S./Mexico Border indicating functional connectivity (Buchalski et al. 2015). However, connectivity between the U.S. and Mexico is threatened by the bollard fence that was built across 3 miles of PBS habitat within the Jacumba Wilderness in 2020. The barrier fence has cut-off a third of the movement corridors between the U.S. and Mexico and if completed it will eliminate the ability for PBS to reach vital resources between the two countries and eliminate gene flow. Interstate 8 and Highway 74 are major threats to connectivity and overpass structures are necessary if connectivity is to be maintained. Additional factors that may hinder recovery efforts range-wide are disease, climate change, the loss of natural water sources and the lack of regular maintenance for artificial water sources, reduction and fragmentation of bighorn sheep habitat, habitat modification due to invasive nonnative plants, bighorn sheep use of urban areas, and human related disturbance of essential sheep habitat especially during lamb-rearing season around the urban centers, recreational areas, and near the U.S./Mexico border.

Map 1

Peninsular Bighorn Sheep
Recovery Regions
3,400 km²

1 – San Jacinto Mountains – 168 km²
2 – N. Santa Rosa Mountains – 194 km²
3 – C. Santa Rosa Mountains – 257 km²
4 – S. Santa Rosa Mountains – 562 km²
5 – Coyote Canyon – 250 km²
6 – N. San Ysidro Mountains – 86 km²
7 – S. San Ysidro Mountains – 117 km²
8 – Vallecito Mountains – 708 km²
9 – Carrizo Canyon – 866 km²

☐ USFWS Critical Habitat
☐ Anza-Borrego Desert State Park
☐ City Centers
☐ Wind Farm Infrastructure

BACKGROUND

Peninsular bighorn sheep (*Ovis canadensis nelsoni*) inhabiting the Peninsular Ranges of southern California are a federally listed endangered species. The California Department of Fish and Wildlife (CDFW) carries out population monitoring following guidelines set forth in the Recovery Plan and under USFWS Endangered Species Permit TE163017-1. This report summarizes PBS radio-collar monitoring, disease surveillance, and cause-specific mortality investigations undertaken by CDFW from 1 June 2020 to 31 May 2021.

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).

All recovery regions combined contain approximately 3,400 square kilometers of "essential" PBS habitat. The USFWS Recovery Plan defines essential habitat as "those areas that provide bighorn sheep with the various physical and biological resources (e.g., space, food, water, cover) potentially needed for: 1) individual/population growth and movement, and 2) normal behavior with protection from disturbance" (USFWS 2000, p. 154).

RECOVERY PROGRAM OVERVIEW

Monitoring Activities

Activities conducted during this reporting period were tied to recovery elements with the Recovery Plan. Section II of the Recovery Plan addresses the need to "Initiate or continue research programs necessary to monitor and guide recovery efforts". Monitoring activities are covered in sections II.D.2.1 (Monitor population status), II.D.2.1.2 (Monitor distribution), and II.D.2.1.4 (Monitor survivorship and cause-specific mortality) of the Recovery Plan.

CDFW monitored all Very High Frequency (VHF) and Global Positioning System (GPS) radio-collared bighorn sheep range-wide using a combination of satellite, remote-download, and field monitoring. Monitoring efforts focused on the following: 1) radio-collared sheep status (alive/dead), 2) mortality investigations, 3) observations of sheep group composition, health, lamb recruitment and survival, and 4) spatial and temporal movements.

CDFW Personnel

Mr. Randy Botta, Senior Environmental Scientist (Specialist) CDFW South Coast Region, is the Endangered Species Permit (TE163017-1) Principal Officer and provides all notifications and reports to USFWS. Ms. Janene Colby, Environmental Scientist with the South Coast Region, is the bighorn sheep biologist for recovery regions 4-9. Ms. Erin Schaeffer,

Environmental Scientist with the Inland Deserts Region is the bighorn sheep biologist for recovery regions 1-3. Ms. Colby and Ms. Schaeffer are responsible for oversight of range-wide monitoring activities.

RADIO-COLLAR STATUS

The Recovery Plan recommends maintaining active radio-collars on approximately 25-30% of the PBS population within each recovery region. Maintaining a representative sample of radio-collared PBS is important for generating reliable mark-resight population estimates and accurately tracking trends in distribution and movement patterns, adult survivorship, cause-specific mortality, and overall health status. The cost associated with radio-collars and capture operations are extremely high and it has become increasingly difficult for CDFW to procure funds on a consistent basis. Without consistent funding to maintain active radio-collars on minimally 25% of PBS within each recovery region each year, it will be impossible to accurately estimate population abundance and viability. With limited funding, CDFW has focused efforts on radio-collaring ewes since they are the reproductive base of the population.

At the beginning of the reporting period (1 June 2020), the 9 recovery regions contained 77 (74F, 3M) active radio-collared bighorn sheep (Table 1). Over the reporting period, 60 radio-collars were added, 18 radio-collars either dropped off or became nonfunctional (censored), and 19 were lost due to mortalities. At the end of the reporting period (31 May 2021), there were 100 (97F, 3M) active radio-collared bighorn sheep. Range-wide, approximately 13% of the estimated ewe population was radio-collared at the beginning of the reporting period compared to 18% at the end of the reporting period (based on 2016 generalized ewe population survey estimate of 552). Currently, the percentage of radio-collared ewes in recovery regions 4 through 9 falls far below the recommended minimum of 25% (Table 1). Uneven distribution of radio-collars across recovery regions is due to funding often being tied to specific areas only. On average, approximately 19% of radio-collars are lost each year due to deaths (13%) and collar failure or drop-off (6%); therefore, regular captures and collaring events are necessary to maintain a representative sample of marked animals. Additional radio-collars will be deployed in November 2021 in all recovery regions.

Table 1. Distribution and number of active radio-collared female (F) and male (M) bighorn sheep within the 9 recovery regions during the 1-year reporting period beginning on 06/01/2020 and ending on 05/31/2021. Collar additions resulted from collaring activities in fall 2020. Collar losses were due to mortalities, pre-programmed collar drops and radio-collars that became nonfunctional (Censored). The estimated percentage of females' radio-collared (% F Collared) at the end of May 2021 is based on the generalized ewe (plus female yearlings) abundance estimate of 552 obtained from the 2016 helicopter survey.

Category	SJM F	SJM M	NSRM F	CSRM F	CSRM M	SSRM F	SSRM M	CoC F	CoC M	NSYM F	NSYM M	SSYM F	SSYM M	VM F	VM M	CC F	CC M	total F	total M
Active Collars 6/1/2020	5	1	12	7	0	9	0	1	0	5	0	4	0	16	0	15	2	74	3
Additions	+8		+8	+12										+10		+22		+60	
Mortalities	-1		-1	-2		-1				-1		-1		-7		-5		-19	
Censored	-3		-9			-4										-2		-18	
Active Collars 5/31/21	9	1	10	17	0	4	0	1	0	4	0	3	0	19	0	30	2	97	3
% F Collared	28%		36%	26%		7%		2%		14%		10%		19%		18%		18%	

CAPTURE AND RADIO-COLLARING

During this reporting period, CDFW managed capture activities while Leading Edge Aviation carried out helicopter captures under contract with CDFW. Captures were conducted from 26 October through 2 November 2020 on State, Federal and Tribal lands throughout the Peninsular Ranges within eastern San Diego, western Imperial, and western Riverside counties. Recovery regions where captures occurred included the SJM, NSRM, CSRM, VM, and CC. Helicopter capture was funded through CDFW South Coast Region Habitat Conservation Program, CDFW Big Game Fund Account, Federal Wildlife Restoration Act Grant G2098061, Coachella Valley Conservation Commission and USFWS Tribal Wildlife Grant funding.

VHF and Iridium satellite GPS-collars (collectively referred to as radio-collars) were fitted to adult ewes in the targeted recovery regions 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 processed at base camp by CDFW staff or field processed by Leading Edge Aviation. Processing 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 and Wildlife Health Lab 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 7 days of capture, 60 ewes were fitted with radio-collars for the first time (Table 1) and 7 radio-collared ewes were recaptured and fitted with new radio-collars. Of the 67 ewes captured, 54 were deployed with satellite GPS collars and 13 with VHF collars. All radio-collared ewes were fitted with unique combinations of colored radio-collars and or ear tags to facilitate individual identification.

The average age of captured ewes was 6 years, and all were in fair to good condition. No injuries to sheep occurred during the capture. Collared bighorn sheep were closely monitored on foot and via the internet, where applicable, for 45 days post-capture. All bighorn sheep survived except for 1 ewe in recovery region 3 which was killed by a mountain lion 2 days post-capture.

POPULATION ABUNDANCE

From 1996 to 2010, the range-wide PBS population steadily increased from an estimated 277 to 955 (Table 2). While surveys are typically conducted biennially, they were not conducted in 2012, 2014, 2018 or 2020. The last range-wide population surveys were conducted in 2016 and estimated a stable range-wide PBS population of 884. The 2016 survey marked the first time since PBS were listed as an endangered species that 25 ewes or more were counted in each recovery region. As such, 2016 marked year 1 of 6 consecutive years in meeting criterion 1 in section II.B.2 for downlisting PBS from endangered to threatened status (USFWS 2000). Unfortunately, because surveys were not conducted in 2018 or 2020 due to lack of state-wide helicopter services and/or funding limitations, it is unknown if 25 ewes were maintained within each recovery region for the past 4 years. Currently, it is unknown whether the range-wide population has remained stable, increased, or decreased since the last survey; therefore, without regular population estimates it is not possible to assess if recovery goals are being met.

CAUSE-SPECIFIC MORTALITY

CDFW attempts to investigate all PBS mortalities in a timely manner to accurately assess cause of death and health status at time of death. When possible, a necropsy is performed, and tissue samples are collected for disease testing. The amount of subcutaneous and visceral fat, bone marrow color and texture, and condition of horns and teeth are used as indicators of health status at time of death. In 2006, CDFW developed a detailed protocol for mortality investigations and criteria for categorizing cause of death. Cause of death can be grouped into 5 general categories:

1. **Predation** - primary cause of death is due to a predator (typically mountain lion and occasionally coyote). There are 3 levels of confidence within this category based on findings from the mortality investigation: 1) Predation (direct evidence of predation) 2) Probable predation (preponderance of indirect evidence of predation) 3) Possible predation (some indirect evidence of predation).
2. **Nonpredation** - cause of death does not meet predation criteria and is attributed to other causes, such as age-related diseases, pneumonia, injury, fall, dystocia, etcetera. If predation is ruled out but the cause of death cannot be discerned, it is categorized as nonpredation – unknown.
3. **Unknown** - cause of death cannot be determined due to scavenging of the carcass or advanced stage of decomposition. Predation versus nonpredation cannot be ruled out or in.

4. **Capture-related** - any death that occurs while a bighorn sheep is being captured or that occurs within the first month after capture.
5. **Urban-related** - any cause of death associated with the urban environment such as vehicle collision, drowning, urban-related injury, or ingestion of poisonous plants.

Table 2. Population abundance estimates (adult rams + adult ewes + yearlings) per Recovery Region (RR) for PBS from 1994 to 2016 based on helicopter surveys. Bighorn Institute (BI) conducted helicopter surveys in RR 1-4 from 1994-2008 and used a variety of statistical methods to generate population abundance estimates (Green italic numbers). CDFW conducted helicopter surveys in RR 5-9 from 1994-2008, and RR 1-9 in 2010 and 2016: population abundance estimates (blue bold numbers) were generated using Chapman's (1951) modification of the Peterson estimator (Seber 1982) unless otherwise noted. Due to a lack of a CDFW helicopter contract and/or lack of funding, surveys were not conducted in 2012, 2014, 2018, or 2020.

Recovery Region	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
RR 1 - San Jacinto Mtns.	17	19	23	17	22	32	21	26	16	No Range-wide Survey	No Range-wide Survey	56	No Range-wide Survey	No Range-wide Survey
RR 2 - N. Santa Rosa Mtns.	a	a	22	32	40	57	49	77	90	No Range-wide Survey	No Range-wide Survey	37	No Range-wide Survey	No Range-wide Survey
RR 3 - C. Santa Rosa Mtns.	117[a]	94[a]	72	53	115	No Surveys	163	122	133	No Range-wide Survey	No Range-wide Survey	119	No Range-wide Survey	No Range-wide Survey
RR 4 - S. Santa Rosa Mtns.	a	a	35	51	84	No Surveys	179	155	149	No Range-wide Survey	No Range-wide Survey	83	No Range-wide Survey	No Range-wide Survey
RR 5 - Coyote Canyon	29	37	35	35	35	47	42	52	66	No Range-wide Survey	No Range-wide Survey	69	No Range-wide Survey	No Range-wide Survey
RR 6 - N. San Ysidro Mtns.	68	39	34	33	47	50	79	82	72	No Range-wide Survey	No Range-wide Survey	59	No Range-wide Survey	No Range-wide Survey
RR 7 - S. San Ysidro Mtns.	19	26	41	39	41	47	38	53	55	No Range-wide Survey	No Range-wide Survey	42	No Range-wide Survey	No Range-wide Survey
RR 8 - Vallecito Mtns.	29	28	45	64	155[b]	150[b]	77	123[b]	142	No Range-wide Survey	No Range-wide Survey	163	No Range-wide Survey	No Range-wide Survey
RR 9 - Carrizo Canyon	58	34	28	82	127	101[b]	145	186[b]	232	No Range-wide Survey	No Range-wide Survey	256	No Range-wide Survey	No Range-wide Survey
Total*	337	277	335	406	666	Un-known	793	876	955	Unknown	Unknown	884	Unknown	Unknown

*This is the sum of recovery regions (Generalized) rather than a range-wide population abundance estimate.
[a]BI reported 1 helicopter survey estimate for all recovery regions combined (RR 2-4) in the Santa Rosa Mountains in 1994 and 1996.
[b]Due to the low proportion of radio-collared animals observed a "markless" population estimator was used.

Radio-Collared Mortalities (Range-wide)

Between 1 June 2020 and 31 May 2021 there were 19 radio-collared mortalities (Table 3). The number of mortalities listed in descending order by recovery region were VM = 7, CC = 5, CSRM = 2, SJM = 1, NSRM = 1, SSRM = 1, NSYM = 1, and SSYM = 1. Seven ewes were pregnant at the time of their death and 4 ewes were observed with a lamb at their side in the weeks prior to their deaths.

Based on the 28-year average, 12.9% of all active radio-collared PBS die each year with predation (hereafter includes possible lion, probable lion and lion predation combined) accounting for 7.7%, unknown causes 2.4%, nonpredation 1.8%, capture related 0.5%, and urban related 0.4% (Figure 1). Over the current reporting period, 13.9% of all active radio-

collared bighorn sheep died with predation accounting for 7.3%, unknown causes 0.7%, nonpredation 4.4%, capture related 0%, and urban related 1.5%.

Table 3. Cause of death for 19 active radio-collared bighorn sheep by recovery region within the Peninsular Ranges of Southern California from 1 June 2020 to 31 May 2021. Ewe identifications (Animal ID) numbers in bold were pregnant at time of death and animal IDs underlined were observed with a lamb in the weeks prior to their deaths. Pneumonia – presumptive means tissue samples were collected, and final lab results are pending.

Recovery Region	Ewe Group or Sub-ewe Group	Animal ID	Sex	Age (years)	Mortality Date	Mortality Cause
1 SJM	SJM	**523**	F	Adult	3/8/2021	Pneumonia - presumptive
2 NSRM	NSRM	**529**	F	Adult	12/28/2020	Lion Predation
3 CSRM	West	**352**	F	9	11/4/2020	Lion Predation
3 CSRM	Guadalupe	411	F	13	4/4/2021	Nonpredation - unknown
4 SSRM	Sheep Canyon	409	F	11	1/20/2021	Unknown
6 NSYM	NSYM	316	F	8	3/11/2021	Lion Predation
7 SSYM	SSYM	379	F	10	10/12/2020	Lion Predation
8 VM	Vallecito Mtns	327	F	9	9/5/2020	Nonpredation - dehydration
8 VM	Vallecito Mtns	460	F	12	9/6/2020	Nonpredation - dehydration
8 VM	Vallecito Mtns	320	F	13	9/21/2020	Nonpredation - dehydration
8 VM	Vallecito Mtns	328	F	18	11/23/2020	Lion Predation - probable
8 VM	Vallecito Mtns	**323**	F	15	1/20/2021	Lion Predation
8 VM	Sunset Mtn	377	F	11	12/6/2020	Lion Predation
8 VM	Fish Creek Mtns	326	F	13	4/11/2021	Nonpredation - unknown
9 CC	In-Ko-Pah	**452**	F	4	1/14/2021	Urban related - roadkill Interstate 8
9 CC	In-Ko-Pah	515	F	9	3/28/2021	Urban related - roadkill Interstate 8
9 CC	Tierra Blanca	**500**	F	4	3/9/2021	Lion Predation
9 CC	Carrizo Canyon	**508**	F	6	4/9/2021	Lion Predation
9 CC	Carrizo Canyon	511	F	10	5/21/2021	Lion Predation - possible
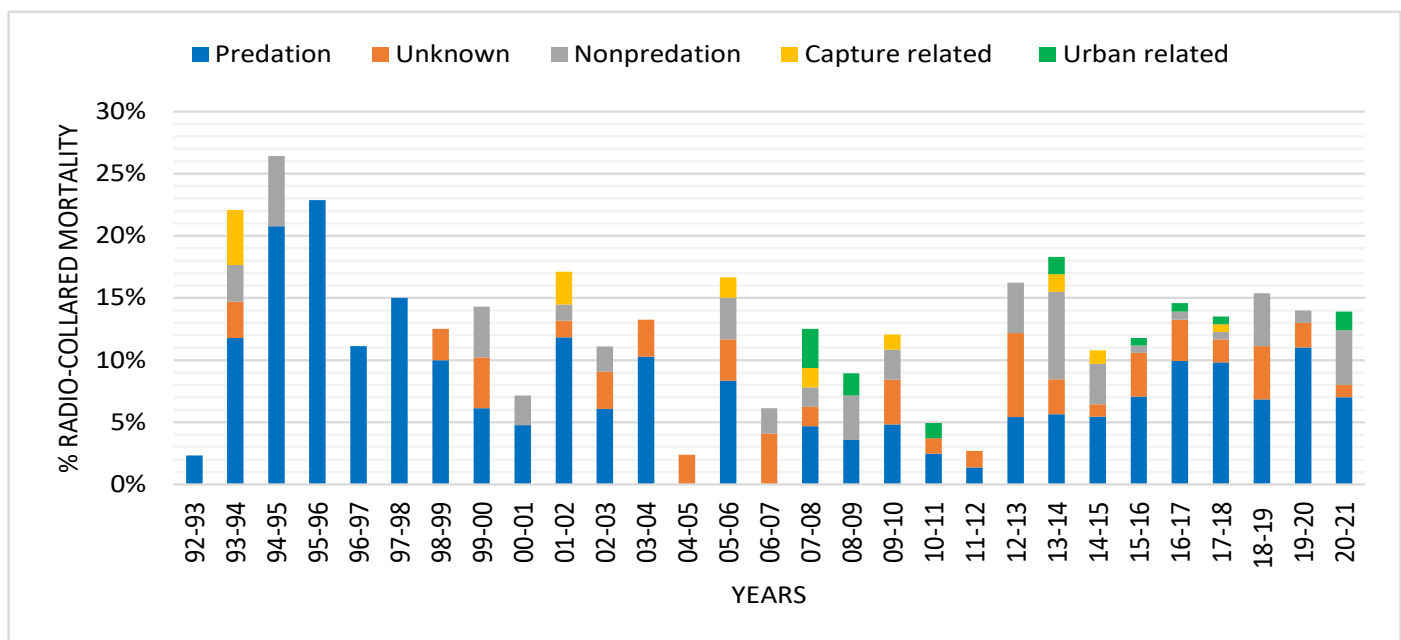
Figure 1. Percentage of radio-collared PBS mortality (number of radio-collar deaths ÷ number of radio-collared sheep) due to predation, unknown, nonpredation, capture related, and urban related causes for all radio-collared PBS over 29 reporting periods. A reporting period is 12 months starting on June 1 of one year and ending 31 May of the following year. First reporting period: 1 June 1992 to 31 May 1993 (92-93). Current reporting period 29: 1 June 2020 to 31 May 2021 (20-21).

According to the long-term data, predation risk is highest from December through March when most ewes are either pregnant or caring for a lamb (Figure 2). The current reporting period followed a similar trend with all 10 predation deaths occurring between October and May (Table 3) and 7 of 10 ewes either pregnant or caring for a lamb at the time of death. Poor health, injuries, or age-related disease such as chronic sinusitis or tooth infections may increase the risk of predation. Most ewes that died due to predation were ≥ 8 years old with an average age of 9.6 years (n =10, age range 4-18 years, median = 9, mode = 10). At the time of ewe 323's death she was 15 years old, pregnant, and had a severe tooth infection with bony changes to the right side of the mandible. CSRM ewe 352 was assumed to be in good health prior to being killed by a lion a few days post-capture; however, capture myopathy or possibly an internal injury sustained during capture may have made her more vulnerable to predation. Likewise, poor health may have been a contributing factor in the predation death of NSYM ewe 316 who suffered from multiple bouts of respiratory distress over the years based on direct observations. Interestingly, ewe 316 was attacked by a mountain lion before dawn on a cliff above County Road S22. Both lion and ewe tumbled over the cliff and onto the road where a county worker driving around a blind turn almost ran into them. The lion jumped off the ewe's back and ran away. The ewe stood bleeding on the side of the road before heading off the road as well. CDFW biologist J. Colby was contacted by the Highway Patrol and responded shortly after the attack. The lion did not return, and Colby witnessed the ewe's death the following afternoon. Based on the necropsy examination, the ewe died of blunt force trauma to the abdominal cavity sustained in the fall from the cliff during the lion attack.
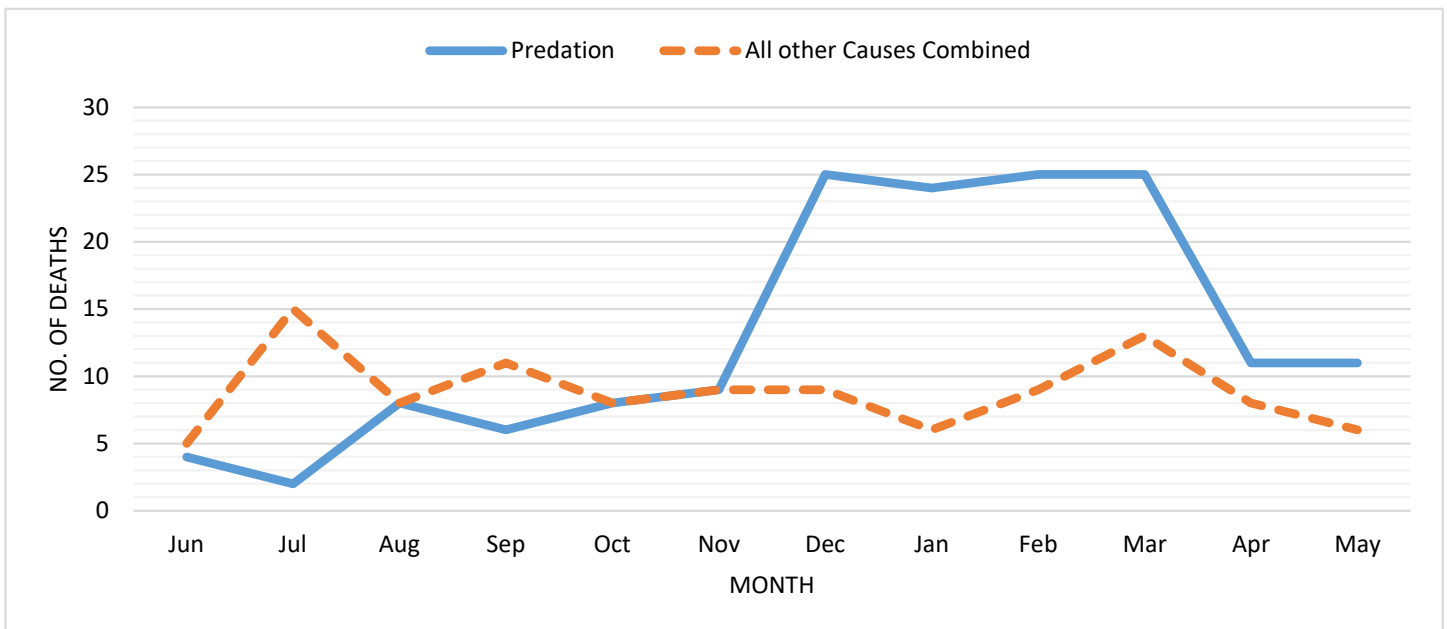

Figure 2. Average monthly percentage of mortalities due to predation (n = 158) and due to all other causes combined (n = 107) for all radio-collared bighorn sheep (n = 2056) over 28 years (1 June 1993 to 31 May 2020).

The percentage of nonpredation deaths for the current reporting period was 2.4 times higher than the 28-year average. The cause of this sharp increase is largely due to the deaths of 3 radio-collared ewes that were attributed to dehydration (Table 3). The Vallecito Mountains ewe group, in recovery region 8, has become dependent upon an artificial water source (Whale Peak Guzzler) that was installed 30 years ago by Anza-Borrego Desert State Park. The guzzler system failed to store rain water over the Fall 2019/Spring 2020 rainy season because a broken pipe leading from the rain collection mat to the storage tanks went unnoticed. As a result, the guzzler went dry by mid-summer which led to the deaths of at least 3 ewes and 1 lamb within this ewe group. Long-term drought conditions in the neighboring Fish Creek Mountains to the east of the Vallecito Mountains may have contributed to the death of ewe 326 as well. In the SJM, ewe 523 may have died of pneumonia based on the appearance of abnormal lung tissue and a thick nasal discharge at necropsy. Tissue samples collected at necropsy have been archived until funding is available for testing. In the CSRM, ewe 411s death did not meet the criteria for predation but an exact cause could not be determined. Most ewes that died due to nonpredation causes were ≥ 9 years old with an average age of 11 years (n = 6, age range 6-13 years, median = 12.5, mode = 13).

Delays in detecting and investigating a sheep's death prevents an accurate assessment of the cause of death due to extensive decomposition and/or scavenging of the carcass. The percentage of unknown deaths was much lower than the 28-year average due to quicker response times for mortality investigations over the current reporting period. Quick response times are mainly due to an increase in the number of satellite GPS collars fitted to bighorn sheep that can send text messages to biologists within 4 hours after a sheep's death. Furthermore, there are two field biologists rather than one to share the burden of mortality investigations which results in faster response times. Ewe 409 was not wearing a satellite collar and because the ewe died in a very remote location in the SSRM recovery region, the VHF signal was not detected on mortality mode until several months post-mortem resulting in an inability to assess if the cause of death was due to predation or nonpredation.

The percentage of urban related deaths for the current reporting period was 1% higher than the 28-year average due to an increase in vehicle traffic on roads used as movement corridors by PBS. Ewe 452 was 4 years old, healthy, and pregnant when she was struck and killed while crossing the east-bound lanes of Interstate 8. Ewe 515 was 9 years old, healthy, and was observed with a 1-month-old lamb just days prior to being killed while crossing the east-bound lanes of Interstate 8. Both ewes were struck and killed in a common crossing area used during the lamb-rearing season.

Non-collared Mortalities (Range-wide)

Documentation and mortality investigations of non-collared bighorn deaths and/or injuries occur when discovered by CDFW personnel during field monitoring or when reported by the public or government agencies. These mortalities are not representative of the overall PBS population because they are found by chance alone and often by the public near urban centers. For instance, lambs with active pneumonia infections have been documented in every recovery region; however, most pneumonia-related deaths in lambs are documented in urban areas because they are more visible and easily found in comparison to sick lambs in very remote areas.

For the current reporting period, there were 34 opportunistically found (33 non-collared and 1 nonfunctioning-collared) PBS deaths reported (Table 4). The urban environment was directly responsible for most of the reported deaths (38%) with 9 deaths due to vehicle collisions and 3 deaths due to drowning in the Coachella canal at PGA West in La Quinta. Interstate 8 and Highway 74 continue to be the deadliest roadways for PBS to cross within the Peninsular Ranges. On Interstate 8, 2 ewes and 2 rams were killed by vehicles while attempting to cross the Interstate. Including 2 radio-collared ewes killed by vehicles, a record number of 6 PBS were killed on Interstate 8 during the current reporting period. On Highway 74, between recovery regions 2 and 3, a female lamb and 2 rams were killed while attempting to cross the highway during the spring of 2021. Lastly, 2 rams were killed when attempting to cross County Road S22 within recovery region 6 during the spring of 2021.

The second highest cause of reported non-collared PBS deaths was attributed to predation (26%) with 5 deaths in recovery region 5, 2 deaths in recovery region 8, 1 death in recovery region 6, and 1 death in recovery region 1 (Table 4). In recovery region 5, 3 rams and 2 ewes were all killed by mountain lions near water sources between June and November 2020. Recovery Region 8 had the second highest predation rate with 2 lambs killed by a lion in April 2021 within the Lizard Wash ewe group. While mountain lion predation is common, documentation of coyote predation is rare. In July 2020, the skeletonized remains of a yearling ram was discovered in the yard of a Borrego Springs resident in July 2020. Based on bighorn sheep and coyote tracks found upon investigation, it appears the young ram had been chased by coyotes away from escape terrain located 4 km to the west into the desert flats, pinned down along the homeowner's fence line and killed and quickly consumed by coyotes.

Fifteen percent of reported non-collared PBS deaths was attributed to pneumonia. In recovery region 2, a lamb was found dead in November 2020 at the Bighorn Country Club golf course. A necropsy exam indicated the 8-week-old lamb had a severe case of pneumonia, diarrhea, and contagious ecthyma. Of note, this lamb was born in September rather than during the typical lamb-rearing season of January through May. In the NSRM, an increasing number of lambs are being born outside of lamb-rearing season. This alarming trend might be due to ewes losing their lambs to pneumonia early in the

lamb rearing season which allow them to start estrus and become pregnant again before the end of May resulting in a fall to winter birth.

Three PBS (lamb, ewe, and yearling ewe) were discovered dead in the same location in the Bear Creek area of the CSRM in March 2020. Predation was definitively ruled out, but the exact cause of death has not yet been determined (tissue samples have yet to be tested). A more likely cause is oleander poisoning. Oleander bushes are found within every nearby golf community in La Quinta, and if they were foraging on an oleander bush together, their deaths would coincide.

Table 4. Cause of death for 33 non-collared and 1 nonfunctioning-collared bighorn sheep found opportunistically by recovery region within the Peninsular Ranges of Southern California from 1 June 2020 to 31 May 2021. All mortalities were investigated by CDFW.

Recovery Region	General Location	Mortality Date	Age (Years)	Sex	Mortality Cause
1 SJM	Indian Canyon	12/15/2021	7	M	Unknown
1 SJM	Skyline Trail	3/19/2021	6	M	Lion Predation - possible
2 NSRM	Bighorn Country Club	11/8/2020	Lamb	F	Pneumonia
2 NSRM	S. of Cathedral City	12/5/2020	19	F	Unknown (nonfunctioning collar)
2 NSRM	Art Smith Trail	3/21/2021	lamb	F	Pneumonia
2 NSRM/3 CSRM	Highway 74	3/28/2021	5	M	Urban Related - roadkill
2 NSRM/3 CSRM	Highway 74	3/29/2021	4	M	Urban Related - roadkill
2 NSRM/3 CSRM	Highway 74	5/5/2021	Lamb	F	Urban Related - roadkill
3 CSRM	PGA West	6/3/2020	Lamb	M	Pneumonia
3 CSRM	Coachella Canal at PGA West	6/29/2020	5	M	Urban Related - drowned
3 CSRM	Bear Creek	3/5/2021	Yearling	F	Nonpredation - unknown
3 CSRM	Bear Creek	3/6/2021	9	F	Nonpredation - unknown
3 CSRM	Bear Creek	3/8/2021	Lamb	F	Nonpredation - starvation
3 CSRM	PGA West	8/4/2020	Lamb	F	Urban Related - drowned
3 CSRM	Coachella Canal	8/4/2020	5	M	Urban Related - drowned
4 SSRM	N. F. Palm Wash Tenaja	9/15/2020	15	F	Drowned - assumed
5 CoC	Cougar Canyon	6/18/2020	7	M	Lion Predation - possible
5 CoC	Lower Willows	7/7/2020	3	M	Lion Predation
5 CoC	Lower Willows	7/8/2020	4	F	Lion Predation
5 CoC	Lower Willows	7/9/2020	Yearling	F	Lion Predation
5 CoC	Cougar Canyon	11/10/2020	6	M	Lion Predation
6 NSYM	Borrego Springs	7/9/2020	Yearling	M	Coyote Predation - probable
6 NSYM	County Road S22	2/4/2021	9	M	Urban Related - roadkill
6 NSYM	County Road S22	4/10/2021	7	M	Urban Related - roadkill
8 VM	Sentenac Canyon	7/15/2020	Lamb	M	Pneumonia - presumed
8 VM	Whale Peak Guzzler	9/5/2020	Lamb	Unk	Nonpredation – assumed dehydration
8 VM	Sunset Mountain	10/5/2020	Lamb	M	Nonpredation – presumed pneumonia
8 VM	Lizard Wash	4/18/2021	Lamb	M	Lion Predation
8 VM	Lizard Wash	4/18/2021	Lamb	Unk	Lion Predation
9 CC	Jacumba Wilderness	7/28/2020	Lamb	M	Nonpredation – presumed dehydration
9 CC	Interstate 8 East bound	7/9/2020	7	M	Urban Related - roadkill
9 CC	Interstate 8 East bound	11/25/2020	10	F	Urban Related - roadkill
9 CC	Interstate 8 East bound	1/15/2021	3	M	Urban Related - roadkill
9 CC	Interstate 8 East bound	3/17/2021	3	F	Urban Related - roadkill

This is the first reporting period that death attributed to dehydration has been documented for both non-collared (2 lambs) and collared PBS (3 ewes). Climate change, lack of commitment to maintain artificial water sources by land managers, and a combination of human disturbance and habitat fragmentation have all resulted in PBS dying due to lack of water. Most notable was the death of a male lamb in the Jacumba Wilderness of recovery region 9. In July 2020, a male lamb became separated from its mother (dam) while they were attempting to cross from the US into Mexico through a border fence construction zone (Photo 2 and Title page photo). Ewes give birth to their lambs in the eastern portion of the Jacumba Wilderness and during the summer months they move into Mexico where there are more reliable water sources. Without the guidance from its dam or other bighorn, this lamb did not know where to obtain water and quickly became extremely dehydrated and lethargic. CDFW biologist J. Colby was called to the scene and was able to get the lamb to drink a few liters of water which quickly revived the lamb (Photo 3). A temporary water station was set up near the construction zone for the lamb to utilize. After 3 days, the lamb recuperated and wandered off. Unfortunately, the lamb was found dead, likely due to dehydration, a few weeks later near a construction road 9 km to the northwest.

Photo 2. Male lamb searching for water in the wet sand of a construction zone on the southwest side of Skull Valley next to the Mexico border. The lamb had become separated from its dam while attempting to cross through the construction site in order to reach summer water sources in Mexico.

Photo 3. CDFW biologist gives thirsty lamb water at the border construction site.

EWE SURVIVAL

Radio-collared animals can be used to estimate survival rate within a population. Population viability is most sensitive to changes in ewe survival (Ruben et al. 2002); therefore, it is crucial to have consistent representative samples of radio-collared ewes in every recovery region to accurately track trends in survivorship. Without a consistent representative sample (e.g., the percent of collared ewes in the population is too small), it is not possible to discern which factors are influencing survival trends among regions and the radio-collared ewes can no longer be used as a reliable indicator of survival.

For the current reporting period, average survival of radio-collared ewes was 92.3% ± 14% in the SJM, 95.0% ± 10% in the NSRM, and 89.4% ± 13% in the CSRM (annual Kaplan-Meir survival rates reported as mean percent survival ± 95% Confidence Interval). Unfortunately, the percentage of radio-collared ewes was too low in Recovery Regions 4 – 9 to accurately estimate ewe survival.

LAMB SURVIVAL AND RECRUITMENT

Respiratory disease has been a persistent problem in PBS across all recovery regions of the Peninsular Ranges. The

bacterium *Mycoplasma ovipneumoniae* (*M.ovi*) has been identified as the primary pathogen associated with pneumonia in wild sheep populations throughout the western United States (Besser et al. 2008, and Besser et al. 2012). From 1999 to 2015, approximately 51% of PBS range-wide tested positive for the presence of *M.ovi* (Washington Animal Disease Diagnostic Laboratory, unpublished data). Pneumonia can have devastating effects on wild sheep populations, including additive mortality in lambs leading to poor lamb survival and recruitment for many years after a disease outbreak. Lamb survival to weaning is one of the strongest demographic indicators of bighorn sheep population health and recruitment is a good predictor of population trend (Cassirer et al. 2017). Persistently low recruitment below 30% may pose a significant obstacle in population recovery (Cassirer et al. 2013).

CDFW utilizes lamb:ewe ratios as an index of lamb survival (survival to ~ 3 to 5 months) and yearling:ewe ratios as an index of recruitment (survival to 1 year). Because pregnancy rates for radio-collared ewes are consistently high among all years, 94% average from 2008-2021, lamb:ewe and yearling:ewe ratios serve as good proxies for lamb survival and recruitment. Lamb:ewe ratios and yearling:ewe ratios are based on group observations obtained during field monitoring of radio-collared ewes. Lamb survival and recruitment can drastically vary by season, year, ewe group and proximity to neighboring ewe groups; therefore, it is vital for these data to be collected consistently over time so trends can be detected.

Lamb survival and recruitment data have been collected by CDFW since 2008 in the CoC, NSYM and SSYM recovery regions and was expanded to the In-Ko-Pah and Tierra Blanca ewe groups of Carrizo Canyon Recovery Region 9 in 2010 and 2014 respectively (Table 5). These efforts expanded to the SJM, NSRM, and CSRM as personnel and funding resources became available in subsequent years (Table 6). In the CSRM Recovery Region, lamb recruitment and survival indices are divided into 2 groups (Wild and Urban) based on different habitat use patterns. The Urban CSRM sub-ewe group forages almost exclusively year-round within the golf communities in the City of La Quinta whereas the Wild CSRM sub-ewe groups forage only on native vegetation outside of the urban environment.

Lamb survival and recruitment indices continue to be highly variable among ewe groups and years (Tables 5 & 6). The factors influencing disease severity among ewe groups and years is not well understood but are likely a result of differences is in the number of infected and pathogen shedding ewes, the virulence and timing of pathogen introduction, and the exposure (contact) rates (Cassirer et al. 2013, and Plowright et al. 2013). Once disease is introduced into a population, infection is often maintained by asymptomatic carriers (Plowright et al. 2016, Cassirer et al. 2017). In the NSYM where lamb recruitment and survival data collection has been most consistent, recruitment has been well below 30% in 10 out of the last 13 years. Interestingly, the only year where synchrony among ewe groups existed was in 2016 when lamb survival and recruitment was high in all 7 ewe groups that observation data were obtained. For all years that both survival and recruitment data were available for ewe groups (n = 62), recruitment was >30% only 22 times. In general, when lamb survival was ≥65%, lamb recruitment was good (≥30%) and when lamb survival was below 65% lamb recruitment was poor (<30%). In all ewe groups that lamb survival has been below 65%, lambs with symptoms of pneumonia have been observed. Similarly, another study found that pneumonia-related mortality was identified whenever lamb survival was <50% (Cassirer et al. 2017). In the CoC, NSYM, and SSYM, where long-term data exists, the general trend is of chronically low lamb recruitment and survival interspersed by a few years of good recruitment. In the Tierra Blanca ewe group of Recovery Region 9, recruitment has been good in 3 out of 7 years but the general trend is of decreasing lamb survival and recruitment. In the In-Ko-Pah ewe groups of recovery region 9, the long-term trend is more encouraging with recruitment above 30% in 6 out of 10 years. Not enough years of observation data have been consistently collected by CDFW in the SJM, NSRM, and CSRM to identify long-term trends in survival and recruitment; however, lambs with symptoms of pneumonia are observed each year in all 3 recovery regions and lamb mortality due to pneumonia has been documented in both the NSRM and CSRM.

Recruitment of 2020 lambs to yearlings was well below 30% in the Tierra Blanca ewe group (10%), SJM (11%), NSRM (16%), NSYM (17%), and the Wild sub-ewe groups in the CSRM (22%) (Tables 5 & 6). In contrast, lamb recruitment was above 30% in the Urban sub-ewe group in the CSRM and the In-Ko-Pah ewe group (52%). Lamb recruitment in 2021 is predicted to be poor since lamb survival indices in 2021 were all well below 65%. Unfortunately, 2020 recruitment and 2021 survival indices for Coyote Canyon and the SSYM could not be obtained due to the low number of radio-collared ewes in these Recovery Regions during the reporting period.

Table 5. Index of lamb survival to approximately 3 to 5 months old (Survival) and recruitment of lambs to yearlings (Recruited) in Coyote Canyon (CoC), North San Ysidro Mountains (NSYM), South San Ysidro Mountains (SSYM), and the In-Ko-Pah (IKP) and Tierra Blanca (TB) ewe groups within Carrizo Canyon (CC) recovery region. Lamb survival was calculated from lamb:ewe ratios from group observations obtained in the field from May-June of the year lambs were born and paired with yearling:ewe ratios (recruited) from January - June of the following year. For example, in 2020 in NSYM, 24% of lambs survived to 4 months old (Survival), and only 17% were recruited to yearlings. Bold Blue numbers highlight recruitment ≥ 30%, Bold green numbers highlight survival ≥ 65%, Asterisk = data were not collected, a = Lamb:ewe ratio obtained from Anza-Borrego Desert State Park annual sheep count for CoC, b = due to low number of radio-collared ewes, not enough observation data were collected for an index, c = reassessed based on subsequent data.

Year	CoC Survival	CoC Recruited	NSYM Survival	NSYM Recruited	SSYM Survival	SSYM Recruited	IKP-CC Survival	IKP-CC Recruited	TB-CC Survival	TB-CC 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%	c20%	18%	93%	b	51%	26%	*	32%
2014	25%	22%	38%	34%	b	27%	10%	8%	17%	15%
2015	35%	27%	19%	11%	47%	23%	86%	35%	70%	41%
2016	73%	52%	66%	43%	94%	42%	75%	33%	67%	32%
2017	a41%	24%	77%	34%	83%	32%	b	26%	35%	33%
2018	31%	18%	33%	22%	22%	11%	41%	13%	28%	21%
2019	a43%	28%	20%	19%	5%	1%	c67%	40%	57%	28%
2020	29%	b	24%	17%	20%	b	67%	52%	11%	10%
2021	b		42%		b		35%		40%	

Table 6. Index of lamb survival to approximately 3 to 5 months old (Survival) and recruitment of lambs to yearlings (Recruited) in the Urban and Wild sub-ewe groups of the CSRM (Central Santa Rosa Mountains), the Northern Santa Rosa Mountains (NSRM), and the San Jacinto Mountains (SJM). Lamb survival was calculated from lamb:ewe ratios from group observations obtained in the field from May-June of the year lambs were born and paired with yearling:ewe ratios (recruited) from January - June of the following year. For example, in 2020 in Urban sub-ewe group of CSRM, 47% of lambs survived to 4 months old (Survival), and 33% were recruited to yearlings. Bold Blue numbers highlight recruitment ≥ 30%, Bold green numbers highlight survival ≥ 65%, Asterisk = data were not collected, a = Lamb:ewe ratio changed due to previous reporting typo error, b = observation sample size too small to calculate survival/recruitment indices.
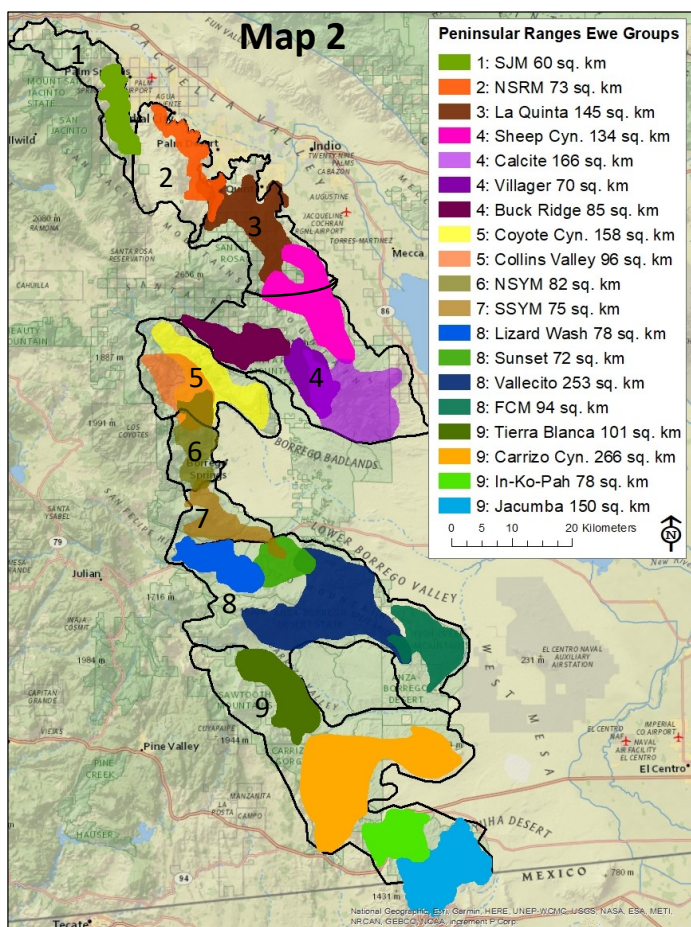
Year	Urban CSRM Survival	Urban CSRM Recruited	Wild CSRM Survival	Wild CSRM Recruited	NSRM Survival	NSRM Recruited	SJM Survival	SJM Recruited
2014	*	*	*	38%	*	*	*	*
2015	53%	11%	66%	36%	*	*	*	*
2016	86%	67%	65%	a33%	*	*	*	*
2017	77%	19%	61%	b	*	*	*	*
2018	83%	*	38%	28%	*	4%	*	14%
2019	*	b	29%	b	b	24%	4%	7%
2020	47%	33%	b	22%	17%	16%	13%	11%
2021	43%		30%		53%		30%	

Environmental factors as well as ewe behavior may also contribute to asynchronous rates of pneumonia-induced mortality in lambs. In the Peninsular Ranges, pneumonia-induced mortality in lambs typically peaks when lambs are between 1 and 3 months of age at a time when ewes and lambs are concentrated within nursery groups (Colby & Botta 2012). The density of ewes and lambs as well as the duration within nursery grounds is dependent on the quality and quantity of forage (J. Colby, CDFW unpublished data). During drought years, when forage conditions are poor, there is a low density of ewes and lambs for a short duration within nursery grounds which may decrease both the probability of the correct timing of pathogen introduction and the exposure rates to lambs. Reciprocally, during wet years, when forage conditions are good, there is a high density of ewes and lambs for a longer duration within nursery grounds which may increase both the

probability of the correct timing of pathogen introduction and exposure rates to lambs. Consistent, high quality forage conditions, such as those provided by golf courses, allow large numbers of ewes and lambs to concentrate within a very small area for prolonged periods of time and thus may facilitate the spread of disease to a larger percentage of the lambs within the nursery group. However, sick lambs that are able to have regular access to water and quality forage, and thus maintain their body weight, are more likely to survive a bout of pneumonia.

In the NSYM, the 2021 lamb rearing season marked the first year that ewes brought their young lambs down to forage at the de Anza community and golf course within Borrego Springs. Throughout the lamb rearing season, up to 18 ewes and their lambs foraged each day at the golf course and surrounding community. Introduction of lambs to the urban environment marks a turning point in ewe behavior and habitat use after which the use of the urban environment increases significantly. Prior to 2021, lamb survival and recruitment indices for the two sub-ewe groups in the NSYM have been pooled since both groups spend a portion of the lamb-rearing season within the same area. In 2021, lamb survival for the sub-ewe group that foraged at de Anza was 50% whereas lamb survival for the sub-ewe group that did not use de Anza was 17%: pooled lamb survival was 42%.

Map 2

Peninsular Ranges Ewe Groups
- 1: SJM 60 sq. km
- 2: NSRM 73 sq. km
- 3: La Quinta 145 sq. km
- 4: Sheep Cyn. 134 sq. km
- 4: Calcite 166 sq. km
- 4: Villager 70 sq. km
- 4: Buck Ridge 85 sq. km
- 5: Coyote Cyn. 158 sq. km
- 5: Collins Valley 96 sq. km
- 6: NSYM 82 sq. km
- 7: SSYM 75 sq. km
- 8: Lizard Wash 78 sq. km
- 8: Sunset 72 sq. km
- 8: Vallecito 253 sq. km
- 8: FCM 94 sq. km
- 9: Tierra Blanca 101 sq. km
- 9: Carrizo Cyn. 266 sq. km
- 9: In-Ko-Pah 78 sq. km
- 9: Jacumba 150 sq. km
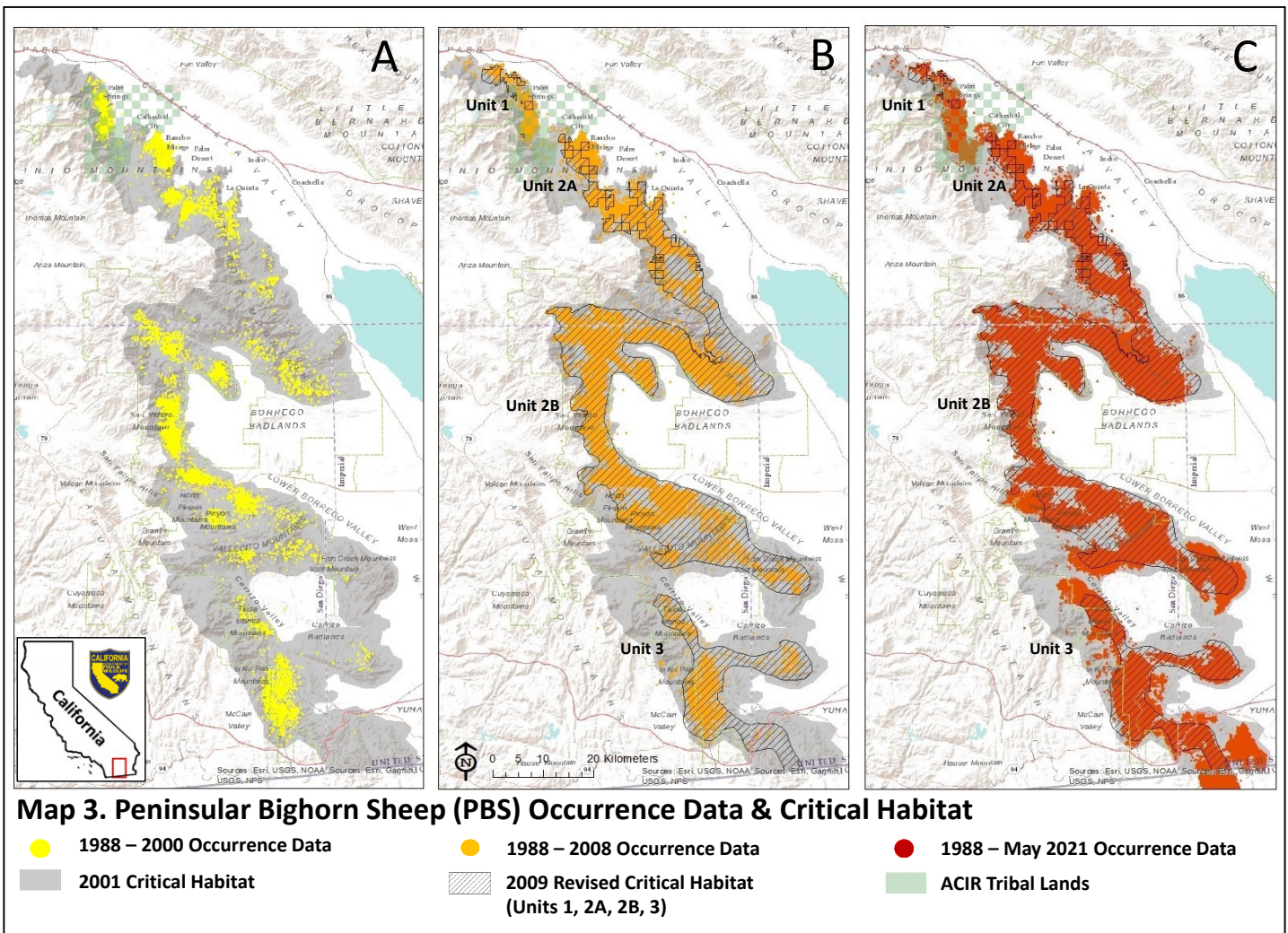
0 5 10   20 Kilometers

DISTRIBUTION AND MOVEMENT

Since 2009, CDFW has deployed GPS collars on bighorn sheep range-wide to build a foundation of knowledge on the distribution, movement, and ewe group structure within the Peninsular Ranges. For this purpose, the GPS location data for each collared individual is analyzed and organized into 3 seasons: summer (1 June – August 31), pre-lambing (1 September – 31 December), and lamb-rearing (1 January – 30 May). Ewes with similar seasonal movement patterns, particularly during the lamb-rearing season, are grouped together to form an ewe group home range map that captures the most commonly shared areas. Ewes that display distinct movement patterns within these ewe groups are further classified into sub-ewe groups. Presently, there are 19 ewe groups identified in the Peninsular Ranges (Map 2). Additionally, several sub-ewe groups have been identified within almost every ewe group. While the majority of ewes are philopatric (faithful to natal home range), GPS data reveals that movement between ewe groups, particularly during the lamb-rearing season, are much more common than previously identified (Rubin et al. 1998). Furthermore, a recent genetic study found that natal dispersal occurred within both sexes and that gene flow throughout the range is common (Buchalski et al. 2015).

The 9 recovery regions encompass habitat that is considered essential for the recovery of PBS (USFWS 2000). The members of the recovery team, as well as other biologists with expert knowledge of PBS, selected essential habitat based on the physical and biological features that were known to be important to PBS. The recovery team understood that the data available at the time of listing was based on a low population with a limited number of radio-collared animals that did not represent the habitat use and movement of the entire herd. Furthermore, if the population were to reach recovery levels, a larger area that included connectivity between occupied patches would be needed. One of the most important purposes of mapping essential habitat was to "identify those lands in need of protection, restoration, and management that are essential to bighorn sheep recovery" (USFWS 2000 p. 153). Therefore, essential habitat encompassed all areas, occupied and unoccupied, that possessed the features essential for a self-sustaining population of PBS with a high probability for long-term survival (USFWS 2000).

While essential habitat described in the Recovery Plan serves as a guide for site-specific management actions needed to bring about the species' recovery, critical habitat designation is a regulatory action that identifies specific areas that are essential for the species' conservation. On February 1, 2001, USFWS published the final rule for critical habitat designation (66 FR 8650) that encompassed approximately 3,420 km^2 of contiguous PBS habitat that largely represented the same footprint of essential habitat delineated in the Recovery Plan (Map 3A). Then on May 14, 2009, the Service revised the final rule (74 FR 17288) and eliminated approximately 55% of critical habitat to encompass 4 noncontiguous units totaling approximately 1,500 km^2 (Map 3B). Justification for the change was based on revised methodology that used more specific habitat information and additional occurrence data that determined the areas removed did not contain the physical or biological features essential to the conservation of PBS. Corridors between the 4 revised critical habitat units were not included because the best available data at that time provided no specific information as to what areas were used for movement corridors between units. Additionally, USFWS removed critical habitat designation within areas of unit 1 and 2A (Recovery Regions 1 & 2) because the area falls within the sovereign jurisdiction of the Agua Caliente Band of Cahuilla Indians (Tribe) and the land is already conserved under the Tribal Habitat Conservation Plan. While the majority of PBS habitat lies within other federal and state protected lands, this should not be cause for elimination from critical habitat status.

Map 3. Peninsular Bighorn Sheep (PBS) Occurrence Data & Critical Habitat

- 🟡 **1988 – 2000 Occurrence Data**
- 🟠 **1988 – 2008 Occurrence Data**
- 🔴 **1988 – May 2021 Occurrence Data**
- ⬜ **2001 Critical Habitat**
- ▨ **2009 Revised Critical Habitat (Units 1, 2A, 2B, 3)**
- 🟩 **ACIR Tribal Lands**

Occurrence data obtained since 2009, clearly demonstrate that PBS have shifted their habitat use to both higher and lower elevations outside of the 2009 revised critical habitat but largely still within the 2001 critical habitat, most notably in Recovery Regions 4, 8 and 9 (Map 3C). Furthermore, there are now location data that shows specific movement corridors between all units. The 2009 revised critical habitat designation did not take into consideration how climate change may influence the distribution and movement of PBS. A recent study that examined 34 years of satellite data within the Peninsular Ranges demonstrated that decreases in precipitation and increases in temperature are responsible for a

significant decline in vegetation within the lower elevations of the study area (Hanston et al., 2021). Significant losses of vegetation translates to significant losses of forage which will require PBS to adjust their habitat use. Likewise, CDFW has documented that numerous natural water sources are no longer reliable particularly within Recovery Regions 4 and 8. In light of known structural changes to vegetation mainly at lower elevations but also at the higher elevations (Hanston et al. 2021) concurrent with changes in habitat use by PBS since listing, the USFWS should re-analyze and adjust the critical habitat designation to ensure that corridors and habitat currently occupied and unoccupied will be protected in a changing climate. Research comparing climate and vegetation data with PBS occurrence data over the past 20 years is needed to develop a predictive model that can be used to guide management decisions for recovery efforts.

The following sections briefly describe ewe group home ranges for each recovery region based on cumulative data collected from GPS-collared ewes since 2009 to present. Ewe group home ranges described in this report only represent radio-collared ewes and do not represent all PBS habitat use, particularly that of rams, within each recovery region. Furthermore, GPS data has not been well represented spatially and temporally in some of the most remote recovery regions due to logistical constraints. Therefore, home ranges represented in this report should be viewed as the "minimum" footprint of habitat use. Consistent funding is needed so that a representative sample of both ewes and rams are fitted on a regular basis with GPS collars to provide a more complete picture of habitat use in a changing environment.
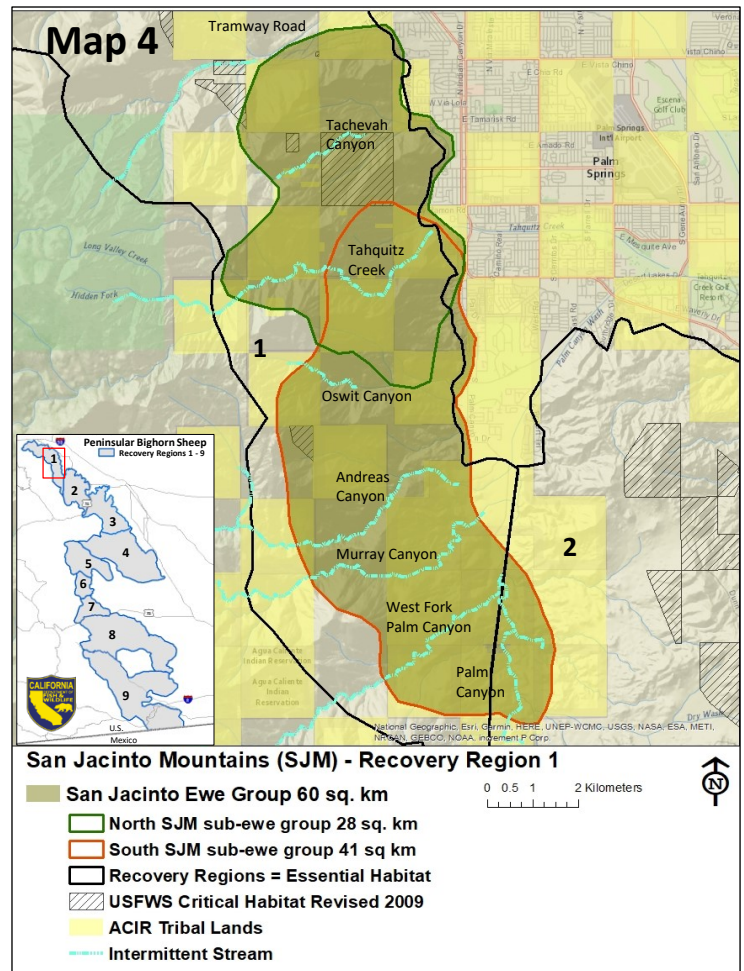
San Jacinto Mountains Ewe Group – Recovery Region 1

Currently, the SJM ewe group home range is approximately 60 km^2 and consists of 2 sub-ewe groups that share some lamb-rearing areas but in general use different water sources during the summer months at the north and south ends of the recovery region (Map 4).

North SJM sub-ewe group

The north SJM sub-ewe group home range encompasses approximately 28 km^2 and extends from the south side of Tramway Road to Oswit Canyon. One radio-collared ewe (ewe 522) in this sub-ewe group crossed Tramway Road in April 2021 and spent about 2 weeks on the north side of Leatherneck Ridge before returning to the north sub-ewe group (Map 5). This movement had not yet been documented via GPS collar data, although PBS utilized that area historically.

South SJM sub-ewe group

The south SJM sub-ewe group home range is approximately 41 km^2 and extends from the north side of Tahquitz Canyon down to Palm Canyon. Two of the radio-collared ewes in the south sub-ewe group ventured beyond the ewe group's core home range and intermingled with the north sub-ewe group just south of the Tramway Road. One of these ewes (ewe 520) also moved east into the NSRM and intermixed with the NSRM ewe group (Map 5). Two additional ewes (ewe 526 and 432) similarly crossed Palm Canyon and ventured into the NSRM before returning to the SJM. This is the first time that ewes have been documented moving between the SJM and NSRM. This is significant because the 2009 USFWS revised

critical habitat designation for PBS did not maintain this connecting habitat due to the lack of evidence of movement corridors between the NSRM and SJM.

Northern Santa Rosa Mountains Ewe Group – Recovery Region 2

Currently, the NSRM ewe group home range is approximately 73 km² and consists of 2 sub-ewe groups (Map 6) that generally use different lamb-rearing areas and different water sources during the summer months at the north and south ends of the recovery region.

North NSRM sub-ewe group

The north NSRM sub-ewe group home range is approximately 44 km² and extends from the mountains west of Cathedral City to Cahuilla Hills with core areas on the slopes surrounding Bradley and Magnesia Canyons. The radio-collared ewes in this group never ventured far from these core areas.
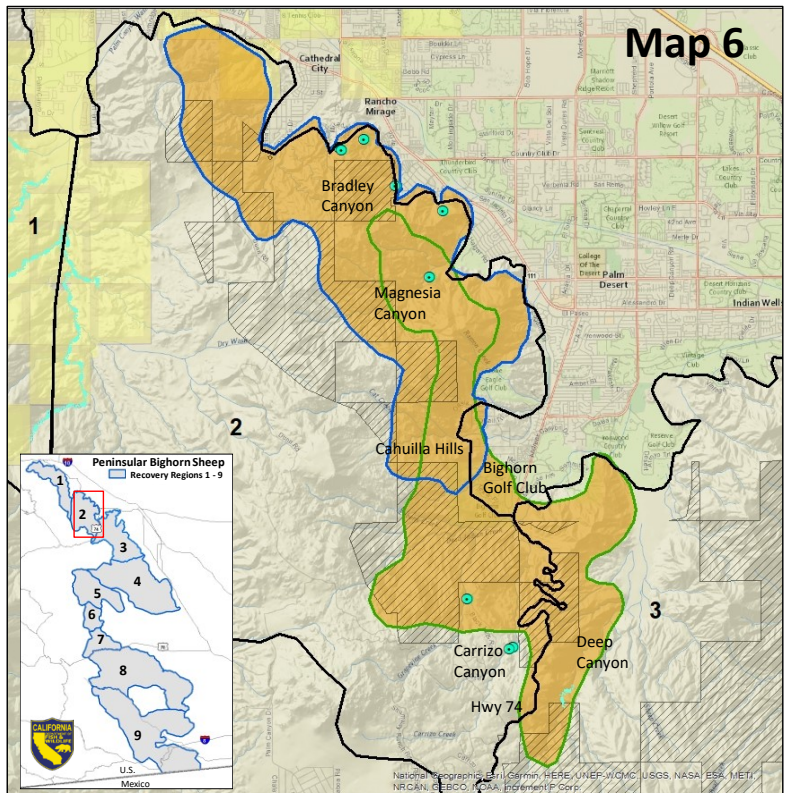
South NSRM sub-ewe group

The south sub-ewe group home range is approximately 40 km² and extends from Bradley Canyon to Deep Canyon with core areas surrounding Dead Indian and Carrizo Canyons (Map 6). This south sub-ewe group (3 of the 4 radio-collared ewes) crossed Highway 74 to Deep Canyon (CSRM) more frequently and stayed for greater periods of time in 2020 and 2021 than previous years (Map 7). With each passing year, the south sub-ewe group also increases their use of the Bighorn Golf Club course in Palm Desert, particularly during the summer and fall months.

Central Santa Rosa Mountains Ewe Group – Recovery Region 3

The La Quinta ewe group, in the CSRM, is about 145 km² and consists of 3 sub-ewe groups— Guadalupe, West and Urban (Map 8).
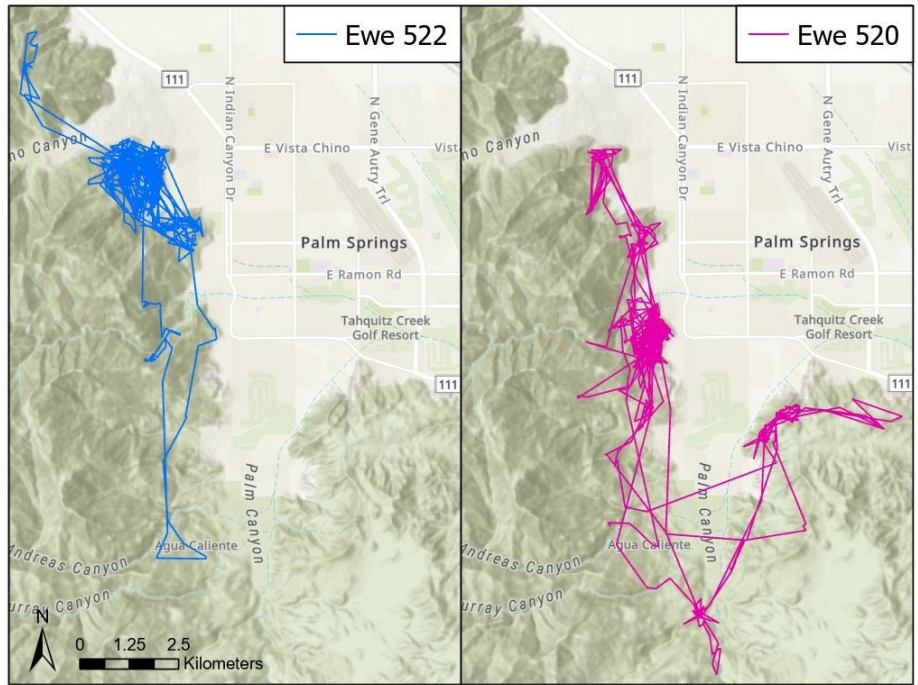

Map 5. GPS collar data are linked sequentially through time to demonstrate ewe 522 (north sub-ewe group) and ewe 520's (south sub-ewe group) approximate movements for the 2020-2021 reporting period. The connecting lines between GPS collar locations do not demonstrate the path traveled.


Northern Santa Rosa Mountains (NSRM) - Recovery Region 2

- ▦ **N. Santa Rosa Mountains Ewe Group 73 sq. km**
- ▭ North NSRM sub-ewe group 44 sq. km
- ▭ South NSRM sub-ewe group 40 sq. km
- ▭ Recovery Regions = Essential Habitat
- ▨ USFWS Critical Habitat Revised 2009
- ▯ ACIR Tribal Lands
- ◉ Artificial Water Sources
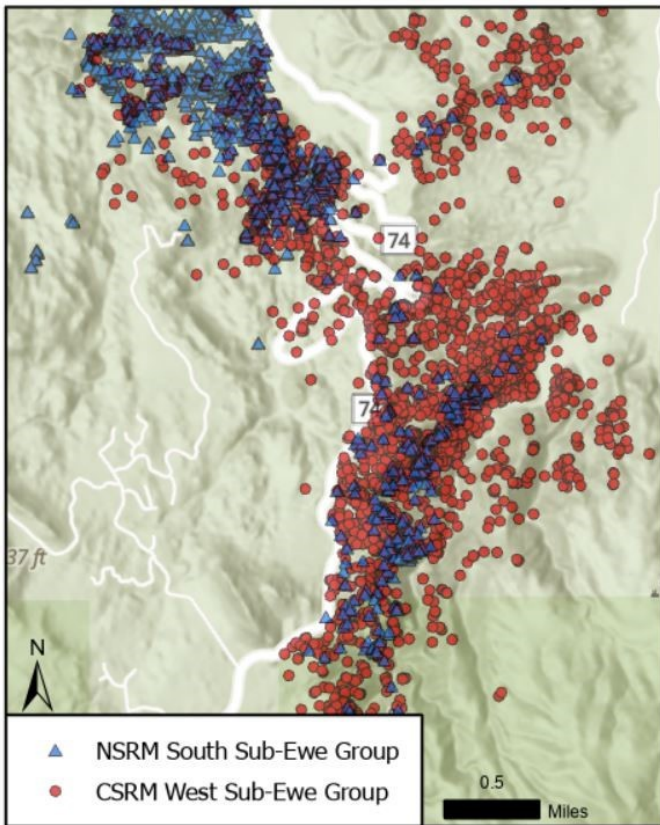
Map 7. GPS location data from radio-collared ewes in the NSRM and CSRM that regularly crossed Highway 74 (thick, white line) and utilized the adjacent recovery region during the 2020-2021 reporting
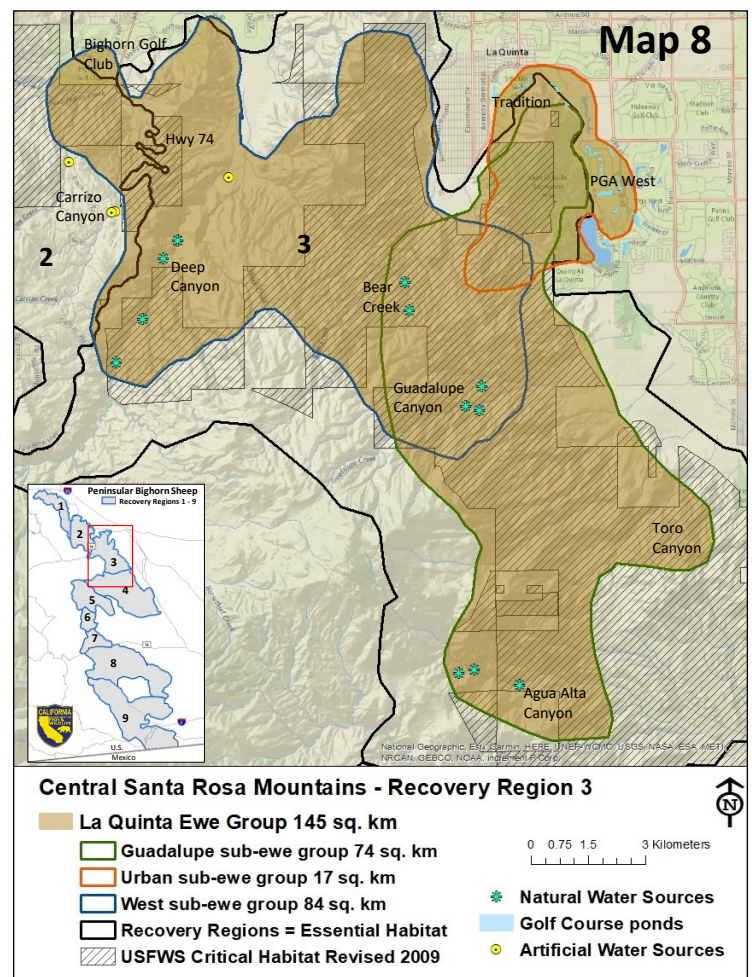
Guadalupe sub-ewe group

The Guadalupe sub-ewe group home range is approximately 74 km^2 and extends from the slopes just south of Tradition Golf Club to Agua Alta Canyon with the core area surrounding Guadalupe Canyon. GPS location data indicate that this sub-ewe group does not use the urban landscape for forage or water and is referred to as a "wild" sub-ewe group (Map 8).

West sub-ewe group

The West sub-ewe group home range is approximately 84 km^2 and extends from the west side of Highway 74 to Guadalupe Canyon with the core area surrounding Deep Canyon. Previously, radio-collared ewes in this sub-ewe group did not cross Highway 74 or utilize the urban landscape for resources. However, this year four newly collared ewes from the West sub-ewe group regularly moved back and forth across Highway 74 between Deep Canyon and Carrizo Canyon (Map 8). One of these radio-collared ewes also began to spend time at Bighorn Golf Club.

Urban sub-ewe group

The Urban sub-ewe group home range is approximately 17 km^2 and extends from the slopes above Tradition and SilverRock Golf Courses to The Quarry at La Quinta with core areas at PGA West Golf Course and community (Map 8). This sub-ewe group increased their use of Lake Cahuilla Regional Veterans Park during this reporting period. A radio-collared ewe was also documented spending time on Coral Mountain, although CDFW has received multiple reports from the public observing PBS on Coral Mountain in the past.

Southern Santa Rosa Mountains Ewe Groups – Recovery Region 4

The SSRM is the 3rd largest recovery region that contains 4 ewe groups—Sheep Canyon, Calcite, Villager, and Buck Ridge (Map 9). The recovery region is one of the least studied areas due to limited access points to reach PBS habitat. The terrain occupied by these ewe groups is diverse with the southeastern portion consisting of low elevation xeric badlands and the northwestern portion consisting of high elevation pinyon pines and junipers.

Sheep Canyon Ewe Group

The Sheep Canyon ewe group home range is approximately 134 km^2 and extends 22 km from Toro Canyon to Barton Canyon (Map 9). The northern third of this ewe group's home range extends across the dividing line between recovery regions 3 & 4; however, most of the home range lies within recovery region 4 with concentrated use between Martinez Canyon and Barton Canyon. This ewe group uses much lower elevation habitat compared to the other ewe groups in this recovery region with an average elevation use of 498 m (1633 ft).

During the summer months, water is obtained from springs within Sheep Canyon and occasionally in the upper reaches of Martinez Canyon. Lamb-rearing season is concentrated on the northeast and southeast sides of Martinez Canyon.

Our current understanding of this ewe group is based on just 5 GPS-collared ewes with collectively 5.2 years of GPS data from November 2015 through January 2021. Unfortunately, the last GPS collared ewe died in January 2021 and there are currently no plans to capture and radio-collar more ewes in this remote area.

Calcite Ewe Group

The Calcite ewe group home range is approximately 166 km^2 and resides within the southeastern most area of recovery region 4 (Map 9). Average elevation used by this ewe group is 638 m (2093 ft).

This ewe group does not demonstrate a high level of philopatry for nursery grounds, likely due to the scarcity of reliable high-quality vegetation. The most common areas that ewes gather during the lamb rearing season are on the eastern slopes between Wonderstone Wash and Palm Wash and the upper portion of Palo Verde Wash. This ewe group primarily utilizes the North Fork Palm Wash Tenaja, Wonderstone Seep, Rattlesnake Spring and Natural Rock Tanks as water sources. However, these natural water sources are no longer reliable due to prolonged drought conditions. As a result, the Calcite ewe group has steadily increased their use of higher elevation habitat each summer from an average of 445 m in 2017 to 739 m in 2020. In the pre-lambing season, ewes typically move to low elevation habitat and push beyond the southern and eastern boundary of 2009 revised critical habitat.
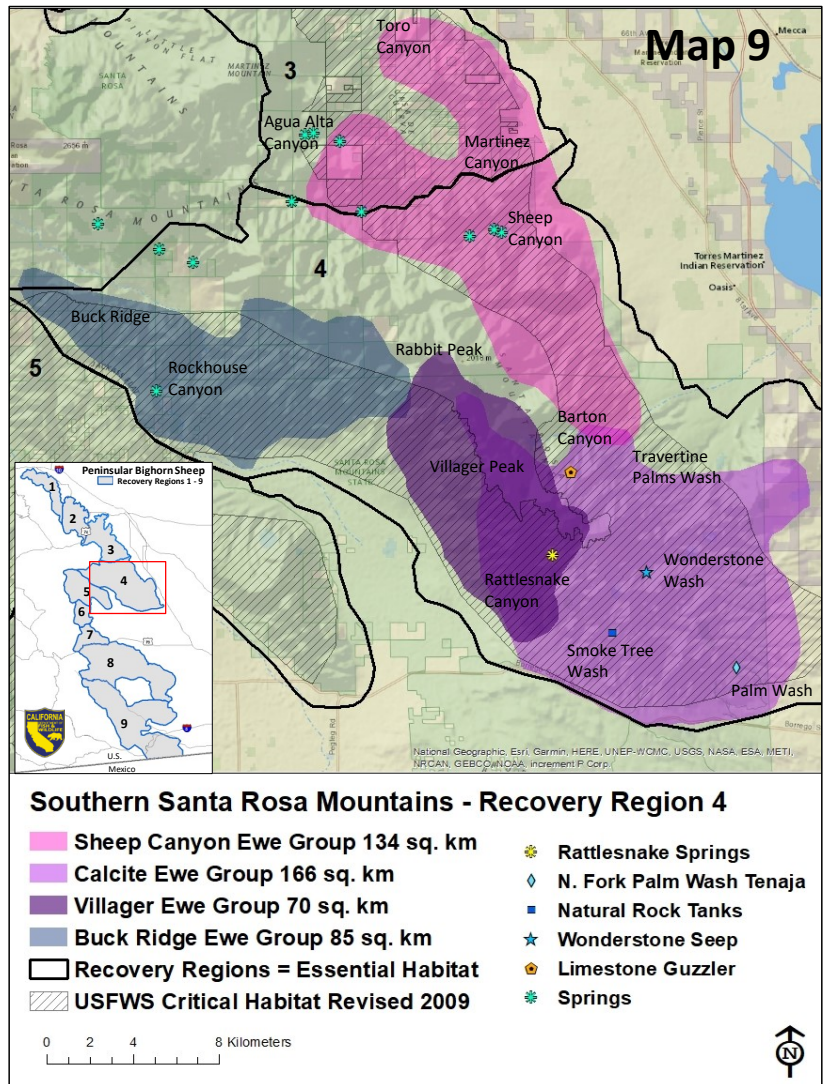
Villager Ewe Group

The Villager ewe group home range is approximately 70 km² and straddles a ridgeline for 14 km from Rabbit Peak (2018 m) to the desert floor at the mouth of Rattlesnake Canyon (Map 9). The home range for this ewe group is at higher elevation than any other ewe group in the Peninsular ranges with an average elevation of 1025 m (3363 ft).

Lamb rearing habitat is on the southwest-facing slopes of Rattlesnake Ridge overlooking Clark Dry Lake. The slopes are extremely steep and rugged and are dotted with Pinyon Pines and Junipers at the upper elevations. This habitat is in stark contrast to the lower elevation and xeric habitat used during the lamb rearing season by the Calcite ewe group.
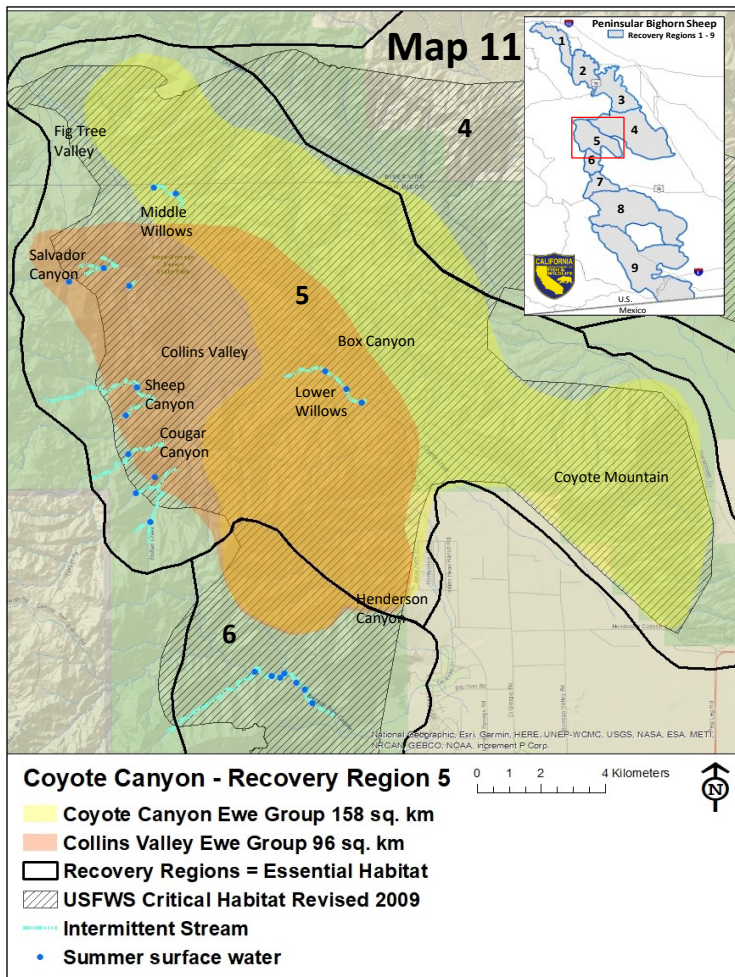
The Villager and Calcite ewe groups' home ranges overlap on the eastern side of Rattlesnake Canyon during the summer months when both ewe groups use Rattlesnake Springs. However, as Rattle Springs has become increasingly unreliable, the Villager ewe group has moved to higher elevation habitat on the northwest-facing slopes of Villager Peak.

The 2009 revised critical habitat designation removed much of the high elevation habitat, particularly above 1400 m (4600 ft), as it was thought to not contain the physical or biological features essential to the conservation of PBS. However, GPS data collected since 2009 indicates that high elevation habitat, especially during the summer months, is crucial to the survival of the Villager ewe group as well as the other ewe groups within recovery region 4 (Map 10).
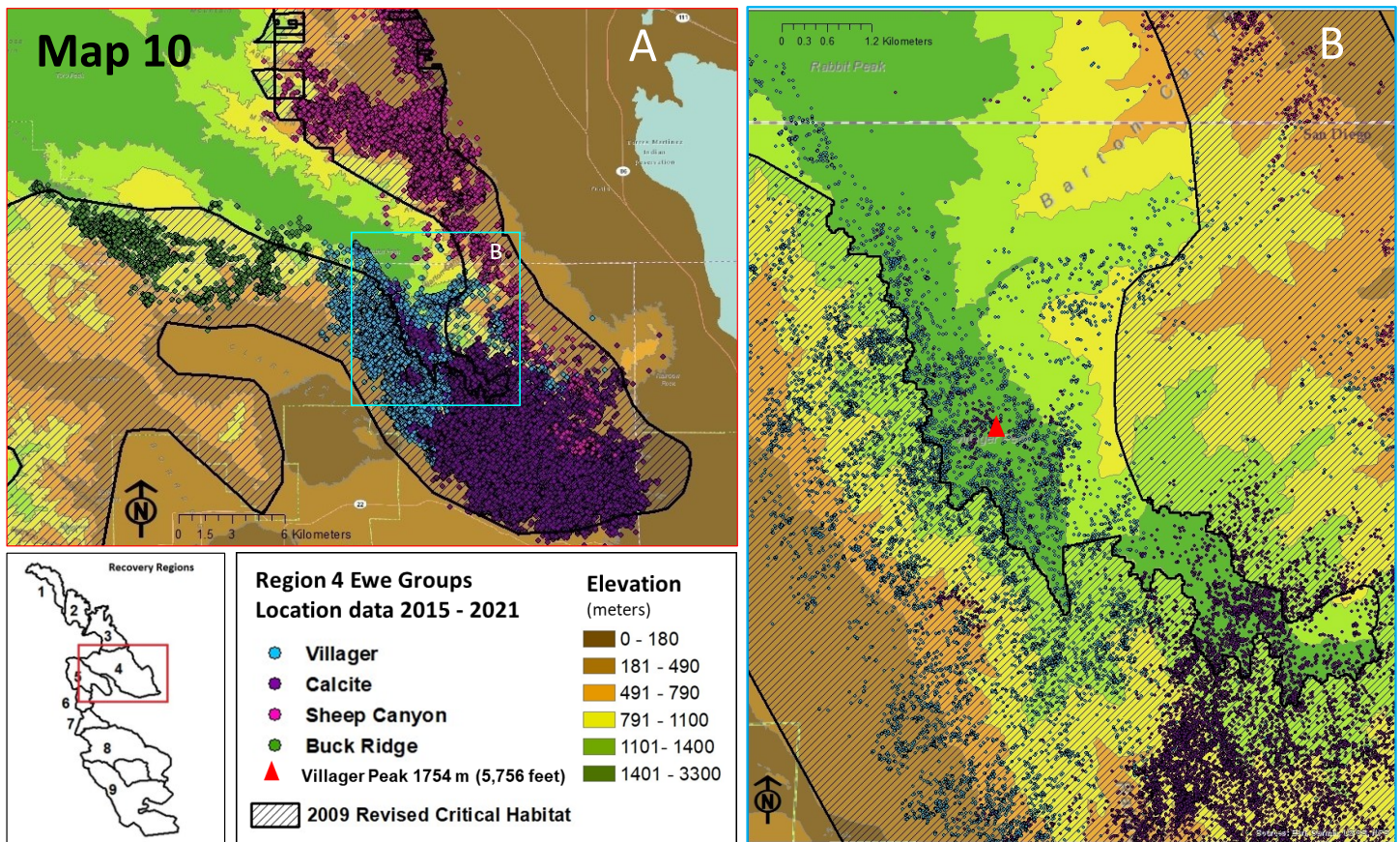
Buck Ridge Ewe Group

The Buck Ridge ewe group home range is approximately 85 km² and extends 19 km from Buck Ridge to the west-facing slopes below Rabbit Peak (Map 9). There is limited GPS data to inform us on detailed movements within this ewe group. The average elevation used by this ewe group is the second highest in the Peninsular Ranges at 965 m (3165 ft). For the current reporting period, there were no GPS-collared ewes and only 1 VHF-collared ewe in this area.

Coyote Canyon - Recovery Region 5

- ▨ **Coyote Canyon Ewe Group 158 sq. km**
- ▨ **Collins Valley Ewe Group 96 sq. km**
- ▢ **Recovery Regions = Essential Habitat**
- ▨ **USFWS Critical Habitat Revised 2009**
- ┅ **Intermittent Stream**
- • **Summer surface water**

Coyote Canyon Ewe Groups – Recovery Region 5

Coyote Canyon is the 5th largest recovery region with an area of 250 km^2 and contains the Coyote Canyon and Collins Valley ewe groups (Map 11). The region is defined by numerous perennial streams and extensive riparian habitat. Virtually the entire recovery region is within Anza-Borrego Desert State Park with no paved roads and limited unpaved roads.

Our historical understanding of ewe group structure is based on GPS data collected on 15 ewes between 2009 and 2016. These data had defined 2 ewe groups with a fair amount of ewe group sub-structuring most likely due to the multitude of water sources in numerous canyons throughout the region. The two ewe groups are distinguished by the two separate areas used during the lamb-rearing season. Current information on ewe group structure and seasonal habitat use is inadequate due to the lack of GPS-collared ewes over the past several years and with only 1 VHF-collared ewe for the current reporting period.

Coyote Canyon Ewe Group

The Coyote Canyon ewe group home range is approximately 158 km^2 and extends 25 km from Fig Tree Valley to Coyote Mountain (Map 11). This ewe group is defined by high philopatry to the lambing and nursery grounds located on Coyote Mountain. Water during the summer months is obtained from three locations along Coyote Creek (Middle Willows, Lower Willows, and Second Crossing). A subset of ewes remain on the northeast side of Coyote Creek year-round whereas another sub-set of ewes will cross to the southwest side of the creek between Lower Willows and Henderson Canyon typically during the summer and pre-lambing seasons.

Collins Valley Ewe Group

The Collins Valley ewe group home range is approximately 96 km^2 and extends 13 km from Salvador Canyon to Henderson Canyon (Map 11). The Collins Valley ewe group does not utilize Coyote Peak during the lamb-rearing season but instead uses the mountains to the North of Henderson Canyon. During the summer months, ewes mainly use water sources to the west of Collins Valley located in Salvador, Sheep, and Cougar Canyons but may also use Lower and Middle Willows at times.

Northern San Ysidro Mountains Ewe Group – Recovery Region 6

The NSYM is the smallest recovery region with an area of 86 km^2 and is defined by 2 major canyons, each with a perennial creek, and numerous palm oases. Most of the recovery region lies within the bounds of Anza-Borrego Desert State Park with the eastern edge adjacent to the small town of Borrego Springs. County Road S22 cuts across the southeastern-most edge of the recovery region. The NSYM ewe group home range is approximately 82 km^2 and contains two sub-ewe groups that are distinguished by the canyons they prefer to use during the summer months (Map 12).

Map 12

Vern Whitaker Horse Camp

5

Henderson Canyon

Borrego-Palm Canyon

6

Borrego Springs

Hellhole Canyon

S22

Dry Canyon

Culp Canyon

Peninsular Bighorn Sheep
Recovery Regions 1 - 9

Northern San Ysidro Mountains - Recovery Region 6

Northern San Ysidro Ewe Group 82 sq. km
Palm Canyon sub-ewe group 82 sq. km
Hellhole sub-ewe group 29 sq. km
USFWS Critical Habitat Revised 2009
Recovery Region Boundaries = Essential Habitat
Pupfish Pond - Artificial water source
DeAnza artificial ponds
Summer Natural Water Sources
Intermittent Streams

0   0.75   1.5   3 Kilometers

Palm Canyon sub-ewe group

The Palm Canyon sub-ewe group home range is approximately 82 km² and extends 16 km from the mountains to the west of Vern Whitaker Horse Camp, within recovery region 5, to Culp Canyon located in recovery region 7. The majority of radio-collared ewes spend all 3 seasons within the area surrounding Borrego-Palm Canyon (BPC). However, a subset of these ewes will utilize the north side of Henderson Canyon and Coyote Peak, within recovery region 5, during the first few months of the lamb-rearing season.

Since 2016, the Palm Canyon sub-ewe group has increased low elevation habitat use while decreasing high elevation habitat use (Map 13). The cause of this change is not known but may be a response to prolonged drought conditions and increased habituation to people in conjunction with easy access to water and high-quality forage at de Anza Country Club golf community and to an artificial water source in low-elevation habitat in BPC. In the past, there were numerous areas where bighorn sheep could obtain surface water in the upper portion of BPC during the summer months; however, each summer these sources are less reliable (Map 12). The areas that still have pockets of water during the summer months are choked with dense riparian vegetation due to the lack of

2016-17

2020-21

Map 13. Southern San Ysidro Mountains Ewe Group - Elevation habitat use comparison

Elevation

0 – 300 meters (Low elevation – Flat)
301 – 600 meters (Medium elevation – Lower half of slopes)
>600 meters (High elevation – Mid to upper slopes)

Ewe 310 Location data (10 locations per 24 hours)
Perimeter of de Anza Country Club Golf Community
Perimeter of Borrego-Palm Canyon Campground

flash flood scouring since the early 2000s. Bighorn sheep avoid entering dense riparian areas as they pose a high risk of predation.

The Palm Canyon sub-ewe group began shifting habitat use during the winter and fall months from areas surrounding the creek within BPC to foraging at the de Anza Country Club community starting in 2009. While the amount of time spent within the golf community has increased incrementally each year, ewes typically return to BPC to give birth and raise their lambs for the first 6 months away from the urban environment. In 2021 a fundamental shift occurred when most ewes in the Palm Canyon sub-ewe group brought their 2-week-old lambs onto the golf course and stayed through the entire lamb-rearing season. Lambs that are raised within the urban environment have no natural fear of humans and thus the use of the urban environment will likely increase significantly in the coming years.

Hellhole sub-ewe group

The Hellhole sub-ewe group home range is approximately 29 km² and extends 9 km from the north side of BPC to Culp Canyon in recovery region 7. The core lamb-rearing habitat resides on the slopes above and below County Road S22 while the summer is typically spent within Hellhole Canyon. These ewes occasionally utilize BPC as well but to date none have utilized the de Anza community.

Southern San Ysidro Mountains Ewe Group – Recovery Region 7

The SSYM is the second smallest recovery region with an area of 117 km² that resides within Anza-Borrego Desert State Park. The north and south boundaries of this recovery region are defined by County Road S22 and Highway 74 respectively while County Road S3 bisects the eastern third of the recovery region from north to south. Natural water sources are found at the northwestern (Tubb Canyon area) and southwestern (Sentenac Canyon) sections of the recovery region with 1 artificial water source (Pinyon Ridge Guzzler) located in the central section.

The SSYM ewe group encompasses approximately 75 km² and consists of 2 sub-ewe groups that share the same lamb-rearing area but use different areas during the summer months (Map 14). There is currently no collared PBS within this ewe group; however, below is a review of home range use based on GPS-data collected from 2009 through 2017.

Tubb Canyon sub-ewe group

The Tubb Canyon sub-ewe group home range is approximately 60 km² and extends 17 km from Dry Canyon in recovery region 6 to Quartz Vein Wash in recovery

region 8. Summer months are spent in the area surrounding Tubb Canyon that has several natural water sources and one guzzler. The core lamb-rearing area is on the south-facing slopes above County Road S3.
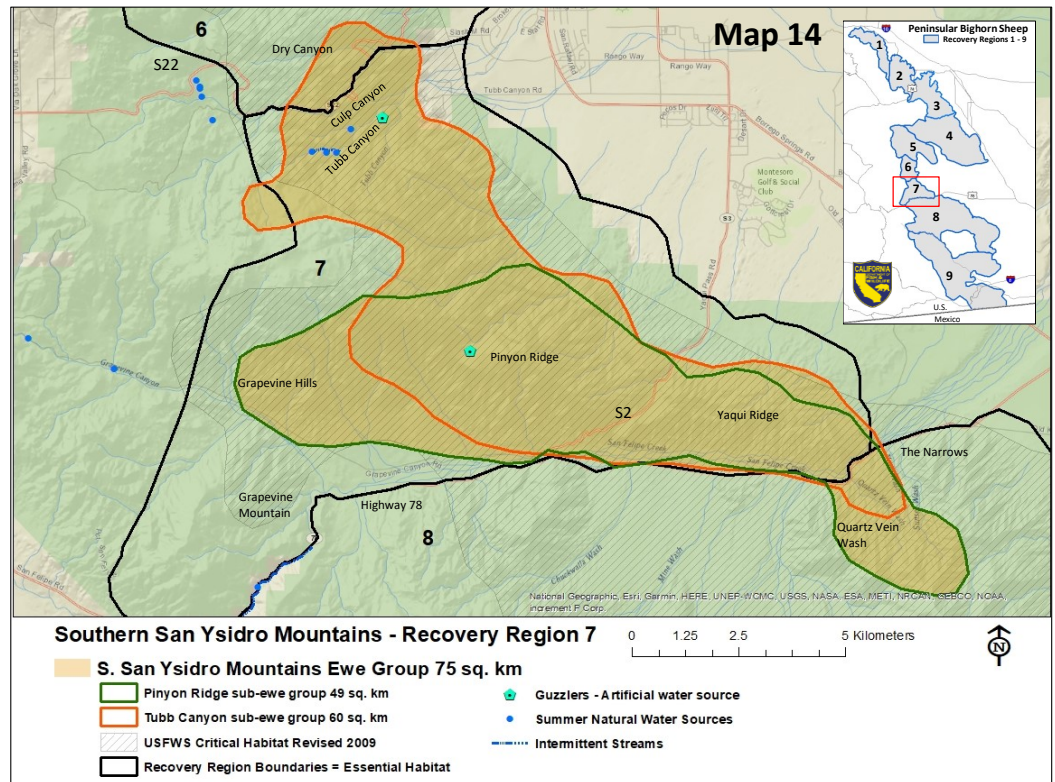
Pinyon Ridge sub-ewe group

The Pinyon Ridge sub-ewe group home range encompasses approximately 49 km^2 and extends 15 km from the Grapevine Hills to Quartz Vein Wash in recovery region 8. The Pinyon Ridge sub-ewe group spends summer months on the south-facing slopes of Pinyon Ridge. There is one guzzler in this area, but remote camera photos show that sheep seldom use it. Grapevine Mountain within the SSYM recovery region is not included in the home range map for the Pinyon Ridge sub-ewe group due to lack of current GPS data for this area; however, two VHF-collared ewes have been observed using Grapevine Mountain during the fall months.

Vallecito Mountains Ewe Groups – Recovery Region 8

The Vallecito Mountains is the second largest recovery region with an area of 708 km^2. Most of the recovery region resides within Anza-Borrego Desert State Park with the except of the Fish Creek Mountains that is administered by the Bureau of Land Management (BLM). There are 4 ewe groups in the Vallecito Mountains—Lizard Wash, Sunset, Vallecito, and Fish Creek Mountains (Map 15).
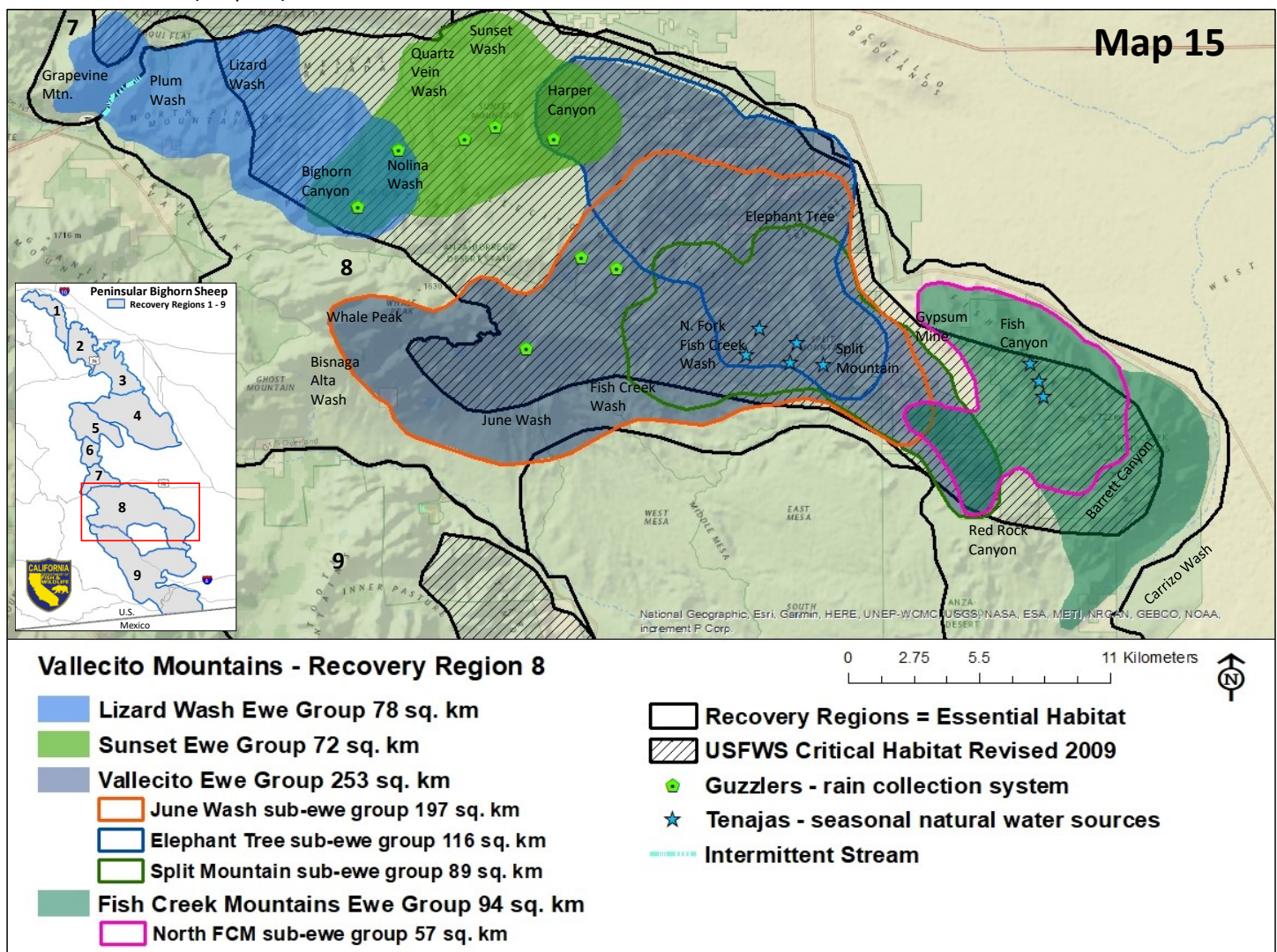
Lizard Wash Ewe Group

The Lizard Wash ewe group home range is approximately 78 km^2 and extends 16 km from Grapevine Mountain to Nolina Wash (Map 15). Nolina Wash defines the eastern boundary for this ewe group; however, a few radio-collared ewes occasionally move to Sunset Mountain for several days each year. The average elevation used by this ewe group is the third highest in the Peninsular Ranges at 768 m (2518 ft).

GPS data collected from 2014 through May 2021 indicates that Bighorn Canyon and Lizard Wash are used as the primary lamb-rearing habitat. The year-round core area for this ewe group is between Lizard and Plum Washes. While this area was designated by USFWS as critical habitat in 2001, it was removed in the 2009 revised critical habitat as it was determined that the area did not contain the physical or biological features essential to the conservation of PBS. However, current data clearly shows that the original 2001 critical habitat designation was a better predictor of PBS habitat (Map 16).
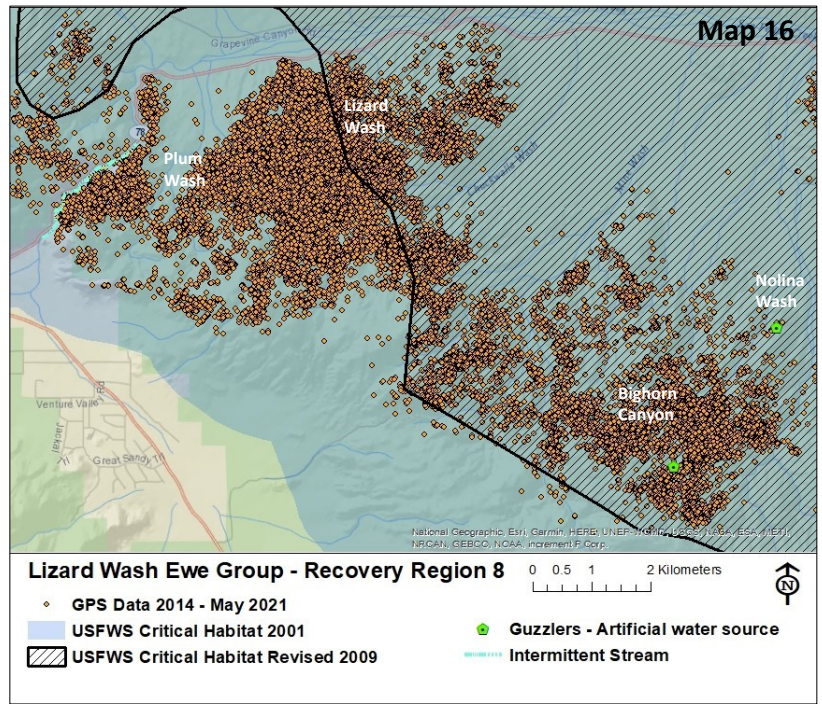
The 2009 revised critical habitat removed the corridor between recovery regions 8 & 9 with the justification that the best available data at that time provided no specific information as to what areas were used as movement corridors between the two recovery regions. In 2018, CDFW acquired GPS location data that provided a specific movement pathway between recovery regions 8 and 9 (Map 17). Ewe 371 was originally captured in Lizard Wash in October 2015 and fitted with a VHF-radio collar. However, in August of 2017 the ewe was observed at Agua Caliente County Park (ACCP) in the Tierra Blanca Mountains of recovery region 9. This was the first documented movement by a radio-collared ewe between recovery regions 8 and 9. To understand the connectivity between the two recovery regions, Ewe 371 was recaptured in Lizard Wash in November 2017 and fitted with a satellite collar. According to satellite data, ewe 371 stayed in the Lizard Wash area until June 2018 when she moved down to the Tierra Blanca Mountains. The route south started from Nolina Wash, skirted around the west side of Whale Peak, down through Bisnaga Alta Wash, across County Road S2 and ended at ACCP. On the return trip in mid-July, ewe 371 went back up Bisnaga Alta Wash but contoured across the lower western slopes of Whale Peak and ended at Mine Wash. In 2018, the guzzlers that supply water for this ewe group during the summer months were dry, and it is possible that ewe 371 moved to ACCP where springs were abundant. Also, 3 PBS were struck and killed by vehicles crossing County Road S2 in 2018 between ACCP and Whale Peak. This emphasizes the importance of corridors that may only be used occasionally but are still critical in times of drought.
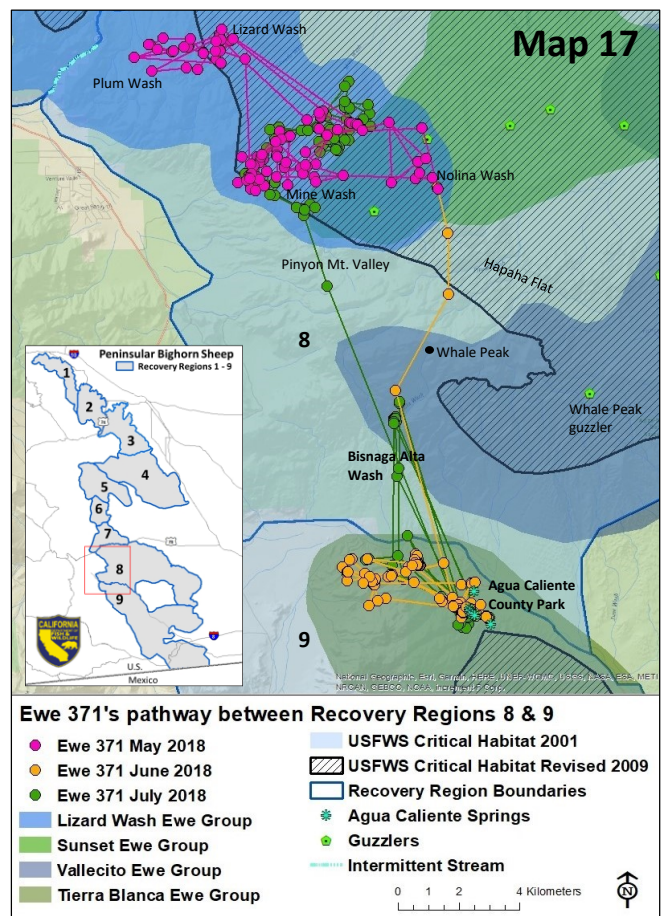
Sunset Ewe Group

The Sunset ewe group home range is approximately 72 km^2 and extends 13 km from Nolina Wash to the east side of Harper Canyon (Map 15). It is bound by Highway 78 in the north and extends 7 km to Harper Flats at the southern boundary. The core area is Sunset Mountain with only occasional forays to the west of Pinyon Wash or to the east of Harper Canyon.

The most common lamb-rearing area is the south and east-facing slopes of Sunset overlooking Harper Canyon and Harper Flats. Summers are spent on the slopes surrounding Sunset and Pinyon Wash Guzzlers on the west side of the mountain. During the pre-lambing season, the lower elevations in Quartz Vein Wash and Sunset Wash are used heavily.

Movement across Highway 78 into recovery region 7 has not been captured with GPS data or from observations of VHF-collared ewes with the caveat that there have been limited data for this ewe group. Conversely, collared ewes from the SSYM ewe group have been documented crossing Highway 78 and spending time within the Quartz Vein area.
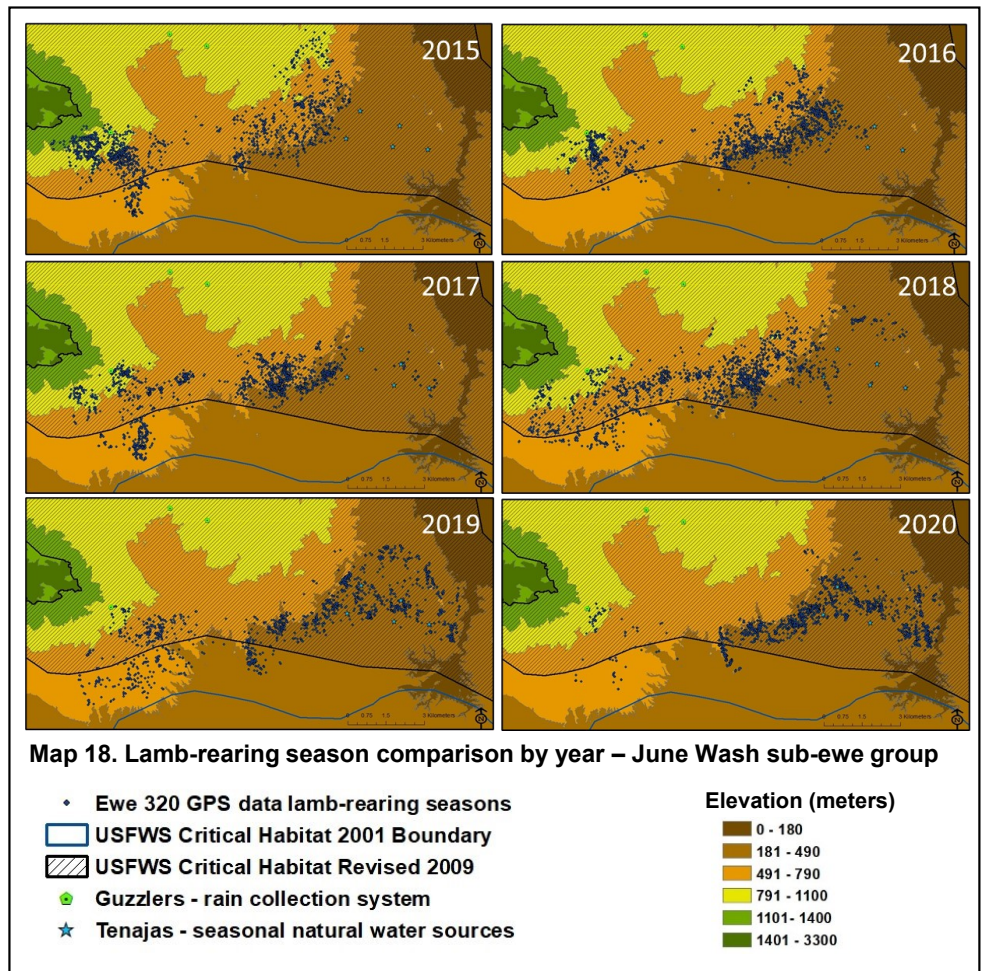
Vallecito Ewe Group

The Vallecito ewe group home range encompasses approximately 253 km² and extends 26 km, from west to east, from Whale Peak to Red Rock Canyon. The northern boundary extends 14 km in width from Harper Canyon to Fish Creek Wash drainage to the south. The Vallecito ewe group consists of 3 sub-ewe groups—Elephant Tree, June Wash, and Split Mountain (Map 15).

The Elephant Tree sub-ewe group home range is approximately 116 km² and extends from Harper Canyon in the northwest to Split Mountain in the southeast. The year-round core area is the mountains to the northwest of Elephant Tree. Ewes shift up and down in elevation rather than moving to different areas throughout the seasons. The average elevation during the lamb-rearing season is 532 meters. For the first few months of the lamb-rearing season, ewes are within low elevation habitat foraging on catclaw acacia found in drainages and barrel cactus in the alluvial fan of Elephant tree. As the lambing season progresses, ewes move to higher elevations. Summer months are spent at the highest elevations (average 765 m) in areas that do not have any permanent water sources. In the pre-lambing season, ewes return to low elevation habitat with an average elevation of 488 meters.

The June Wash sub-ewe group home range is approximately 197 km² and stretches 25 km from Whale Peak in the west to Red Rock Canyon in the east.

There are two core lamb-rearing areas—one surrounding June Wash and the other between the North Fork of Fish Creek Wash and the west side of Split Mountain. Between 2015 and 2020, the average elevation used by 5 GPS-collared ewes during the lamb-rearing season decreased each year (Map 18). During extended drought conditions, ewes depend on plants such as catclaw acacia that grow in the numerous low-elevation washes. Low-elevation washes surrounding June Wash and Sandstone Canyon were removed in the 2009 revised critical habitat (Map 19).

Map 18. Lamb-rearing season comparison by year – June Wash sub-ewe group

- • Ewe 320 GPS data lamb-rearing seasons
- ▢ USFWS Critical Habitat 2001 Boundary
- ▨ USFWS Critical Habitat Revised 2009
- ⬠ Guzzlers - rain collection system
- ★ Tenajas - seasonal natural water sources

Elevation (meters)
- 0 - 180
- 181 - 490
- 491 - 790
- 791 - 1100
- 1101 - 1400
- 1401 - 3300

During the summer months, PBS concentrate around the guzzler near Whale Peak but occasionally move to the east in the Fish Creek drainage where tenajas hold water for short periods of time following summer rainstorms. During the pre-lambing season when high quality forage is sparse, ewes spread out into most of the low elevation habitat.

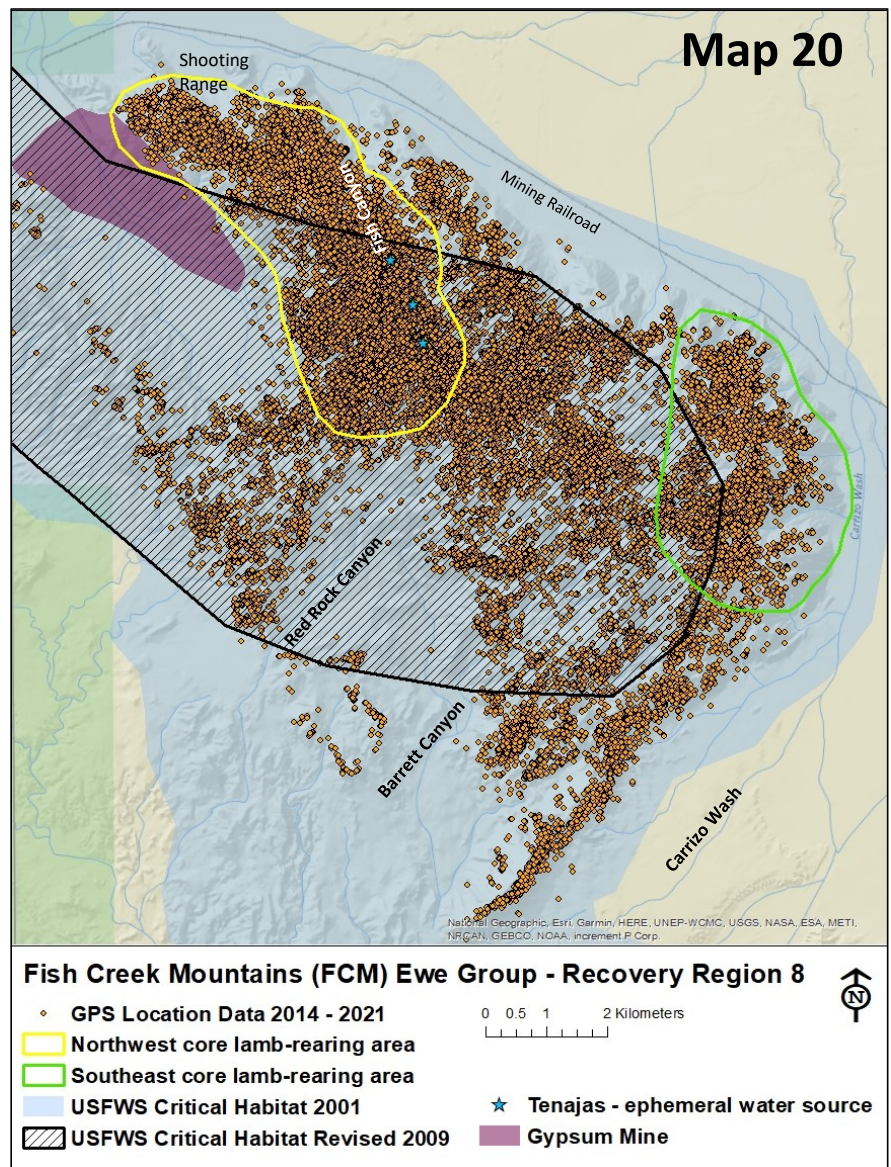The Split Mountain sub-ewe group is approximately 89 km² and extends from North-Fork Fish Creek Wash to Red Rock Canyon. This sub-ewe group's seasonal use is very similar to the June Wash sub-ewe group with the exception that these ewes do not cross to the west of the Fish Creek Wash.

Map 19

Vallecito Ewe Group - Recovery Region 8
- GPS data for 5 Ewes 2014 - 2020
- USFWS Critical Habitat 2001
- USFWS Critical Habitat Revised 2009
- Guzzlers - rain collection system
- Tenajas - seasonal natural water sources

0 0.75 1.5   3 Kilometers
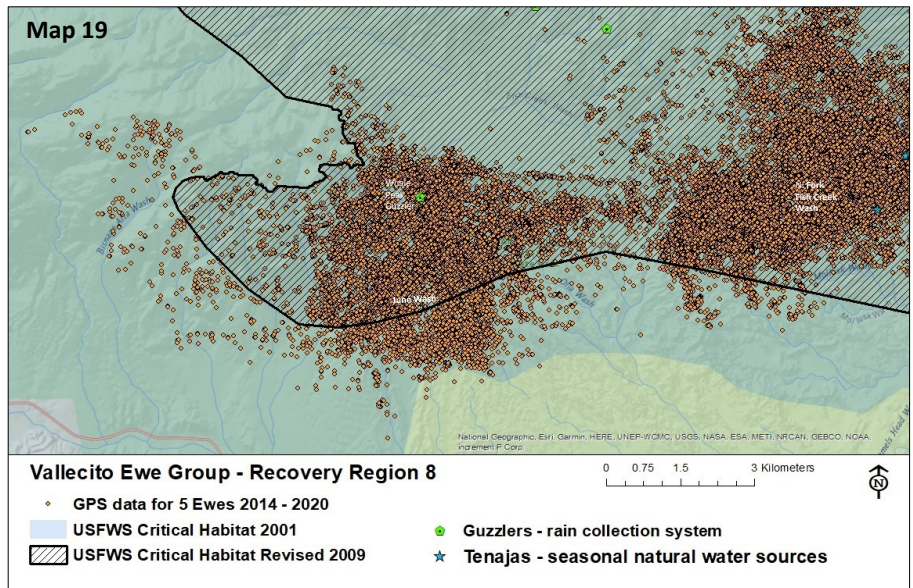
Fish Creek Mountains Ewe Group

The Fish Creek Mountains (FCM) ewe group home range is approximately 94 km² and extends 16 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). Our understanding of the FCM ewe group is rudimentary as this area is extremely rugged and difficult to access.

Based on GPS data collected on 7 ewes from 2014 through 2020, there are two sub-ewe groups—a northwest sub-ewe group and a southeast sub-ewe group. The core area for both sub-ewe groups is in a major northwest/southeast trending canyon (hereafter referred to as "Fish Canyon") at the northwest end of the mountain range. Fish Canyon has numerous ephemeral water sources (Tenajas) that rarely supply water during the summer months. Summer GPS location data for both sub-ewe groups is not concentrated around the tenajas—further evidence that the tenajas are dry most summers. Instead, both ewe groups spread out at the higher elevations during the summer months. Despite the lack of permanent water sources, none of the radio-collared ewes have moved outside of the Fish Creek Mountains.

Map 20

Fish Creek Mountains (FCM) Ewe Group - Recovery Region 8
- GPS Location Data 2014 - 2021
- Northwest core lamb-rearing area
- Southeast core lamb-rearing area
- USFWS Critical Habitat 2001
- USFWS Critical Habitat Revised 2009
- Tenajas - ephemeral water source
- Gypsum Mine

0 0.5 1   2 Kilometers

The Northwest sub-ewe group does not move south of Barrett Canyon whereas the Southeast sub-ewe group utilizes all areas within the FCM. The two ewe groups are differentiated by their core lamb-rearing habitat. The northwest sub-ewe group's core lamb-rearing habitat straddles the northwest ridgeline of Fish Canyon whereas the Southeast sub-ewe group concentrates on the east-facing slopes overlooking Carrizo Wash (Map 20). Almost half of the Northwest and the majority of the Southeast sub-ewe groups' core areas are beyond the boundary of the 2009 revised critical habitat. Furthermore, habitat used throughout the year at the south end of the range was removed from critical habitat. This area is likely used as a corridor between the Fish Creek Mountains and the Coyote Mountains to the south, although this movement has yet to be captured by GPS location data.

Carrizo Canyon Ewe Groups - Recovery Region 9

Carrizo Canyon is the largest of the 9 recovery regions that encompasses an area of 866 km^2 and contains 4 ewe groups—Tierra Blanca, Carrizo Canyon, In-Ko-Pah, and Jacumba (Map 21).
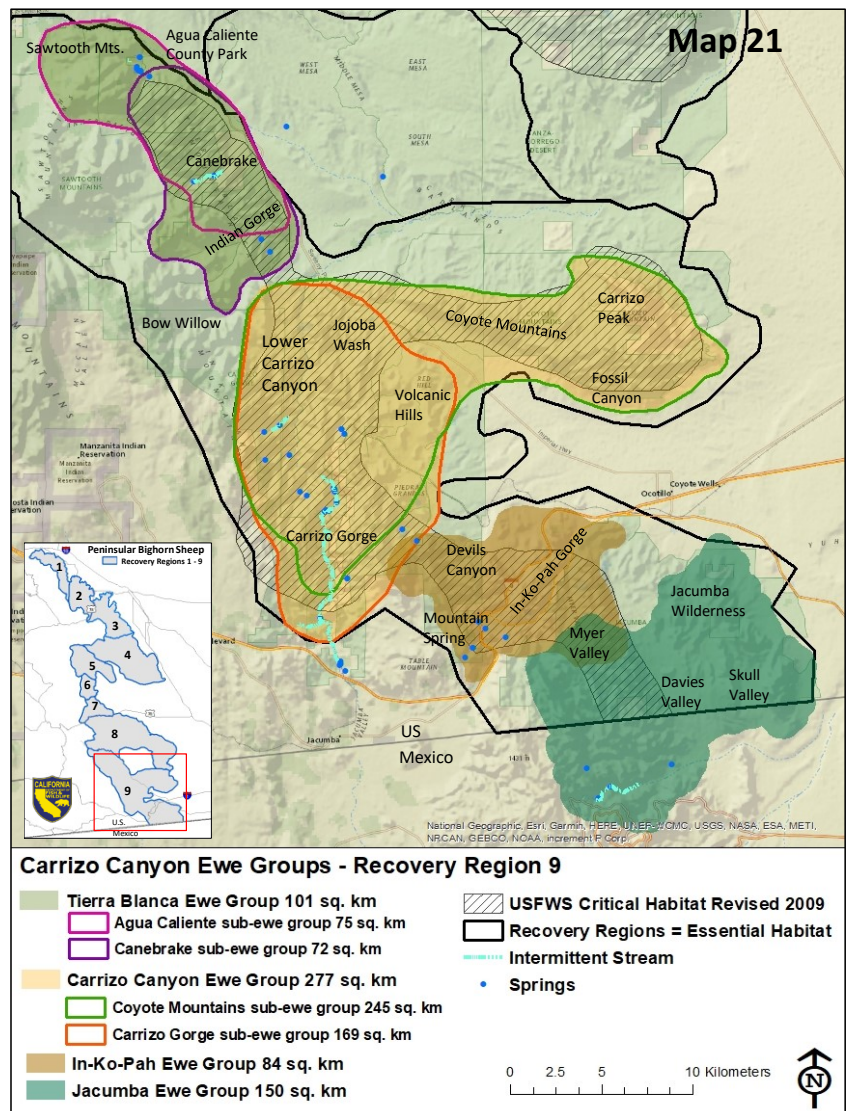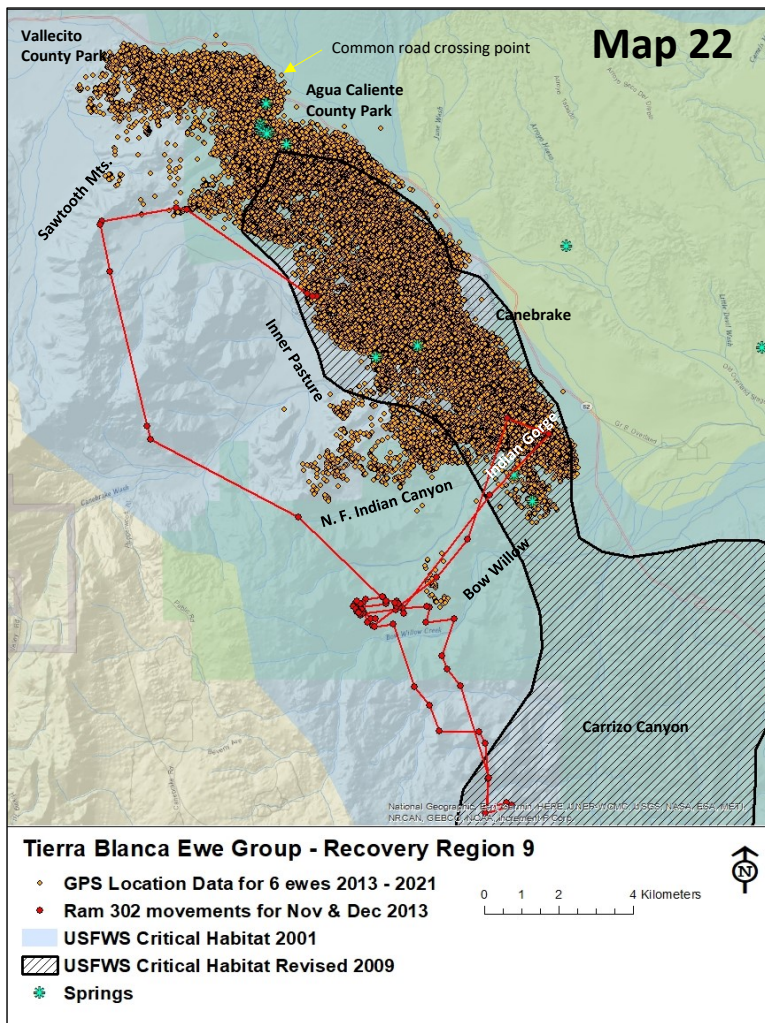
Tierra Blanca Ewe Group

The Tierra Blanca ewe group is approximately 101 km^2 and extends 18 km from the Sawtooth Mountains in the north to Bow Willow Canyon in the south and consists of 2 sub-ewe groups—Agua Caliente and Canebrake (Map 21).

The Agua Caliente sub-ewe group home range is approximately 75 km^2 and extends 16 km from the Sawtooth Mountains to Indian Gorge. This ewe group is not very philopatric; however, the most common areas used during the lamb-rearing season are either on the east-facing slopes of the Sawtooth Mountains overlooking County Road S2 or on the east-facing slopes of the Tierra Blanca Mountains between Moonlight Canyon and Canebrake Canyon.

The Agua Caliente sub-ewe group is concentrated in the area surrounding the numerous springs at Agua Caliente County Park (ACCP) during the summer months. The park closes for the summer at the end of May, at which point the ewes take over the campground during the day and forage on mesquite and catclaw acacia scattered throughout the campground. In July and August, the rams join the ewes within the campground. The campground reopens in September, and PBS abandon the campground but stay on the periphery of the slopes for a few weeks before dispersing.

In recent years, the Tierra Blanca ewe group has been observed more frequently in low elevation

Map 21

Carrizo Canyon Ewe Groups - Recovery Region 9

Tierra Blanca Ewe Group 101 sq. km
Agua Caliente sub-ewe group 75 sq. km
Canebrake sub-ewe group 72 sq. km
Carrizo Canyon Ewe Group 277 sq. km
Coyote Mountains sub-ewe group 245 sq. km
Carrizo Gorge sub-ewe group 169 sq. km
In-Ko-Pah Ewe Group 84 sq. km
Jacumba Ewe Group 150 sq. km
USFWS Critical Habitat Revised 2009
Recovery Regions = Essential Habitat
Intermittent Stream
Springs

Map 22

Vallecito County Park

Common road crossing point

Agua Caliente County Park

Sawtooth Mtns

Inner Pasture

Canebrake

Indian Gorge

N. F. Indian Canyon

Bow Willow

Carrizo Canyon

National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Tierra Blanca Ewe Group - Recovery Region 9

- ◇ GPS Location Data for 6 ewes 2013 - 2021
- ● Ram 302 movements for Nov & Dec 2013
- USFWS Critical Habitat 2001
- ▨ USFWS Critical Habitat Revised 2009
- ✳ Springs

0 1 2 4 Kilometers

N

habitat browsing on a variety of cactus plants during the pre-lambing season underscoring the importance of low elevation habitat during times of drought.

The Canebrake sub-ewe group home range is approximately 72 km^2 and extends 14 km from Moonlight Canyon (one canyon to the south of ACCP) to the north side of Bow Willow Canyon. Summer months are mainly spent on the slopes surrounding the water sources in Canebrake Canyon and occasionally at Torote Bowl south of Indian Gorge. Core lamb-rearing habitat is located on the slopes surrounding Indian Gorge.

The upper third of the Agua Caliente and the southwestern portion of the Canebrake sub-ewe groups' home ranges reside outside of the revised 2009 critical habitat boundary. Map 22 clearly shows that the 2009 critical habitat designation underestimates the physical and biological features essential to the conservation of PBS. If ram 203's data were not included, it would appear that the 2001 critical habitat overestimated the physical and biological features essential to the conservation of PBS. Therefore, it is worth repeating that home ranges presented in this report should be considered the *minimum* habitat footprint for GPS-collared ewes since rams are rarely collared due to funding constraints. Ram 203's data also illustrates that the 2009 critical habitat corridor between the Tierra Blanca Mountains and Carrizo Canyon is insufficient.

For the current reporting period, VHF-collared Tierra Blanca ewes were observed within the Carrizo Ewe Group to the south and within the Vallecito sub-ewe group in recovery region 8. Ewe 496 was observed near Dolomite Mine in the Coyote Mountains in March 2021. The CDFW biologist observed the ewe as she moved from the mine, crossed S2 and headed west into Jojoba Wash. Ewe 497 has been observed south of Rockhouse Canyon in lower Carrizo Canyon. This ewe has also been observed in recovery region 8 on the lower south slopes of Whale Peak. Tierra Blanca ewes are often observed crossing County Road S2 just north of ACCP and foraging in the drainage. Rams have also been observed on a low rise across the drainage and this is the most likely route PBS take back and forth between recovery regions 8 & 9.

Carrizo Canyon Ewe Group

The Carrizo Canyon ewe group should not be confused with Carrizo Canyon recovery region. The Carrizo Canyon ewe group is approximately 277 km^2 and consists of 2 sub-ewe groups—Carrizo Gorge and Coyote Mountains (Map 21). The two sub-ewe groups share the same water sources during the summer months within Carrizo Canyon but utilize different habitats during the lamb-rearing season.

The Carrizo Gorge sub-ewe group home range is approximately 169 km^2 and extends 20 km from the entrance of Carrizo Canyon to Tule Canyon near Interstate 8. During the summer months, ewes concentrate in Carrizo Gorge where there are numerous water sources. During the pre-lambing season, ewes can be found throughout Carrizo Canyon. There is not a well-defined lamb-rearing area; however, most ewes move to the lower and drier elevations located at the northwest and

northeast side of Carrizo Canyon. The Volcanic Hills, which is outside of critical habitat, has also been identified as a lambing-rearing area based on GPS location data and direct observations of ewes with newborn lambs.
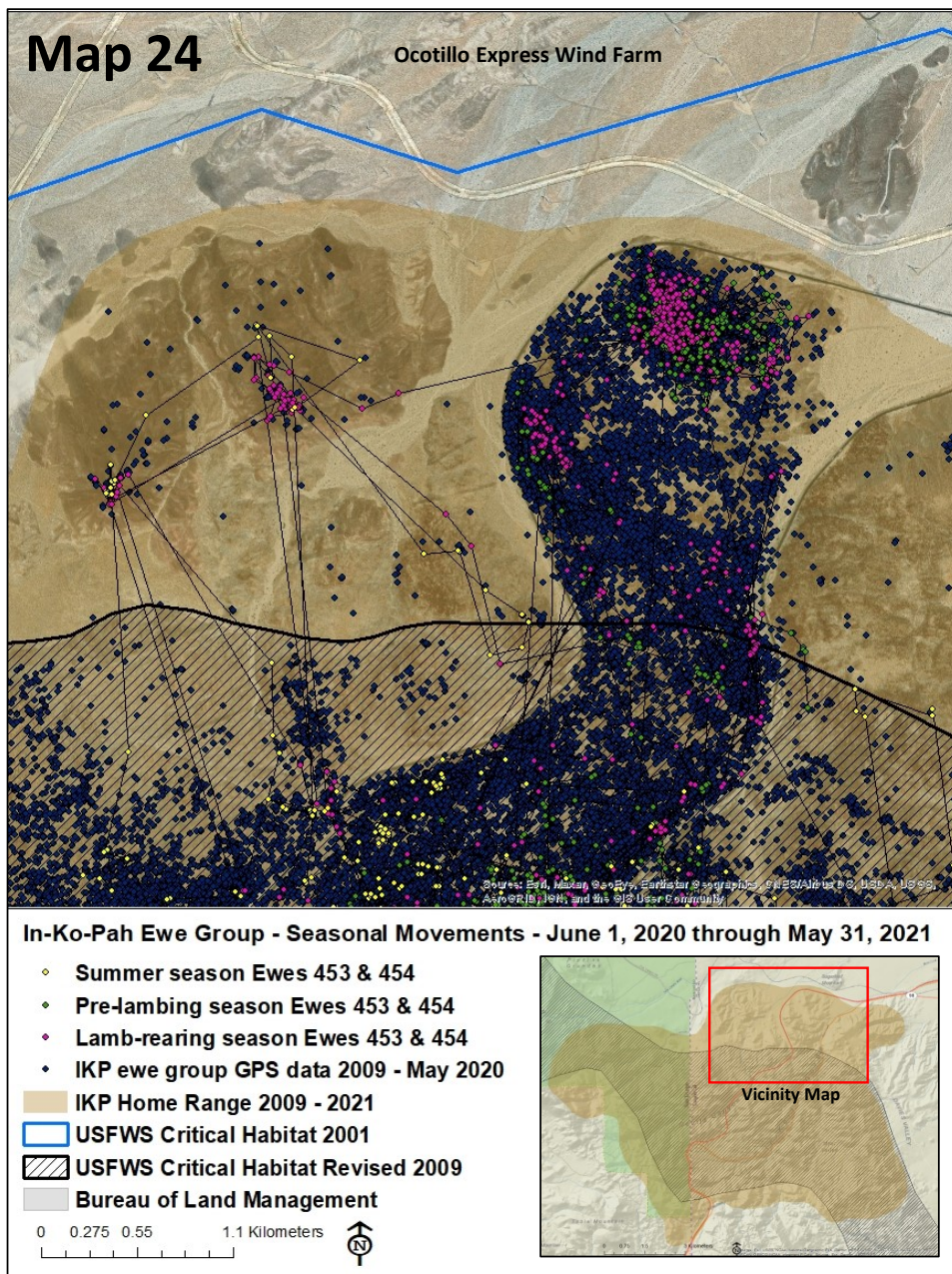
The Coyote Mountains sub-ewe group (not to be confused with the Coyote Mountain ewe group in recovery region 5) is approximately 245 km^2 and encompasses most of Carrizo Canyon and all of the Coyote Mountains. During the summer and pre-lambing season, this ewe group stays within Carrizo canyon and uses most of the same areas as the Carrizo Gorge sub-ewe group. However, there is a tendency to concentrate in the lower half of Carrizo Canyon and avoid the upper reaches of Carrizo Gorge. At the end of the pre-lambing season, ewes move to the area surrounding Jojoba Wash and the Volcanic Hills as they prepare to make the 18 km trek to the east side of the Coyote Mountains for the lamb-rearing season. Compared to Carrizo Canyon, the Coyote Mountains are much lower and drier with poor quality forage and no permanent sources of water. There have been no documented cases of lion predation in the Coyote Mountains and likely ewes trade good nutrition for a lower risk of predation compared to Carrizo Canyon.

The most common routes that ewes take between Carrizo Canyon and the Coyote Mountains are between Sweeney Pass and the Volcanic Hills (Map 23). Based on a combination of GPS data and direct observations, 70% of ewes cross between Jojoba Wash and the area around Dolomite Mine. Crossing routes in the Volcanic Hills are outside of the revised 2009 critical habitat.

Lastly, several Carrizo Canyon ewes have been documented moving for short periods of time into the Tierra Blanca Mountains to the North and one ewe has been documented moving into the In-Ko-Pah ewe group to the south. During
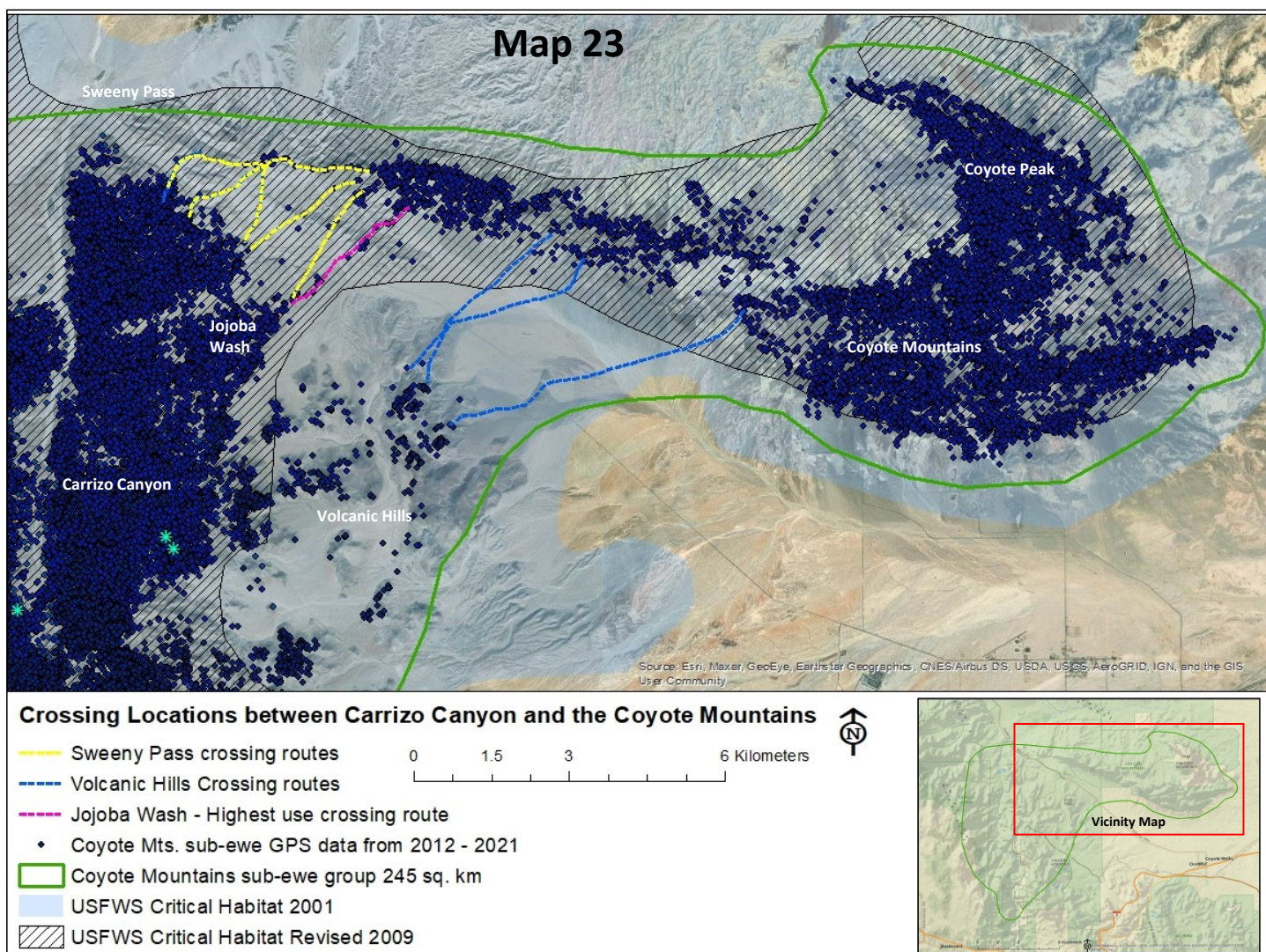
the current reporting period, an 8-month-old lamb was seen in an agricultural community on the west outskirts of El Centro in August 2020. The likely starting point for this lamb was either the Coyote Mountains or the south end of the Fish Creek Mountains. When the CDFW biologist arrived, the lamb could not be found; however, there were numerous lamb and ewe tracks found alongside the canal.

Map 24

Ocotillo Express Wind Farm

In-Ko-Pah Ewe Group - Seasonal Movements - June 1, 2020 through May 31, 2021

- ○ Summer season Ewes 453 & 454
- ◇ Pre-lambing season Ewes 453 & 454
- ◇ Lamb-rearing season Ewes 453 & 454
- ◆ IKP ewe group GPS data 2009 - May 2020
- IKP Home Range 2009 - 2021
- USFWS Critical Habitat 2001
- USFWS Critical Habitat Revised 2009
- Bureau of Land Management

0   0.275 0.55   1.1 Kilometers

Vicinity Map

In-Ko-Pah Ewe Group

The In-Ko-Pah (IKP) ewe group home range is approximately 84 km² and is bisected by Interstate 8 in the area surrounding Mountain Springs, Devils Canyon, In-Ko-Pah Gorge, and Myers Valley (Map 21).

The core area during the summer is at higher elevation habitat surrounding Mountain Springs to the west of Interstate 8. During the pre-lambing season, ewes spread out across the entire home range.

Core lamb-rearing habitat is located in the northeast "Island" created by the divergence of the west and east-bound lanes of Interstate 8. Since 2019, ewes have increased their use of low elevation habitat to the west of the core lamb-rearing area and adjacent to the Ocotillo Express Wind Farm (Map 24). Ewes and their lambs are often observed foraging on barrel cactus that grow in abundance on the low volcanic hills in this area. During times of drought when green annuals are not available, ewes and their lambs rely heavily on cactus plants to meet their nutritional needs. Unfortunately, low elevation habitat that lacks escape terrain may increase lambs' risk of coyote predation.

The In-Ko-Pah ewe group is unique among all ewe groups in the Peninsular Ranges in that its home range is bisected by an Interstate. Unsurprisingly, radio-collared ewes in this ewe group have a significantly higher percentage of deaths due to vehicle collisions (35%) relative to any other ewe group in the Peninsular Ranges. Based on roadkill reports obtained since 2012 that include non-collared bighorn sheep, the majority of PBS killed on Interstate 8 are ewes (Figure 3). The most common time of year for ewes to be killed by vehicles is March when ewes are moving back and forth across the Interstate while foraging during the peak of lamb-rearing season and again in November when they are moving into the Island in advance of lamb-rearing season.
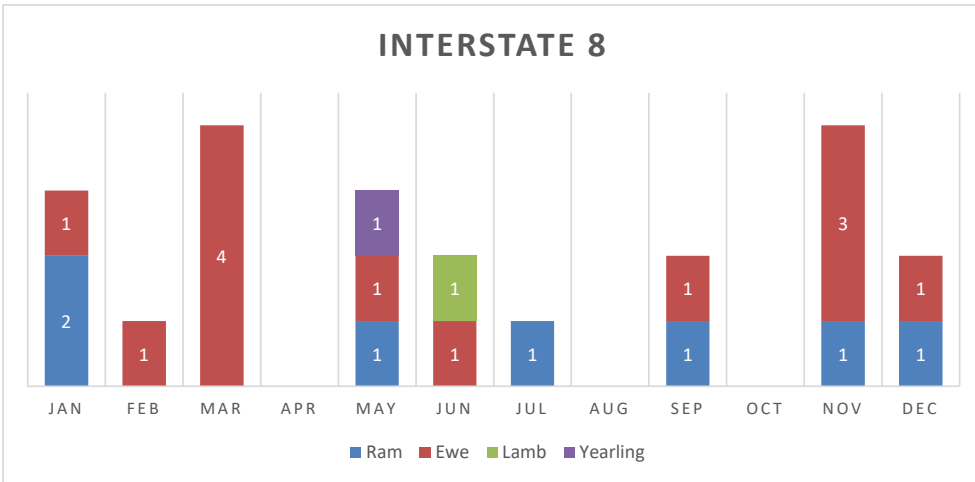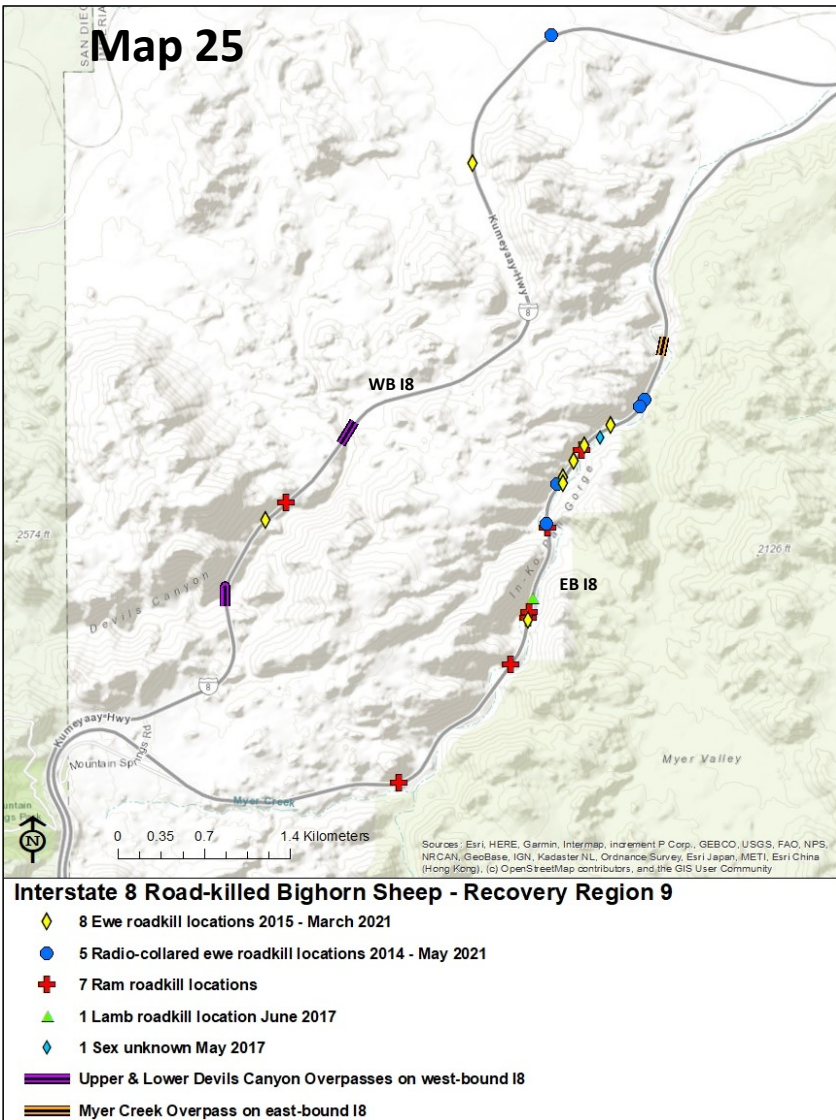
INTERSTATE 8

Figure 3. Number of Peninsular bighorn sheep killed by vehicles, by month and sex, on Interstate 8 in the In-Ko-Pah Gorge between 2012 and May 2021 (n = 22).

Map 25

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Interstate 8 Road-killed Bighorn Sheep - Recovery Region 9

◇ 8 Ewe roadkill locations 2015 - March 2021
● 5 Radio-collared ewe roadkill locations 2014 - May 2021
✚ 7 Ram roadkill locations
▲ 1 Lamb roadkill location June 2017
◆ 1 Sex unknown May 2017
▬ Upper & Lower Devils Canyon Overpasses on west-bound I8
▬ Myer Creek Overpass on east-bound I8

The east-bound lanes are much deadlier for PBS than the west-bound lanes and there are several factors that might account for this difference (Map 25). On the west-bound lanes, there are two overpasses that traverse Devils Canyon, which is extremely deep, and ewes are comfortable contouring mid-slope beneath the overpasses. On the east-bound lanes, there is only 1 overpass across Myer Creek. PBS are not comfortable passing beneath this overpass as it is close to the ground which requires sheep to travel through the bottom of the wash. Vehicles on the west-bound lanes are travelling slowly up a steep grade whereas vehicles on the east-bound lanes are travelling quickly down the grade.

Since 2009, much knowledge has been gained about the In-ko-Pah ewe groups movements based on 14 GPS-collared ewes. Individual ewe behavior determines whether the east-bound lanes of Interstate 8 are treated as a semi-permeable barrier or a complete barrier to movement. While all 14 ewes crossed the west-bound lanes of Interstate 8 on a regular basis, 6 ewes (43%) never crossed the east-bound lanes—all 6 ewes were adults when captured. Half of the ewes that did cross east-bound I8 were < 3 years old when captured and did not cross the east-bound lanes until they were ≥ 3 years old (Map 26). Once ewes started crossing, they quickly increased the amount of crossing events. All but one of the ewes that crossed the east-bound lanes and entered Myer Valley would commingle with the Jacumba ewe group. Thirty-six percent of all In-Ko-Pah radio-collared ewes would occasionally spend a few weeks during the lamb-rearing or summer season within the Carrizo Gorge ewe group to the northwest.

Thirty-four percent of the In-Ko-Pah ewe group's home range is outside of the revised 2009 critical habitat boundary including core lamb-rearing habitat in the north and foraging habitat on the western and southwestern edge of the home range. Additionally, important seasonal movement corridors within the home range and between the Carrizo Canyon ewe group and the Jacumba ewe group were not included (Map 27).
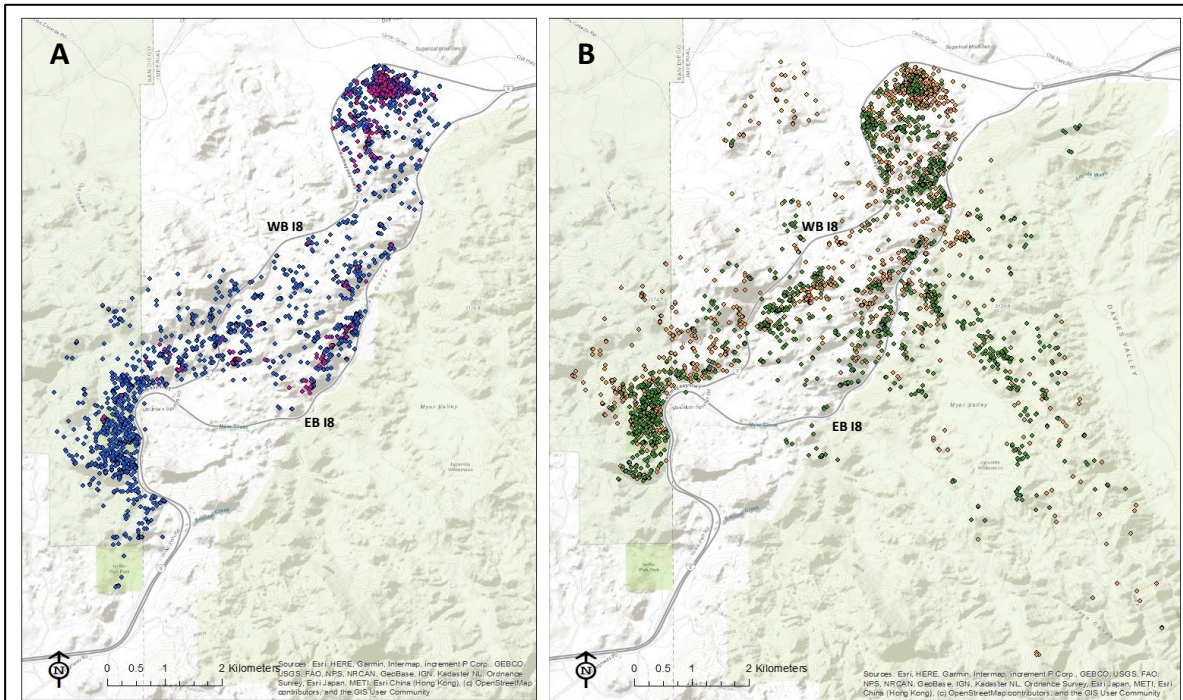
Map 26. Ewe 454 GPS Location Data for East & West-Bound Interstate 8 -Recovery Region 9

- ● Capture age 1.5 years: Nov & Dec 2017 data
- ● Age 2 years: 2018 Data – Not crossing EB I8
- ● Age 3 year: 2019 Data – Crossing EB I8
- ● Age 4 years: 2020 Data – Crossing EB I8

Map 27
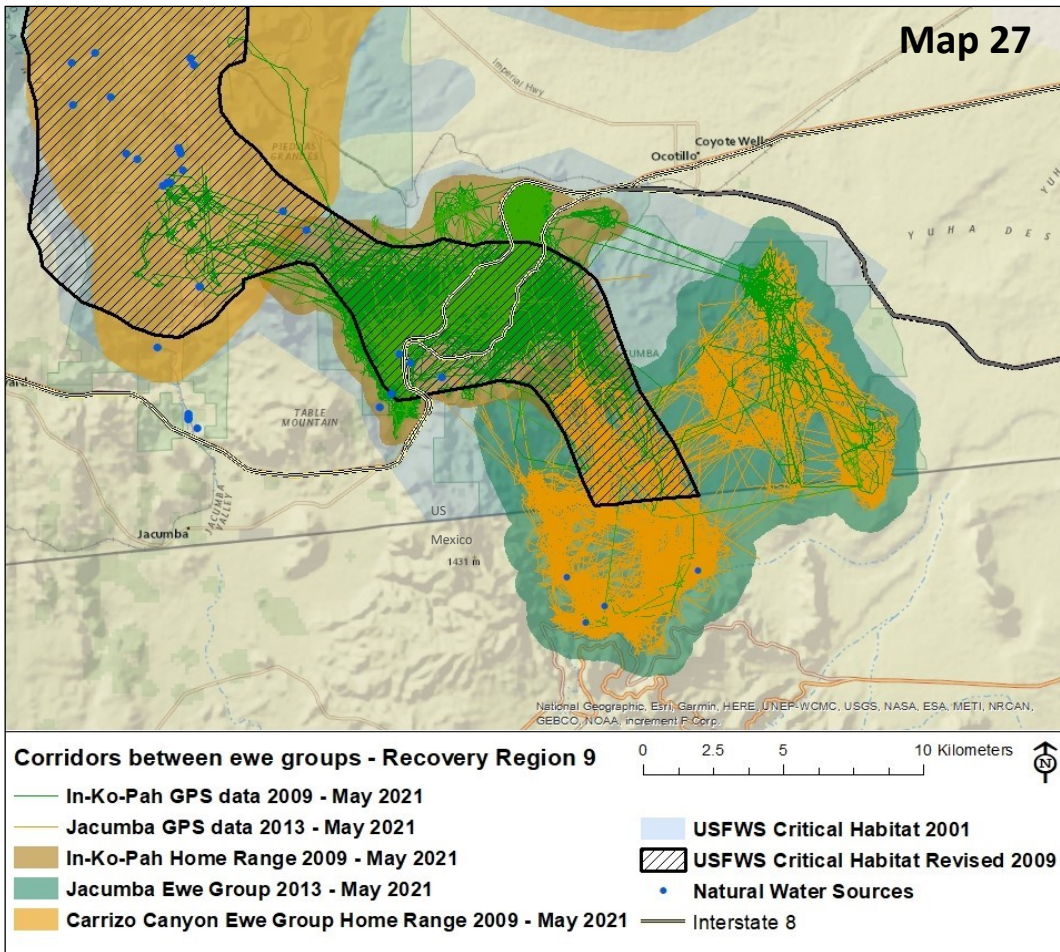
Corridors between ewe groups - Recovery Region 9

— In-Ko-Pah GPS data 2009 - May 2021
— Jacumba GPS data 2013 - May 2021
In-Ko-Pah Home Range 2009 - May 2021
Jacumba Ewe Group 2013 - May 2021
Carrizo Canyon Ewe Group Home Range 2009 - May 2021

USFWS Critical Habitat 2001
USFWS Critical Habitat Revised 2009
● Natural Water Sources
— Interstate 8

Jacumba Ewe Group

The Jacumba ewe group home range currently encompasses approximately 150 km^2 of which 64% of the home range lies within the United States (U.S.) and 36% lies within Mexico (Map 21). The home range extends 13 km from the Jacumba Wilderness in the U.S. to Highway 2 in Mexico and is 16 km wide from west to east. Davies Valley drains from north to south and divides the higher elevation habitat to the west from the lower and drier elevation habitat to the east. Most reliable water sources are found in the higher elevations within Mexico.

Our understanding of habitat use and movement corridors for the Jacumba ewe group is based on GPS data collected from 4 ewes and 3 rams from 2013 through 2017. At the time, there was not a border barrier fence and PBS could move freely between the U.S. and Mexico. There was estimated to be approximately 30 ewes within the Jacumba ewe group based on a sub-sample of the 2016 CDFW helicopter population survey for recovery region 9.

During the pre-lambing and lamb-rearing seasons, GPS-collared ewes divided their time almost evenly between the US and Mexico (Map 28 A & C). There were 5 core areas of contiguous habitat along the boundary between the U.S. and Mexico that were frequently used by PBS during the pre-lambing and lamb-rearing seasons with 3 areas of concentrated use to the west of Davies Valley and 2 areas to the east of Davies Valley. Two high use corridors across Davies Valley connected the eastern and western portions of PBS habitat within the U.S. A third corridor across Davies Valley connected the western habitat within Mexico to the eastern side of Skull Valley with a fourth corridor connecting the east and west sides of Skull Valley along the U.S./Mexico Border.

During the summer months, PBS concentrated within Mexico on the north-facing slopes of a deep riparian canyon with reliable water sources (Map 28 B). Only 2 core areas along the U.S./Mexico border were used on the west side of Davies Valley with very little movement across Davies Valley to the eastern portion of their range.

None of the radio-collared ewes and only 1 of the radio-collared rams moved north across Interstate 8.

In April of 2020, U.S. Customs and Border Protection (CBP) started construction on an 11-mile border barrier fence that would bisect PBS habitat in the Jacumba Wilderness. CDFW submitted comments and recommendations to assist CBP in avoiding or minimizing potential impacts to endangered bighorn sheep from border barrier construction; however, because the border barrier project was deemed an emergency, environmental regulations and review were waived. Fence construction started at the eastern end of the Jacumba Mountains and progressed westward through PBS habitat. A paved road was built through Davies Valley that cut across several key bighorn movement corridors and a paved road built into Skull Valley that went through core lamb-rearing habitat (Map 29). Construction activities occurred during the peak of the lamb-rearing season and most construction staging areas were within sensitive lamb-rearing habitat and movement corridors (Photo 1 & photo on Title Page). Before the project was discontinued in December 2020, 5.3 km (3.3 miles) of bollard fence was built across 33% of PBS movement corridors between the U.S. and Mexico. Unfortunately, the effects of construction activities to PBS movement patterns is not known because there were no GPS-collared sheep during the construction phase.

To document how the border fence might affect PBS movement, CDFW attempted to capture and collar 5 ewes in the Jacumba Wilderness in October 2020 while construction was on-going. Unfortunately, very few PBS were found and only 1 ewe was captured and fitted with a satellite collar (Ewe 516). In September and October, PBS are typically moving back into the U.S. from Mexico; however, warm weather or construction activities may have discouraged their return. Initial GPS data from ewe 516 indicates that she is crossing the border at the west end of the range but has not moved to the eastern half of the Jacumba Wilderness (Map 29). CDFW will attempt to capture more PBS in the fall of 2021.

USFWS 2009 revised critical habitat covers only 13% of the area known to be used by the Jacumba ewe group and completely discounts all of the core lamb-rearing habitat which resides in the eastern portion of the Jacumba wilderness. Furthermore, it does not include known seasonal movement corridors across Davies Valley or movement corridors that

have been documented between the In-Ko-Pah and Jacumba Ewe Groups in the eastern and western portions of the Jacumba Wilderness (Map 27).

Map 28 – Jacumba Ewe Group Pre-barrier Fence Habitat Use
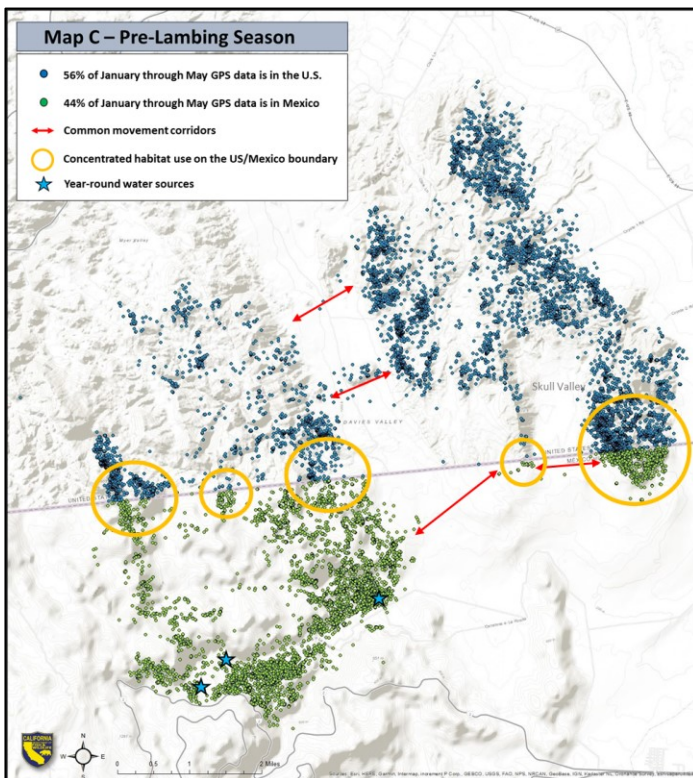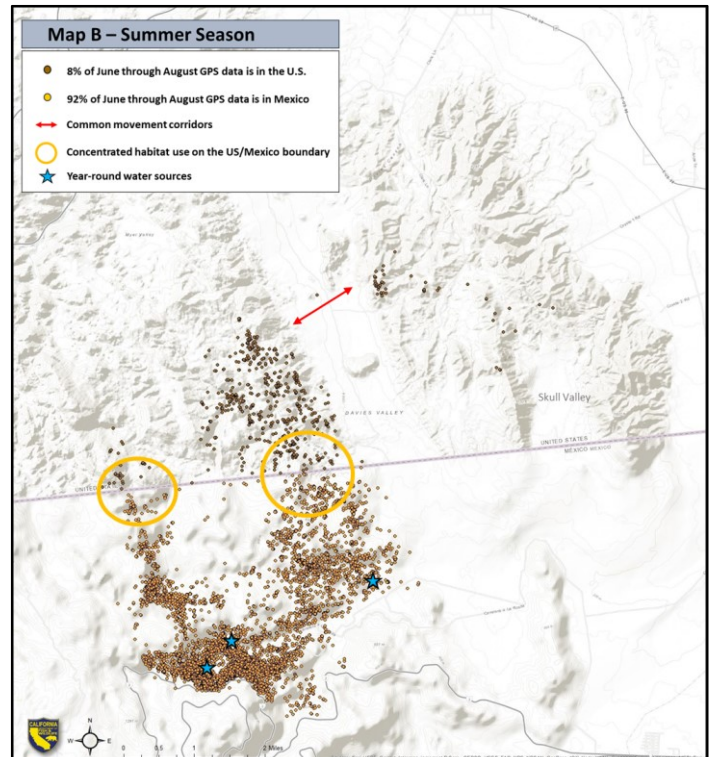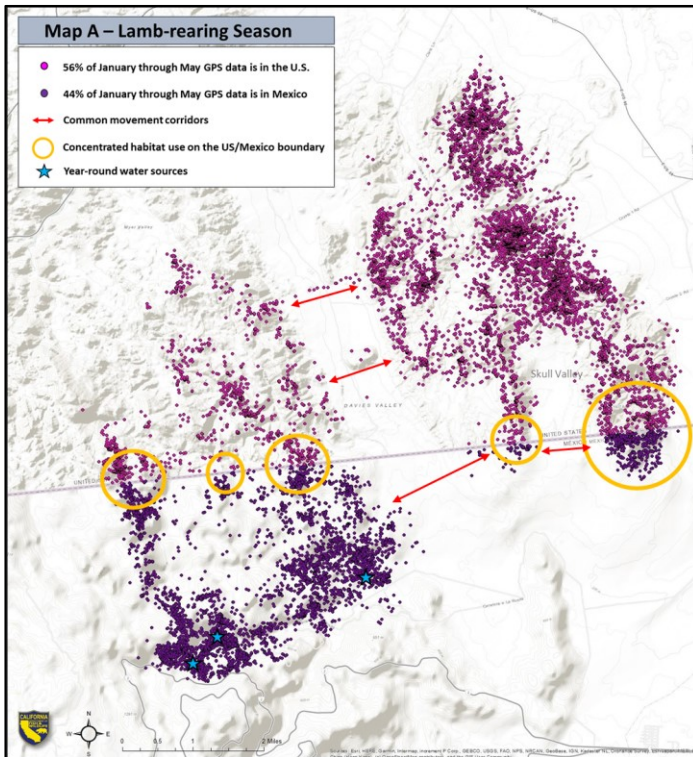
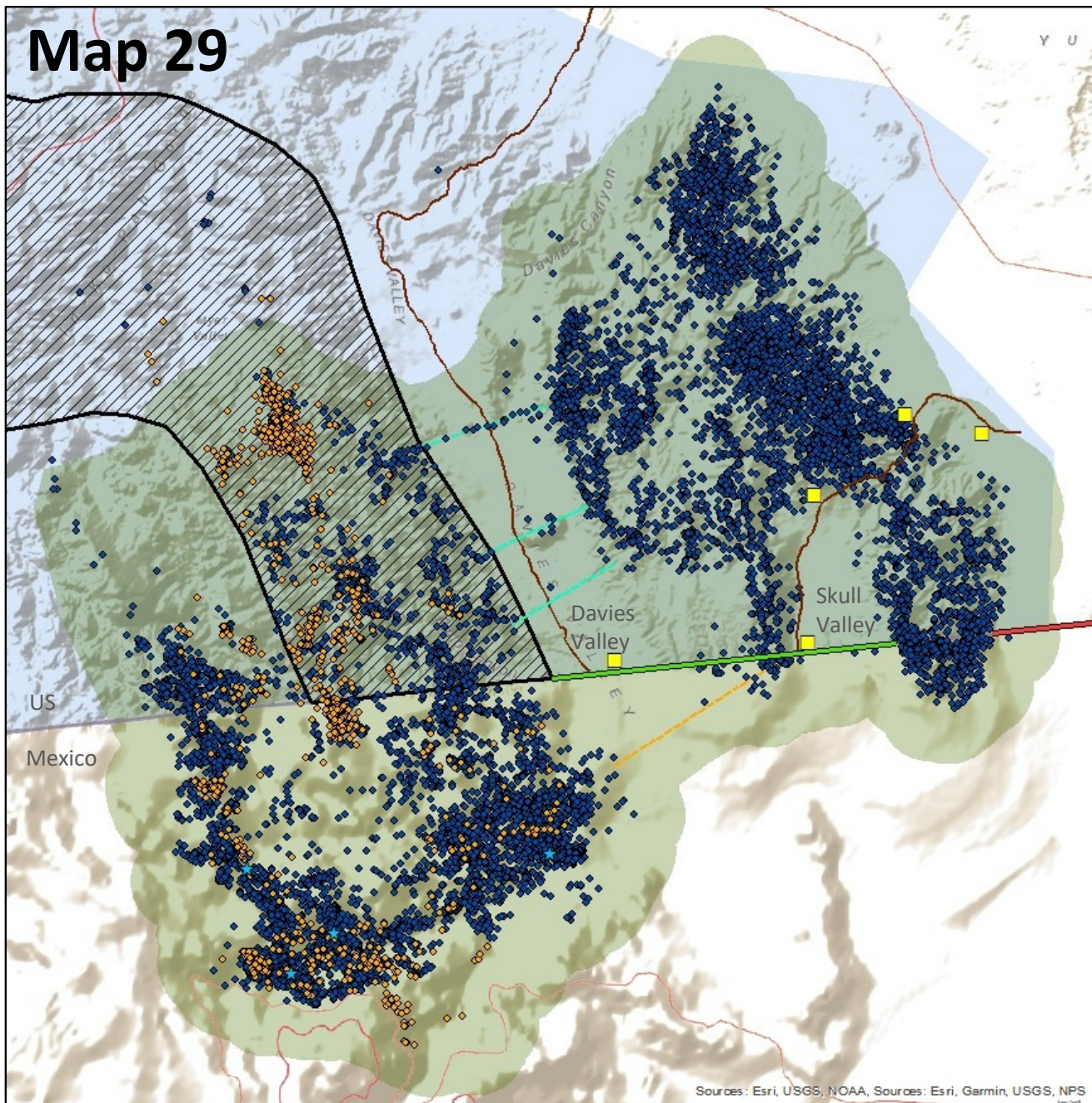**Map 28 A, B, & C: Jacumba Ewe Group Pre-Barrier Fence Habitat Use**

Global Positioning System (GPS) data from 4 collared Peninsular bighorn ewes captured by the California Department of Fish and Wildlife in October 2013 within the Jacumba Wilderness in Imperial County, Southern California. These data demonstrate the importance of habitat use both within the United States and Mexico for the continued viability of this subpopulation. Red arrows show the most common areas used as movement corridors and yellow circles show areas of concentrated use along the border.

Map A. Lamb-rearing season (January through May) GPS data for years 2014 through 2017 (n = 15298). A slight majority of habitat use during the lamb-rearing season is within the eastern portion of the Jacumba Wilderness in the U.S.; however, both sides of the International border are vital to PBS during this season.

Map B. Summer season (June through August) GPS data for years 2014 through 2016 (n = 7706). Most sheep habitat use is within Mexico likely due to the deeply shaded canyon with riparian habitat and reliable water sources relative to the Jacumba Wilderness at this time of year.

Map C. Pre-lambing seasons (September through December) GPS data for years 2013 through 2016 (n = 15158). Patterns of habitat use are similar to lamb-rearing season with only a slight majority of use within the United States relative to Mexico.

Map 29

Sources: Esri, USGS, NOAA, Sources: Esri, Garmin, USGS, NPS

Jacumba Ewe Group & the Border Barrier Fence

- ◆ Pre-Barrier GPS data 2013 - 2017
- ◇ Ewe 516 Nov 2020 - May 2021
- ── Bollard Fence built between May & Dec 2020
- ▪ Construction Staging Areas
- ── Paved Roads built during fence construction
- ┄ Davies Valley Main Corridors
- ┄ US/Mexico Corridor eliminated

- Jacumba overall home range 2013 - 2021
- USFWS Critical Habitat Revised 2009
- USFWS Critical Habitat 2001
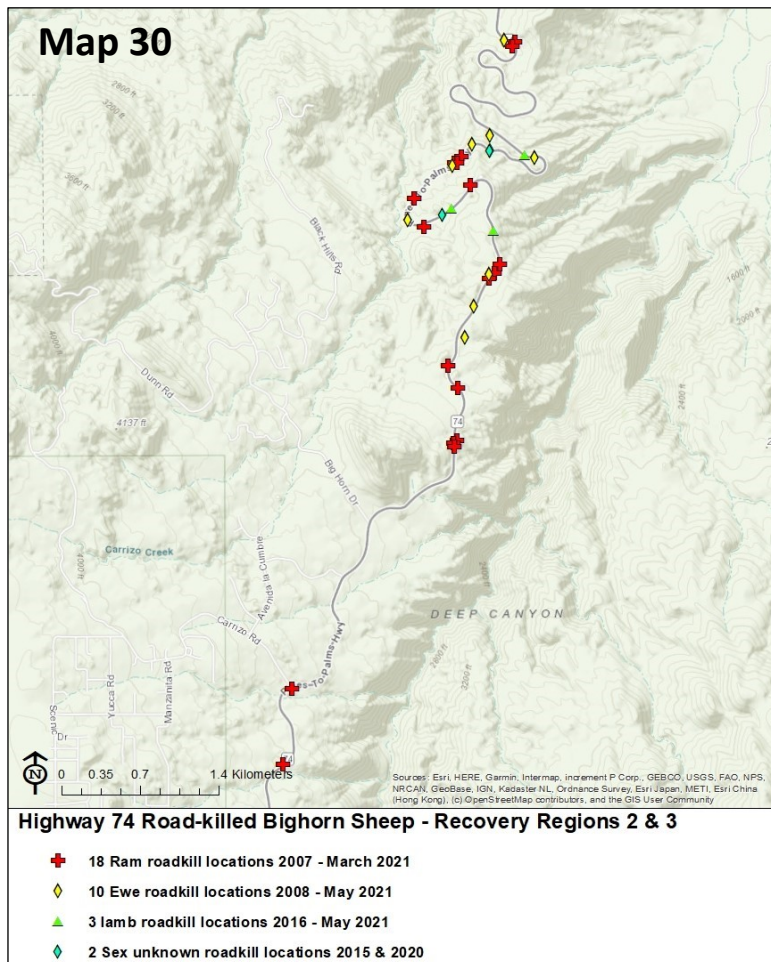- ★ Natural Water Sources

0   0.75   1.5   3 Kilometers

THREATS TO RECOVERY

The objective of the Peninsular Ranges bighorn sheep Recovery Plan is to secure and manage habitat to alleviate threats so that the population can increase to the level that PBS may eventually be reclassified to threatened status, and ultimately delisted (USFWS 2000). A stable to increasing population trend must be attained to meet the first two delisting criteria; however, criterium 3 will be most important to attain for the long-term viability of the population. Delisting criterium 3 states that regulatory mechanisms and land management commitments need to be established that will provide long-term protection of PBS and all essential habitat. "Given the major threat of fragmentation to species with metapopulation structures, 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. In preparation for delisting, protection by means other than the Endangered Species Act must be assured. Such protection should include alternative mechanisms for regulation by Federal, State, and local governments, and land management commitments that would provide the protection needed for continued population stability" (USFWS 2000, p. vii).

Section II.D.1-3 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. These actions (generally described) include, but may not be limited to, the following: 1) Protect, acquire, enhance, and restore essential PBS habitat, 2) Maintain and re-establish connectivity throughout all habitat, 3) Maintain existing water sources and consider providing additional sources on public lands if water is thought to be a limiting factor in a particular area, 4) reduce or eliminate detrimental human activities within bighorn sheep habitat, 5) research disease and preventive measures, and 6) develop and implement a trails management program with affected land management agencies that include public education, seasonal closures, and regulation enforcement.

Map 30

Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Highway 74 Road-killed Bighorn Sheep - Recovery Regions 2 & 3

+ 18 Ram roadkill locations 2007 - March 2021
◇ 10 Ewe roadkill locations 2008 - May 2021
▲ 3 lamb roadkill locations 2016 - May 2021
◆ 2 Sex unknown roadkill locations 2015 & 2020

Recovery Regions 1 - 3

Two overarching threats to the recovery of PBS in recovery regions 1-3 are obstructed habitat connectivity and human disturbance due to their proximity to the Coachella Valley urban center. According to section II.B.2 in the Recovery Plan for bighorn sheep in the Peninsular Ranges, downlisting criterion 2 states that "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 habitats (USFWS 2000)." Although PBS can move between recovery regions 1-3, Highway 74 impedes sheep movement between the NSRM and CSRM and continues to be a hazard for crossing sheep. Despite two flashing warning signs located at key sheep-crossing zones, drivers often proceed at speeds well beyond the speed limit increasing the risk for a bighorn-car collision. Every year more sheep are struck and killed by vehicles while attempting to cross the highway (Table 7, Map 30).

Human Related Disturbance

Human disturbance in areas identified as, or adjacent to, essential sheep habitat also continues to be a
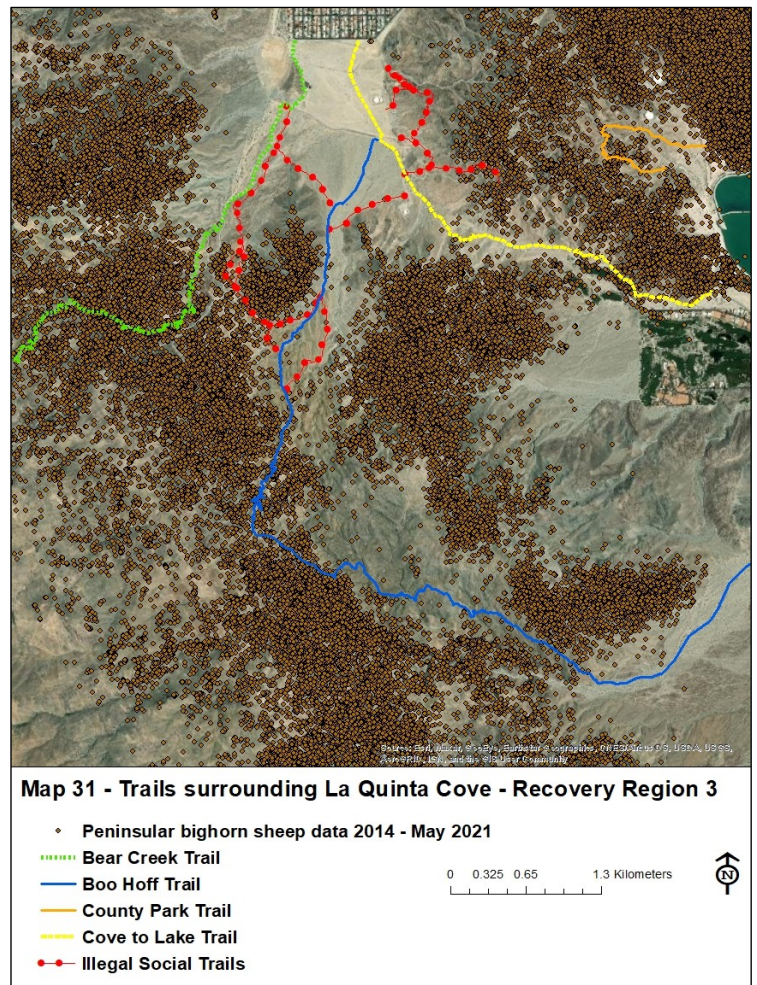
major concern within these 3 recovery regions. The Recovery Plan (sections II.D.1.1.1-1.2.2) states that, "essential habitat comprises those areas believed to be necessary for a self-sustaining bighorn population with a high probability for long-term survival (recovery) in the Peninsular Ranges of the 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 (USFWS 2000)." Disturbance to and loss of essential habitat are largely caused by 1) recreational trail use (legal and illegal) and 2) urban development in this region, which can result in sheep 3) using the urban interface—another activity that threatens PBS recovery.

Table 7. Documented road-killed bighorn sheep within the Peninsular Ranges. ‡ Data are from January 2021 to 31 May 2021. Dash line = No data are available on Interstate 8 prior to 2012.

Road	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021‡	Total
Highway 74	2	2	1	1	1	1	1	3	4	4	2	6	0	2	3	33
Interstate 8	-	-	-	-	-	1	0	1	2	5	4	2	1	2	4	22
Co. Rd. S22	1	0	0	2	0	2	0	0	0	0	0	1	0	0	2	8
Co. Rd. S3	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	4
Co. Rd. S2	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	4
Highway 78	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	4
Highway 111	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Jefferson Str.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Total by year	4	3	2	3	2	4	1	4	7	10	8	12	4	4	9	77
% by year	5%	4%	3%	4%	3%	5%	1%	5%	9%	13%	10%	16%	5%	5%	12%	100%

The SJM, NSRM and CSRM are popular destinations for recreational users and several popular trails pass through essential sheep habitat (Map 31). For example, the CSRM 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. Furthermore, there has been a proliferation of illegal trails (i.e., social trails) that are often used by mountain bikers and hikers in areas identified as sheep escape terrain, movement corridors, and lambing and nursery habitat across all three recovery regions. An additional ongoing issue is public misinformation or disregard to trail rules regarding dog restrictions and mode of transportation (e.g., hiking, biking, horseback riding, etc.) on trails.

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 (sections II.D.1.2.2.1 a-f.) (USFWS 2000). Deploying enforcement personnel during peak use periods to monitor rule compliance, enforce trail rules and educate the public would drastically improve overall protection of bighorn

Map 31 - Trails surrounding La Quinta Cove - Recovery Region 3

- Peninsular bighorn sheep data 2014 - May 2021
- Bear Creek Trail
- Boo Hoff Trail
- County Park Trail
- Cove to Lake Trail
- Illegal Social Trails

0   0.325 0.65   1.3 Kilometers

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 San Jacinto and Santa Rosa Mountains. The enforcement of trail rules has been led by the City of Palm Springs via a new city ordinance approved in fall 2019, that prohibits dogs on hiking trails in the San Jacinto and Santa Rosa Mountains (now a finable offence). The Palm Springs Volunteer Trail Rangers have also started parking themselves at popular trailheads to inform the public about the presence of PBS and discuss why hiking with dogs in bighorn habitat poses a risk to bighorn sheep recovery. While a step in the right direction, these enforcement efforts need to expand beyond Palm Spring's city limits.

Urban Development

Urban Development within and adjacent to sheep habitat continue to be a major concern within these 3 recovery regions. In the SJM, the Desert Palisades subdivision continues to construct additional homes on ~110 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 are improperly fenced and or allowed to run loose which can potentially spread disease to the wild sheep population.

In the CSRM, two proposed developments, called Coral Mountain Resort (929 acres) and Travertine (800 acres), came to light in late 2020. These two properties are adjacent to each other and run from Coral Mountain to Madison Street to the east and to the base of the Santa Rosa Mountains to the south and west. These properties are described to be a massive surf park, large stadium-like light system, residential homes, and a hotel. Peninsular bighorn are known to utilize the surrounding Santa Rosa Mountains, including Coral Mountain, and these developments may have a lasting negative impact on the CSRM "wild" sub-ewe group if development occurs.

Use of the Urban Interface

PBS throughout recovery regions 1-3 utilize the urban environment to varying degrees, but this is a major problem in the CSRM. Since 2012, a growing number of bighorn sheep have foraged at PGA West, SilverRock, and Tradition golf courses daily. In April 2017, the City of La Quinta constructed a temporary bighorn sheep exclusion fence along the base of the mountains at SilverRock golf course. Although this fence has minimized (though not fully excluded) sheep use of SilverRock, sheep have drastically increased their use of adjacent urban properties, namely Tradition golf course, PGA West golf course and community, the Quarry at La Quinta golf course, Lake Cahuilla Veterans Regional Park, and Riverside County Sheriff Shooting Range. These urban interfaces provide unlimited availability to food and water in a desert landscape, which has resulted in unnaturally large bighorn herds (60+ individuals) utilizing these properties every day. The congregation of these unnaturally large herds encourages disease spread among individuals, often M.ovi and or contagious ecthyma, and can have major detrimental effects on lamb survival. Furthermore, additional mortalities occur when bighorn consume poisonous plants from community gardens and drown in the Coachella Canal which runs between some of these urban properties and the mountains (see mortality Table 4). This year was also the first time that PBS crossed *onto* 58th Ave., a 45 mi/hr road, accessible by moving into the urban interface through Lake Cahuilla Veterans Regional Park. Bighorn were reported running down 58th avenue on 3 different instances before they found their way back to the park.

The construction of fencing to exclude bighorn sheep from golf courses and residential areas in La Quinta is an important step toward preventing urban related mortalities and enhance efforts toward conservation of sheep in the CSRM. Fortunately, fencing at the urban interface is identified as a site-specific recovery action for the Santa Rosa Mountains south of Highway 74 (i.e., the CSRM) in Section II.D.1.2 of the Recovery Plan (USFWS 2000). After almost 5 years of planning, construction of an additional bighorn exclusion fence in La Quinta is expected to begin fall 2021 and require multiple years to complete. This new fence will extend from the south end of the SilverRock fence and follow along the Coachella Canal to the south end of the PGA West property. The fence will then go up and over the mountain to Lake Cahuilla Veterans Regional Park, following the western boundary to the south and ending the Quarry at La Quinta gated community. This fence is expected to eliminate urban-related bighorn deaths on these developed properties (expect

Tradition golf course, where use will likely increase when the other areas are fenced off), but we also expect that the sudden exclusion of bighorn from their previously relied upon food and water sources will be a tough transition for the bighorn—particularly because this urban sub-ewe group has been relying on these resources exclusively for almost 10 years. 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. It is also unlikely that the desert landscape could biologically support the current and abnormally large herd. Moreover, the fence alignment removes 112 acres of prime, and annually utilized, lamb parturition and rearing habitat, forcing the bighorn to seek new suitable lambing habitat after years of use.

Recovery Regions 4 – 9

In recovery regions 4-9, PBS largely enjoy the protections within state and federal wilderness lands that are not adjacent to a major metropolitan area, as is the case in recovery regions 1 – 3. Regardless, most of the threats to recovery are due to anthropogenic causes including climate change, habitat loss, habitat fragmentation, habitat degradation, human related disturbances, and disease introduced by domestic animals resulting in chronically low lamb-recruitment. Also of concern is predation coinciding with low population numbers. Due to a lack of population surveys over the past 4.5 years it is unknown if any of the recovery regions suffer from concerningly low population numbers.

Habitat Fragmentation

Anthropogenic habitat fragmentation occurs when connectivity is lost due to the construction of roads or fences through PBS habitat. Without a doubt, Interstate 8 and the barrier fence on the U.S./Mexico border pose the greatest threats to functional connectivity within the Peninsular Ranges.

Connectivity is important for maintaining genetic diversity (Epps et al. 2005) and to allow free movement for PBS to reach all resources necessary to sustain life, especially during periods with drought conditions. While there is currently substantial gene flow among PBS populations within and across the U.S./Mexico border (Buchalski et al. 2015), loss of functional connectivity due to anthropogenic barriers will have devastating effects to the viability of the populations.

Roads can act as either semi-permeable barriers or absolute barriers to movement depending on the traffic load and individual sheep behavior. PBS that do cross roads risk injury or death depending on the amount of traffic on the road. Roads that act as barriers, to varying degrees, in recovery regions 4-9 are County Roads S22, S2, S3, Highway 78, and Interstate 8—which constitutes the greatest threat to connectivity. Since 2012, there have been 22 reports of PBS killed on Interstate 8, with 2021 on track to be the deadliest year to date (Table 7). Since 33% of radio-collared ewes killed on the Interstate are not reported, the death toll for the population is likely much higher. As traffic increases on the Interstate, it will no longer be possible for PBS to cross the east-bound lanes and connectivity will be lost.
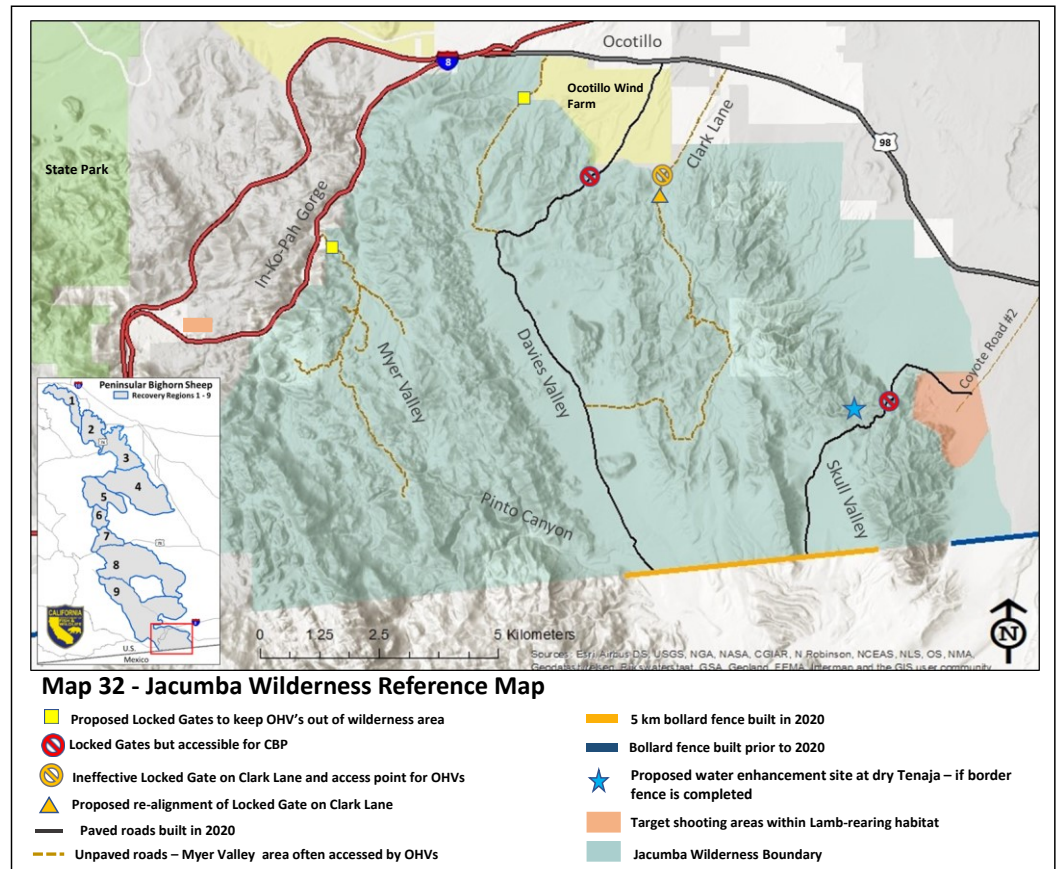
Maintaining and re-establishing connectivity throughout all habitat is listed as a site-specific task (II.D.1.1.3.5, USFWS 2000) that is needed before delisting can occur. A wildlife overpass on the east-bound lanes (along with funnel fencing) and funnel fencing to the underpasses on the west-bound lanes of Interstate 8 are needed to prevent the loss of habitat connectivity between lambing habitat and summer water sources for the In-Ko-Pah ewe group and to maintain connectivity among ewe groups. Extensive GPS data collected since 2009 has identified the most common crossing points where a wildlife overpass would be beneficial to PBS. Moreover, a wildlife overpass feasibility report was conducted by Pattern Energy in 2017 as required mitigation for the Ocotillo Express Wind Farm. Enough information has been gathered and now is the time for action. CDFW staff continues to recommend that USFWS and renewable energy project proponents implement reestablishing connectivity by building wildlife overpasses and funnel fencing along the I-8 In-Ko-Pah Gorge corridor.

Bighorn sheep crossing warning signals is listed as a site-specific action to reduce the extent of vehicular related mortality to PBS (II.D.1.3.1.2). Since building a wildlife overpass over Interstate 8 will take years to complete, flashing warning lights at key locations along both the east and west bound lanes are warranted. County roads S22, S2, S3 and Highway 78 would also benefit from flashing warning lights placed at key PBS crossing points. While these recommendations were made by

the Recovery Plan 22 years ago, they have yet to be executed except on Highway 74. Reduction of the speed limit through specific high-use crossing zones may also reduce PBS mortality if used in conjunction with enforcement and Radar speed feedback signs that alert motorists of their current speed.

Bighorn sheep in the Jacumba Wilderness are dependent on resources both in the U.S. and Mexico. Currently, the border barrier fence in the Jacumba Wilderness has decreased the number of movement corridors by 33%, but sheep are still able to move between the U.S. and Mexico at the western end of their home range (Map 29). If the bollard fence is completed by a future administration, the impacts to the viability of the Jacumba ewe group will be devastating. Additively, when Interstate 8 becomes a complete barrier to movement due to increased traffic, the Jacumba ewe group will be isolated and unable to reach needed resources. Furthermore, the border fence will effectively stop all gene flow between the U.S. and Mexico populations.

In the event that the border fence is ever completed, a plan and funding should already be in place to add an artificial wildlife water system within the Jacumba Wilderness. It is not needed currently with access maintained to Mexico. Careful consideration should be given to the placement of the water source. It should not be placed near the border fence as this would have the potential to increase predation on bighorn sheep by trapping them up against the fence; furthermore, border patrol activities would likely discourage use by bighorn sheep. The best placement would likely be at a tenaja in the southeastern portion of the Jacumba Wilderness that is known to sheep but is dry during the summer months (Map 32).

Map 32 - Jacumba Wilderness Reference Map

- ▪ (yellow square) Proposed Locked Gates to keep OHV's out of wilderness area
- 🚫 Locked Gates but accessible for CBP
- ⊘ Ineffective Locked Gate on Clark Lane and access point for OHVs
- △ Proposed re-alignment of Locked Gate on Clark Lane
- ── Paved roads built in 2020
- ┄┄ Unpaved roads – Myer Valley area often accessed by OHVs
- ▬ (orange) 5 km bollard fence built in 2020
- ▬ (blue) Bollard fence built prior to 2020
- ★ Proposed water enhancement site at dry Tenaja – if border fence is completed
- ▪ (orange shading) Target shooting areas within Lamb-rearing habitat
- ▪ (teal shading) Jacumba Wilderness Boundary

Habitat Loss and Degradation

Loss of habitat is considered to be the most significant threat to the long-term viability of bighorn sheep populations (Bleich et al. 1996). Wind projects, mining operations, and border fence construction within lands administered by the BLM in recovery regions 8 and 9 have all resulted in the physical loss of habitat; however, the effects of climate change are more insidious. Climate change has significantly reduced the amount of available forage within essential habitat over the past 34 years (Hanston et al., 2021). Concurrent with the decline in vegetation, natural water sources in recovery regions 4 and 8 are no longer reliable, and guzzlers are either no longer being maintained or are in dire need of maintenance and repairs.

The majority of PBS habitat in recovery regions 4-9 is within Anza-Borrego Desert State Park; therefore, "the recovery of the species hinges greatly on the successful management of bighorn sheep habitat in this State park" (USFWS 2000, p.

52). The Park was actively engaged in projects to enhance, restore, and protect PBS habitat long before the species was listed. However, a renewed commitment to promote conservation of PBS within the Park boundaries is needed at this time.

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 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 which allowed native plant species to thrive. In order to prevent tamarisk reinfestation, the Park resource crew used pulled tamarisk seedlings from all riparian areas on an annual basis; however, this resource activity is no longer done on a regular basis. As a result, tamarisk are now resurging in numerous areas of the Park such as Sentenac Canyon in recovery region 8, Borrego-Palm and Hellhole Canyons in recovery region 6, all drainages in Coyote Canyon (recovery region 5), and Carrizo Canyon in recovery region 9.

Privately owned Canebrake Canyon provides an important water source for sheep for the south Tierra Blanca sub-ewe group in recovery region 9. 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.

Maintaining existing water sources (both natural and artificial) and providing addition water sources, if water is thought to be a limiting factor, is identified as a site-specific recovery action (Section II.D.1.1.3.4). However, research on carrying capacity is needed to assess whether water enhancement projects would be effective in the long-term in an arid environment with poor quality and quantity forage.
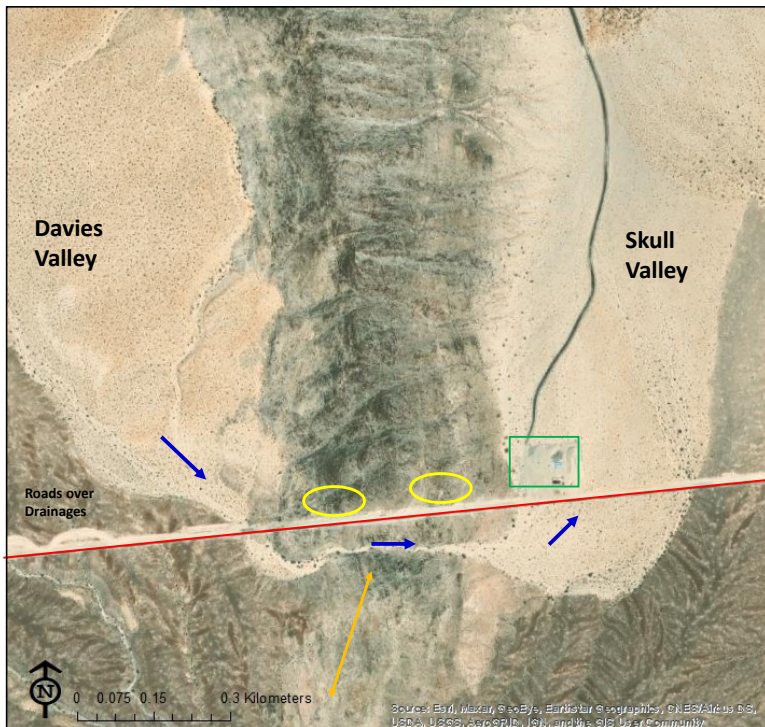
For over 30 years, the Park has maintained 8 guzzler systems for PBS in the Vallecito Mountains in recovery region 8. Lack of regular guzzler maintenance in 2020 resulted in the deaths of several radio-collared sheep (refer to section on radio-collared mortalities, pg. 8) The Park's trustee responsibility to provide water for PBS and maintain guzzler functionality in the Vallecito Mountains is more important now than ever before due to climate change.

The small number of springs and tenajas that serve as water sources for PBS in recovery region 4 are no longer reliable. Radio-collared PBS have responded to the lack of water during the summer months by moving to higher elevations (Map 10). If drought conditions continue these water sources may no longer meet the needs of sheep within this recovery region. Examination of habitat use of radio-collared sheep within the SSRM and placement of cameras at springs will help determine whether water enhancement projects may be warranted.

There are no permanent sources of water in the FCM, and ephemeral sources rarely supply water during the summer months. Despite the lack of permanent water, none of the radio-collared ewes in the past 7.5 years have moved outside of the Fish Creek Mountains (Map 20). This is the only ewe group that has not had any radio-collared ewes killed by mountain lions. Addition of artificial water sources might change this dynamic; therefore, at this time it is not warranted.

The FCM ewe group resides largely outside the protection of BLM wilderness 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 range (Map 20).

The construction of the border fence in the Jacumba Wilderness resulted in significant habitat loss and degradation (Photo 1). Plants that provide forage for PBS were destroyed in the process of building roads and construction staging areas. All major drainages that provide flood waters to plants within Skull Valley and across the border in Mexico were blocked by the border fence and roads (Map 33, Photo 4 & 5). The size and placement of the culverts do not allow water to pass

Map 33 – Bollard Fence – habitat loss & degradation in Jacumba Wilderness

Davies Valley

Skull Valley

Roads over Drainages

0 0.075 0.15   0.3 Kilometers

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Bollard Fence on US/Mexico Border (red line)	**Construction site & road to site, removed vegetation** (green box)
Drainage flow blocked by bollard fence and roads (blue arrow)	
PBS movement pathway blocked (orange arrow)	**Rockfall fencing entrapment hazard for PBS** (yellow circle)

Photo 4. Flood gates built into the bollard fence at the bottom of most, but not all, drainages were to be unlocked and opened during flood events: however, all are welded shut.

Blocked drainage

Culvert pipes

erosion

Base for Lights

Lat: 32.629323°
Long: -115.968414

Photo 5. Construction road paralleling border fence destroyed vegetation and blocks all the drainages. Culvert pipes (red circle) are extremely small diameter and ineffective. Infrastructure for night-lighting is in place.

Photo 6. Rockfall wire fence bolted and draped down a cliff face can entrap bighorn sheep.

under the roads (Photo 5). Storm gates built into the bollard fence that were to be opened during flood events are all soldered shut (Photo 4) and some major drainages have no flood gates. The infrastructure for lighting along the border is in place but not completed (Photo 5). The effects of night lights in lamb-rearing habitat is not known but likely would be deleterious. Rockfall fencing within lambing-habitat is a potential hazard for entrapment of adult bighorn sheep and lambs (Photo 6).

Human Related Disturbance

Illegal incursions by off-highway vehicles (OHVs) within PBS habitat disturbs and displaces PBS and destroys habitat for both bighorn sheep and other animals. Disturbance by OHV are most concerning in the Split Mountain area of Anza-

Borrego Desert State Park. This area is the home for the Vallecito ewe group in recovery region 8. Numerous signs have been placed at the entrance to Split Mountain but without the regular presence of State Park rangers, OHVs will continue to disregard the signs.

The In-Ko-Pah and Jacumba ewe groups in recovery region 9 face increasing challenges posed by human disturbance at renewable energy developments and access roads related to border security and border wall construction and maintenance. Presently, target shooting is allowed on BLM land within the I-8 Island and on the border between BLM Wilderness and BLM multi-use areas. These shooting ranges are within lamb-rearing habitat. 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. It is not known to what extent these activities may alter, discourage, or restrict sheep movement and use of important resources. There have been several instances, documented by the CDFW biologist, when low flying border security helicopters have disrupted normal sheep activities. Exacerbating the situation, recreational OHVs are accessing the Jacumba Wilderness via a jeep trail off Interstate 8 and off Highway 98 (Map 32). Installing locked gates at access points where incursions are occurring will help minimize the disturbance to PBS and destruction of habitat and culturally sensitive sites.

Mountain Spring is an important source of water for bighorn sheep in the In-Ko-Pah ewe group. Mountain Spring is on San Diego County Park land and is adjacent to the west-bound 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 needs to be closed to the public in order to protect the watering rights of bighorn sheep during the summer months.

Use of the Urban Interface

The Palm Canyon ewe group in recovery region 6 continues to increase their use of the de Anza community and golf course. The development poses a threat to the health and survival of sheep in this recovery region due to the following: 1) ingestion of poisonous ornamental plants such as oleander, 2) facilitation of disease spread 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 encourages residence to install safety fences around pools and ponds, replace all toxic plants with native plants, and avoid single-strand wire fences that have resulted in the strangulation of sheep. An 8-foot-tall perimeter fence is the only method that will keep sheep out of the community.

Disease

Disease epizootics (analogous to disease epidemics in humans) are a major limiting factor in restoring large, healthy, wild sheep populations throughout western North America (Singer et al. 2000). Likewise, disease epizootics were the major contributing factor for declines in PBS populations from the 1970s to the mid-1990s (Fredrickson and Mills 2009). Clinical signs of pneumonia (coughing, nasal discharge, droopy ears, lethargy, and weight loss) were first noted in the 1970s in the NSRM and within some areas of Anza-Borrego Desert state park (USFWS 2000). Pneumonia-induced mortality in lambs continues to be a problem throughout the Peninsular Ranges. CDFW and collaborators have actively been investigating the causative pathogen or pathogens and the possible factors that drive the timing, duration, and severity of respiratory disease outbreaks within the Peninsular Ranges.

Predation

Recovery regions 5 and 6 have the highest mountain lion predation rates (both 68%) relative to all other recovery regions. These regions both have extensive riparian corridors with numerous perennial streams for mountain lions to access even during the summer months when predation rates typically drop in most other recovery regions. Over a 4-day period in July 2020, a single mountain lion ambushed and killed 3 bighorn sheep that had come down to drink water at Lower Willows in Coyote Canyon. Due to drought conditions, the water in the creek has receded and bighorn sheep must enter thick willows to access water, which increases their risk of predation. Cutting back vegetation where sheep access water might help decrease predation events. The second highest predation rate is in recovery region 8 (61%) where there are

no perennial creeks but there are 8 guzzlers. State Park volunteers have maintained remote cameras at the guzzler since 2015. Reviewing these photos might help assess the timing of mountain lion visitation at guzzlers relative to mountain lion predation events and whether turning off guzzlers during the winter months might decrease predation events in this region.

ACKNOWLEDGMENTS

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