CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

PENINSULAR BIGHORN SHEEP 2012 ANNUAL REPORT

AND RECOVERY PROGRAM REVIEW 1993 - 2012

A cooperative effort by the California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and California Department of Parks and Recreation

This report presents information on the status, distribution, and management of peninsular bighorn sheep in eastern San Diego County and portions of Riverside and Imperial Counties, California

Report prepared by Janene Colby and Randy Botta

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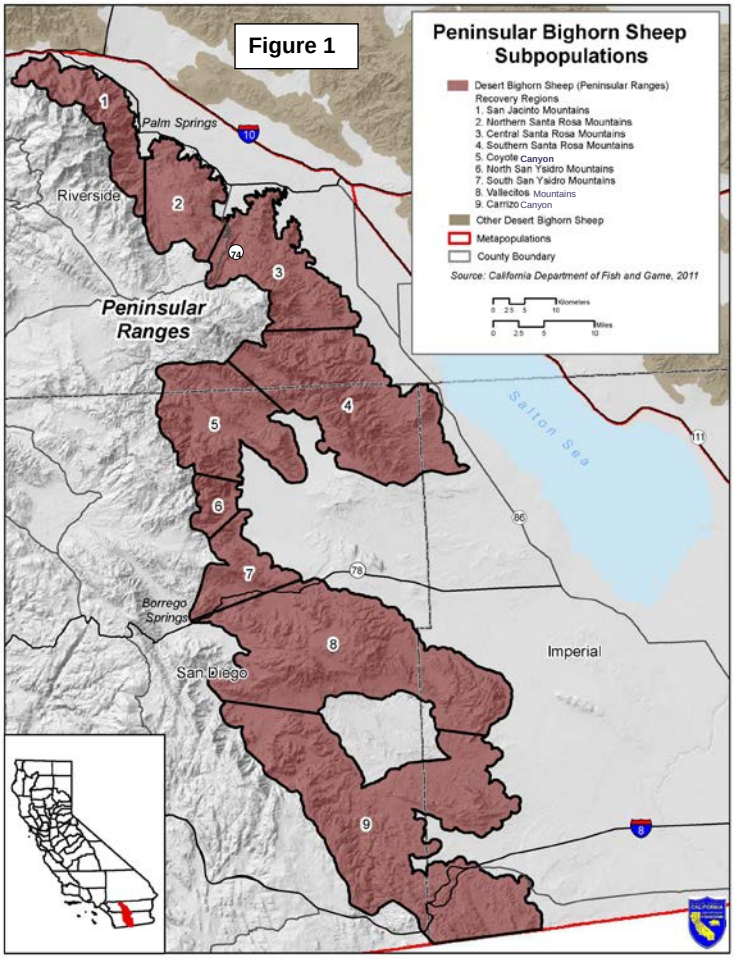
BACKGROUND

This report highlights information collected by the California Department of Fish and Wildlife (CDFW) on bighorn sheep (*Ovis canadensis nelsoni*) capture and radiocollaring, cause specific mortality and survival, distribution and movement, and percentage of collared bighorn sheep in the Peninsular Mountain Ranges of southern California from 1 January 2012 through 31 December 2012. The report also provides population estimates from 1994 – 2010 for 7 recovery regions, cause specific mortality and survival rates of collared females from 1993 – 2012 for 5 recovery regions, and lamb survival and recruitment from 2008 – 2012 for 4 recovery regions. A discussion of current recovery threats and management strategies in 7 recovery regions is also included.



The Peninsular bighorn sheep population contains nine designated recovery regions occupying portions of western Riverside and Imperial Counties and eastern San Diego County (Figure 1). CDFW conducted monitoring activities in seven of nine recovery regions located east of Highway 74: Central Santa Rosa Mountains (CSRM), Southern Santa Rosa Mountains (SSRM), Coyote Canyon (CoC), Northern San Ysidro Mountains (NSYM), Southern San Ysidro Mountains (SSYM), Vallecito Mountains (VM), and Carrizo Canyon (CC). CDFW jointly monitored CSRM with the Bighorn Institute (BI), while the Northern Santa Rosa Mountains (NSRM) and San Jacinto Mountain (SJM) recovery regions located west of Highway 74 were monitored solely by BI.

CDFW conducted ground monitoring of radiocollared sheep weekly in the CoC, NSYM, and SSYM recovery regions and twice monthly in CC. Ground monitoring of collared sheep in the CSRM, SSRM, and VM occurred as opportunity allowed. Ground monitoring efforts were focused on: 1) detection of mortality signals from collared sheep, 2) recording locations of collared sheep moving between recovery regions, and 3) observation of lambs associated with collared females to determine survival. Aerial telemetry monitoring was conducted from a Vulcanair Partenavia P68 fixed-winged aircraft for all recovery regions one to three times per month. Aerial flights were used to monitor collared sheep for mortality and track movements.

As part of the on-going Peninsular Ranges bighorn sheep monitoring and recovery program and U.S. Customs and Border Patrol (CBP) border monitoring project, CDFW in cooperation with the U.S. Fish and Wildlife Service (USFWS) conducted a bighorn sheep capture during November 2012 within the CC recovery region. A range-wide bighorn sheep helicopter survey typically undertaken in even

numbered years was not conducted during the 2012 reporting period. However, this report will utilize survey estimates from 1994 to 2010 to summarize long-term demographic trends in each of the recovery regions managed by CDFW.

PERSONNEL

CDFW Resource Management and Air Services Divisions

Oversight for recovery of peninsular bighorn sheep in 2012 was provided by Mr. Steve Torres, Environmental Program Manager and Dr. Ben Gonzales, Senior Wildlife Veterinarian with the Department's Resource Management and Policy Division. Dr. Gonzales also acted as veterinary coordinator on capture operations and population health and disease issues. Mr. Tom Evans, Warden/Pilot for the Department's Air Services Division piloted all aerial telemetry flights.

CDFW South Coast Region, Wildlife Management Program

Mr. Randy Botta, Senior Wildlife Biologist for the South Coast Region, provided oversight for field monitoring activities, assisted with aerial telemetry flights and supervised one field position working east of Highway 74. Field telemetry monitoring, mortality investigation, and reporting were carried out by Ms. Janene Colby, Environmental Scientist with the South Coast Region.

RECOVERY PROGRAM OVERVIEW

Activities conducted during 2012 were tied to recovery elements contained in the Recovery Plan for Bighorn Sheep in the Peninsular Ranges, California (USFWS 2000: Section II.). Section II of the recovery plan addresses the need to "Initiate or continue research programs necessary to monitor and guide recovery efforts". Activities conducted in 2012 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.

Capture and Radiocollaring

As part of the on-going Peninsular Ranges bighorn sheep monitoring and recovery program and CBP border monitoring project, CDFW in cooperation with the USFWS conducted a bighorn sheep capture during November 2012 within the CC recovery region. The project objective was to capture and fit Very High Frequency (VHF) and Global Positioning System (GPS) radiocollars to a subset of adult male and female bighorn sheep in CC to: 1) increase the number of collared females and add collared males to identify whether human activities modify movement and behavior, 2) maintain collars on approximately 30% of the female population for mark-resight surveys by collaring new females and replacing collars that were no longer functional, 3) better define the timing and movement patterns of bighorn sheep crossing the west and east bound lanes of Interstate 8 (I-8), 4) determine the timing and movement patterns of bighorn sheep crossing into and out of Mexico, and 5) better define sheep distribution and ewe group structure.

Helicopter capture activities were conducted by Leading Edge Aviation under contract with USFWS. Captured bighorn sheep were transported via helicopter to a base camp where they were processed and radiocollared by CDFW personnel. CDFW personnel received support and assistance from USFWS, Bureau of Land Management (BLM), and CBP. A total of 20 bighorn sheep (n = 6M/14F) were captured and collared during the two day operation. On 1 November, capture activities were conducted

in the area surrounding In-Ko-Pah Gorge and Mountain Springs. A total of 14 bighorn sheep (n = 4M/10F) were captured and fitted with collars (5 females originally radiocollared in 2009 were re-collared). Additionally, an 11-month-old female lamb and a yearling female were captured but due to their size collars were not fitted and they were released with ear tags only. On 2 November, capture activities were conducted in the area surrounding Carrizo Gorge: a total of 6 bighorn sheep (n = 2M/4F) were captured and fitted with collars (3 females originally collared in 2009 were re-collared). All bighorn sheep were released without incident and there were no capture related deaths. One-month post-capture no mortalities were detected and visual observations found all sheep in good condition.

Funding for helicopter capture services and 8 radiocollars was provided by CBP. Funding for 12 radiocollars was provided by CDFW, South Coast Region Wildlife Program.

Population Monitoring

As recommended in the recovery plan for peninsular bighorn sheep, CDFW maintains, to the extent possible, active VHF radiocollars on approximately 25-30% of all females in each recovery region. Maintaining at least 25% collared females is important for generating reliable mark-resight population estimates based on helicopter surveys. Since 1993, CDFW has conducted helicopter surveys in the fall of even numbered years and captures to fit needed collars on sheep during the fall of odd numbered years; however, no captures were conducted in 2011, and in 2012 only sheep in CC were fitted with collars. Furthermore, an anticipated range-wide helicopter survey was not conducted in 2012 due to lack of a CDFW helicopter contract. As a result, all 7 recovery regions (CSRM, SSRM, CoC, NSYM, SSYM, VM and CC) fell well below the recommended percentage of marked females. At the beginning of the 2012 reporting period the 7 recovery regions east of Highway 74 contained a total of 73 (4M/69F) active collars and at the end of 2012 there were a total of 63 (8M/55F) active collars. Collars were lost through mortality in the CSRM, CoC, NSYM, SSYM, and VM while collars became non-functional in the NSYM, VM, and CC. The number of collars fitted to males and females and the percentages of marked females in each recovery region at the beginning and end of 2012 are listed in Table 1 below.

Table 1. Distribution and numbers of radiocollars for female (F) and male (M) bighorn sheep within recovery regions east of Highway 74 at the beginning and end of 2012. The estimated percentage of females radiocollared (% F Collared) at the end of 2012 is based on the ewe abundance estimates from the 2010 range-wide helicopter survey.

	CSRM		SSRM		CoC		NSYM		SSYM		VM		CC	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M
1/1/2012	9	0	1	0	15	1	10	0	10	2	7	1	17	0
additions	0	0	0	0	0	0	0	0	0	0	0	0	6	6
recollared	0	0	0	0	0	0	0	0	0	0	0	0	(8)	0
mortalities	-1	0	0	0	-2	0	-3	0	0	-1	0	-1	0	0
censored	0	0	0	0	0	0	-3		0	0	-3	0	-8	0
12/31/2012	8	0	1	0	13	1	4	0	10	1	4	0	15	6
% F Collared	11%		1%		28%		10%		28%		5%		11%	

Specific monitoring objectives undertaken in 2012 as described in the recovery plan for peninsular bighorn sheep were:

1. Monitor the status, dynamics, and trends of bighorn sheep.

2. Determine distribution and movement patterns of adult sheep. Identify whether or not there is significant movement of ewes within, and between recovery regions. Determine locations, timing, and frequency of road crossing points within and among recovery regions.

3. Monitor adult survivorship and cause-specific mortality. Continue to collect data in a manner that will allow comparison of survivorship and cause-specific mortality among recovery regions, years, and management strategies.

4. Identify and monitor disease, pathogens and vectors that may be limiting adult productivity and lamb survivorship.

Population Size and Estimation

All population estimates presented focus on female (ewe) bighorn sheep since they are the reproductive base of the population and recovery goals center on maintaining 25 females within each recovery region for 12 consecutive years. Although the 2012 helicopter survey was not conducted, range-wide and individual female group size and lamb:ewe ratios (lambs per 100 females) based on previous helicopter surveys are included in this report to summarize long-term trends in abundance estimates. Yearling:ewe ratios based on helicopter surveys are not included in this report due to unreliability stemming from the difficulty of observers to distinguish yearling females from yearling males and adult females from the air. Results of the July 2012 Anza-Borrego Desert State Park (ABDSP) waterhole count for specific sites within the SSRM, CoC, NSYM, and SSYM recovery regions is also provided.

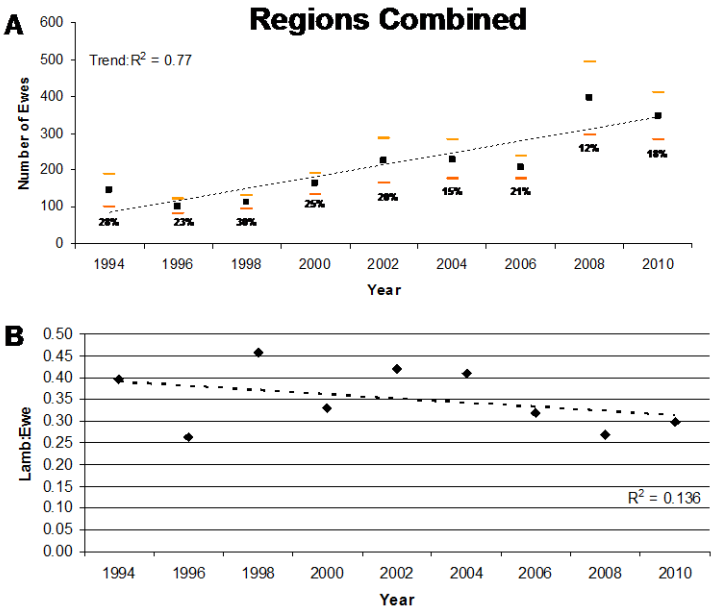


Figure 2–A. Overall ewe abundance estimates (includes yearling females) of seven recovery regions (black squares), based on CDFW biennial helicopter surveys conducted from 1994 through 2010 (excluding the Santa Rosa and San Jacinto Mountains). Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate. The estimated percent of the ewe population radiocollared during each survey year is beneath each abundance estimate. The black dashed line represents the trend.

Figure 2-B. Lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010 (excluding the Santa Rosa and San Jacinto Mountains). The black dashed line represents the trend.

The overall range-wide female abundance estimates from 1994 through 2010 (excluding the San Jacinto and Santa Rosa Mountains) exhibited a stable to increasing population (mean = 214.2 $\pm$ 33.7 SD; range 102 – 395). However, female abundance in 2008 was most likely overestimated (Figure 2-A) based on the large confidence intervals associated with the estimate. Large confidence intervals result when the percent of marked sheep in the population are low in conjunction with observing few marked sheep during surveys. Lamb:ewe ratios since 1994 appear stable (mean = 0.35 $\pm$ 0.07 SD; range 0.26 – 0.46) and have only twice fallen below the desired index of 30% lamb survival (Figure 2-B).

Central Santa Rosa Mountains: The 2010 CDFW helicopter survey estimated 71 (95% CI: 61.7 – 81.3) females in this recovery region and it has remained stable from 2006 to 2010 (2006 & 2008 estimates were provided by Bighorn Institute and methods may vary from CDFW). From 2006 to 2010, the lamb:ewe ratio remained above 35% and had increased to 51% in 2010. ABDSP does not conduct an annual waterhole count within this recovery region.

Southern Santa Rosa Mountains: The 2010 CDFW helicopter survey estimated 84 (95% CI: 47.4 – 121.4) females in this recovery region and it has remained stable from 2006 to 2010 (2006 & 2008 estimates were provided by Bighorn Institute and methods may vary from CDFW). From 2006 to 2010, the lamb:ewe ratio has remained above 20% and was 27% in 2010. The July 2011 ABDSP waterhole count conducted at Rattlesnake Spring detected 84 sheep (14M/43F/27L) with a lamb:ewe ratio of 69%. The number of sheep detected during the 2012 waterhole count decreased almost by half to 43 sheep (12M/20F/11L) with a lamb:ewe ratio of 58% (Count results do not cover all water sources in this region).

Coyote Canyon: The CoC female abundance estimates from 1994 through 2006 remained stable at above 20 females (mean = 26.2 ± 8.0 SD; range 21 – 46: Figure 3-A) and has increased above 30 females in the past 2 survey efforts; however, the variance for the 2010 estimate was large and the estimate is most likely inflated. Another indication that this estimate may be inflated is the Catch-Per-Unit-Effort (CPUE) index for 2010 which indicated a decline from 2008 rather than an increase. CPUE is a measure of the number of sheep observed during a survey divided by the number of hours

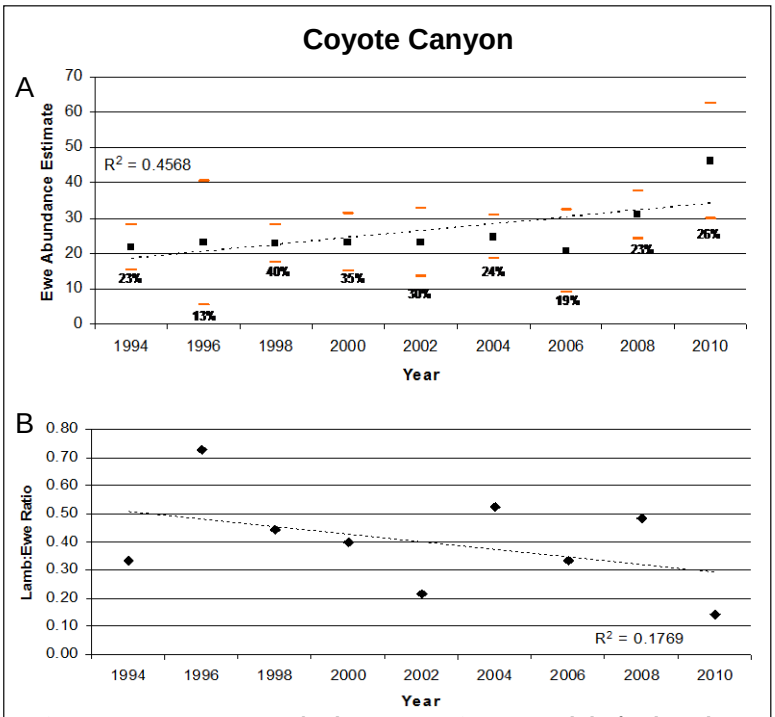


Figure 3-A. Coyote Canyon ewe abundance estimates (ewe count includes female yearlings: black squares), based on CDFW biennial helicopter surveys conducted in the fall from 1994 through 2010. Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate. The estimated percent of the ewe population radiocollared during each survey year is beneath each abundance estimate. The black dashed line represents the trend.
Figure 3-B. Coyote Canyon lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010. The black dashed line represents the trend.

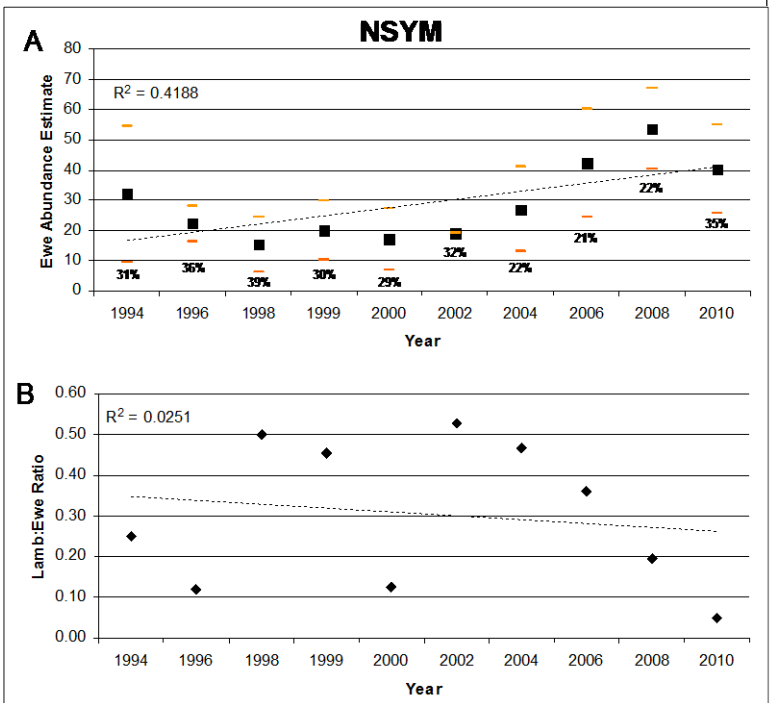


Figure 4-A. NSYM ewe abundance estimates (ewe count includes female yearlings: black squares), based on CDFW biennial helicopter surveys conducted in the fall from 1994 through 2010. Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate. The estimated percent of the ewe population radiocollared during each survey year is beneath each abundance estimate. The black dashed line represents the trend.
Figure 4-B. NSYM lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010. The black dashed line represents the trend.

spent searching. CPUE can be used to validate the integrity of the mark-resight population estimate. The CPUE for 2010 was 7.18 (41 sheep were observed in 5.71 flight hours), in contrast the 2008 CPUE was 11.11 (53 sheep observed in 4.71 flight hours). Lamb:ewe ratios have remained well above 30% except in 2002 and 2010 (mean = 0.40 ± 0.17 SD; range 0.14 – 0.73: Figure 3-B). The July 2011 ABDSP waterhole count in Lower, Middle, and Upper Willows, Box Canyon, and Monkey Hill areas detected 97 sheep (26M/57F/14L): results indicated a lamb: ewe ratio of 25%. The 2012 ABDSP waterhole count gave very similar results and detected 101 sheep (26M/59F/16L): the lamb:ewe ratio was 27% (Count results do not cover all water sources in this region).

Northern San Ysidro Mountains: The NSYM female abundance estimate has increased steadily since 2002 with numbers well above 25 females since the 2006 survey (mean = 28.8 ± 12.8 SD; range 15 – 54: Figure 4-A). In contrast, lamb:ewe ratios have shown a steady decline over 4 helicopter survey efforts from a high of 53% in 2002 to only 5% in 2010 (mean = 0.30 ± 0.18 SD; range 0.05 – 0.53: Figure 4-B). The July 2011 ABDSP waterhole count in Borrego Palm Canyon and Hellhole Canyon detected 70 sheep (22M/45F/3L): results indicated a lamb:ewe ratio of 7%. The 2012 ABDSP waterhole count detected 64 sheep (24R/30F/10L): the lamb:ewe ratio was much higher than 2011 at 33% (refer to section on Lamb Survival for more details).

Southern San Ysidro Mountains: The SSYM female abundance estimate has remained stable and has maintained >22 females since 1998 (mean = 26.7 ± 9.1 SD; range 12 – 42: Figure 5-A). While lamb:ewe ratios have declined from a high of 74% in 1994, they have remained well above 30% in most years and have yet to dip below 20% (mean = 0.40 ± 0.16 SD; range 0.21 – 0.75: Figure 5-B). The July 2011 ABDSP waterhole

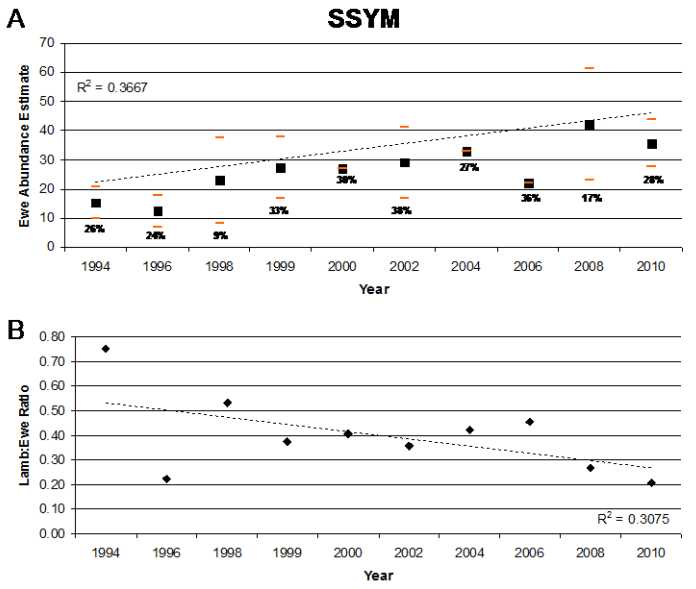


Figure 5-A. SSYM ewe abundance estimates (ewe count includes female yearlings: black squares), based on CDFW biennial helicopter surveys conducted in the fall from 1994 through 2010. Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate. The estimated percent of the ewe population radiocollared during each survey year is beneath each abundance estimate. The black dashed line represents the trend.
Figure 5-B. SSYM lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010. The black dashed line represents the trend.

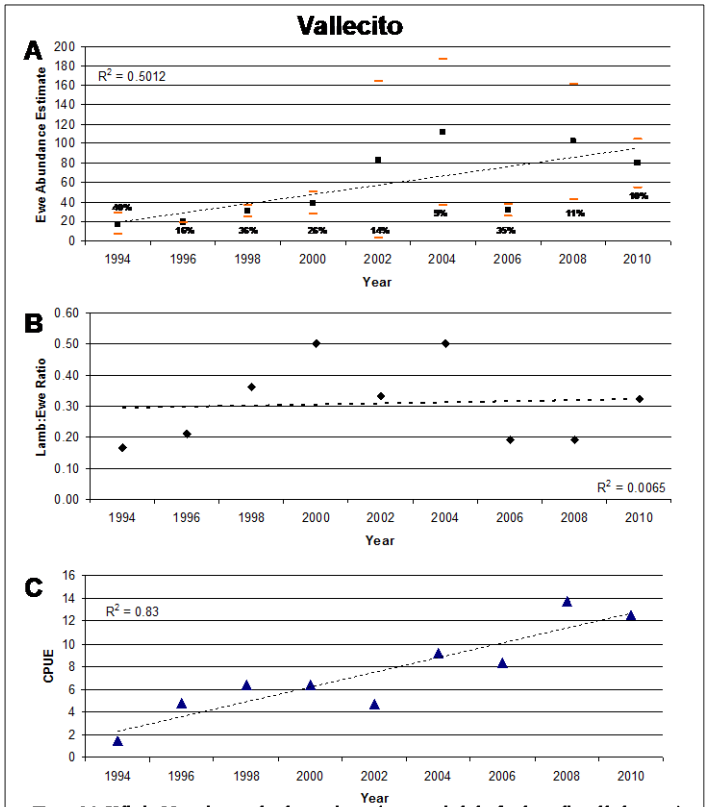


Figure 6-A. Vallecito Mountains ewe abundance estimates (ewe count includes female yearlings: black squares), based on CDFW biennial helicopter surveys conducted in the fall from 1994 through 2010. Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate (orange asterisk above the 2008 estimate represents the upper confidence interval of 797). The estimated percent of the ewe population radiocollared during each survey year is next to each abundance estimate. The black dashed line represents the trend.
Figure 6-B. Vallecito Mountains lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010. The black dashed line represents the trend.
Figure 6-C. Catch-per-unit-effort (CPUE) is an index that measures the number of sheep observed during a helicopter survey divided by the number of hours spent searching (blue triangles). The black dashed line represents the trend.

count in Tubb Canyon and on Montezuma Grade detected 76 sheep (37M/27F/12L): results indicated a lamb:ewe ratio of 44%. The 2012 ABDSP waterhole count detected 54 sheep (23R/23F/8L): the lamb:ewe ratio was 35% (count results do not cover all water sources in this region).

Vallecito Mountains: Female abundance estimates have varied greatly from 2002 through 2010 due to a combination of low numbers of marked sheep in conjunction with observing few marked animals during survey efforts (Figure 6-A). However, the overall trend is increasing and has remained above 30 females since 1998 (mean = 57.2 ± 37.0 SD; range 18 – 112). This increasing trend is validated with concurrent increases in CPUE indices (Figure 6-C). Lamb:ewe ratios have vacillated each year but average around 30% (mean = 0.31 ± 0.13 SD; range 0.17 – 0.50: Figure 6-B). ABDSP does not conduct waterhole counts in the VM. Remote cameras were placed within this recovery region during the summer of 2012 in a joint effort between ABDSP and CDFW. Currently, a method is being developed to analyze these data to obtain an estimate for female abundance, lamb:ewe and yearling:ewe ratios for 2012.

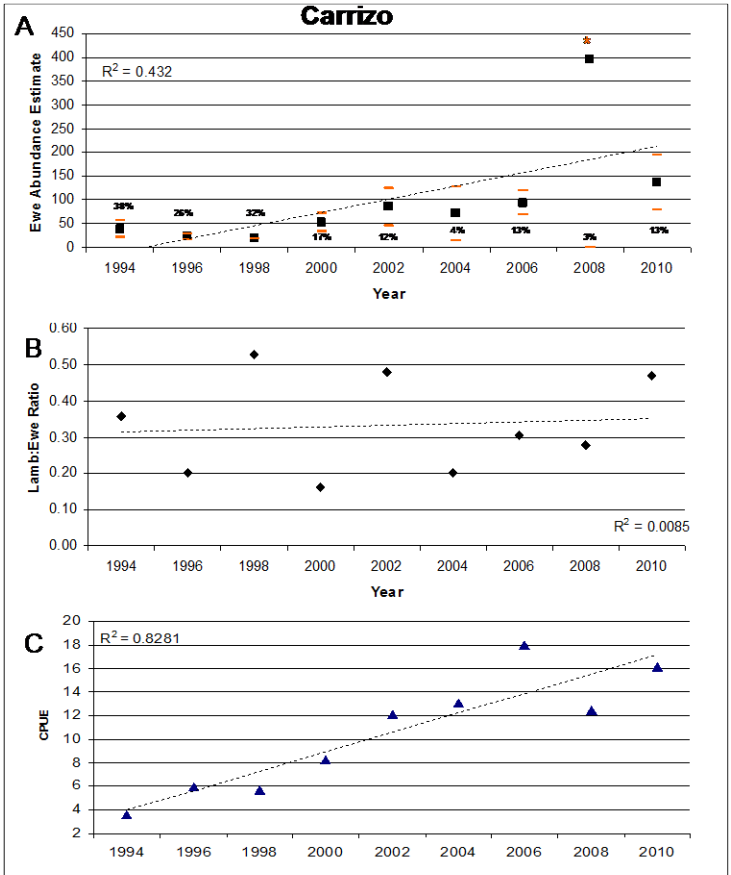


Figure 7-A. Carrizo Canyon ewe abundance estimates (ewe count includes female yearlings: black squares), based on CDFW biennial helicopter surveys conducted in the fall from 1994 through 2010. Orange vertical lines depict the upper and lower 95% confidence intervals for each estimate (orange asterisk above the 2008 estimate represents the upper confidence interval of 797). The estimated percent of the ewe population radiocollared during each survey year is next to each abundance estimate. The black dashed line represents the trend.
Figure 7-B. Carrizo Canyon lamb to ewe ratio (ewe count includes female yearlings: black diamonds), based on CDFW biennial helicopter surveys conducted from 1994 through 2010. The black dashed line represents the trend.
Figure 7-C. Catch-per-unit-effort (CPUE) is an index that measures the number of sheep observed during a helicopter survey divided by the number of hours spent searching (blue triangles). The black dashed line represents the trend.

Carrizo Canyon: Female abundance estimates have been well above 25 females since 2000; however, the number of marked females has been below 14% since 2002 and as low as 3% in 2008 which resulted in an inflated population estimate for that year (mean = 101.8 ± 116.0 SD; range 19 – 395: Figure 7-A). A high CPUE would validate the high female abundance estimate for 2008; but instead, the CPUE was even lower than in 2006 or 2010 (Figure 7-C). For 2008, a rough estimate of approximately 100 females would match the current trend in female abundance for this recovery region. Lamb:ewe ratios have vacillated around 30% and for the past 3 survey years has shown a steady increase (mean = 0.33 ± 0.14 SD; range 0.16 – 0.53: Figure 7-B). There are no current estimates of female abundance and ABDSP does not conduct waterhole counts within CC.

Distribution and Movement

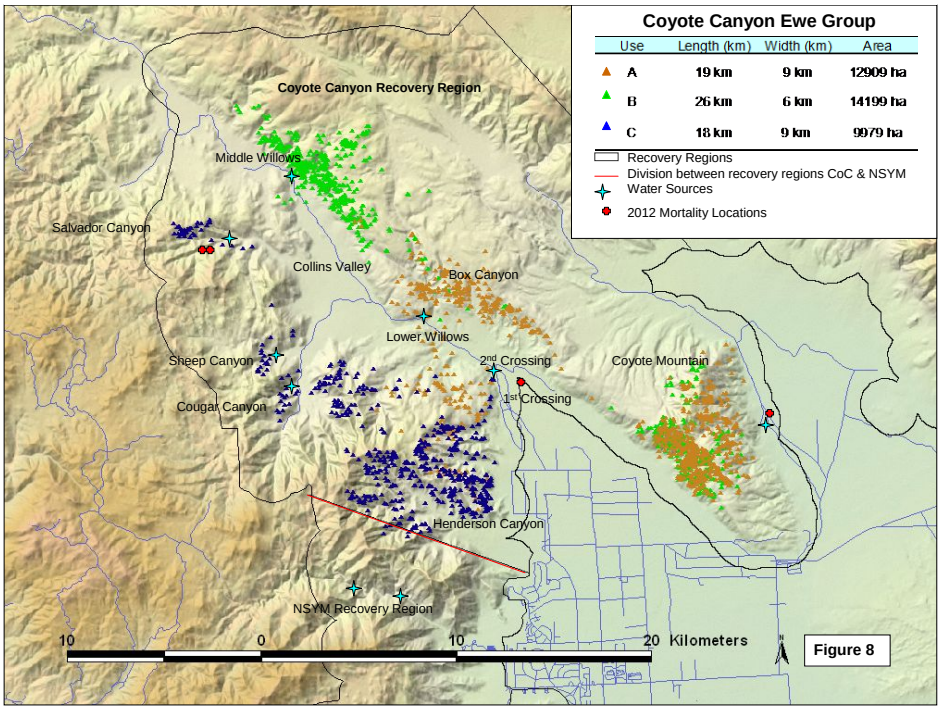
During 2012, CDFW monitored 73 adult radiocollared bighorn sheep in seven recovery regions located east of Highway 74 to document habitat use, distribution, and movement. Patterns of use were similar to those reported in 2011 for CoC, NSYM, SSYM, VM and CC. Bighorn Institute monitored, by ground, movements of collared sheep within the CSRM. Field staff detected collared and un-collared bighorn sheep of various age classes and sex moving between recovery regions and between different geographic areas in the same recovery region. CDFW documented movements of females, and younger

females in particular, from the NSYM to CoC and between the VM and SSYM. These movements appear to be regular seasonal movements rather than short exploratory bouts. Movements across two-lane highways in the NSYM, SSYM, and VM and across I-8 in CC were documented. The frequency of movement across roads increased during the rut and during the lambing season in all recovery regions.

Central Santa Rosa Mountains: CDFW monitored 9 radiocollared female bighorn sheep twice monthly by air in this recovery region. Throughout 2012, collared sheep were primarily documented inhabiting the La Quinta and Martinez Canyon areas of the CSRM. A nine-year-old collared female was detected on mortality in Martinez Canyon in October and died of unknown causes. The remaining 8 collars are expected to become non-functional before the end of 2013 leaving no active collars within this recovery region. Without the presence of marked animals future estimates of abundance, documentation of movements, and determination of cause-specific mortality will not be possible.

Southern Santa Rosa Mountains: CDFW monitored 1 radiocollared female bighorn sheep twice monthly by plane in this recovery region. Six collars became non-functional in 2011 and it is expected that the remaining collar will become non-functional within the first 6 months of 2013 leaving no active collars for this recovery region. Without the presence of marked animals future estimates of abundance, documentation of movements, and determination of cause-specific mortality will not be possible.

Coyote Canyon: CDFW monitored 16 radiocollared bighorn sheep in this recovery region (1M/15F). Aerial monitoring was conducted one to two times per month with ground monitoring occurring at least once a week. The average age of collared females in 2012 was 8 years with a range evenly dispersed from 4 - 13 years. A 10-year-old female died of unknown causes in July in Salvador Canyon, and a 9-year-old female was found dead of unknown causes within a gravel-pit operation at the eastern base of Coyote Mountain. At the end of 2012, 14 collars remained active (1M/13F).



There were 3 general patterns of use by females within the Coyote Canyon Recovery Region (Figure 8):

A. Coyote Mountain - Lower Willows - North Henderson - Females in this group used Coyote Mountain most frequently during the lambing season. Summer and fall months were spent

near water sources at Lower Willows in Box Canyon and areas north of Henderson Canyon. The size of this use area is approximately 19 km x 9 km and encompasses 12,909 ha.

B. Coyote Mountain - Middle Willows - This group of females also used Coyote Mountain for lambing; however, there was little use of the Box and Henderson Canyon areas in the fall and summer. Instead, summer and fall months were mainly spent on the east slopes above Upper Willows in Coyote Canyon where water was present. The size of this use area is approximately 26 km x 6 km and encompasses 14,199 ha.

C. North Henderson – Collins Valley - This group of females did not use Coyote Mountain during the lambing season but instead used the areas surrounding Henderson Canyon (most likely on the south-facing slopes); however, a female found dead in February appeared to be moving from the NSYM to Coyote Mountain across the flats (Figure 8: mortality site near 1st crossing). Typically, during summer, water is accessed at Lower Willows, Cougar, Sheep, and Salvador Canyons, and 2nd crossing; however, in 2012 Coyote Creek ran past 1st crossing. None of these collared females were documented using water within Borrego Palm Canyon in the NSYM. The size of this use area is approximately 18 km x 9 km and encompasses 9,979 ha.

Northern San Ysidro Mountains: CDFW monitored 10 radiocollared females, 2 ear-tagged males, and 1 ear-tagged female within this recovery region. The average age of marked females in 2012 was 9 years with a range of 4 to 14 years. Monitoring was conducted by air two times per month with ground monitoring occurring at least once a week. Opportunistic observations were obtained for ear-tagged sheep. Three collared females were lost due to mortalities and 3 collars became non-functional. Two of the remaining 4 collars are expected to become non-functional before the end of 2013. Without an adequate number of marked animals future estimates of abundance, determination of cause-specific mortality, and documentation of disease and movements will be difficult if not impossible.

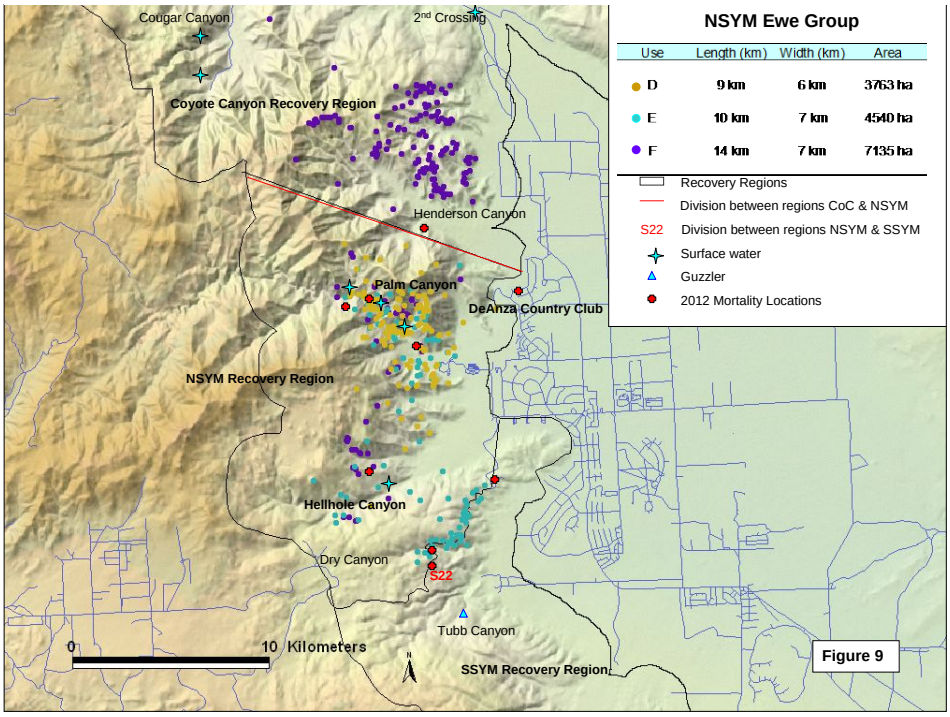


Figure 9

There were 3 general patterns of use within the Northern San Ysidro Mountains Recovery Region (Figure 9):

D. Borrego Palm Canyon – Hellhole Canyon – Habitat use for this group of females was concentrated within Borrego Palm Canyon (BPC) with some use in Hellhole Canyon. The

size of this use area is approximately 9 km x 6 km and encompasses 3,763 ha. In 2012, this group's nursery grounds were primarily on south-facing slopes in the upper reaches of BPC. Females were observed leaving their lambs within the nursery grounds and crossing the canyon to forage within a recent burn (2011 Eagle wildland fire) on the north-facing slopes. Water can be found at numerous locations along the canyon bottom and sheep used these areas to obtain water in the summer and fall months. However, in 2009, sheep began shifting fall use from areas surrounding the creek within BPC to foraging at the DeAnza Country Club golf course and surrounding homes. Each year since 2009, sheep have increased their use of this area in terms of the length of seasonal use and time spent each day within the development. In 2012, groups of 10 to 32 sheep (including four 10-month-old lambs) used the DeAnza development on a daily basis from early September through December (see section on *Threats and Concerns*).

E. Borrego Palm Canyon – Hellhole Canyon – Dry Canyon – Since 2009, fewer females in this group have been documented using Dry Canyon for lambing and as a nursery ground during the winter and spring. Water is obtained mainly in Hellhole Canyon during the summer and fall with occasional use in BPC. One radiocollared female switched from utilizing the SSYM to year-round use within this portion of the NSYM recovery region. The females that utilized Dry Canyon during the lambing season crossed Highway S22 on a regular basis. Males more typically crossed this road during the rut. Presently, none of the collared females have been documented using DeAnza Country Club. The size of this use area is approximately 10 km x 7 km and encompasses 4,540 ha.

F. Hellhole Canyon to Henderson Canyon – Two young radiocollared females used the areas surrounding Hellhole Canyon and BPC in summer and fall and then switched use to areas surrounding Henderson and Sheep Canyon (within the CoC recovery region) during the spring. The size of this use area is approximately 14 km x 7 km and encompasses 7,135 ha. The predominance of younger females in this group may account for the large area used relative to the females in BPC.

Southern San Ysidro Mountains: CDFW monitored 12 radiocollared bighorn sheep in this recovery region (2M/10F) as well as 2 ear-tagged females, and 1 non-functioning collared-female. The average age of marked females in 2012 was 9 years with a range of 6 to 16 years. Monitoring was conducted by air twice a month with ground monitoring occurring at least once a week. Opportunistic observations were obtained for ear-tagged and non-functioning

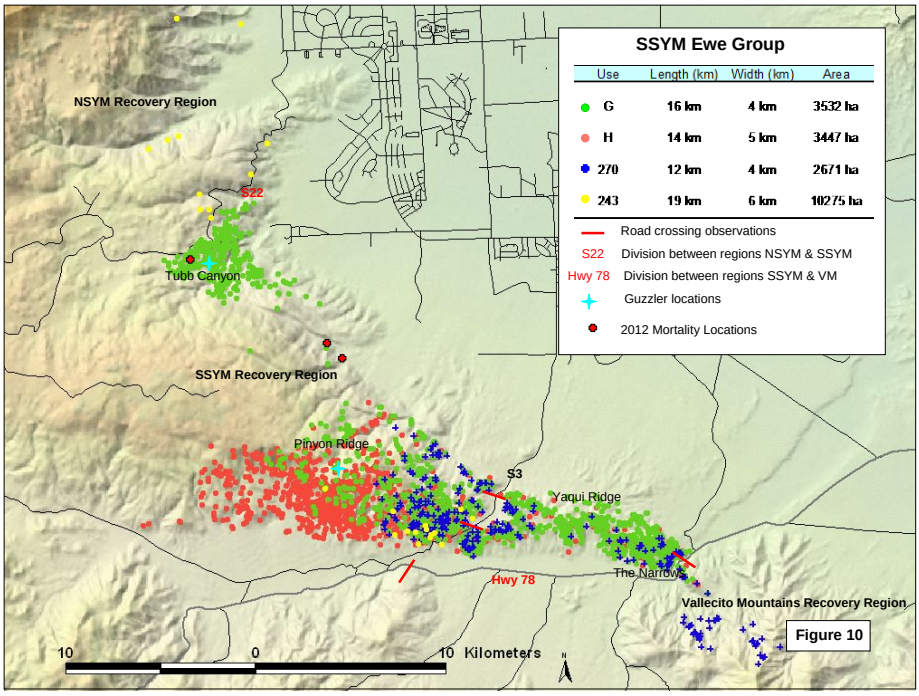


Figure 10

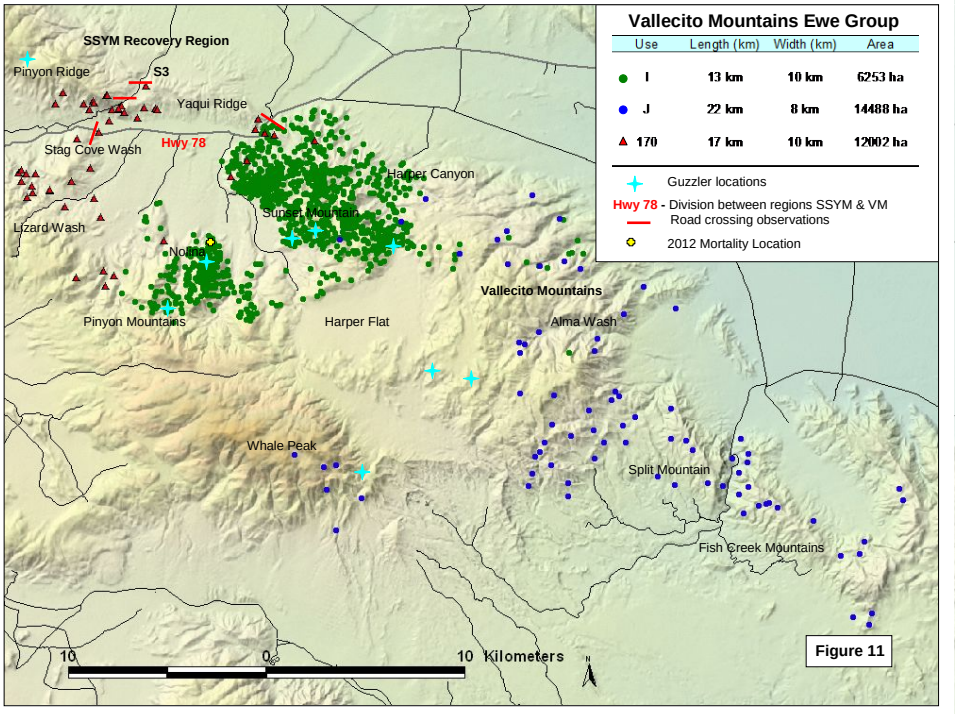
collared sheep. One collared male was lost due to mortality, resulting in 11 collared animals at the end of 2012. Without an adequate number of marked animals future estimates of abundance, determination of cause-specific mortality, and documentation of disease and movements will be difficult.

There were 2 main patterns of movement and use within the Southern San Ysidro Mountains Recovery Region (Figure 10):

G. Tubb Canyon – This group of females used the Tubb Canyon area during the summer and fall. Upon the onset of winter, and just prior to lambing season these females moved to Pinyon and Yaqui Ridge. Lambing occurred on Pinyon and Yaqui Ridge with one central area on Pinyon Ridge used for the nursery grounds. The size of this use area is approximately 16 km x 4 km and encompasses 3,532 ha. Past monitoring has revealed that in the spring, females from this group may cross Highway 78 at the narrows into the VM recovery region. Time spent in the VM was usually brief, lasting anywhere from one to three days.

H. Pinyon Ridge – This group of females used the area surrounding Pinyon Ridge during summer and fall. There are two reliable sources of water in this recovery region: the Tubb Canyon guzzler and several natural springs in an adjacent canyon, and the Pinyon Ridge Guzzler. It is not clear where females in this group obtain water as they have not been captured by remote cameras placed at the Tubb Canyon and Pinyon Ridge guzzlers in 2011 or 2012, nor have they been documented using the springs surrounding Tubb Canyon according to past GPS data and visual observations. Yaqui Spring may be a possible source; however, there has been no evidence of recent sheep use and the water is virtually inaccessible due to surrounding dense vegetation. Several of these females have previously been documented crossing Highway 78 at the Narrows into the VM recovery region for several days at a time. One radiocollared female crossed Highway 78 at the Narrows to give birth and eventually crossed back into the recovery region to join the nursery group on Pinyon Ridge. Home range size for this group is 14 km x 5 km and encompasses 3,447 ha.

Vallecito Mountains: CDFW monitored 8 adult radiocollared bighorn sheep in this recovery region (1M/7F). Monitoring was conducted by air twice a month and ground monitoring occurring as opportunity allowed. One male died of unknown causes over the summer and 3 collars became non-functional. Only 4 collars remained functional at the end of 2012 with 2 predicted to become non-functional in 2013. The average age of collared females in 2012 was 11 years with a range of 4 to13



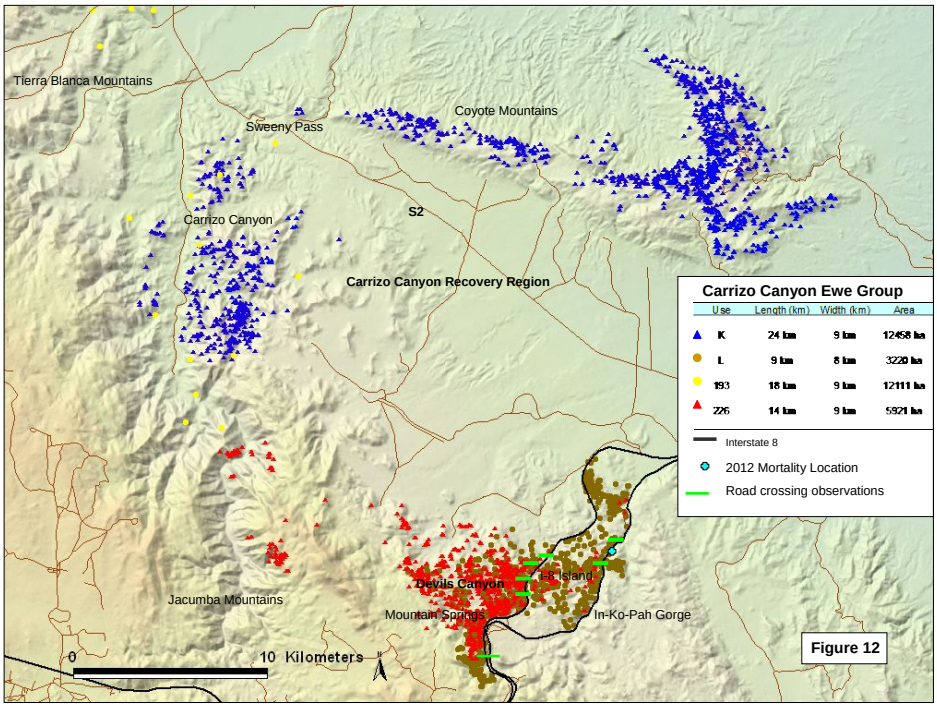
years. Telemetric location and movement data for these females was limited in 2012. Movement patterns are briefly reviewed and details can be obtained from the 2011 Annual Report.

There appears to be at least 2 main patterns of movement and use within the Vallecito Mountains Recovery Region (Figure 11):

I. Sunset Mountain – Pinyon Mountains - Habitat use of radiocollared sheep was concentrated mainly on Sunset Mountain with some use in the Pinyon Mountains and occasional movement east of Harper Canyon. There were no documented locations for these sheep south of Harper Flat. The size of this use area is approximately 13 km x 10 km and encompasses 6,253 ha.

J. Vallecito Mountains to Fish Creek - Two collared females spent time in the Vallecito and Fish Creek Mountains. There are presently not enough location data for these females to discern seasonal use patterns but the Fish Creek Mountains appear to be used during the lambing season. None of the collared females have been documented on Sunset Mountain or in the Pinyon Mountains and thus they may represent a separate group within this recovery region. The size of this use area is approximately 22 km x 8 km and encompasses 14,488 ha.

Carrizo Canyon: CDFW monitored 17 females at the onset of 2012 with the addition of 12 new radiocollared bighorn sheep (6M/6F) and 8 females re-collared in November 2012. Concurrently, 8 collars became non-functional, ending the year with 21 active collared sheep (6M/15F). The average age of collared females in 2012 was 6 years with a range of 3 to 12 years. During the November capture 19 sheep were deployed with solar-powered GPS equipment. Movement patterns for these sheep will be tracked, mapped, and reported in 2013.



There are presently 2 sheep groups documented within the Carrizo Canyon Recovery Region (Figure 12):

K. Carrizo Canyon – Coyote Mountains – This group of females used Carrizo Canyon from May through October. All but one radiocollared female moved across Highway S2 to utilize the Coyote Mountains during lambing season. It is thought that sheep cross into the Coyote Mountains at Sweeney Pass on Highway S2. Recently fitted solar-powered GPS collars are scheduled to collect location data from 20 minute intervals to 2 hour intervals (depending on

voltage) which should pinpoint the timing and specific location of movements across the highway. The size of this use area is about 24 km x 9 km and encompasses 12,458 ha. Past aerial location data indicated a collared female used the Tierra Blanca Mountains during lambing season; however, this collar is now non-functional. Females that inhabit the Tierra Blanca Mountains year-round may represent a 3rd sheep group in the CC recovery region but there are presently no collared sheep in this range.

L. In-Ko-Pah – During 2012, 5 of 6 radiocollared females stayed within the area encompassing Mountain Springs, Devils Canyon (west-bound side of I-8), In-Ko-Pah Gorge (east-bound side of I-8), and within the island created by divergence of the east- and west-bound lanes of I-8. Females were detected within the island during winter and spring and the remainder of the year near Mountain Spring located along the north side of the west-bound lanes of I-8. Several of the lambing locations for these females were located at the north end of the I-8 Island. Movement in and out of the island from the west was documented at various locations and included sheep crossing directly over the freeway as well as using underpasses at Devils Canyon. Two collared females crossed the east-bound lane of I-8 and remained for short periods of time east of I-8. One of these females likely used this area for lambing. The size of this use area is approximately 9 km x 8 km and encompasses 3,220 ha. A third collared female was documented as having a different use pattern than the above females. This female moved from the Mountain Spring area into lower Carrizo Canyon for the first part of lambing season, then returned to the Mountain Spring and island area. The size of her use area is 14 km x 9 km and encompasses 5,921 ha. Five of the collared females were re-collared during the November 2012 capture along with an additional 6 females and 6 males. The deployment of solar-powered GPS collars should allow for the collection of more detailed information concerning timing and frequency of movements as well as exact road crossing points over the coming years.

Cause-Specific Mortality and Survival

In 2012, CDFW detected and investigated 9 radiocollared sheep mortalities east of Highway 74 (Table 2). Mortalities by recovery region were CSRM = 1; CoC = 2; NSYM = 3; SSYM = 2; and VM = 1. In the NSYM, a female was likely killed by a lion in Henderson Canyon in February. In April, a female that had been documented to have a sick lamb was killed by a lion in the upper portion of BPC. In July, a young male was found dead of unknown non-predation causes near Nolina Guzzler in the VM. Also in July, a female died of unknown causes in the upper portion of Salvador Canyon in CoC. This death may have been due to predation but was not investigated until October due to lack of field staff. In September, a female was found dead of unknown cause within a gravel pit operation at the base of Coyote Mountain in CoC. Also in September, an ear-tagged male was found dead in Tubb Canyon in the SSYM: it was categorized as unknown-non predation but most likely it

Table 2. Cause of death for radiocollared bighorn sheep – January 1 to December 31, 2012 east of Highway 74.

Sheep ID	Location	Sex	Age (yrs.)	Month	Cause
260	NSYM	F	6	February	Lion (probable)
257	NSYM	F	5	April	Lion
271	Vallecito	M	4	July	non-predation
220	CoC	F	10	July	unknown
182	CoC	F	9	September	unknown
139	SSYM	M	15	September	non-predation
9010	CSRM	F	9	October	unknown
137	NSYM	F	15	November	Lion
209	SSYM	M	9	December	Lion (probable)

was due to natural causes. In October, a female in the CSRM died in Martinez Canyon of unknown causes. In November, a female was killed by a lion on a ridgeline above Hellhole Canyon in the NSYM. Several months prior to her death, this female had been observed coughing severely, moving stiffly and slowly, and often by herself. In December, a male was likely killed by a lion in Glorietta Canyon in the SSYM.

There were 10 mortalities of non-collared sheep investigated east of highway 74 (Table 3). In the NSYM recovery region, 3 lambs between 8 and 12 weeks-of-age were found dead with no signs of predation. Numerous sick lambs had been seen in BPC, and cause of deaths was most likely due to pneumonia. An approximately 10-month old male-lamb was found dead within DeAnza Country Club: cause of death was categorized as unknown but it likely was related to urban factors. The lamb was 1 of 4 lambs (3M/1F) known to have survived through the summer in BPC. Prior to its death it had been documented on numerous occasions foraging in the DeAnza development but appeared healthy with good body weight. Two sheep were killed by vehicles on Highway S22 and one male was killed on the east-bound lane of I-8 between Ocotillo and Jacumba. A yearling ram died in CoC of unknown causes but it was possibly due to predation. A 9-year-old male died of unknown causes in the SSYM but it was likely not due to predation.

Table 3. Cause of death for unmarked bighorn sheep – January 1 to December 31, 2012 east of Highway 74.

Location	Sex	Age	Month	Cause
CoC	F	13 years	February	unknown
NSYM	unknown[a]	8 weeks	April	pneumonia
NSYM	unknown[a]	7 weeks	April	pneumonia
NSYM	F	12 weeks	June	pneumonia
NSYM	unknown[b]	unknown	June	vehicle
CoC	M	yearling	July	unknown
I-8	M[c]	9 years	November	vehicle
NSYM	M	13 years	November	vehicle
NSYM	M[d]	42 weeks	December	urban
SSYM	M	9 years	December	unknown

a report from ABDSP visitor with photos which show intact carcass with no sign of predation. Assumed due to pneumonia.
b report from Mark Jorgensen of sheep leg found on road(S22) and assumed animal hit by vehicle
c Ram struck and killed on east-bound lane of Interstate 8.
d Lamb found by resident of DeAnza behind houses. Cause of death unknown but related to urban use and possibly oleander poisoning.

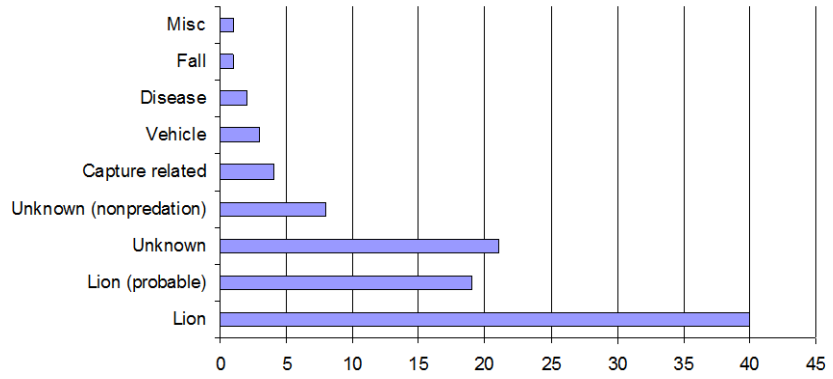


Figure 13. Percent of radiocollared bighorn sheep mortalities by cause 1993 – 2012 (excluding San Jacinto Mountains and NSRM).

In 2012, the number and percentage of radiocollared mortalities by cause were: lion predation = 4 (44%); unknown = 3 (33%), and non-predation = 2 (22%). Causes and percentage of documented mortalities in 2012 were consistent with that documented since 1993 for all other causes (Figure 13). The number of collared sheep mortalities in 2012 (n = 9) was slightly above the yearly average of 7.5 $\pm$ 3.5 SD, and range 3 – 17.

Female radiocollared mortalities in the 5 recovery regions (CoC, NSYM, SSYM, VM, and CC) were examined for differences in the number and cause of mortality within and among each region from 1993 to 2012 (Table 4). Of the documented 113 female mortalities in these recovery regions since

1993, 65% were attributed to lions, 16% unknown, 7% unknown non-predation, 5% miscellaneous causes, 4% capture related, and 4% vehicle collisions. None of the recovery regions stand out as having a higher percentage of overall mortalities. The percent of females killed by lions in the NSYM was slightly higher than the other 4 recovery regions. While only 4% of collared females had been killed by vehicles, almost all (3%) occurred in the SSYM. The average annual survival rate for collared females in all 5 recovery regions from 1993 to 2012 was 87% (Figure 14 A-F). When survival rates were broken down by recovery region, all occasionally dipped below 75%; however, in general all maintained stable survival rates > 80% (Kaplan-Meier survival rates of radiocollared females were calculated from the beginning to the end of each calendar year).

Table 4. Comparison of percent of all radiocollared ewe mortalities from 1993 to 2012 in CoC, NSYM, SSYM, VM and CC regions by cause within each region and among regions. Cause breakdown: Lion, UN = Unknown, N-P = Non-Predation, Miscellaneous causes = Misc, C-R = Capture-Related, V = Vehicle, and T-R = Total by Region.

Region	Lion	UN	N-P	Misc	C-R	V	T-R
CoC	14%	6%	1%	1%	0	0	22%
NSYM	16%	2%	1%	2%	1%	1%	22%
SSYM	12%	4%	1%	0	1%	3%	20%
VM	12%	1%	2%	1%	2%	0	17%
CC	12%	3%	3%	1%	0	0	19%
Total by Cause	65%	16%	7%	5%	4%	4%	100%

Lamb Survival Monitoring

In 2007, CDFW documented several sick lambs and lamb deaths in BPC located in the NSYM recovery region. Results from the 2007 ABDSP waterhole count held in July indicated a low lamb:ewe ratio of 7% in BPC relative to other locations (12% for the SSYM, 26% for CoC, and 78% for Rattlesnake Springs in the SSRM). Numerous hikers had also reported finding sick or dead lambs in BPC during the spring of 2007. As a result of anecdotal evidence of high lamb mortality, CDFW initiated a pilot study in 2008 in order to test the feasibility and logistics of monitoring radiocollared females and their lambs in the NSYM, SSYM, and CoC. The main objective was to examine lamb survival to 3 and 6 months and examine the timing of parturition, lamb production, lamb:ewe ratios (lambs per 100 females), and timing of sick lambs and lamb deaths. Initial results indicated assessing 6 month survival was not reliable due to the limited time lambs spend with their dams at 6 months of age. Survival to 6 months was discontinued and replaced with examination of yearling:ewe ratios as an index of lamb recruitment.

Methods: CDFW has monitored lamb survival in the CoC, NSYM and SSYM recovery regions since 2008, and the In-Ko-Pah (IKP) group (within the CC recovery region) since 2010. All results reported for CoC, NSYM, and SSYM are from 2008 – 2012 unless otherwise stated and all results reported for IKP are from 2010 – 2012 unless otherwise stated. Data collected were used to generate descriptive statistics for comparisons between recovery regions for radiocollared females and their lambs concerning lamb production, timing of parturition, lamb survival to 3 months, onset of lamb sickness, and timing of lamb deaths. For details on methods of collecting observations refer to the

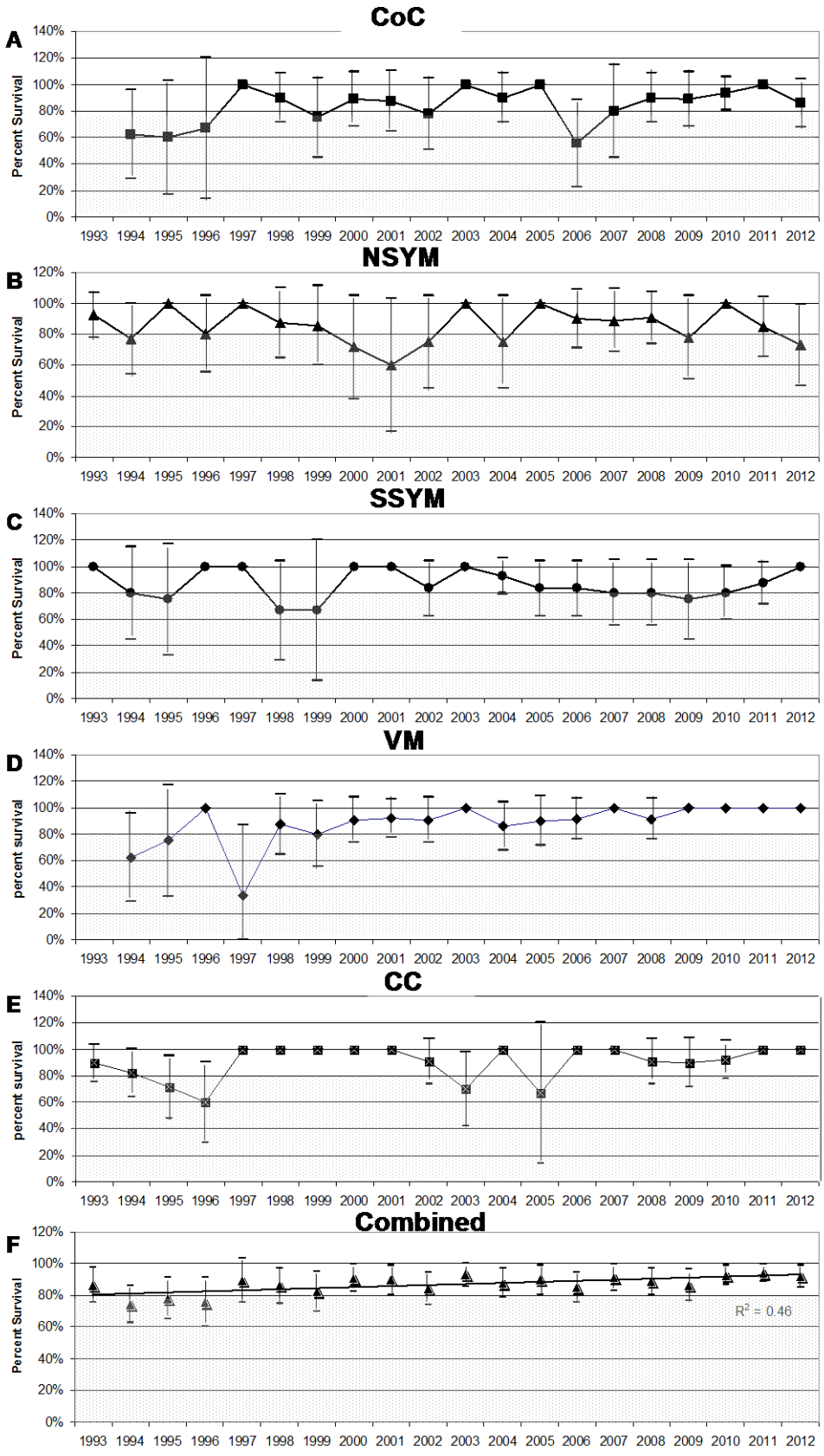


Figure 14. Annual Kaplan-Meier survival rates of radiocollared females for 1993 – 2012 in CoC (A), NSYM (B), SSYM (C), VM(D), and CC (E). Graph F is the annual survival rates (shadowed triangles) and trend line (solid line) for A-E combined. Bars and vertical lines represent upper and lower 95% confidence intervals.

CDFW Lamb Survival Report for 2009. Descriptive statistics were generated for comparisons between recovery regions from group observations of collared and non-collared females to asses lamb:ewe ratios as an index of lamb survival to 3 months, and yearling:ewe ratios as an index of lamb recruitment. MiniTab statistical software was used to examine the difference among recovery regions for: the mean number of females and lambs per group observation each May and June of all years, and the mean number of yearlings per group observation each January – June of all years using One-way Analysis of Variance (ANOVA), Levene's Test for equal variance, and Tukey Post-Hoc Test for pair-wise comparisons among means; Kruskal-Wallis test was used if the assumption of homogeneity of variance was violated.

Age Structure and Lamb Production: In the CoC recovery region, a total of 16 marked females have been monitored over 5 years. The average age over all years is 7.0 $\pm$ 2.3 SD; Mode = 7; range 2 – 13 years; n = 61: average lamb production over all years is 90%. In the NSYM, a total of 15 marked females have been monitored over 5 years. The average age over all years is 8.6 $\pm$ 3.8 SD; Mode = 10; range 2 – 15 years; n = 57: average lamb production is 93%. In the SSYM, a total of 21 marked females have been monitored over 5 years. The average age over all years is 8.9 $\pm$ 2.9 SD; Mode = 10; range 3 – 16 years; n = 63: average lamb production over all years is 87%. In IKP, a total of 6 marked females have been monitored over 3 years. The average age over all years is 5.5 $\pm$ 2.4 SD; Mode = 4; range 2 – 9 years; n = 18: average lamb production over all years is 83%. Lamb production appears lower in IKP; however, 5 females have produced lambs each year while 1 female has not been pregnant over all 3 study years (from age 3 in 2010 through age 5 in 2012).

Timing of parturition: In the CoC, NSYM, and SSYM recovery regions, peak lambing season occurred in March in 2008, February in 2009 through 2011, and January in 2012 (except in the SSYM). IKP followed a similar trend with peak lambing season in February of 2010 and 2011 and January in 2012 (Table 5).

Lamb Survival to 3 Months (based on marked females): Monitoring and confirming the status of lambs belonging to radiocollared females has been most successful throughout all years for the NSYM and SSYM recovery regions due to accessibility and relatively close viewing distances. Observations and confirming lamb status in CoC is more difficult due to the amount of effort and time required to obtain observations. As a result, the most reliable results and comparisons are between lamb survival in the NSYM and SSYM. Observations in IKP have been reliable with

Table 5. Timing of parturition of radiocollared ewes from 2008 – 2012 in CoC, NSYM, SSYM, and IKP ewe groups.

CoC

Year	January	February	March	April	May
2008			**100%**		
2009		**78%**	22%		
2010	40%	**50%**			10%
2011		**100%**			
2012	**89%**	11%			
Total	27%	**53%**	18%		2%

NSYM

Year	January	February	March	April	May
2008		44%	**56%**		
2009	10%	**90%**			
2010	10%	**70%**			
2011	9%	**91%**	0%		
2012	**75%**	25%			
Total	19%	**67%**	15%		

SSYM

Year	January	February	March	April	August
2008		14%	**71%**	14%	
2009		**50%**	**50%**		
2010	18%	**64%**	18%		
2011	14%	**71%**	7%	7%	
2012	9%	**64%**	18%		0.09
Total	10%	**57%**	27%	4%	0.02

IKP

Year	January	February	March	April	May
2010	20%	**60%**	20%		
2011	0%	**100%**	0%		
2012	**60%**	40%	0%		
Total	27%	**67%**	7%		

close viewing distances but the sample size is small and the time-frame is shorter than the other recovery regions.

From 2008 to 2012 in the CoC recovery region, lamb survival to 3 months was confirmed for 35%, unknown in 53%, and 12% were known to have died (n = 60); in the NSYM, lamb survival to 3 months was confirmed for 37%, unknown in 9%, and 54% were known to have died (n = 54); in the SSYM, lamb survival to 3 months was confirmed for 67%, unknown in 12%, and 21% were known to have died (n = 52); and in the IKP, lamb survival to 3 months was confirmed for 93%, unknown in 7%, and no lambs were confirmed to have died (n = 15). The overall trend for 3 month lamb survival in CoC is difficult to conclude due to the high percent of unknown cases each year except in 2009 (Figure 15). Lamb survival has steadily decreased each year in the NSYM; in contrast, for the SSYM, lamb survival increased from 2008 to 2011 with a slight decrease in 2012. In IKP, 15 lambs born over 3 years were known to survive with only the fate of 1 unknown (Figure 15).

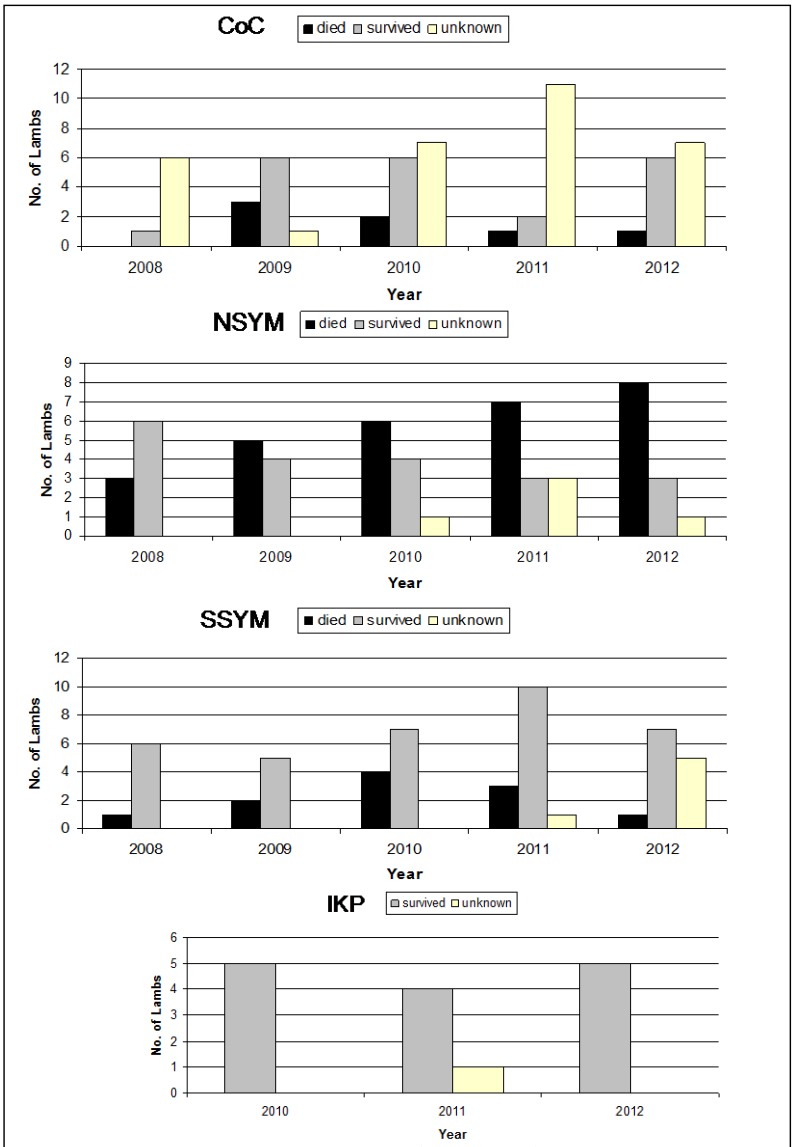


Figure 15. Three-month survival status for lambs of radiocollared ewes in CoC, NSYM, SSYM, and IKP ewe groups from 2008 to 2012. Number of lambs that died prior to 3 months (black bars), lambs that survived to 3 months (gray bars), and fate of lambs unknown (yellow bars).

Timing of disease/death: In the CoC recovery region, lambs were observed sick between 5 and 12 weeks old (n = 4). Observations of sick lambs were often difficult due the viewing distances typically greater than 500 m and most likely early signs of sickness were missed. Typical signs of sickness were coughing, droopy ears, and lethargy. Of the lambs that died (n = 9), 44% died between 8 and 9 weeks and the remainder died prior to 14 weeks. In the NSYM, viewing distances were typically < 300 m and lambs were observed sick between 3 and 20 weeks old (n = 22) with the majority (36%) observed sick at 8 weeks. Typical signs of sickness included exudates from nose (snotty nose), diarrhea, coughing, droopy ears, weight loss, and lethargy. Observations of lambs that appeared to have "swollen noses" were common as well. Extremely sick lambs would spend most of their time near water. Lambs were documented to die between 3 and 18 weeks (n = 35) with the majority (51%) of deaths occurring between 8 and 10 weeks and 91% died at or before 14 weeks. In the SSYM, viewing distances were typically ~ 400 m and lambs were observed sick between 6 and 39 weeks (n = 17) with the majority (53%) observed sick between 10 – 13 weeks. Typical signs of sickness included snotty nose, coughing, droopy ears, and lethargy. Lambs were documented to die between 1 and 18 weeks (n = 16) with the majority (63%) of deaths occurring between 6 and 14 weeks and 88% died before 18

weeks. In IKP, viewing distances were < 300 m and lambs were observed sick between 4 and 8 weeks (n = 5). Typical signs of sickness were diarrhea and slight snotty noses. No lambs were documented to die in this region but the fate of one lamb was unknown.

Lamb Survival to 3 Months and Recruitment (based on group observations): Group observation data were collected from January – June and October – December of each year from 2008 through 2012. Based on the total number of lambs observed from 2008 – 2012, on average, the highest percent (28%) of lambs were observed in April (Figure 16). Typically at this point, most lambs have been born and are approaching 3 months of age: past this point lamb survival begins to quickly decline. Based on this trend, May and June combined are the best months to assess the average number of lambs seen per group observation and lamb:ewe ratios as an index of 3 month lamb survival. Lamb:ewe ratios obtained from October – December group observations are not reliable because too few observations are obtained and lambs have a tendency to avoid areas where males pursue adult females (and lambs) during the rut. The highest number of yearlings is observed in January and February but yearlings remain at the periphery of nursery groups through June (Figure 16). Based on this trend, January –June are the best months to assess the average number of yearlings per group observations and yearling:ewe ratios as an index of lamb recruitment.

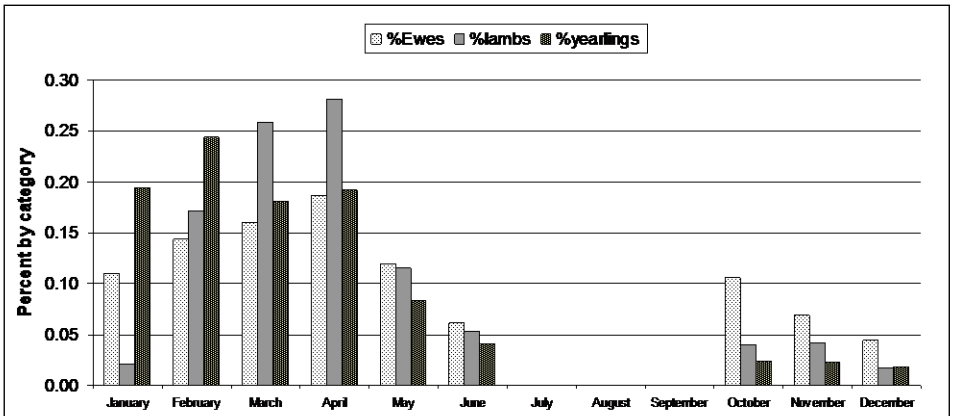


Figure 16. Percent by category of ewes, lambs, and yearlings observed from 2008 – 2012. Observations were not obtained consistently in July – September of most years and were therefore not included.

There were no differences among recovery regions in the number of females observed (P = 0.238 ANOVA) but there were significantly fewer lambs observed in CoC and NSYM compared to the SSYM and IKP (P = 0.004, ANOVA: Figure 17). It may be noted among recovery regions, the NSYM had the highest number of females and the lowest number of lambs observed (Figure 17) yet there were no differences among recovery regions for the number of yearlings observed (P = 0.174 Kruskal-Wallis). This indicates that lamb losses prior to 3 months are much greater in the NSYM and CoC than in the SSYM and IKP but at the end of the first year recruitment levels are virtually the same among all recovery regions. Examination of lamb:ewe ratios (3 month survival) and yearling:ewe ratios (recruitment) show similar results (Table

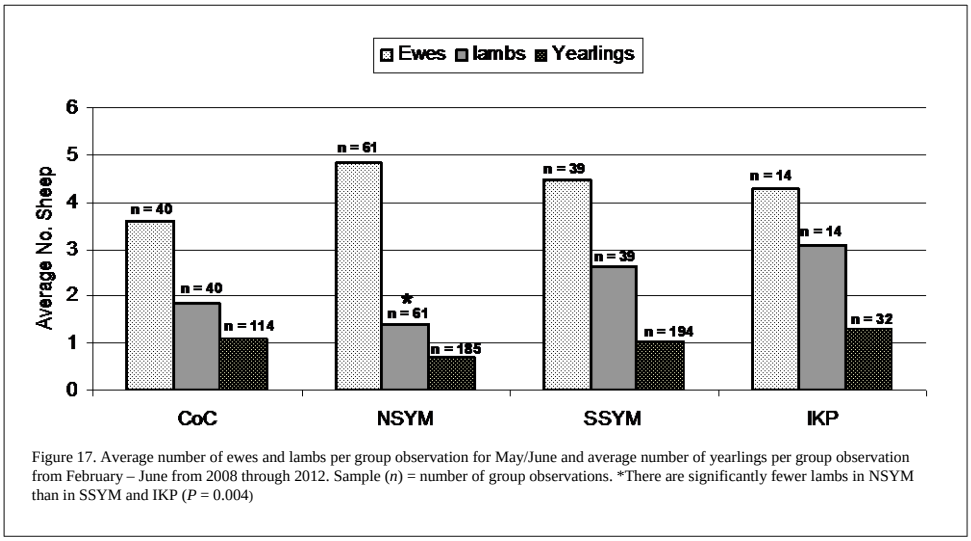


Figure 17. Average number of ewes and lambs per group observation for May/June and average number of yearlings per group observation from February – June from 2008 through 2012. Sample (n) = number of group observations. *There are significantly fewer lambs in NSYM than in SSYM and IKP (P = 0.004)

6). Average 3 month lamb survival in CoC (51%), SSYM (58%) and IKP (72%) over all years has remained stable (Table 6); however, CoC has experienced lower 3 month survival in 2010 (37%) and 2012 (36%). In comparison, lamb survival in the NSYM has steadily declined from 43% in 2008 to 13% in 2012. The 2012 estimate is believed to be accurate as the same 4 lambs were consistently seen through June and over the summer months. In 2011, 3 month survival levels were good in all recovery regions (except in NSYM) but recruitment to yearlings (2012) was extremely poor in CoC (4%) and NSYM (3%) and much lower than in prior years for both SSYM (17%) and IKP (20%). Again, this demonstrates that the majority of lamb losses occurred after 3 months of age in CoC, SSYM, and IKP (Table 6).

Table 6. Index of lamb survival (3M Survival) and recruitment of lambs to yearlings (Recruitment) from 2008 – 2012 in CoC, NSYM, SSYM, and IKP ewe groups. Three-month lamb survival was calculated from lamb:ewe ratios from group observations obtained from May-June of one year and matched with yearling:ewe ratios (recruitment) from January - June the following year. For example in 2011 in NSYM, 21% of lambs survived to 3-months-old (3M Survival), and 3% survived to yearlings (Recruitment) in 2012.

Years		CoC		NSYM		SSYM		IKP	
3M Survival	Recruitment	3M Survival	Recruitment	3M Survival	Recruitment	3M Survival	Recruitment	3M Survival	Recruitment
2008	2009	66%	21%	43%	21%	64%	29%	—	—
2009	2010	51%	31%	30%	24%	41%	18%	—	—
2010	2011	37%	24%	14%	19%	61%	28%	79%	39%
2011	2012	56%	4%	21%	3%	58%	17%	63%	20%
2012	*	36%	*	13%	*	63%	*	70%	*
Average		51%	21%	29%	16%	58%	25%	72%	28%

* Recruitment of 2012 lambs has not yet been determined.

—Observations in IKP did not start until 2010

Group observations of disease – All signs of disease in lambs of non-collared females from group observations were documented. In the CoC recovery region, 10% of all lambs observed showed symptoms of disease. Viewing distances in this region were great, but even at great distances lambs could be observed with droopy ears, coughing, and acting lethargic. Finer details such as exudates from noses could not be seen. In the NSYM, 51% of all lambs observed showed signs of sickness. Common signs of sickness were diarrhea, snotty nose, swollen nose, coughing, weight loss, and lethargy. In the SSYM, 10% of all lambs observed showed signs of disease. Common signs of sickness were snotty nose, coughing and droopy ears. In IKP, 15% of all lambs observed showed symptoms of disease. The most common signs were diarrhea, droopy ears, snotty nose and coughing (in IKP, almost all signs of sick lambs occurred in 2012).

Lamb Survival Discussion: From 2008 – 2012, lamb production among all recovery regions (CoC, NSYM, SSYM, & IKP) was high. The majority of lambs in all regions are born in February with a slight trend towards earlier parturition each year since 2008. In a study conducted in the Peninsular Ranges from 1993 – 1996, 55% of lambs were born in March (Rubin, Boyce & Bleich 2000). The shift to earlier parturition could be due to a combination of several factors including differences in resolution between studies and within the present study (particularly after the first year of the study in 2008), shorter winter rains and drier springs, and increasing lamb losses each year due to disease. Lamb disease may be a likely cause of this shift as evidenced by the shift in the majority of lambs being born in February for both CoC and NSYM from 2009 - 2011 to January in 2012 following heavy lamb losses in 2011 (Tables 5 & 6).

Lamb survival based on observations of radiocollared females and from group observations both demonstrate heavy lamb losses in the NSYM recovery region prior to 3 months of age due to disease. In CoC, there are also significantly fewer lambs observed at 3 months but it is unclear if this is due to disease or some other factors. Recruitment levels among all recovery regions are similar which demonstrates that lamb losses occur prior to 3 months in the CoC and NSYM and after 3 months in the SSYM and IKP. However, while average recruitment over all years is similar, in the NSYM and to some degree CoC, the trend in recruitment has consistently decreased, whereas in the SSYM and IKP it oscillates around an average. Further detailed analysis comparing recruitment among years rather than over all years may demonstrate lower recruitment in NSYM. Disease has been documented in all recovery regions but virulence may be greater in the NSYM while in the SSYM and IKP other factors such as summer drought and poor forage conditions may contribute more to lamb deaths (differences in vegetation among the recovery regions have not been examined; however, sheep in both CoC and NSYM appear to have better forage quantity and quality due to riparian areas created by perennial water sources). The viability of the population is most sensitive to changes in female survival rather than survival of lambs (Rubin, Boyce, & Caswell-Chen 2000); however, females (particularly young females) with sick lambs may be at greater risk of predation. For instance, females with sick lambs are closely monitored and once lambs die, females will typically stay close to their dead lambs up to 3 days and this behavior may increase their risk of predation. All group observation data differentiate between females > 4 years-old and females $\leq$ 4 years-old. These data show that the highest percent of young females are seen in IKP (37%), followed by CoC (22%), with the NSYM and SSYM having only 14% young females observed.

Lamb survival monitoring of radiocollared females has required intensive field observations; however, much has been learned concerning lamb production, timing of parturition, and onset of disease, symptoms, and timing of death. In the future, monitoring of yearling:ewe ratios as an index of lamb recruitment may be the most efficient and effective indicator of population health within each recovery region. Furthermore, all recovery regions must maintain at least 25% radiocollared sheep in order to obtain accurate estimates of female abundance and continue to monitor movements within and among recovery regions. Accurate information concerning habitat requirements, important lambing and nursery areas, and documenting changes in use patterns are important in order to preserve and protect present sheep habitat and predict if presently unoccupied habitat may be necessary to sustain future populations as climate changes continue.

RECOVERY THREATS and MANAGEMENT STRATEGIES

Downlisting and delisting goals in the Recovery Plan include: 1) at least 25 females must be present in each of the 9 recovery regions for 6 years (downlisting) and 12 years (delisting) without population augmentation, and 2) the range-wide population must average 750 individuals over 12 consecutive years. Currently, 25 or more females are present in 8 of 9 recovery regions and the range-wide population has averaged over 750 individuals over the last 8 years. The SJM recovery region currently contains an estimated 21 females. Based upon an increasing trend in the number of female sheep in this recovery region over the last several years without augmentation, it is possible that greater than 25 females will be achieved naturally in the next few years.

Because bighorn sheep in the Peninsular Ranges reside in a network of state, federal, private, and tribal government lands which lie adjacent to large human urban populations, reaching recovery goals and assuring long-term protections for sheep will require an understanding of and commitment to eliminating threats within and among recovery regions. Current threats to recovery of the bighorn

sheep population in the Peninsular Ranges as well as possible management strategies to lessen and/or eliminate threats within each recovery region are discussed below.

Central Santa Rosa Mountains - *Threats and concerns – habitat fragmentation, urban use, and human disturbance:* The BI has documented routine movement of sheep from the CSRM to the NSRM recovery regions across Highway 74 and in April a young male was struck and killed on this highway. Also, CSRM males have been documented foraging on golf courses in La Quinta since 2007. Use of golf courses by sheep has increased each year and in February of 2012 females and lambs were reported foraging on courses as well. The use of golf courses change natural foraging patterns of sheep and expose them to a variety of risks associated with use of the urban landscape such as increased predation, vehicle strikes, entanglement, drowning, increased parasite loads, and exposure to toxins. In August, an adult male was found dead at the PGA West golf course (Figure 18). Cause of death was confirmed to be myocardial necrosis as a result of oleander poisoning. A second adult male was found dead in the Coachella Canal near Avenue 52 in La Quinta. Construction of fences at the urban interface is identified as a site specific recovery action for the Santa Rosa Mountains south of Highway 74 in Section II.D.1.2 of the recovery plan. Construction of fencing to exclude bighorn sheep from golf courses and residential areas in La Quinta would be an important step toward preventing urban related mortalities and enhance efforts toward conservation of sheep in the CSRM.

Figure 18. Young ram found dead at PGA West golf course in La Quinta, CA on August 8, 2012. Cause of death confirmed as oleander poisoning (CAHFS Report S1206966).

Southern Santa Rosa Mountains - *Threats and concerns – possible disease, depleting water sources, and human disturbance:* Presently, there is little information concerning possible threats for this recovery region due to a lack of radiocollared sheep. There is a concern whether natural springs and tenajas will be able to continue to meet the needs of sheep within this recovery region. In the past, there have been at least 4 reliable sources of water for sheep in the SSRM: Rattlesnake Springs, Limestone Guzzler, North Palm Wash tenaja, and Natural Rock Tanks tenaja. Rattlesnake Springs serves as an important source of water and in the past few years numerous sheep carcasses have been found near the spring. A remote camera was in place from fall 2011 through summer 2012. No predators, except for an occasional bobcat, have been caught on the camera; however, during the late spring and summer sheep were captured on camera in large numbers throughout the day and night (Figure 19). The refill rate on the spring cannot keep up with the demand and the spring is often dry by 0900. Observations by a CDFW biologist in more accessible areas have demonstrated that sheep with pneumonia will spend increasingly more time near a water source as their disease progresses. This may result in an increased incidence of disease in areas of high sheep concentration. In December of 2011, a lamb was found dead

Figure 19. Bighorn sheep waiting for the spring to fill at Rattlesnake Spring in the SSRM.

at North Palm Wash tenaja and another near Natural Rock Tanks tenaja (cause: unknown non-predation). According to retired ABDSP Superintendent Mark Jorgensen, North Palm Wash tenaja was dry in summer 2012 for only the 3rd time in 42 years. It was the first time the spring has been dry in approximately 10 to 12 years. Palm Wash tenaja serves as a safety valve when Rattlesnake Springs cannot meet the needs of all sheep in the area. Further investigation of whether water sources should be enhanced may be warranted.

Another possible threat to sheep within this recovery region is illegal off-road vehicle use. CDFW biologists and ABDSP personnel have documented unauthorized vehicle use within sheep habitat in numerous washes of the easternmost portion of the Santa Rosa Mountains state wilderness area of ABDSP.

Coyote Canyon **-** *Threats and concerns – water accessibility, predation, disease, and human disturbance:* Sheep within this recovery region regularly cross the bottom of Coyote Canyon far from escape terrain. For example, in September 2012 a radiocollared female was found dead near the Coyote Creek 1st crossing approximately 550 meters from the lower slopes of the NSYM. It appeared this female was attempting to cross to Coyote Mountain, a distance of approximately 1700 meters. While sheep typically use Coyote Mountain only during lambing season, an artificial water source created by holding ponds within the Borrego Sand and Rock Gravel Pit near Clark Dry Lake may be attracting sheep from nearby steep open habitat to an area without direct access to escape terrain and with dense vegetation cover for predators. During 2012, all 4 documented mortalities within CoC (2 collared and 2 un-collared) occurred within 150 meters of a water source. The jeep road from Lower Willows to Middle Willows is closed by ABDSP Superintendent Order from June 1 through September 30 in order to protect the watering rights of bighorn sheep. Coyote Creek is a dynamic system and the area traditionally used by sheep to obtain water at Lower Willows above the closure has filled in with dense vegetation making it impossible for sheep to access water safely at this point. In the past few years, sheep have been accessing water at or just below the closure gate where it is more open and escape terrain is closer. Moving the closure gate to just below 2nd crossing may help to ensure that sheep can obtain water in a safe location without human disturbance. Disease in this recovery region continues to be a threat (refer to section on lamb survival) and CDFW will continue to monitor for possible increases in disease occurrence within this recovery region.

Northern San Ysidro Mountains **-** *Threats and concerns – urban use, vehicle collision, disease, human disturbance, and predation:* An increase in urban use by sheep within this recovery region is of concern. In December 2012, a male lamb ~ 10 months-old was the first documented death within the area surrounding DeAnza Country Club. The carcass had been extensively scavenged and was found > 450 m from the nearest slope and 80 meters behind houses within DeAnza Country Club. While the exact cause of death could not be determined, it was most likely related to use of the urban environment. This development posses a threat to the health and survival of sheep in this recovery region due to possible ingestion of poisonous ornamental plants, increased parasite loads, accidents such as vehicle collisions and drowning in pools or ponds, drinking contaminated water, and increased predation at the urban interface. Presently, CDFW is examining the feasibility of installing fencing along the boundary of ABDSP and DeAnza Country Club.

Another major threat to sheep within this recovery region is movement across Highway S22. One of the most frequently crossed sections of this highway is between mile marker (mm) 13 and 14.5 with several past sheep deaths documented at a specific point just below mm14. While no radiocollared sheep deaths occurred in 2012, there were at least 2 un-collared sheep killed along this road in 2012.

CDFW is currently examining the feasibility of placing flashing lights and signs at locations along stretches of Highway S22 to reduce this risk.

Lambs within this recovery region continue to die of pneumonia each spring (refer to section on lamb survival for details). As lambs become sicker they spend a significant amount of time near the creek in BPC. This occurs at the same time park visitation numbers soar within the canyon. While the sheep in this canyon are habituated, it is not known if constant disturbance in the form of visitors approaching and photographing sick lambs may decrease their chances of survival or impede movement to and from water sources. Increasing the number of Park Docents along known sheep use areas during busy weekends (specifically at the junction of the regular trail and the alternate trail), educating park visitors, and trail maintenance to keep people on existing trails may help ensure sick lambs are not disturbed at this critical time.

While it is acknowledged that female survival is the most important factor in the long-term survival of this population, lamb disease may inadvertently result in an increased risk of predation to adult females. Three radiocollared females were killed by mountain lions in 2012. Two deaths occurred during the lambing season; one female was seen with a sick lamb prior to her death, and the other ewe had been in poor health. In past years, CDFW has documented on at least 5 occasions females standing guard over their dead lambs for up to 3 days. In one of these cases, it resulted in the female being killed by a mountain lion. It is also possible that ravens at the carcass site may key predators to their location. Dead lambs are now removed when found near a female. Monitoring of sick lambs is ongoing within this recovery region.

Southern San Ysidro Mountains **-** *Threats and concerns – vehicle collision, maintaining water sources, and predation*: Sheep within the SSYM recovery region frequently cross Highway S3 between Pinyon and Yaqui Ridge and at the Narrows on Highway 78 (Figure 10 & 20). While sheep have been observed crossing at numerous points along Highway S3, the two most common crossing points are at the north and south ends of Yaqui Pass; and, most vehicle strikes have occurred at these points during the early spring when females are moving between the lambing and nursery grounds. Presently, CDFW is examining the feasibility of placing flashing lights and signs at locations along Highway S3 and Highway 78.

Figure 20. Radiocollared female crossing Highway 78 at the Narrows between the SSYM and VM regions.

Water use at the Tubb Canyon Guzzler was discontinued for a few weeks in the fall due to a break in the pipe. This guzzler is on private property and its continued maintenance is subject to owner permission. A long-term agreement may be warranted to ensure continued operation and use in the future. Springs farther up the canyon have not regularly been used by sheep due to dense vegetation surrounding the springs; however, the Wilson Wildfire in August 2012 cleared vegetation surrounding these springs. As sheep rediscover these springs, it may be advisable that ABDSP keep these areas cleared of vegetation. These actions may serve to assure use of the springs by sheep and minimize risk of predation at the springs.

Vallecito Mountains - *Threats and concerns*: Presently, there is not enough known about sheep within this recovery region due to inaccessibility and the small number of radiocollared sheep. Remote cameras have been in place since 2011 at 8 guzzlers throughout the recovery region. A few sick lambs have been captured on remote cameras but all data have not been reviewed at this time. Without the presence of collared sheep future estimates of abundance, determination of cause-specific mortality, and documentation of movements and disease will not be possible.

Carrizo Canyon - *Threats and concerns – vehicle collisions, habitat fragmentation and loss, and human disturbance:* While female abundance and lamb recruitment are presently high in this recovery region, sheep are faced with increasing challenges posed by renewable energy developments, access road construction and maintenance related to CBP border security and human disturbance. During the 2012 reporting period the Sunrise Powerlink 500-kilovolt transmission line constructed through documented lambing habitat within the I-8 Island was completed and energized. Additionally, installation of wind-turbines for the Ocotillo Wind Farm facility abutting lambing habitat in the In-Ko-Pah Gorge was initiated. Thus far no radiocollared sheep have been killed crossing Interstate 8 that bisects seasonal movement pathways; however, this is inevitable as freeway traffic continues to increase. Un-collared males in past years have been struck and killed on the freeway and in November 2012 a male was killed crossing the east-bound lanes near Myers Creek. GPS location data indicates that Myers Valley may be used by females during lambing season. This same area is used extensively for CBP activities. Collared sheep movements and behavior will be monitored as part of the on-going Peninsular Ranges recovery program and CPB border monitoring project.

In 2012, CDFW staff continued to work with USFWS and renewable energy project proponents to implement vehicle strike hazard reduction (funnel and barrier fencing and signage) and habitat improvement measures required to off-set impacts from energy developments on bighorn sheep in the CC recovery region. It is hoped that the required off-set measures can be fulfilled in a timely manner to reduce strike hazards and improve habitat values for bighorn sheep. However, elimination of vehicle strike hazards will ultimately require the construction of overpass structures along the I-8 In-Ko-Pah Gorge corridor.

REFERENCES

Rubin, E. S., W. M. Boyce, V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81(3): 769-786

Rubin, E. S., W. M.Boyce, and E. P. Caswell-Chen. 2002. Modeling demographic processes in an endangered population of bighorn sheep. Journal of Wildlife Management 66(3):796-810.

U.S. Fish and Wildlife Service. 2000. Recovery plan for bighorn sheep in the Peninsular Ranges, Ca. U.S. Fish and Wildlife Service, Portland, OR. Xv +2 251 pp.