2024-25 Annual Report
Sierra Nevada Bighorn Sheep Recovery Program

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Figure 1. *Sierra bighorn sheep in the Convict Creek herd, Lake Crowley in background. Photo taken during helicopter survey March 25, 2025. Photo credit Trevor Johnson.*

Executive Summary

Good news! In the 2024 reporting period (May 1, 2023 through April 30, 2024), the Sierra bighorn population grew to almost 200 females with more than 100 lambs. Adult female survival was high (97%) and so was the lamb:ewe ratio (62%), resulting in a growth rate of 1.05. This growth rate is robust for Sierra bighorn as they are documented to be uniparous, with each ewe having a single lamb per year. The population is recovering from losing 55% of the population in 2022-23 and is approaching recovery goals for our largest Recovery Unit, the Southern Recovery Unit.

Staff have been busy implementing multiple survey methods to best document the current population, including ground and helicopter surveys, setting and checking remote cameras, and collecting pellet samples. We have repeatedly confirmed that rams are present at both Big Arroyo and Cathedral, but we have not documented any females in those herds since 2022. We have confirmed females are present and reproducing in Convict and Taboose. A member of the public located a Sierra bighorn ram (confirmed by analysis of fecal DNA) ~37 miles south of the Olancha herd unit boundary, the southernmost herd.

We captured 41 Sierra bighorn, including translocating 5 pregnant ewes from Baxter to Gibbs during the spring. GPS collar data from this year showed rams from Gibbs, Cathedral, and Convict questing into novel habitat during the rut. Additionally, we may be documenting a new migration pattern forming in the Baxter herd where animals are crossing into the Acrodectes area during the summer, an area previously used predominately by Sawmill animals. Baxter females in the Mary Austin deme are also expanding to the south using more habitat by Kearsarge Peak. In addition to location data, the Program reviewed accelerometer data from GPS collars to better understand movements surrounding an animal's death.

Mountain lion abundance was comparable to 2023 with 72 lions detected across the study area. Fortunately, lion predation on Sierra bighorn was low (N=6), thanks to a robust lion monitoring and management program. Increasing our lion monitoring and management efforts, and specifically our ability to respond rapidly by removing lions documented to prey on Sierra bighorn, has enabled the Recovery Program to have a more immediate and positive effect on the Sierra bighorn population. We weathered some temporary staff reductions but were still able to capture 25 individual lions, including 8 previously uncollared animals. We also translocated two Sierra bighorn-predating lions out of Sierra bighorn territory: L267M from the Northern Recovery Unit and L252M from the Central Recovery Unit.

Fieldwork is ongoing for an extensive lion kill site investigation project. From 2017 through 2024, we investigated 1,209 kill sites, and we are currently analyzing these data. By quantifying how predation varies across space and time, we can better protect Sierra bighorn source populations for translocations, identify suitable bighorn reintroduction sites, and determine whether individual lions pose a substantial risk to bighorn populations and warrant management intervention.

Introduction

The endangered Sierra Nevada bighorn sheep inhabit the high Sierra and eastern escarpment, occupying some of the most remote and rugged alpine habitat in California (Figures 1-2 and see map of herd units, Figure 3). Despite decades of dedicated conservation work and sustained investment by the State of California, recovery of this unique subspecies remains a long-term challenge. Their continued vulnerability reflects a combination of biological and ecological realities.

Sierra bighorn are currently limited by their small population size, restricted geographic range, and relatively slow rate of population growth. These factors make the subspecies especially sensitive to environmental pressures and unpredictable events. While meaningful progress has been made in expanding the distribution of this sub-species, continued active management will likely be necessary until population numbers increase and the species occupies a broader range across the Sierra Nevada. Expanding both abundance and distribution is essential for improving long-term resilience.

One of the most significant challenges is simply the small number of animals that remain. Small populations are inherently less resilient than large ones because they are more vulnerable to episodic stressors such as severe winters and periods of elevated predation. For Sierra bighorn, these events can have substantial effects on herd growth and recovery, even when habitat conditions remain favorable.

Another important factor is the limited distribution of the species. Sierra bighorn currently occupy only a portion of their historic range within the central Sierra Nevada. Translocations to expand their range into suitable historic habitat have had mixed results. These varied outcomes highlight the complexity of restoring wild mountain sheep populations. Although habitat quality in many release areas appears suitable, successful reestablishment may depend on finding appropriate seasonal ranges and migration routes, because there are no established individuals to pass down this important knowledge.

Population growth is also naturally constrained by the species' reproductive biology. Ewes generally produce only one lamb per year. Pregnancy rates are relatively high, averaging around 85 percent, yet observed lamb:ewe ratios are considerably lower, averaging closer to 50 percent. Because only a portion of surviving lambs are female, annual population growth potential remains modest even under favorable conditions. Researchers continue to study the factors influencing lamb survival, including weather, nutrition, and predation, in order to better understand these dynamics and improve management strategies (Conner et al. 2018, Stephenson et al. 2020, Berger et al. 2022, Forshee et al. 2022, John et al. 2024).

Predation management remains another important component of recovery. Mountain lions are a natural part of the Sierra ecosystem, yet predation can have outsized impacts on small and recovering bighorn populations. Management approaches designed to reduce predation may help support herd growth during this critical recovery period, particularly while population numbers remain low (Gammons et al. 2021).

Moving forward, recovery efforts should continue with careful, science-based management and long-term commitment. Because Sierra bighorn populations are still relatively small and geographically limited, they require continued protection and active stewardship. As herd numbers grow and populations become more connected across the landscape, the subspecies will be better positioned to withstand naturally occurring challenges such as severe winters and periodic predation events. Connectivity brings risk, however, because of the increased potential for the spread of disease in bighorn and this emphasizes the need for a broader geographic distribution. Building that resilience remains the central goal of recovery efforts and offers the best path toward securing the future of this iconic alpine species.

***Figure 2**. A Sierra bighorn ram posing for a remote wildlife camera on November 6, 2024 on Parson's Plateau, Cathedral Range.*

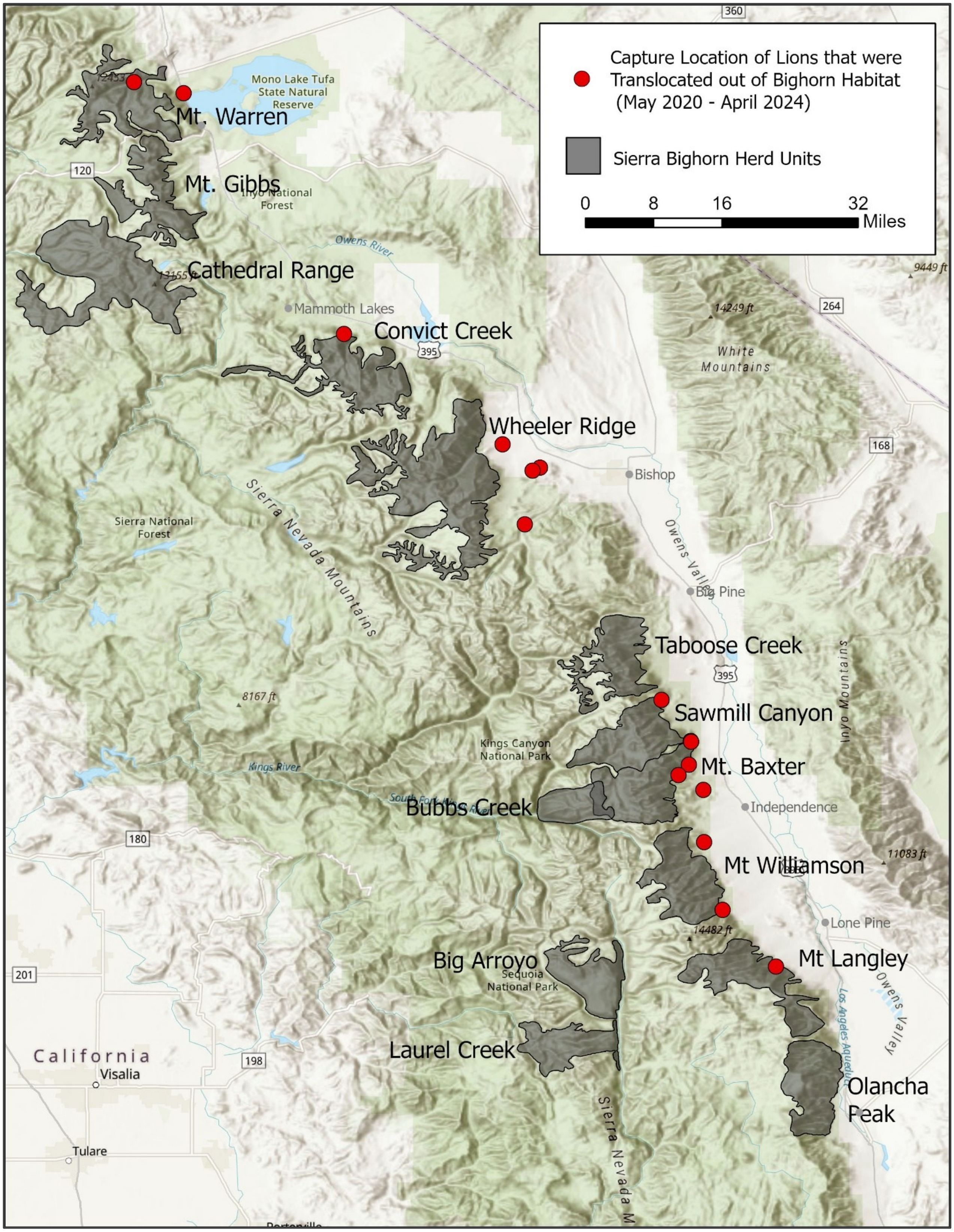

Figure 3. Sierra Nevada bighorn sheep herd units with mountain lion translocation sites. Mountain lions that were translocated away from Sierra bighorn herd units for the protection of Sierra bighorn between 2020 and 2024 are denoted in red, showing their capture locations near Sierra bighorn habitat.

Population Monitoring and Recovery Goals

At this time there are a few previously occupied areas where we have not seen bighorn since the severe winter of 2022-23, but we are still actively surveying these areas with the hope that we will find animals that have gone undetected. These herds (Laurel, Big Arroyo, and Cathedral) include vast and complex terrain, but we are becoming more confident that ewes are no longer present in these herds as we consistently find either no sign of bighorn or only evidence of rams. To assist monitoring efforts, we have expanded our approach to include not only ground surveys and pellet collection, but also remote cameras (Figure 2) and helicopter surveys (Figure 1).

In 2024, we estimated there were 420 Sierra bighorn including 183 females, 103 lambs, and 134 males (Table 1). All age class counts have increased from 2023 (366 total: 175 females, 65 lambs, and 126 males; Greene et al. 2024). Ewes increased by 4%, rams by 5%, and lambs increased by 35%. There are currently 11 herds occupied by females; Baxter continues to be our largest herd with 54 females, followed by Olancha with 33 females (Figures 4-5).

Our survey efforts this year included remote cameras, a March helicopter survey, and many hours of ground counts (Table 1). Remote cameras were placed in the Big Arroyo and Cathedral herds and both detected rams (Figure 2). In the Chagoopa Bowl of Big Arroyo, a remote camera detected two distinctly different males in February and March of 2025. At Cathedral, near Parson's Peak, a camera detected 3 different rams, including collared ram S608M. No females or young animals were found at either location.

Bighorn were observed within the Acrodectes deme of the Sawmill herd, in which bighorn had not been seen since the winter of 2022-23. However, after successfully collaring two animals from Acrodectes, they appear to be more associated with the Baxter herd. Previous collared animals in that area always wintered within Sawmill, which makes it difficult to determine how to categorize these animals, but here they are counted as Baxter animals.

On March 25 and 26 we performed two days of helicopter surveys with Air Shasta. During the surveys, we observed 6 rams in the Cathedral Range between Parson's Peak and Amelia Earhart. This included at least one ram from Gibbs (S696M) that we could identify because he was collared. We were unable to add Cathedral rams to our ground count because there was clear evidence of mixing with Gibbs. At Convict, we observed 7 animals (Figure 1), including 3 adult females, 1 yearling female, 1 lamb, and 2 adult males, corroborating our February 2025 ground observations of 9 animals (2 more rams were seen in February). On March 26, we observed a group of 13 at Georges Creek in Williamson, but we were unable to obtain a full group composition from photos or directly from the air; this nearly matches the 14 animals observed and counted in the Barnard deme of Williamson the previous summer. These helicopter surveys confirmed earlier ground observations but unfortunately did not reveal any "new", or previously undetected, bighorn. During helicopter captures in the fall, however, we detected new bighorn in the Taboose herd when we caught and collared two females—one adult and one yearling. The adult female was lactating, so we believe there was also an additional lamb.

The Recovery Plan (U.S. Fish and Wildlife Service 2007) specifies minimum counts are used to evaluate progress toward downlisting goals, requiring at least 305 females with specific geographic targets in four Recovery Units (Figure 6). We are very near the 155 female target for the Southern Recovery Unit and nearly halfway to the 50 female target in the Central Recovery Unit. We have females distributed in 10 of the 12 essential herd units identified in the Recovery Plan, all but the Kern Recovery Unit herds of Big Arroyo and Laurel (Criteria B2, SNBS Recovery Plan 2007). We recognize that our counts represent a minimum number of bighorn and the true number and distribution may be higher and broader than our current estimate.

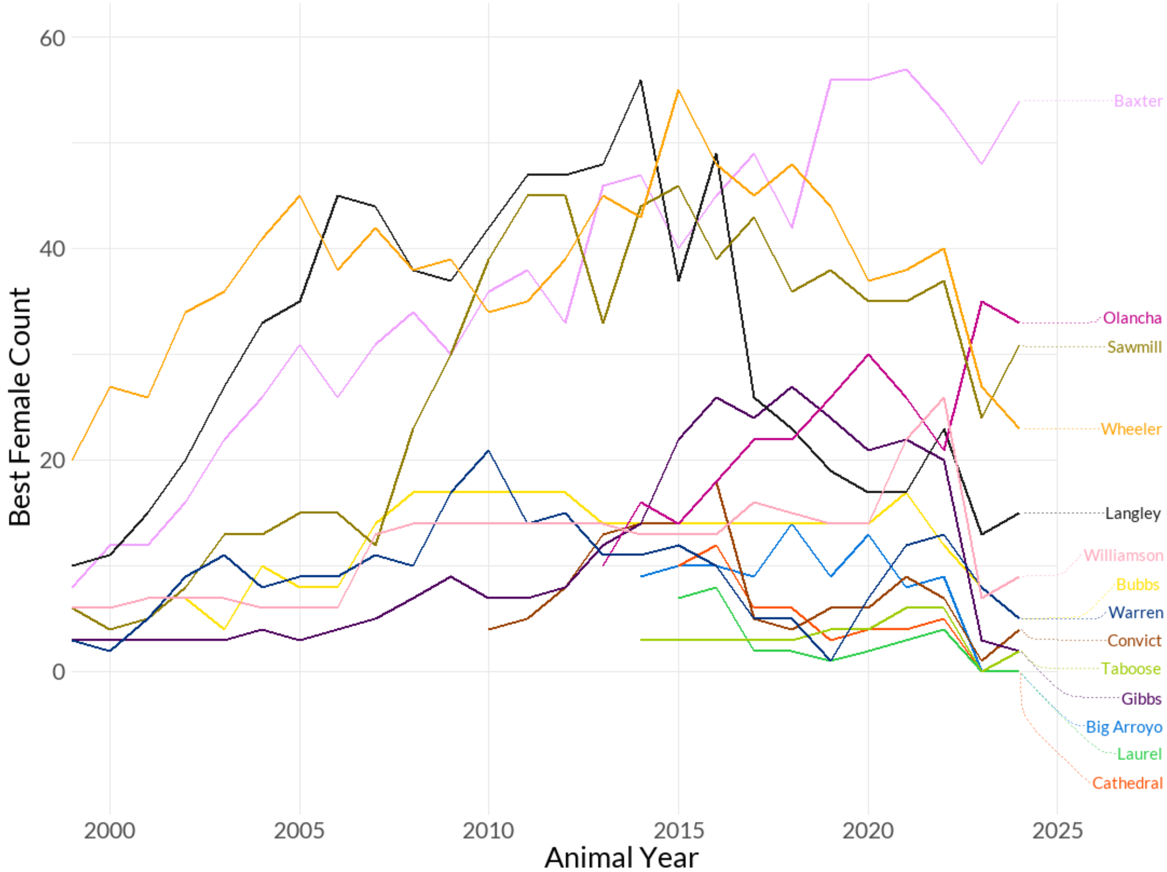

Figure 4. *Minimum counts for female Sierra bighorn from 1999-2024. These data include the best count for each herd and animal year.*

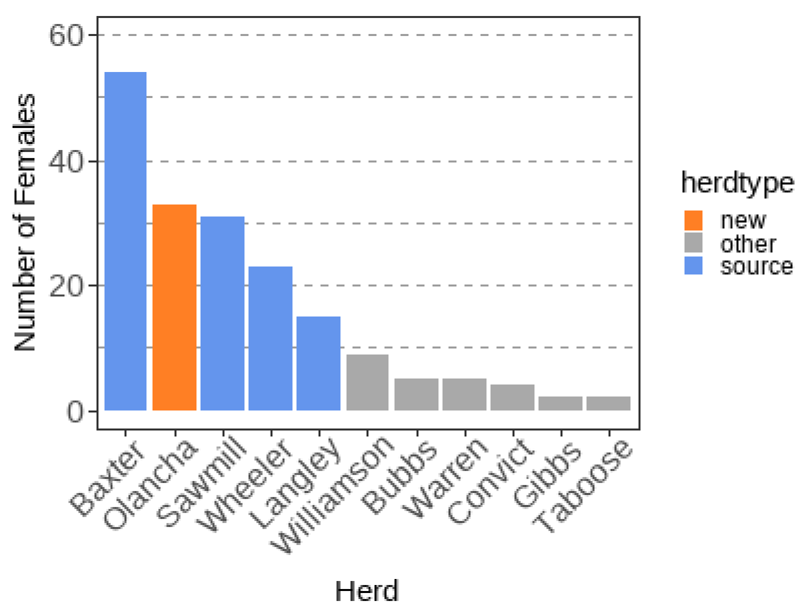

Figure 5. *Minimum counts of female Sierra bighorn in 2024. "New" herds were created through translocations by the Recovery Program beginning in 2013, "source" herds have been used for translocating to and augmenting existing herds, and "other" herds are all of the remaining herds. The three herds in the graph with zero females (Big Arroyo, Cathedral, and Laurel) are all categorized as "new".*

Table 1. *Reconstructed minimum counts (MC) of Sierra bighorn during the 2024 animal year: May 1, 2024 – April 30, 2025. Lambs are not identified by sex. Female and lamb estimates are likely more accurate than male estimates because there is a higher proportion of marked females and survey routes are designed to detect females. Year-end population is altered by all known female mortalities and translocations that occurred after the survey. Counts are from summer surveys, except where indicated. C = data combined from winter and summer surveys.*

Herd	Female Adult	Female Yrlng	Female Total	Lambs	Male Adult	Male Yrlng	Male Total	MC	Year-End Females	Mortality post survey	Notes
Olancha	29	4	**33**	16	9	6	15	**64**	33	0	
Laurel	0	0	**0**	0	0	0	0	**0**	0	0	10 rams seen on Boreal Plateau could possibly be Laurel animals but presumed to be Langley
Big Arroyo	0	0	**0**	0	2	0	2	**2**	0	0	2 distinct males caught on camera in Feb. and March 2025
Langley	14	1	**15**	8	12	5	17	**40**	15	0	
Williamson	9	0	**9**	6	2	1	3	**18**	9	0	
Baxter[C]	46	8	**54**	29	33	6	39	**122**	49	S700F	5 females translocated from Baxter to Gibbs. S700F died after translocation
Sawmill	29	2	**31**	16	4	3	7	**54**	31	0	Includes small uncollared group at Acrodectes
Bubbs	4	1	**5**	4	12	2	14	**23**	5	0	
Taboose	1	1	2	1	4	0	4	7	2	0	Females not observed until 1 lactating AF and 1 YF captured in Oct. 2024
Wheeler[C]	21	2	**23**	18	10	4	14	**55**	21	M268F, S573F, M270U	Mortalities all from lion predation
Convict	3	1	**4**	1	4	0	4	**9**	4	0	Unknown if all females originated in Convict or are recent emigrants from Wheeler
Cathedral	0	0	**0**	0	3	0	3	**3**	0	0	6 rams had been observed in Cathedral, but this included mixing from Gibbs S696M; MC excludes possible Gibbs animals
Gibbs	2	0	**2**	1	9	0	9	**12**	6	S700F, M265U	5 pregnant females translocated in spring from Baxter to Gibbs. S700F died immediately after translocation. A lion killed lamb M265U at high elevation in Dec 2024.
Warren	3	2	**5**	3	3	0	3	**11**	5	0	
Totals	**161**	**22**	**183**	**103**	**107**	**27**	**134**	**420**	**177**		

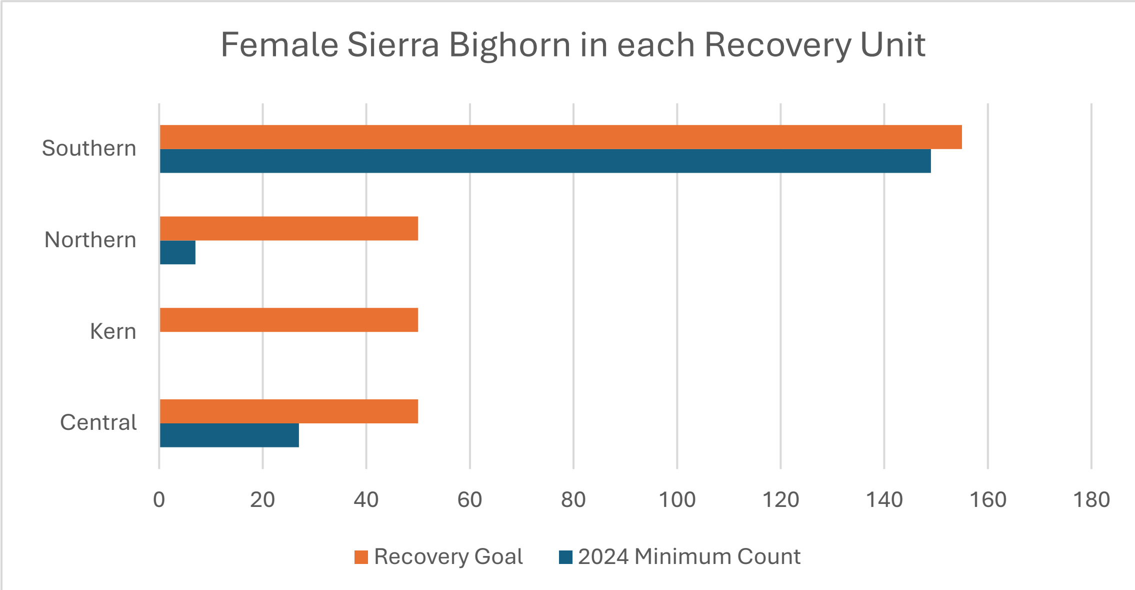

Figure 6. Abundance and distribution of female Sierra bighorn in the 2024 animal year across Recovery Units compared to downlisting goals.

Demographic Rates

This year's population growth was driven by a combination of high adult survival and high recruitment. Adult female survival was 97%, and lamb:ewe ratio was 62% (Figures 7-8), which, combined, are sufficient for positive population growth. This resulted in a λ based on minimum counts of 1.05 (Figure 9; eigenvalue λ = 1.12). This bump in recruitment compared to the previous two years may be driven by increased body condition, indicating ewes have recovered body condition lost during the 2022-23 winter. Our estimate of lamb survival was 0.67, but the ratio method used to calculate this metric (Appendix B) is not very precise, and it is likely not different than the long-term average of 0.72 (Figure 9; Methods described in Appendix B). For many ungulate populations, adult female survival tends to be high and relatively stable, while recruitment is more variable and may respond quickly to changing environmental conditions. When survival is stable, recruitment can be the dominant factor driving population growth. Sierra bighorn do not tend to follow this rule because their adult survival rates exhibit large fluctuations, with significant dips in survival during heavy winters and predation episodes, thus some years adult survival has a larger effect on population growth than recruitment.

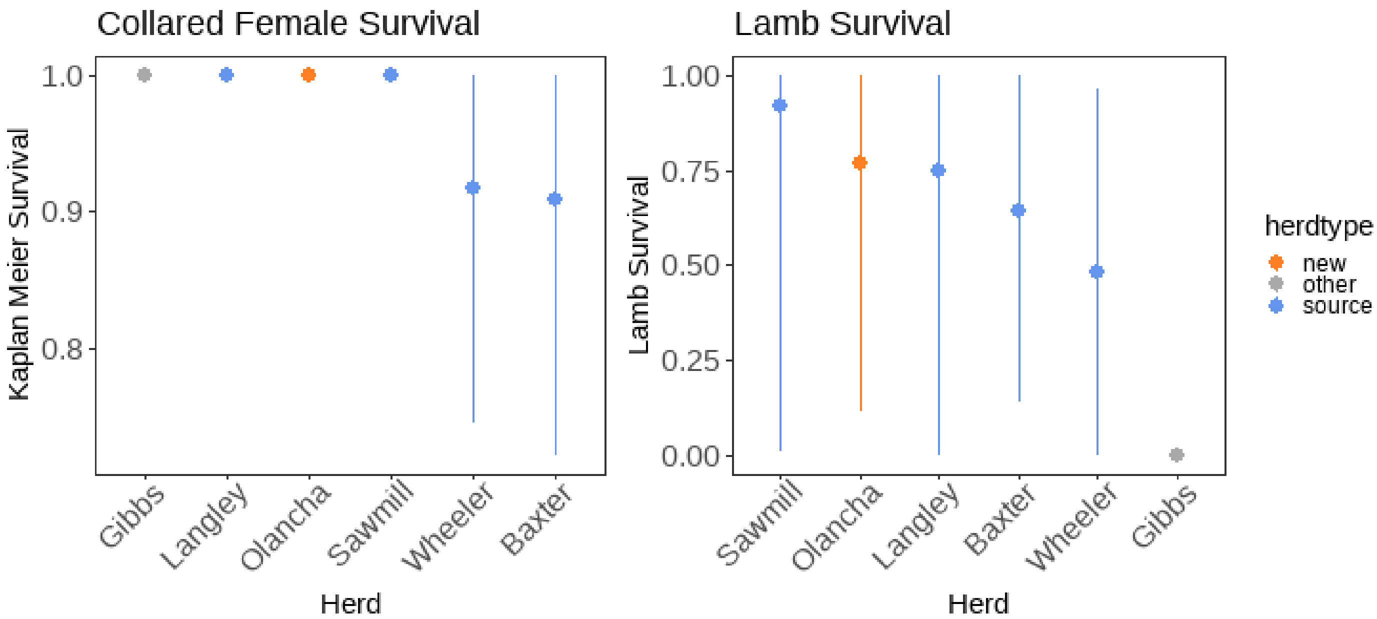

***Figure 7**. Sierra bighorn collared female and lamb survival with 95% confidence intervals, for herds with at least 3 collared females in 2024. Female survival was estimated using Kaplan Meier, and lamb survival was estimated using age ratios. Herds are arranged from largest to smallest value in each graph. "New" herds were created through translocations by the Recovery Program beginning in 2013, "source" herds have been used for translocating to and augmenting existing herds, and "other" herds are all of the remaining herds.*

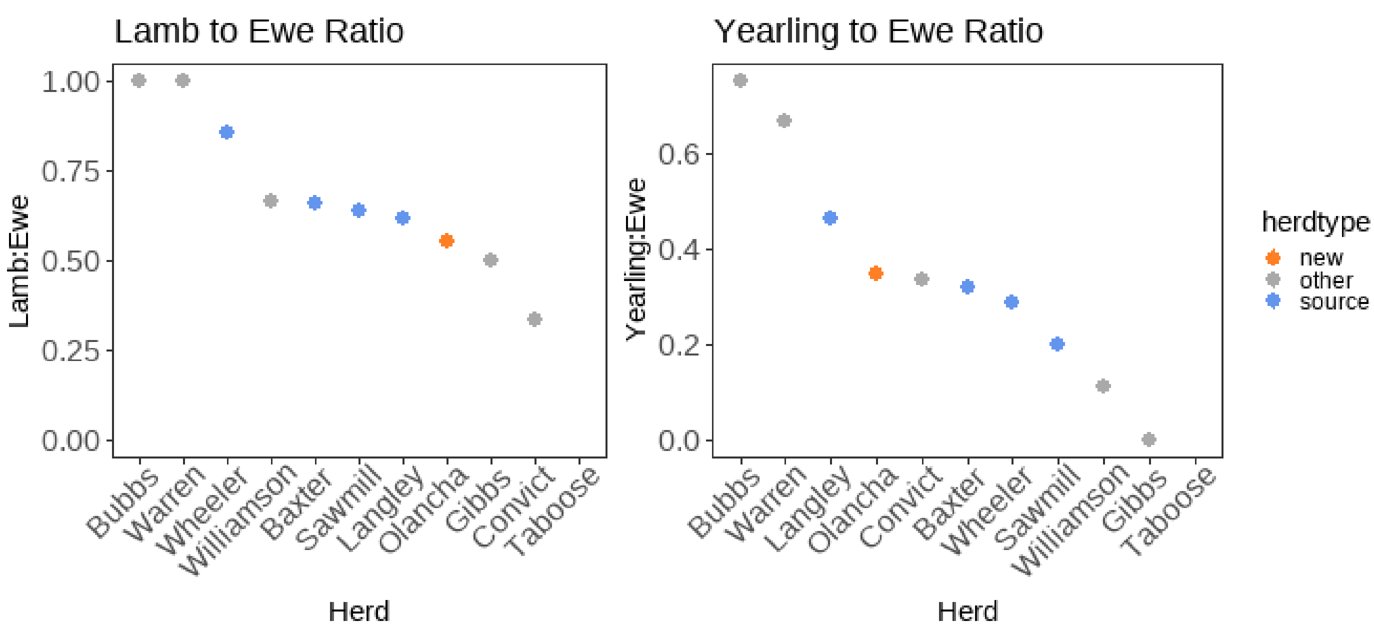

***Figure 8.** Observed ratios of Sierra bighorn lambs and yearlings (males and females combined) to adult females by herd in 2024. Herds are arranged from largest to smallest value in each graph. "New" herds were created through translocations by the Recovery Program beginning in 2013, "source" herds have been used for translocating to and augmenting existing herds, and "other" herds are all of the remaining herds.*

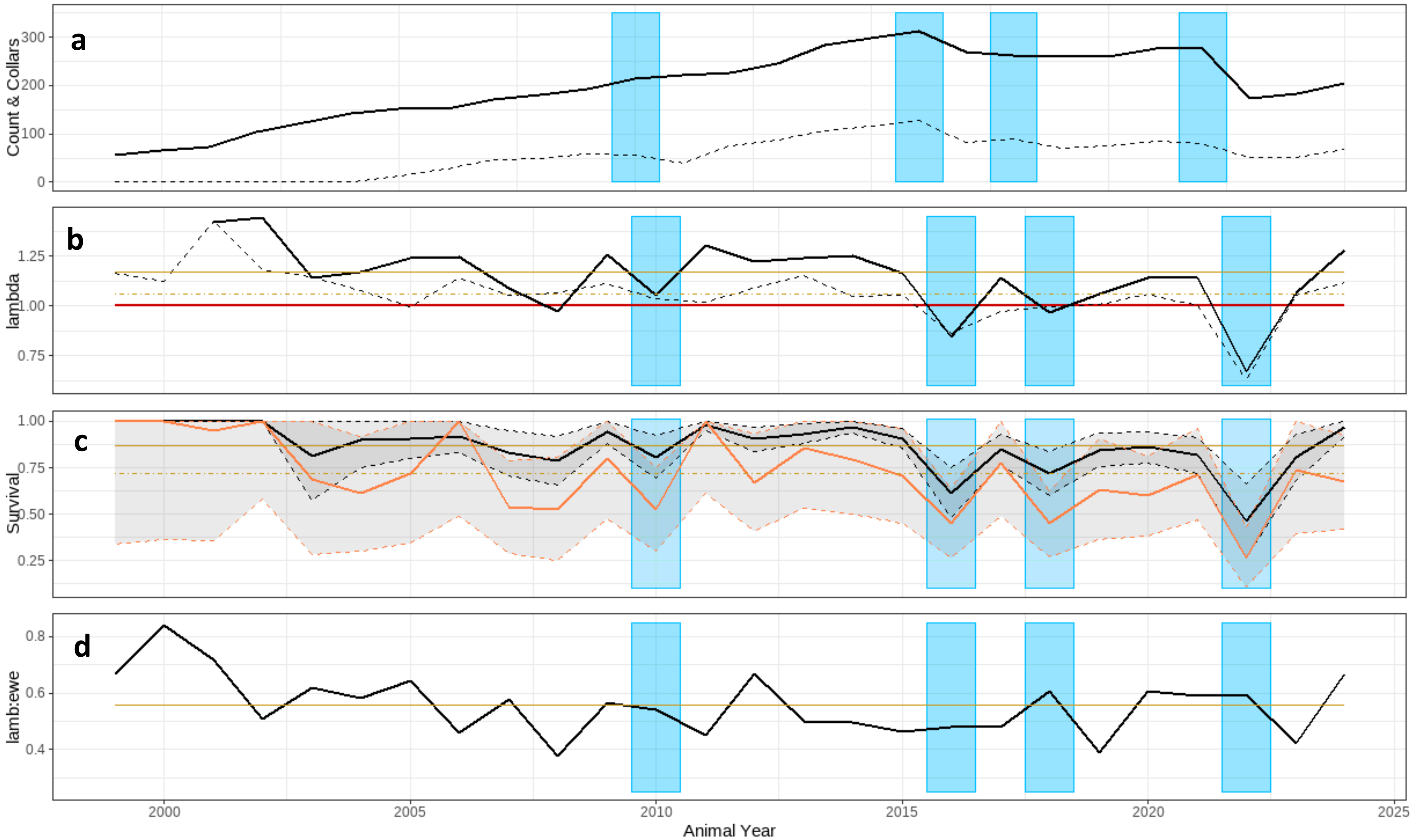

Figure 9. *Long-term and range-wide female Sierra bighorn population estimates and vital rates, 1999-2024; winters with >150% average snow are highlighted in blue.*

a) Total female population estimate (solid black line) and collared females (dashed black line).

b) Lambda (λ) calculated from eigenvalues derived from vital rates (solid black line) and lambda from minimum counts (dashed black line). Averages shown in yellow and dashed yellow, respectively. Red line at 1 differentiates growing vs. declining population.

c) Adult female survival (black line) and lamb to yearling survival (orange line) with 95% confidence intervals. Averages in yellow and dotted yellow respectively.

d) Lamb:ewe ratios as a measure of fecundity; long-term average in yellow.

Range-wide Cause-specific Mortality

We documented 10 Sierra bighorn mortalities this year in five herds (Gibbs, Wheeler, Bubbs, Baxter, and Williamson), including 4 females, 3 males, and 3 lambs of unknown sex. Only two of these mortalities had functional collars, four were identified from collared lion clusters, and four were found opportunistically by the public. The majority of mortalities were caused by lions (6), while three were from unknown cause, and one was capture-related. The capture-related mortality was a female that died within a week of being translocated from Baxter to Gibbs.

Our collaring and monitoring efforts primarily focus on females because they drive the population dynamics. Consequently, the strongest, most consistent and geographically widespread dataset comes from collared females (Figure 10). This year three collared females died within the Baxter, Gibbs, and Wheeler herds: one from lion predation, one from unknown cause, and one from capture.

In general Sierra bighorn tend to die in the winter from either predation or snow, but this varies by herd (Figure 10). For example, when we consider all of the collared female mortalities from 2005-2024 separated by herd, we can see that some herds have a higher proportion of winter mortality (Big Arroyo, Bubbs, Cathedral, Convict, Laurel, Taboose, and Williamson), while other herds are less prone to winter mortality (Baxter, Gibbs, Langley, and Sawmill). Baxter, Langley, and Sawmill also all have a low proportion of snow-related mortality, but, along with Olancha, a relatively high proportion of predation (Figure 10). Whether a herd is more susceptible to predation or snow mortality is likely related to the winter habitat including the amount of low elevation habitat, the amount of overlap with mule deer, and the amount of winter habitat prone to avalanche.

Capture, Collaring, and Translocation

We captured 35 animals in October for monitoring and 6 in March for translocation, for a total of 41 animals: 26 females and 15 males. Captures were performed with a net gun fired from a helicopter by Leading Edge Aviation. All non-translocated animals were released within the herd captured and most (37/41) were equipped with both a VHF and GPS collar, while two had a VHF collar only and two had a GPS collar only. No diseases were detected. One capture mortality occurred seven days after the translocation from Baxter to Gibbs in the spring (S700F). We were not able to determine the specific cause of death for S700F, but due to the timing we consider it to be related to the capture and translocation.

The fall capture added collars to 9 herds including Bubbs, Baxter, Gibbs, Langley, Warren, Olancha, Sawmill, Taboose, and Wheeler. The new collars will increase our ability to monitor these populations. The spring capture was focused on translocation, and 5 pregnant females were moved from Baxter to Gibbs. One additional female was captured and released back to Baxter because she was lactating with a half udder and not pregnant based on ultrasound. We speculated that she may have had a very early lamb, although she also may have had continued lactation from a late lamb, and we did not want to separate the nursing lamb from its mother. In subsequent observations, however, she was not observed with a lamb.

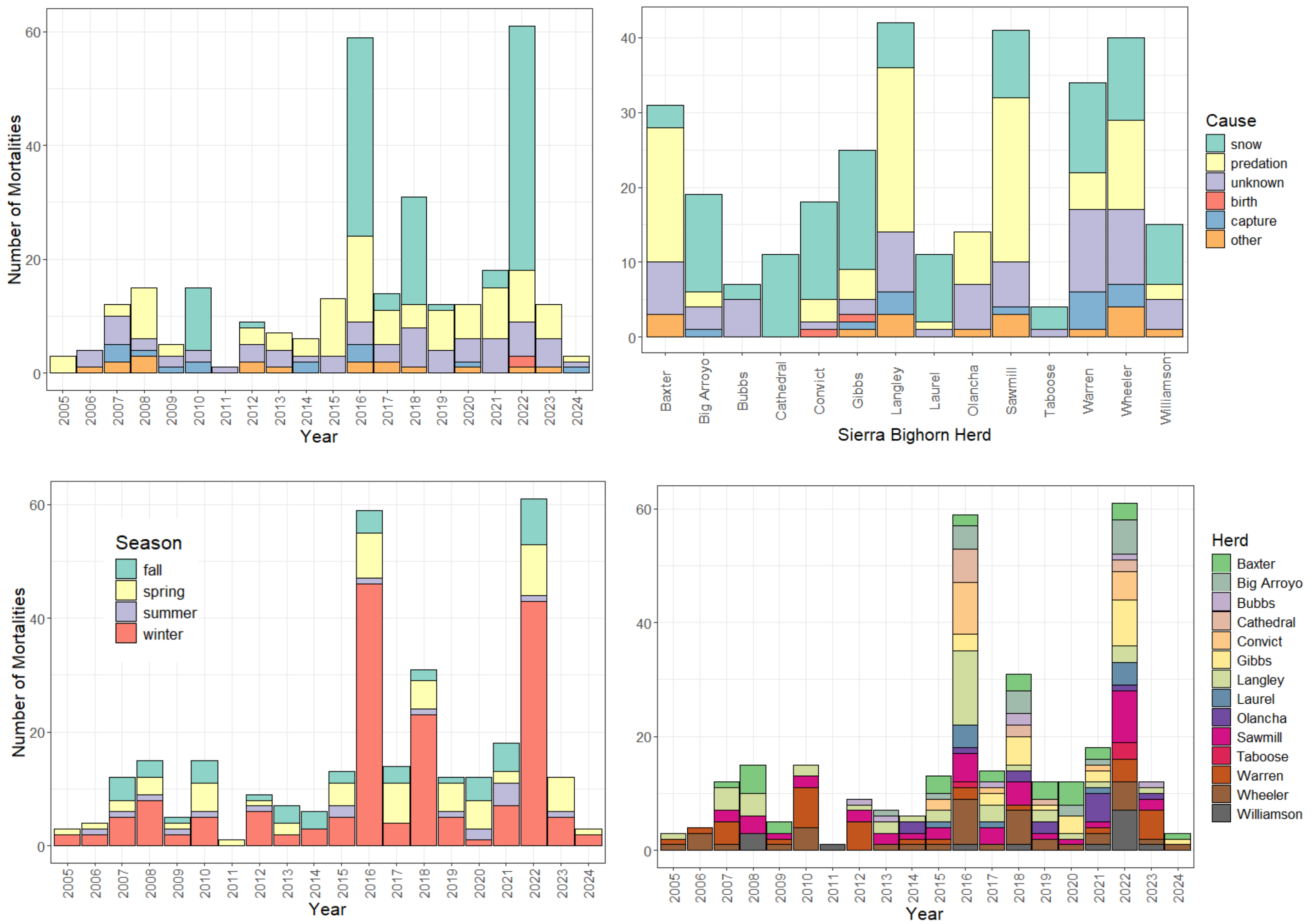

Figure 10. *Collared female Sierra bighorn mortality 2005-2024 by cause of death, season, and herd. The number of mortalities is influenced by the number of collared females at a given time, which trends with the overall population size and varies between herds. The number of herds has increased with time. Graphs do not include censored animals because their cause and date of death are unknown. Mortality cause includes those reclassified in the 2020 review (Stephenson et al. 2022). The category "snow" includes death by avalanche and starvation during winter and spring, and it includes mortalities which are considered snow-related due to their location and timing.*

Sierra Bighorn Movements

The Acrodectes Deme

The Acrodectes deme was initially associated with the Sawmill herd unit with collared females dating back to 2008. These Sawmill Acrodectes females tended to spend summers above Woods Lake on the shoulder of Acrodectes Peak but also crossed over to the west and south sides of the ridge, potentially overlapping with Baxter animals in Ram Canyon near Acrodectes Lake (Figure 11). During the winter some of these animals came down to the mouth of Sawmill Canyon but most stayed high near Colosseum Mountain and just north and east of Sawmill Pass. During the winter of 2022-23, the two collared females (S514F and S515F) in the Acrodectes deme died and no observations were made in this deme until July 2024 when a group of 7 uncollared animals (4 adult females, 1 yearling female, and 2 lambs) were found to the south of Woods Lake.

In October 2024, we captured two animals from the Woods Lake area and initially identified them as part of the Sawmill herd (S691F and S692F). However, during their first winter following capture these ewes came down to lower elevation Baxter winter habitat. It is unclear if these ewes represent offspring of the former Sawmill Acrodectes deme, or if animals from Baxter moved there after the 2022-23 winter. It is possible that we may have double-counted animals in past years, particularly when combining winter and summer counts, due to the possibility that uncollared animals in the vicinity of Woods Lake mixed with animals from the Baxter herd. Maintaining collared animals within the Acrodectes deme will be critical to improving our understanding of this area.

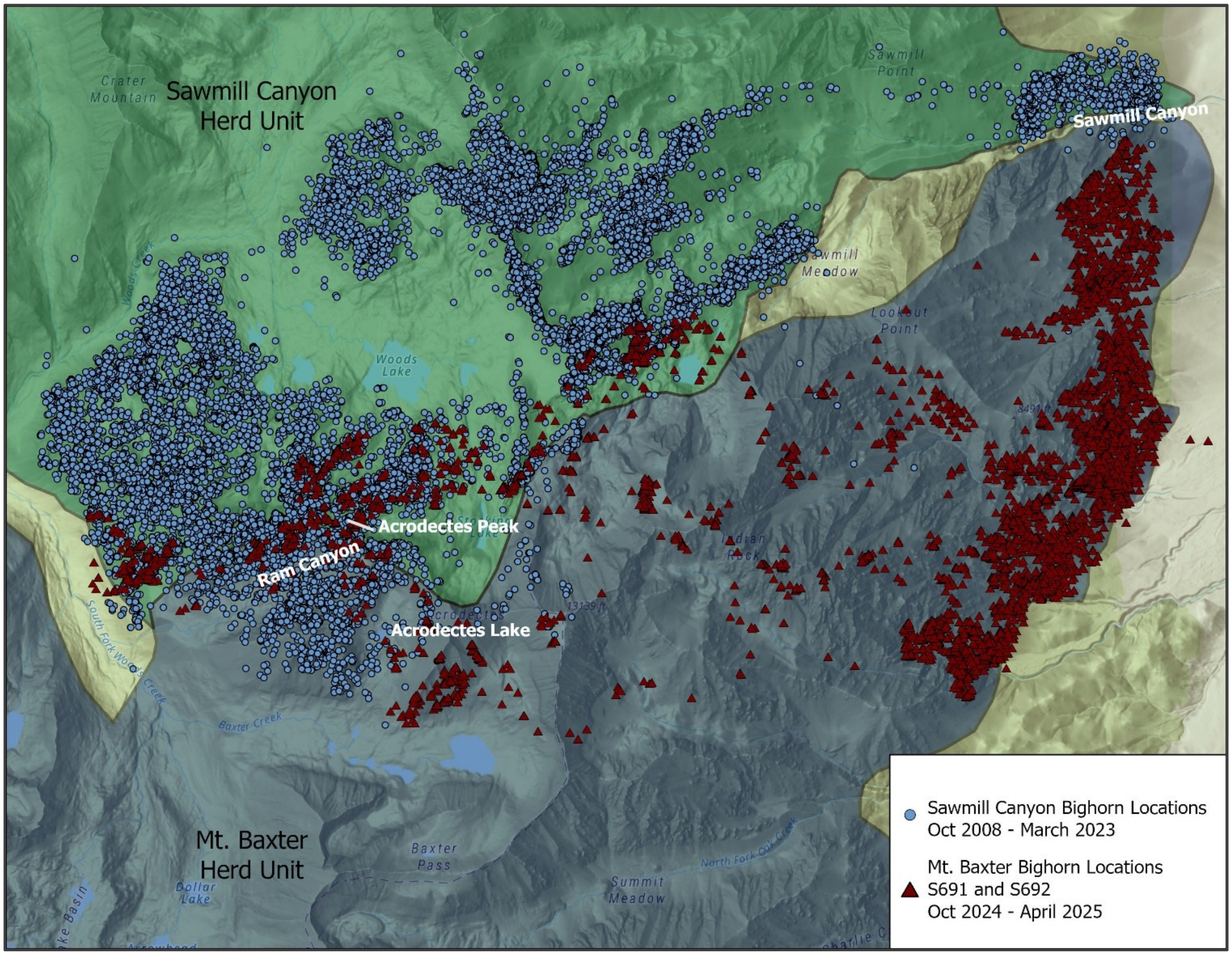

Figure 11. Sawmill Canyon herd Sierra bighorn locations from October 2008 through March 2023, and locations for two newly collared Baxter herd ewes from October through April 2024. Animals from the Baxter and Sawmill herd units appear to overlap spatially, but not necessarily temporally, particularly in the Acrodectes area.

Expansion of the Baxter Mary Austin Deme

Ewe S693F was captured and collared in the fall, and we considered her to be part of the Mary Austin deme in the Baxter herd unit. Not only did she use areas typical of the Mary Austin deme, including Mt. Mary Austin, Parker Lakes, and lower Sardine Canyon, but she also traveled south and spent extensive time on Kearsarge Peak, particularly the south side and western ridge (Figure 12). These movements seem to indicate a natural expansion from the Mary Austin deme to use habitat to the south into the Golden Trout drainage of Onion Valley.

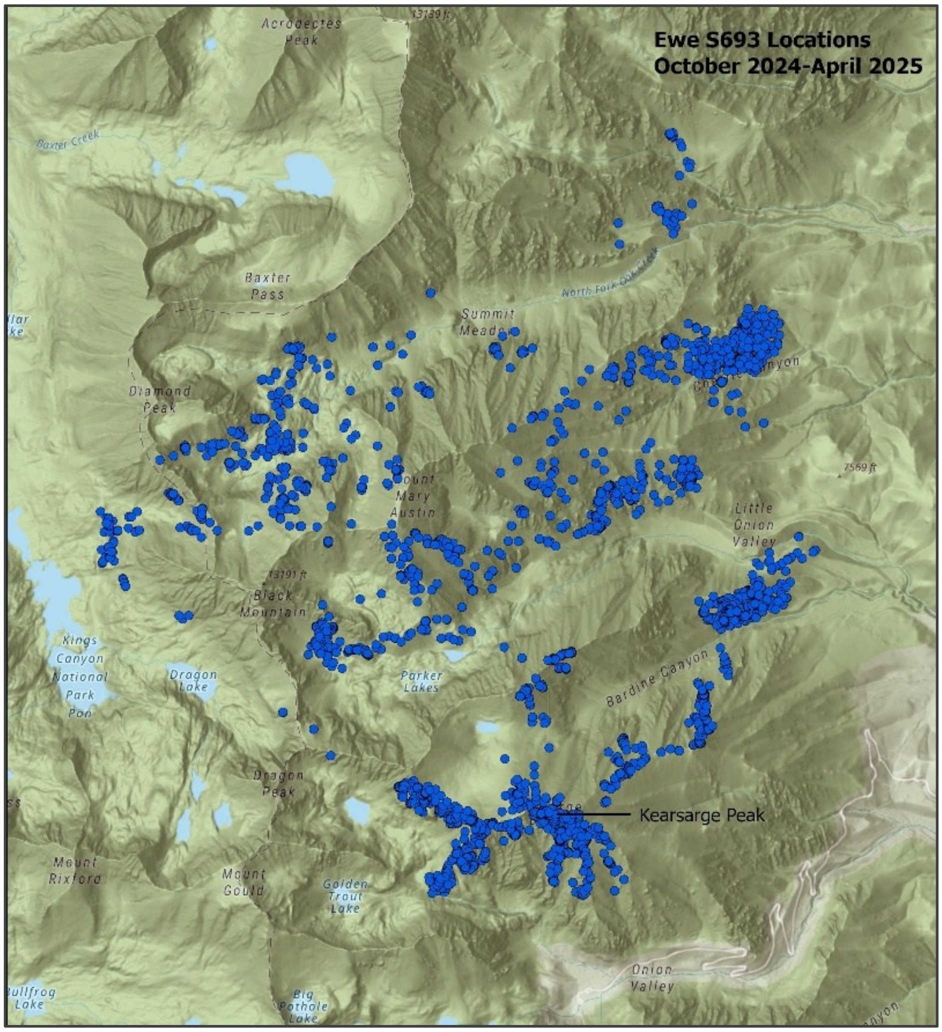

__Figure 12.__ Baxter Sierra bighorn ewe S693F made more expansive movements after her capture in October 2024 than previous Mary Austin deme animals, including visiting the Kearsarge Peak area.

Fall Rut Movements at Cathedral, Gibbs, and Convict

In the fall during the rutting period, rams without established dominance tend to go on long distance quests looking for females. Cathedral ram S608M and Gibbs ram S696M both made long distance movements this fall, and each traveled through both Gibbs and Cathedral herd units (Figure 13). Gibbs S696M also traveled by Tenaya Lake and near Yosemite Valley. Cathedral S608M visited Tuolumne Meadows and traveled along the southern edge of the Grand Canyon of the Tuolumne. Farther south, Convict S657M traveled south from the Convict herd unit into the Wheeler Ridge herd unit including to areas frequently used by Wheeler ewes such as Pine Creek, Morgan Lakes, and Wheeler Ridge (Figure 13). This was a relatively quick foray; he returned to the Convict herd unit within three weeks.

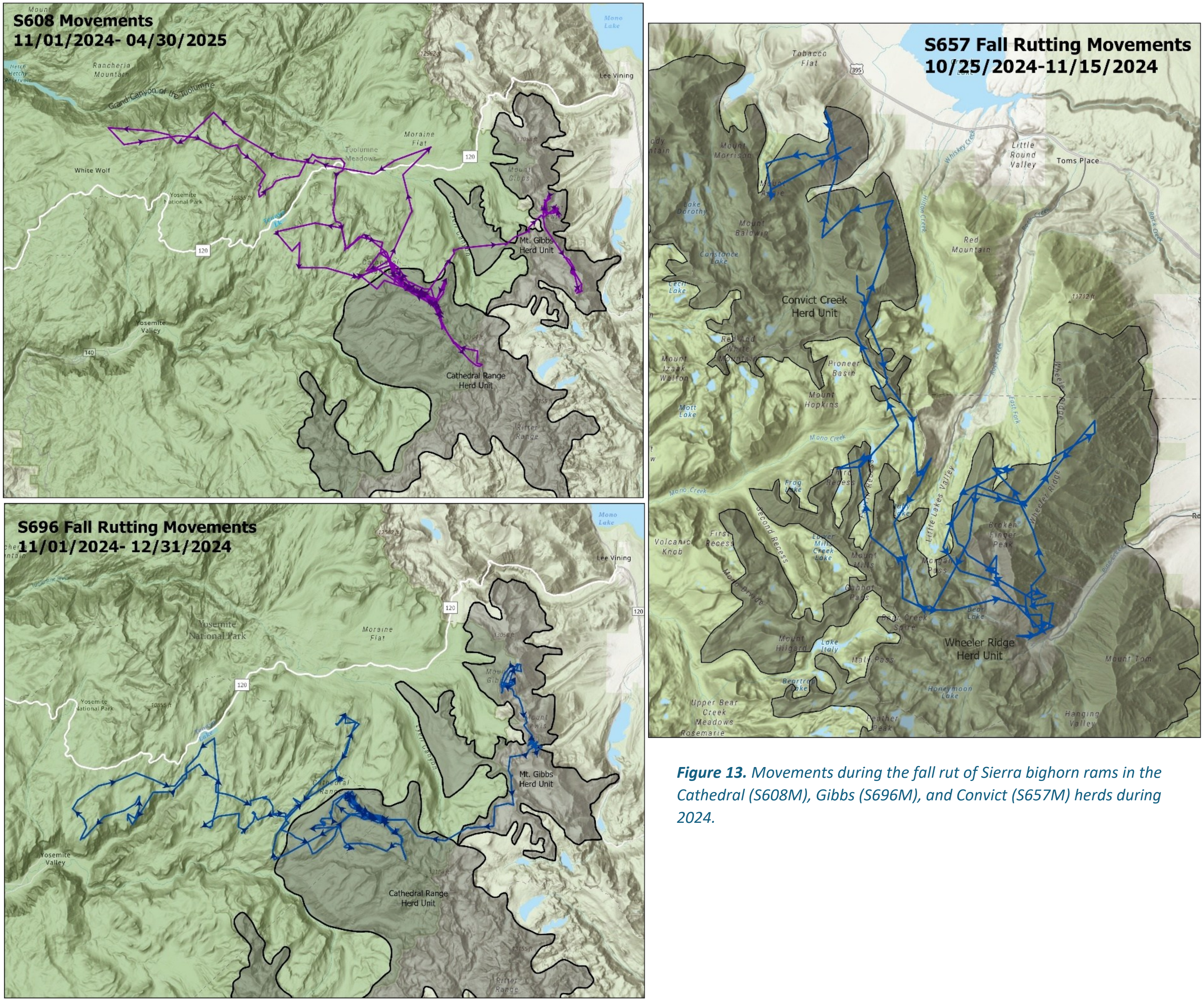

Figure 13. Movements during the fall rut of Sierra bighorn rams in the Cathedral (S608M), Gibbs (S696M), and Convict (S657M) herds during 2024.

Owens Peak Ram

On February 2, 2025, a hiker videoed a bighorn ram in the southern Sierra at 4,800 feet, above Short Canyon near Owens Peak and Inyokern (Figure 14). On February 5, CDFW staff visited the site with the hiker and collected fresh pellet samples. Genetic analysis indicated that the samples matched unequivocally with Sierra Nevada bighorn (see Appendix C for detailed report), and the ram was not a desert bighorn sheep as was first suspected. This ram was more than 37 miles south (direct line) from the southern boundary of the nearest herd and ~28 miles direct line distance south of the nearest known observation of Sierra bighorn in the Olancha herd, making it the southernmost Sierra bighorn that the Program has detected. Currently there is an open and active cattle/sheep allotment between Owens Point and the Olancha herd, which raises concerns about potential disease exposure due to the risk of contact with domestic sheep.

Figure 14. Location of Sierra bighorn ram observed by the public on February 2, 2025, 37 miles south of known Sierra bighorn herds.

GPS Collar Accelerometer Data

Accelerometers measure activity on the x, y, and z planes, capturing the fine-scale movements of an individual in three dimensions. Many of the modern GPS collars deployed on Sierra bighorn have accelerometers which record a measurement of activity at 60-second intervals. Researchers often use accelerometers to study behaviors or energy expenditure; however, we have found they also can help us better determine time of death and offer a window into the end of an animal's life.

Program staff examine accelerometer data to learn more about the timing and patterns surrounding the death of Sierra bighorn (Figure 15). Determining the exact date of an animal's death can help elucidate the possible cause of mortality. For example, a bighorn who died during a big winter storm is more likely to have been killed by an avalanche than had she died the day prior to the storm. It is not uncommon that the impact of an avalanche, rockfall, or caching from a mountain lion can alter or destroy the GPS capabilities of a collar. Often, however, the low-power accelerometer keeps working, providing valuable information about time of death (Figure 15). While we cannot determine cause of death solely from accelerometers, they offer another valuable data stream to improve our understanding of the final hours in the life of a Sierra bighorn.

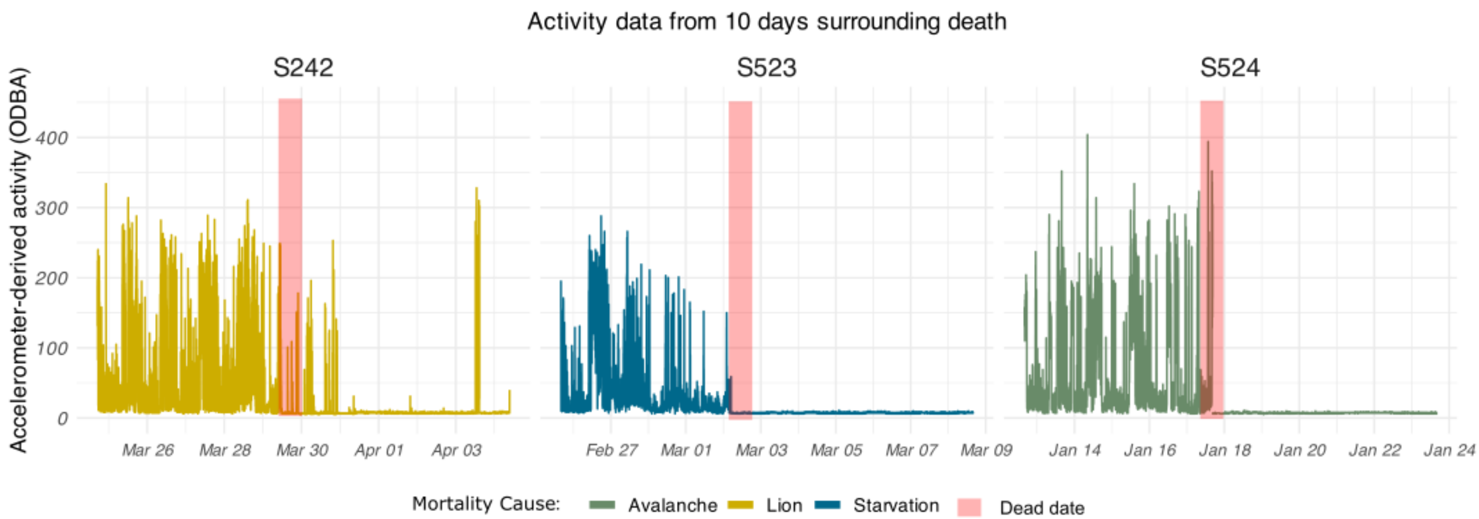

Figure 15. *Accelerometer data from the five days preceding and following death of three Sierra bighorn where the cause of death was considered certain. For these individuals, activity looks like what we might expect the end-of-life activity to look like: post-mortem activity from a predator handling the carcass for the lion kill (S242F), a slow decline in activity for starvation (S523F), and a spike in activity followed by stillness for the avalanche mortality (S524M). Not all end-of-life accelerometer data as clearly fit the expected pattern as these three did, even when the cause of death was certain.*

Mountain Lion Monitoring and Management

Lion Minimum Counts

In the 2024 count year we documented 72 mountain lions in the eastern Sierra population: 27 adult females, 17 adult males, and 28 subadults (Tables 2-3 and Figure 16). Seven of the 28 documented subadults were young juveniles (<6 months old) whose survival is unknown. Our minimum counts of adult male and female lions have been consistent since 2022, indicating a generally stable population. See Tables 2 and 3 for a breakdown of the distribution of age and sex classes of documented lions across Sierra bighorn Recovery Units. Individual lions detected in multiple Recovery Units are counted in the total for each Recovery Unit but only once for the total population estimate of 72 lions.

Table 2. *Minimum counts of all mountain lions documented in Sierra bighorn Recovery Units May 1, 2024 – April 30, 2025.*

	NRU	CRU	ORU	SRU	Outside Recovery Units
Total	9	19	11	25	16
Adult Females	3	9	3	7	6
Adult Males	2	4	5	5	6
Subadults	4	6	3	13	4

Forty-six of the 72 known lions were GPS-collared for some portion of the reporting period. The 26 lions without functional collars consisted of 7 adult females, 3 adult males, and 10 subadults, of which 6 were young juveniles (Table 3). Unmarked individuals and those with non-working collars were identified by physical evidence, such as unique scars and markings, age of dependent subadults, non-functional collars, ear-tags, and unique track features (Appendix B).

Table 3. *Minimum counts of unmarked and non-functionally-collared mountain lions documented in Sierra bighorn Recovery Units May 1, 2024 – April 30, 2025.*

	NRU	CRU	SRU	ORU	Outside Recovery Units
Total	2	5	11	4	4
Adult Females	1	1	2	1	2
Adult Males	0	0	1	1	1
Subadults	1	4	8	2	1

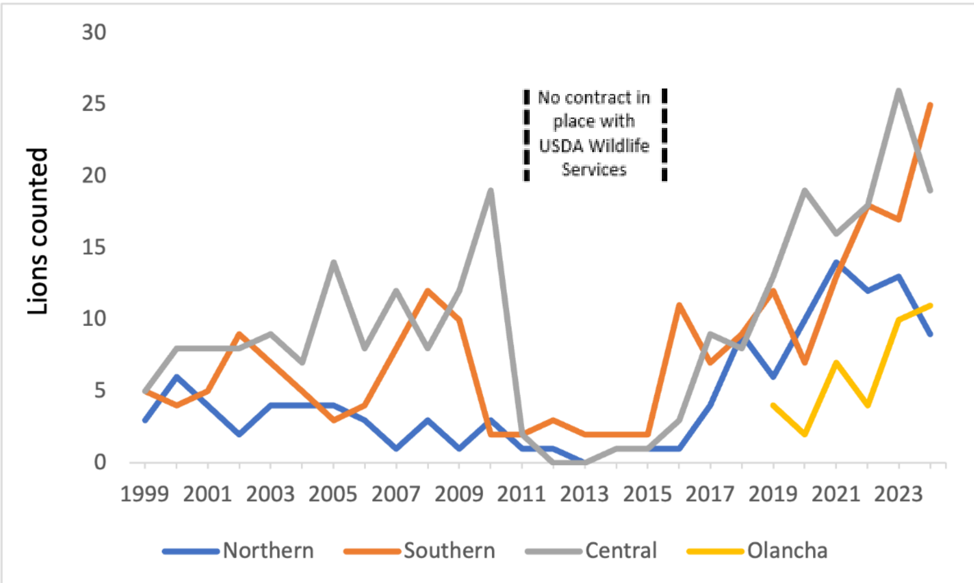

Figure 16. *Mountain lion minimum counts during 1999-2024 in the eastern Sierra. Lion monitoring effort was not consistent during this time period, and the Olancha count zone was added in 2019.*

Lion Captures

We captured 25 lions in 2024, including 8 new individuals. Capture effort was significantly reduced from mid-April 2024 through mid-January 2025 due to staff shortages. Despite these challenges, we were still largely successful in protecting Sierra bighorn from lion predation, most notably by capturing and collaring L267M, a 5-year-old male who we suspect had been hindering the growth of both the Gibbs and Warren herds in the Northern Recovery Unit (described below).

Predation on Sierra Bighorn

We documented six instances of predation on Sierra bighorn by lions in 2024, including 2 ewes and 1 unknown sex adult at Wheeler, 1 ram and 1 unknown sex lamb at Williamson, and 1 unknown sex lamb at Gibbs (Figures 17-18). The two Wheeler ewes were killed by L194F, who was slated for translocation just before she died of natural causes at a very old age in May of 2025. The third Wheeler animal was killed by an uncollared lion, possibly L228M, whose GPS collar was not functioning at the time but was later replaced. L167F killed the lamb at Williamson, and because she was very old and had been involved in livestock depredation we decided that she was not a prime candidate for translocation. We determined that it was unlikely that she would kill another bighorn before she died either of natural causes or vehicle strike, as her home range was bisected by US Highway 395. Indeed, she died on Highway 395 from a vehicle strike in early January 2026, before preying on more Sierra bighorn. The Williamson ram killed in Symmes creek was discovered by a hiker in January 2025 when it was relatively fresh and is believed to have been killed by L281F, who was uncollared at the time. The lamb at Gibbs was killed by L267M in December 2024, two weeks after L267M was collared after seven months of searching for him (described more below).

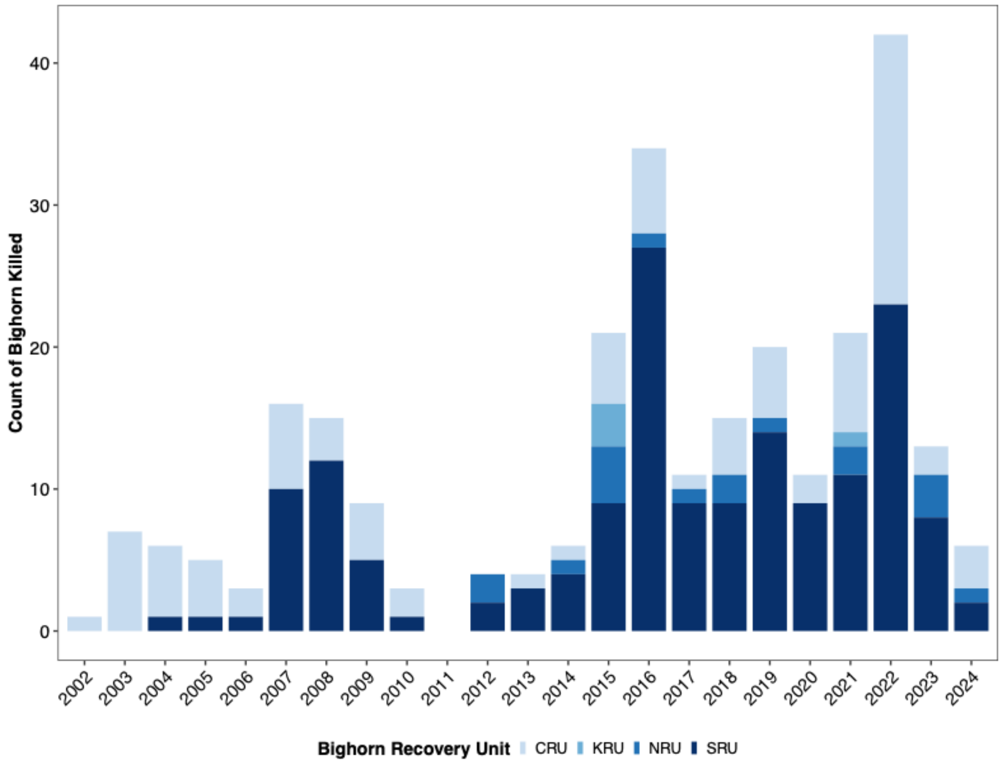

Figure 17. Lion predation on Sierra bighorn by Recovery Unit from 2002-2024. Lion monitoring effort and Sierra bighorn population sizes were not consistent across this time period.

In the 2023-24 report we described the predation of three adult ewes at Warren, two of which occurred at high elevation in early March 2024 (Greene et al. 2024). We believe L267M was responsible for these 3 mortalities, as the pattern of hunting bighorn at high elevation in winter conditions was consistent with his behavior and movements after he was collared November 16, 2024. Two weeks after L267M was captured in Bloody Canyon, he killed a Gibbs lamb at 12,000 feet elevation in the middle of a winter storm, confirming his high elevation predatory behavior. L267M was captured again and translocated away from Sierra bighorn habitat on December 16. In the month between his initial capture and translocation, L267M almost exclusively used high alpine habitat in snowy conditions, apparently subsisting on small prey except for the Gibbs lamb.

Since L267M was translocated, we have not documented any lion predation in the Northern Recovery Unit. L267M demonstrated that lions who do not follow migratory deer herds to low-elevation winter ranges can have devastating effects on small Sierra bighorn herds at high elevations, even in moderate snow conditions. This illustrates that predation should be considered as a potential cause of mortality at all elevations, across seasons. Smaller Sierra bighorn herds, such as those in the Northern Recovery Unit and others with 15 ewes or fewer, are particularly vulnerable to the impacts of lion predation. It only takes a few instances of predation in a year to turn the population trajectory from growth to decline.

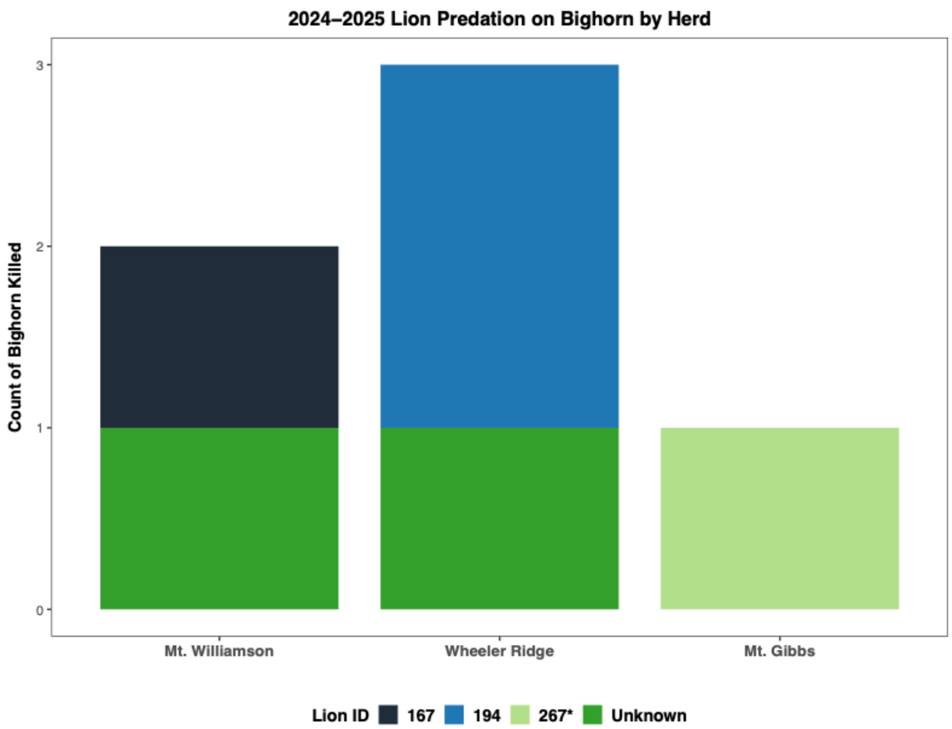

Figure 18*. Lion predation on Sierra bighorn in the 2024 animal year by herd unit and individual lion. Lions denoted with an asterisk were translocated out of Siera bighorn Recovery Units for Sierra bighorn protection during this time period.*

GPS data from collared lions allows us to quantify predation on Sierra bighorn, but many Sierra bighorn-predating lions were collared as mature adults, and predation prior to their collaring could have been undetected. Even low levels of predation can have a significant impact on bighorn herds, and considering each collared lion's total lifespan can help us speculate on how predation may have limited herd growth in years prior to their collaring (Figure 19). As an example, L194F killed 6 ewes in the Wheeler herd between 2021 and 2025, for an average rate of 1.5 ewes killed per year, varying from 0 to 3 in each year. Out of 23 known ewes this low level of predation, with no other causes of mortality, brings the annual female survival probability from 100% to 93.5%, approaching the 90% threshold we often use as a rough threshold to prevent population decline in Sierra bighorn. L194F was not the only lion preying on the Wheeler herd. Prior to her translocation in April of 2023, L229F lived in the Wheeler herd, where she was captured as an 8-year-old adult in January 2023. Between January and April 2023, L229F killed 2 ewes and 2 rams at Wheeler. If we assume that no predation occurs outside the winter months of December-April, this gives us a predation rate of 2 ewes per year for L229F. We estimated that both L229F and L194F were born in 2014, and it is likely that they both lived in Wheeler since they established home ranges as young adults aged 2-3 years old (Figure 19). If both L229F and L194F lived in Wheeler since 2017, and in combination preyed on a total of 3.5 ewes per year, this would require a population of at least 35 ewes to support a growing bighorn population.

In addition to predation losses from L194F and L229F, Wheeler was experiencing losses from an adult male lion (L148M), who killed 3 ewes in 2023, and is known to have resided at Wheeler since at least 2018. If we conservatively assume that L148M killed 1 ewe per year at Wheeler, then it would require a herd of at least 45 ewes to sustain the predation of L148M, L194F, and L229F. Wheeler has not had 45 ewes since 2019, and it is therefore likely that the predation by L194F and L229F would have negated population growth and in fact caused a population decline, regardless of any other causes of mortality. In reality, Wheeler was experiencing predation from more lions in addition to L148M, L229F, and L194F, and in the 2022-23 winter lost a total of 7 ewes to predation, which would have driven adult female survival down to 82.5% for that year and caused a declining population. Furthermore, lion predation is not the only cause of mortality in Sierra bighorn; during the same winter, Wheeler lost at least 6 bighorn to avalanches and starvation (Greene et al. 2023).

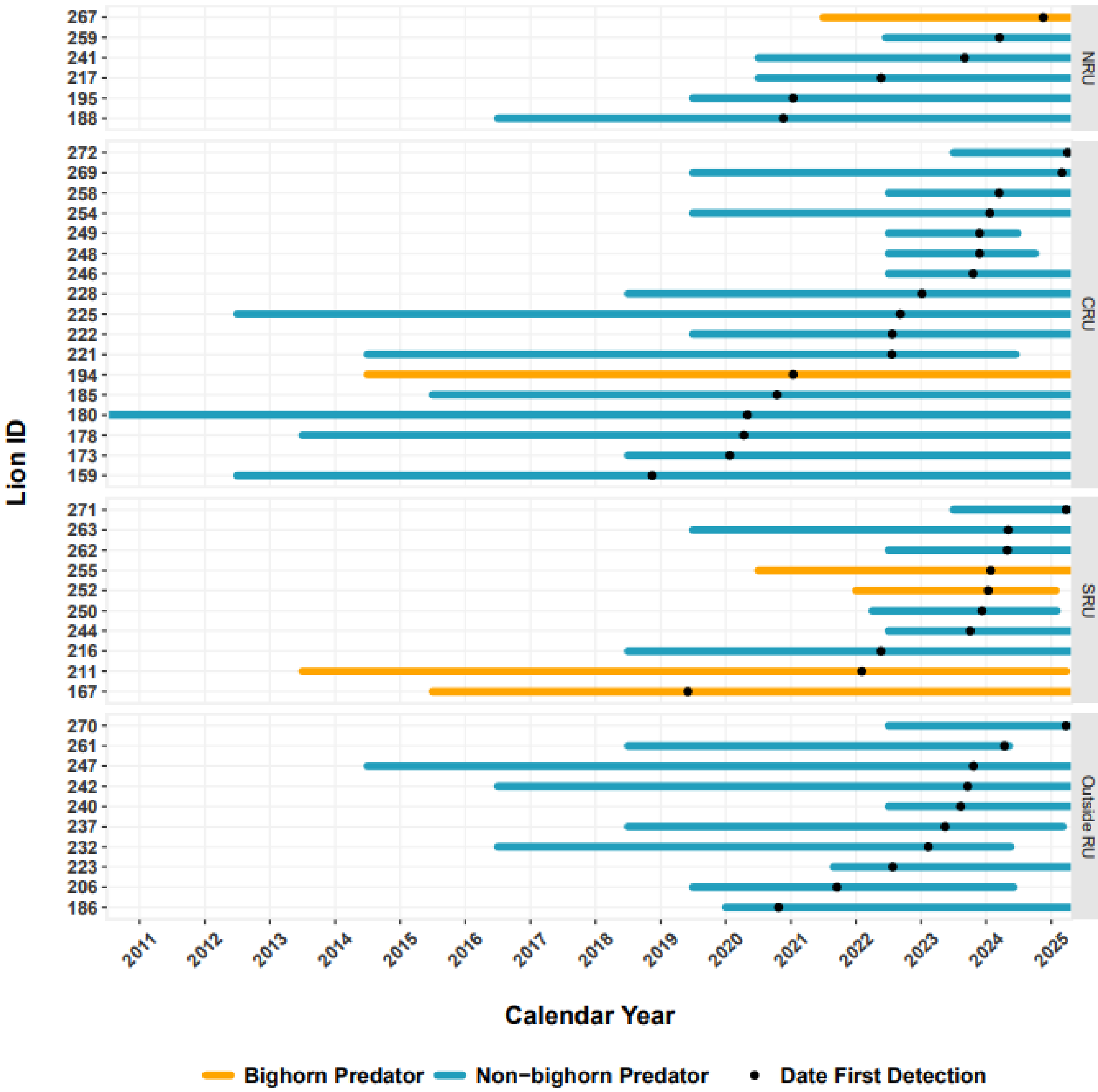

Figure 19. *Temporal presence of collared lions in the eastern Sierra and their known status as Sierra bighorn predators. All collared lions known to be alive during the 2024 animal year are included. Birth year is based on estimated age from gum recession and tooth wear at first capture date (detection). We assume that individual lions maintain the same predatory preferences before and after capture, once they have established a home range.*

Predation Management – Lion Translocations

We translocated two male lions (L252M and L267M) for Sierra bighorn protection in the 2024 animal year in accordance with our Predation Management Strategy (Gammons et al. 2025). L267M was translocated from the Northern Recovery Unit in December of 2024 after he killed the only known lamb in the Gibbs herd. As described above, L267M was believed to be responsible for the loss of three adult ewes in the Warren herd in 2023, causing the loss of 37% of adult ewes and a catastrophic decline in that herd's viability (Greene et al. 2024). Since L267M's translocation we have not detected any lion predation in the Northern Recovery Unit.

The second lion translocated, L252M, was captured as a subadult traveling with his mother in Round Valley in December of 2023. His dispersal wanderings in early 2024 covered vast areas of the Sierra, including alpine habitats west of the crest. He roamed the entire Southern Recovery Unit and large parts of the Kern Recovery Unit as well. In late April of 2024 he killed a yearling ewe in the Baxter herd northwest of the Baxter Pass trailhead. In January of 2025 we captured and translocated him from Symmes Creek in the Williamson herd to prevent any further losses to bighorn in the Southern Recovery Unit.

Translocations have proven to be an effective method for reducing predation on Sierra bighorn, and translocated lions show statistically similar survival to non-translocated ones (Figure 20), supporting translocation as an ethically sound alternative to lethal removal when used appropriately.

Since increasing our mountain lion monitoring and management efforts in 2022 we have seen encouraging results, indicating both better detection and a substantial reduction in lion predation on Sierra bighorn. This is due to a combination of factors including increased staff effort, increased track and camera surveys, rapid responses to collared deer and bighorn mortality alerts, and prompt removal of lions documented to prey on Sierra bighorn in accordance with an updated predation management strategy (Gammons et al. 2025).

In 2022 we documented a high level of predation with 42 Sierra bighorn killed by lions due to increases in our detection of lion predation thanks to increased capture efforts on bighorn winter ranges. In 2023 we documented 13 Sierra bighorn killed by lions, a 69% reduction from 2022, thanks in part to comprehensive translocation removals of bighorn-predating individuals. In 2024 through further lion translocations, we were able to reduce known predation again by half and documented only six instances of predation on Sierra bighorn, representing an 86% reduction in predation since 2022 (Figure 17).

We are encouraged by these results and emphasize the importance of lion management for achieving our long-term goals of meeting recovery criteria and eventual delisting of Sierra bighorn. Furthermore, lion translocation has proven to be an effective, non-lethal method for mitigating predation on endangered Sierra bighorn, with largely positive outcomes for both bighorn and lions.

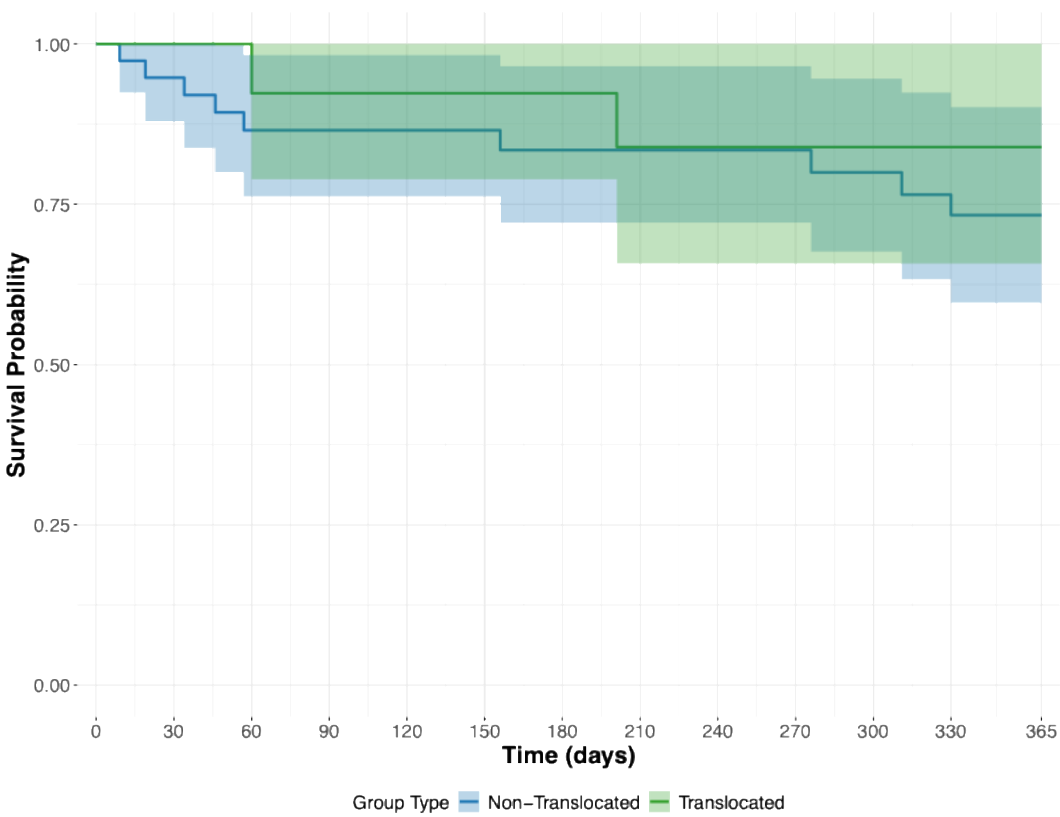

Figure 20. Kaplan Meier survival curves for non-translocated lions during the 2024 animal year (blue) and translocated lions since the 2021 animal year (green) in the eastern Sierra. Translocated lions had similar survival rates to non-translocated lions.

Lion Survival and Mortality

Average annual survival probability across all age and sex classes of lions in the eastern Sierra population was 0.73 (95% CI = 0.6-09). Adult females had a survival probability of 0.87 (95% CI = 0.72-1), males had a survival of 0.66 (95% CI = 0.44-1), and subadults had a survival of 0.42 (95% CI = 0.15-1). Translocated lions exhibited similar survival (0.7, 95% CI = 0.51-0.96) to non-translocated lions (Figure 20). Since adapting our translocation strategy to target specific release sites with known prey densities in 2022, we have seen high survival in translocated lions, with an average across age and sex classes of 0.84 (95% CI = 0.66-1).

We documented 12 lion mortalities in the 2024 animal year from 8 causes, including lethal removal for livestock depredation (n=3), intraspecific killing (n=2), public safety self-defense (n=1), public safety/lion welfare euthanasia (n=1), legal hunter harvest in Nevada (n=1), illegal poaching in California (n=1), roadkill (n=1), and unknown cause (n=2).

Lion Reproduction

We documented the presence of at least 1 offspring in 11 of 20 collared adult females, as well as in 3 of 7 uncollared adult females. We documented a minimum of 9 uncollared juveniles (<6 months old), of whom 7 fates are unknown, and 2 are known to have survived to dispersal. We also documented 9 subadults (>6 months old) whose fates are unknown, and 8 subadults who were collared and their survival rates are reported above.

Lion Kill Site Investigations

Identifying the conditions associated with lion predation on Sierra bighorn is critical for determining where translocation and predator management efforts will be most effective in supporting Sierra bighorn recovery. By quantifying how predation varies across space and time, we can better protect bighorn source populations for translocations, identify suitable bighorn reintroduction sites, and determine whether individual lions pose a substantial risk to bighorn populations and warrant management intervention.

Beginning in 2017, the program began investigating GPS-collared lion kill sites to better understand factors influencing lion diet and predation on Sierra bighorn. These investigations are being used to evaluate how predation on Sierra bighorn varies with environmental conditions, lion demographic characteristics (age class, sex, and female reproductive status), and changes in the abundance of lions, Sierra bighorn, mule deer, and alternative prey.

In total, we investigated 1,209 kill sites from 70 adult lions (42 females and 28 males), including 850 with prey (59 bighorn, 589 deer, and 511 alternative prey), spanning 36 prey categories (Figures 21-22). Kill sites were investigated across all seasons, yielding 321 investigations in summer, 230 in fall, 328 in winter, and 280 in spring. This dataset will be used to predict prey species at uninvestigated kill sites, providing inputs for analyses that will improve understanding of conditions associated with elevated predation on Sierra bighorn and guiding management efforts. Results of these analyses will be reported in subsequent annual reports.

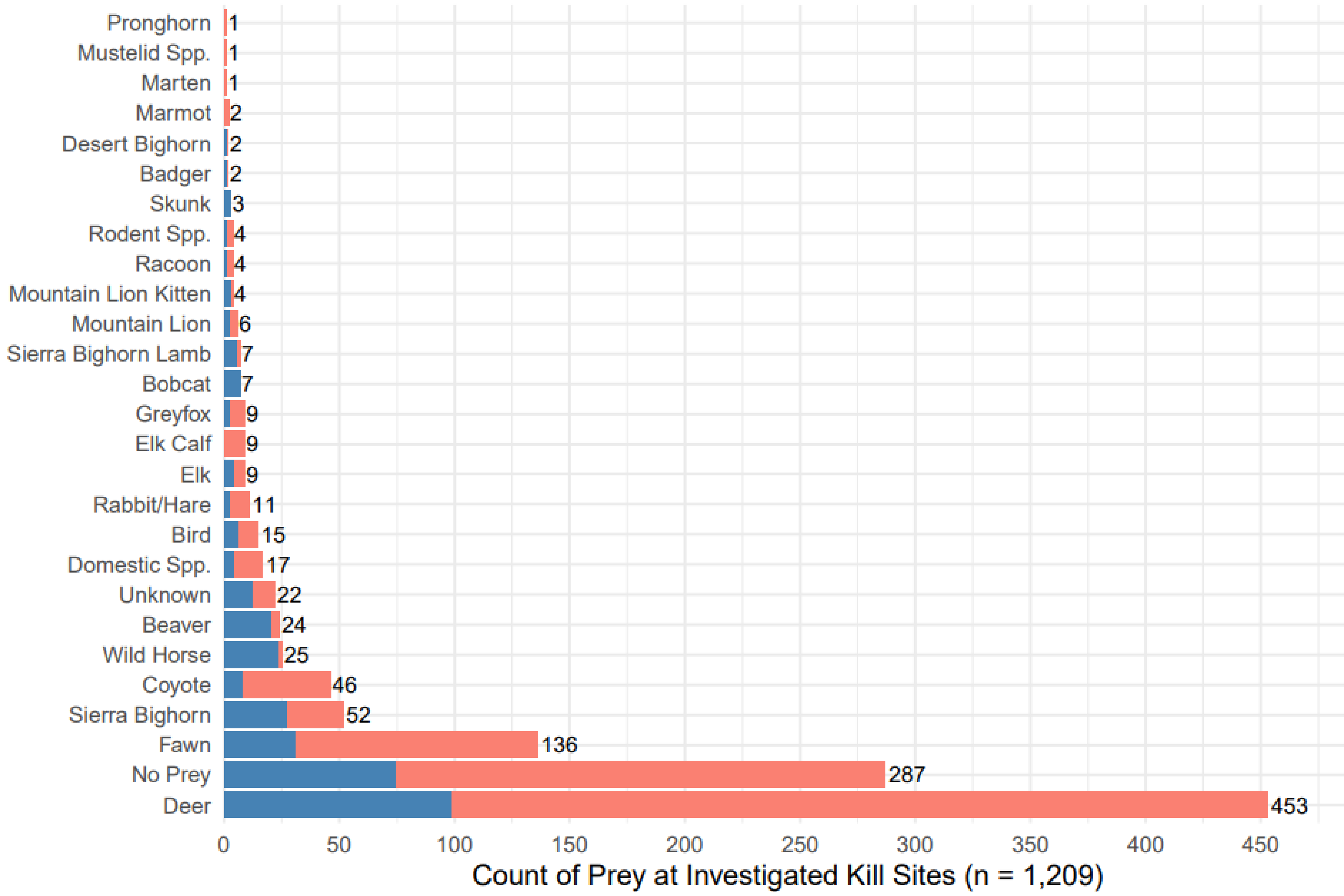

Figure 21. *Number of prey identified at eastern Sierra mountain lion kill sites from 2017 to 2024, separated by lion sex (males in blue, females in pink). Young-of-the-year ungulate prey (e.g., deer fawns and bighorn lambs) are denoted when we were able to identify them and are not included in the totals for each species.*

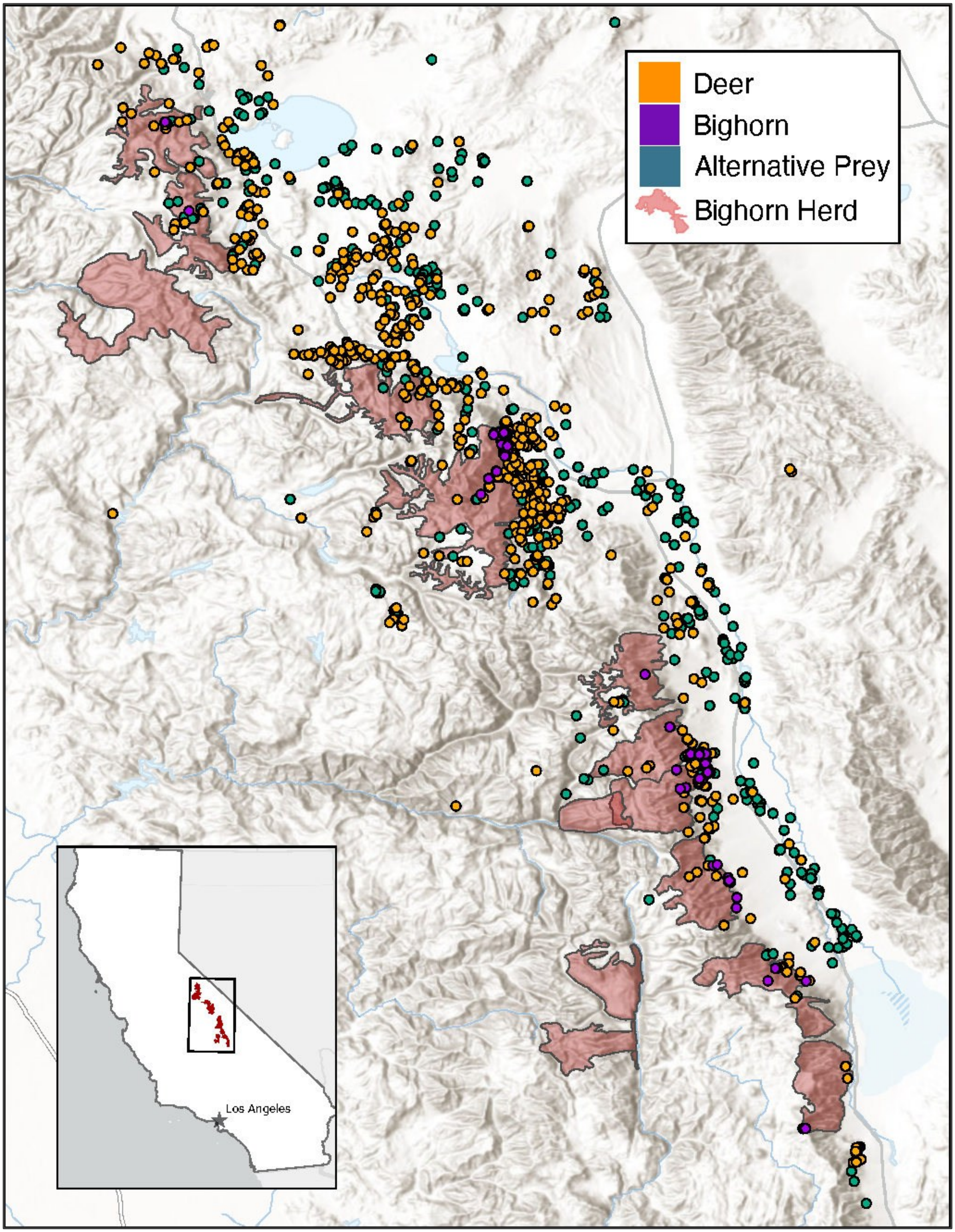

Figure 22. Spatial distribution of investigated mountain lion GPS clusters in the eastern Sierra for mule deer, Sierra bighorn, and alternative prey, relative to Sierra bighorn herd unit boundaries from 2017 to 2024. Alternative prey includes all species other than Sierra bighorn and deer.

Management Considerations

Extreme weather events, such as the heavy snows in recent years, pose challenges for Sierra bighorn. To ensure that Sierra bighorn can persist in a highly variable climate, they need a diversity of habitat use patterns throughout the recovery area. Seasonal ranges across a span of elevations have been identified using habitat models, and Berger et al. (2022) noted the need to identify migratory pathways between high and low elevations. Future restoration efforts for Sierra bighorn will rely on mapping migratory routes.

Sierra bighorn exhibit multiple migratory behaviors – traditional migrants, vacillating migrants, and residents (Denryter et al. 2021). Longer migration routes were observed in native populations of Rocky Mountain bighorn sheep when compared to restored populations (Lowrey et al. 2019). Migration distances likely vary according to the demands imposed by different landscapes in order for bighorn to access needed forage resources and avoid snow. Bighorn sheep populations that exhibit a diverse portfolio of migratory behaviors tend to be more resilient and have greater fitness (Lowrey et al. 2020).

Bighorn sheep in restored populations can learn complex migratory routes, but it may take decades (Jesmer et al. 2018). In doing so, bighorn are able to track plant phenology and optimize diet quality. As bighorn herds increase in size, individuals may explore and unlock new habitats to the benefit of the herd. The decisions we make about where to translocate Sierra bighorn going forward will create opportunities for populations to access more habitat below the winter snow line but may also require bighorn to explore in order to connect winter and summer ranges. Conducting translocations such that they provide for a broad portfolio of migratory behaviors will ensure that the subspecies as a whole is buffered against threats such as severe winters and mountain lion predation.

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This report is available at: https://wildlife.ca.gov/Conservation/Mammals/Bighorn-Sheep/Sierra-Nevada/Recovery-Program/Literature

Appendix A: 2024 Herd Unit Summaries

Olancha

During our survey September 9-11 we accounted for 64 animals: 29 adult females, 4 yearling females, 16 lambs, 9 adult males, and 6 yearling males. All 7 collared females were observed, so we consider this to be a robust female count. The only two known collared males were seen, but the previous year's male count was 20, so this is likely an underestimate of males. Notable during this survey was a single group of 46 animals observed on the north plateau of Olancha Peak including 12 lambs, 28 females, and 6 rams. On October 17, 7 previously uncollared animals were captured and collared, including 5 females and 2 males. No mortalities were detected this year.

Laurel

As part of a trans-Sierra trip June 23-27, surveyors walked down the Kern and onto the Kern Plateau through the Laurel area. No animals were detected.

Big Arroyo

Ram presence persists in the area. In June 2024 a second camera was set up in Chagoopa bowl and confirmed the continued presence of what appear to be two different rams in February and March of 2025.

Langley

Pulling together observations from June through October, we were able to account for 40 animals at Langley including 14 adult females, 1 yearling female, 8 lambs, 12 adult males, and 5 yearling males. Lone Pine Peak S415F was heard but not definitively seen, and the other 5 collared females were seen, making this a good survey. There is a possibility based on differences in observations that 1 of these adult females was a yearling, which fits more precisely with the 2022 count. The Lone Pine Peak deme was observed to have 5 adult females and 2 lambs. The total count includes two groups observed on Mt. Anna Mills; 1 female with a lamb and a group of 6 rams. It is possible there were more females in the group, but they were quickly spooked out of the area; a remote camera was placed nearby to hopefully catch these animals. The ridge from Funston Lake toward the window cliffs was surveyed but no sign was found. This habitat (Anna Mills, Boreal, Funston Lake area) is not technically within any herd unit, and these animals could have originated from Langley, Laurel, or Big Arroyo. For now, we are classifying them within Langley, but we may reconsider this in the future. No mortality was detected in Langley this year.

Williamson

During August we accounted for 9 adult females, 6 lambs, 2 adult males, and 1 yearling male. This included 4 animals in the Williamson deme (2 adult females and 2 lambs) and the rest from the Barnard deme. Both collared females were seen.

In January an unknown lion killed a ram on Shepherd Pass trail, and in March, L167F killed another ram half a mile south of Georges Creek. An additional ram was found dead of unknown cause in the high country above Wales Lake in January.

On March 26 the helicopter survey of Williamson found 13 animals in a group in Georges Creek area. We were unable to get a clear photograph or composition of the group but assume it was the Barnard deme in which 14 animals were counted over the summer.

Baxter

The highest count at Baxter came from observations in February and March accounting for 122 animals: 46 adult females, 8 yearling females, 29 lambs, 33 adult males, and 6 yearling males. This included 10 Mary Austin animals (although they may mix in winter): 4 adult females, 2 yearling females, 2 lambs, 1 adult male, and 1 yearling male. Without accounting for the translocations in the spring, this was the third highest female count at Baxter.

In October, seven animals were captured and collared, including 3 males and 4 females, two of which were targeted recaptures. All animals were released in the Baxter herd. Additionally, two females S691F and S692F were captured in a bit of grey area between Baxter and Sawmill in what has historically been considered the “Acrodectes” deme of Sawmill. However, since capture these animals have consistently migrated to the Baxter winter range and intermittently returned to the “Acrodectes” area of Sawmill as well as areas that are typically considered Baxter summer range. It is possible that if uncollared animals did this in the past, they would have been counted in both Sawmill counts in the summer and Baxter counts in the winter, possibly even a Baxter summer count as well if Baxter and Sawmill summer counts occurred at different times.

In March, 6 previously uncollared adult females were captured and 5 pregnant females were translocated to Mt. Gibbs. One of them, S700F, died shortly after translocation. The sixth captured female was released back into Baxter as she was lactating and not pregnant based on the ultrasound. It is thought she may have had a very early lamb, although she was subsequently observed without a lamb during the spring and summer. In May, adult S463F died of unknown cause.

Sawmill

In July, we accounted for 54 animals at Sawmill including 29 adult females, 2 yearling females, 16 lambs, 4 adult males, and 3 yearling males. This included animals in all three demes: Goodale, Acrodectes, and Perkins. Notably this included a group of uncollared animals at Acrodectes: 3 adult females, 1 yearling female, and 2 lambs. No animals had been observed in the Acrodectes deme in 2023. At Goodale, 8 animals were observed including 4 adult females, 3 lambs, and one yearling male, with the remaining animals all observed in the Perkins deme.

In October, two females, S691F and S692F, were captured in the "Acrodectes" deme but after capture these animals predominately used Baxter habitat in both winter and summer, although they did continue to visit areas near Woods Lake that had previously been identified as Sawmill habitat. Without these collars, it is possible these animals would have been double, or even triple-counted.

No mortalities were detected.

Bubbs

In early August we accounted for 23 animals at Bubbs including 4 adult females, 1 yearling female, 4 lambs, 12 adult males, and 2 yearling males. A collared male and female were observed, and 1 collared male was not seen, but presumed alive and included in the count. The males were seen by a hiker who took a video of them near Glenn Pass. This is likely an underestimate because the count was higher in 2023, and we only had a single female collar to help guide the effort across a huge potential survey area.

In the fall, a male and female were captured in Bubbs Creek. Adult S654M died of unknown cause in March.

Taboose

Only a few observations were made in Taboose that produced a minimum count of 7 animals: 1 adult female, 1 yearling female, 1 lamb, and 4 adult males. The males were observed in May below Red Lake. In the fall, a group of 3 was seen on Birch Mtn. from the capture helicopter, and the adult female and yearling female were captured and collared. No females had been observed in Taboose since the severe winter of 2022-23, but as this herd is very small and covers a large area, we are uncertain if these newly captured animals persisted through the severe winter, or if they re-colonized from Sawmill. Post-capture, S673F showed extensive use in the Taboose herd unit on Kid Mountain and the Palisade Lakes region.

Wheeler

The highest minimum count at Wheeler was obtained combining a summer count of females and lambs with a winter count of males for a total of 55 animals. This included 21 adult females, 2 yearling females, 18 lambs, 10 adult males, and 4 yearling males.

Seven animals were captured in the fall, 4 females and 3 males, including two recaptures with non-functional collars. Three mortalities were detected, all lion kills including 2 females S573F and M268F, killed by L194F, and one bighorn of unknown sex, M270U, killed by an unknown lion.

Convict

In February, we confirmed 9 animals at Convict including 3 adult females, 1 yearling female, 1 lamb, and 4 adult males. The female and lamb count were confirmed with a helicopter survey in March. It is unknown if all of these animals persisted at Convict or are recent emigrants from Wheeler. If they persisted at Convict, then it indicates our last count in 2022 missed some females because at that time we counted 7 females and we documented 6 female mortalities. No mortalities were detected at Convict.

Gibbs

In August, we repeatedly confirmed that 2 adult females and 1 lamb remained in Gibbs, generally found near Mt. Lewis and Parker Peak. Additionally, there was a minimum count of 9 rams for total of 12 animals, before translocations in the spring.

In the fall, we captured and collared 3 males including recapturing S658M. In the spring 5 pregnant females were translocated in from Baxter. Unfortunately, one died within a week related to the capture, but the others survived through the year bringing the total count to 6 adult females, 1 lamb, and 9 adult males. We also documented the death of 1 lamb due to predation by L267M at high elevation, nearly 12,000 feet on Mt. Gibbs in December. At that time there was decent snow coverage, but also windswept gullies to access the high country without requiring extensive travel through snow. L267M was translocated out of the Gibbs herd in late December.

Warren

During the summer we repeatedly observed 11 animals at Warren including 3 adult females, 2 yearling females, 3 lambs, and 3 adult males. In the fall a single male was captured and collared. No mortalities were detected.

Cathedral

In a spring ski survey in May, we observed 3 adult males including S608M. These 3 were repeatedly observed on Parson's Plateau cameras. On March 25, the helicopter survey detected a total of 6 males at Cathedral, including 5 on Parson's Plateau and 1 on Amelia Earhart. This included Gibbs ram S696M and possibly other uncollared Gibbs animals. Because of this mixing, we only included the 3 adult males in the Cathedral count.

Appendix B: Background and Methods

<u>*BACKGROUND*</u>

Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) are a unique subspecies native to the Sierra Nevada in California (Grinnell 1912, Wehausen and Ramey II 2000, Wehausen et al. 2005). They have distinctly wide splayed horns and have been genetically isolated from other bighorn sheep subspecies for roughly 100-300,0000 years (Buchalski et al. 2016). Conservation management has included hunting regulations beginning in 1878, as well as a series of translocations beginning in 1979 (Bleich et al. 1990). The early translocations established the Warren, Wheeler, and Langley herds, and also unintentionally created Gibbs. Despite these efforts, the range-wide population was estimated to be only ~100 individuals in 1995 (U.S. Fish and Wildlife Service 2007).

In 1999, Sierra bighorn were placed on the federal endangered species list, and the California Department of Fish and Wildlife was selected to be the lead agency in the implementation of recovery efforts. Recent bighorn die-offs throughout the west have been associated with the bacterium *Mycoplasma ovipneumoniae* (*M. ovi*), and it is thought that respiratory disease likely drove earlier declines in the distribution and abundance in Sierra bighorn (Wehausen et al. 2011). Fortunately, *M. ovi* has not been detected in the Sierra Nevada based on testing from 2001, and we have observed no clinical signs of respiratory disease, such as coughing or lung lesions, since monitoring began in 1974. Sierra bighorn population dynamics appear to be largely driven by adult female survival (Johnson 2010), and over the last twenty years, the top two causes of mortality are predation by mountain lion (*Puma concolor*) and snow-related death in the form of starvation or avalanche.

The Recovery Program monitors Sierra bighorn abundance, demography, and habitat use to inform management decisions regarding translocation, predator management, and disease risk. We monitor mountain lion abundance, demography, and habitat use because they are the main predator and largest known cause of mortality for Sierra bighorn. Monitoring of Sierra bighorn and lions requires the capture and collaring of animals, ground counts, and the investigation of mortalities and mountain lion kills. Our two main conservation activities are translocation and predator management. Additionally, we work to reduce the potential for disease transmission between Sierra bighorn and domestic sheep, and we promote bighorn recovery through public outreach. We also support and direct academic research.

For brevity we refer to herd units using single word names, for example 'Olancha' for the Olancha Peak herd unit. We refer to Sierra Nevada bighorn sheep as 'bighorn' or 'Sierra bighorn' and mountain lions as 'lions'. Each animal ID number has a prefix: "S" for collared Sierra bighorn, "M" for uncollared Sierra bighorn, and "L" for mountain lion. Postscripts "F", "M", and "U", represent sex of the animal, with "U" for unknown. For bighorn, we use '2024' to represent the animal year May 1, 2024 – April 30, 2025, beginning with lambing season and including the winter of 24-25. In contrast, climatologists refer to water year 2024 as October 2023 - September 2024, which is most clearly associated with bighorn year 2023. "Source" herds (Wheeler, Sawmill, Baxter, and Langley) have contributed to recent reintroductions (starting in 2013) that have supplied animals for "new" herds (Cathedral, Big Arroyo, Laurel, and Olancha).

METHODS

Capture

Capturing Sierra bighorn provides the opportunity to determine body condition, pregnancy status, test for disease, measure genetic diversity, and deploy collars. Body fat and pregnancy are determined using ultrasonography (Stephenson et al. 2020). Capturing bighorn is critical for translocations, and collaring bighorn enables us to monitor habitat use, disease risk, vital rates, and estimate herd size. Capture is done with a net-gun fired from a helicopter (Jessup et al. 1988). Power analyses indicate we need to maintain collars on 35% of the female population in order to detect 10% change in survival per year over 5 years using a known fate survival analysis (German 2010). Functional collars have proven essential for tracking survival and cause-specific mortality. Collared bighorn and collared lions provide complimentary information on predation by mountain lions and one or the other has proven essential in cases where keeping both species collared in any given herd is challenging. We try to maintain this ratio for source herds with >20 females and in newly established herds. We focus capture and collaring efforts on females, as they tend to drive population dynamics. However, collared males can help identify patterns of habitat use and identify and quantify disease risk from contact with domestic sheep, so we also try to maintain some collars on males, particularly in herds near domestic sheep (e.g., Warren, Convict, and Wheeler).

Sierra Bighorn Population Estimation

Although minimum counts are not technically a statistical estimation with confidence intervals, we consider them an "estimate" of the population size. Without confidence intervals it is not possible to know if a low count is indicative of a shrinking population or simply a bad or incomplete count. For this reason, we also developed our own metric of minimum count quality based on the proportion of females that have marks and the proportion of marks seen. "Census" minimum counts are where we think, based on the previous year's count and our familiarity with the herd, as well as known mortalities and recruitment, that we have accounted for every female and lamb in the herd. "Good" minimum counts have at least 20% of females collared and at least 80% of collared females seen. "Poor" minimum counts either have <20% of females collared or <80% of collared females seen during the survey. It is possible that a poor survey may be accurate, particularly in the case of a herd with few marks but in which all of the bighorn were seen. However, these categories allow us to be more confident that a population trend is real if the minimum counts are consistently at the "census" or "good" level.

Minimum counts are "reconstructed" to include bighorn that were not seen during the survey but subsequently determined to have been present based on additional information. All reconstructions are carefully tracked. The most common way minimum counts are reconstructed is to add collared individuals known to be alive but not seen during the survey. A collared animal is censored after two years without visual, GPS collar, or radio telemetry observation; censor date is one month after the last detection. In addition, for herds with near census counts, a count from a given year can often indicate that there must have been more bighorn present in the previous year than were counted. In this case, additional bighorn may be added to a previous year's count. Even with reconstructions, minimum counts tend to underestimate true abundance, particularly in herds with >20 individuals, as it becomes more difficult to locate every individual.

Mark-resight (MR) estimates were calculated for females using Bowden's estimator (McClintock et al. 2009). Within a season, we evaluated each survey individually and also considered combining multiple surveys to identify the MR estimate with the lowest CV. We only report MR estimates with a coefficient of variation (CV) < 0.15.

Our range-wide abundance represents our best estimate of female population size and is compiled from herd unit survey data. However, these range-wide counts are somewhat confounded by seasonal differences in herd surveys. To prevent double-counting translocated bighorn, we only include translocated bighorn in summer counts of receiving herds and remove them from winter counts of source herds. Wheeler and Baxter tend to be surveyed after most winter mortality has occurred, but before lambing. Therefore, the total female count for these herds includes winter impacts on adult and yearling survival but does not include the addition of recruiting lambs or their survival (lamb to yearling). Most other herds are surveyed in summer, prior to any winter mortality. For these herds, the total count of females does not include the impact of winter. Because of this, more complex vital rate analyses based on count data requires separating the data based on survey timing, or alternatively, focusing on data not associated with count data, such as collar survival (e.g., Conner et al. 2018).

We generally estimate that there are 2 males for every 3 females based on past counts in the Sierra Nevada (Wehausen 1980) and various studies on bighorn sheep (e.g., Valdez and Krausman 1999). We believe this ratio is more accurate than our male minimum count because we have so few males collared, and survey effort is focused on finding females. Our collaring efforts focus on females because they tend to drive population dynamics, but we have enough males collared to know that male survival tends to be lower than female survival (Conner et al. 2018). Our more recent ground counts target female home ranges and therefore produce low counts of males because males tend to use different habitat (Schroeder et al. 2010).

Sierra Bighorn Survival Estimation

We estimate herd-specific annual survival rates using the Kaplan Meier staggered-entry estimator (Pollock et al. 1989). Survival rates are based on collared individuals and only use herds with >3 collars. Survival estimates from herds with few collars may show large changes that do not necessarily reflect the underlying population, as well as higher levels of uncertainty caused by stochastic variation among collared bighorn, rather than correctly representing survival of the underlying population.

Sierra Bighorn Lamb Survival

We estimate lamb survival using the age ratio approach (White et al. 1996). We modified this approach using Kaplan Meier estimates of survival from collared females instead of measuring adult survival from carcasses on winter range. The age ratio approach assumes that the proportion of lambs counted in a given survey relative to the proportion of adults counted is constant across all surveys. In other words, the likelihood of seeing a lamb is the same as the likelihood of seeing a female. This seems reasonable for Sierra bighorn survey observations. We bounded adult and lamb survival at 0 and 1. Similar to the variances calculated by White (1996) we used sequential applications of the delta method to calculate the variance of the ratios. Since our adult survival is not based on a ratio calculation, but on the Kaplan Meier method, our calculations are expected to have a somewhat lower variance for similar survey effort.

Sierra Bighorn Pregnancy Rates

Pregnancy rate was determined from ultrasound during spring capture. Proportion of pregnant females observed with lambs was estimated using the range-wide pregnancy rates for adults (85%) and yearlings (55%) combined with the average proportion of yearling females (21%).

Sierra Bighorn Lambda Estimation from Minimum Counts

We estimate the annual population growth rate λ from minimum counts for herds that are consistently counted annually; this includes 11 herds: Cathedral, Warren, Gibbs, Convict, Wheeler, Sawmill, Baxter, Langley, Big Arroyo, Laurel, and Olancha. Bubbs, Taboose, and Williamson are excluded because we have consistently had a difficult time obtaining quality counts annually from these herds.

Sierra Bighorn Eigenvalue Lambda Estimation

We estimate the annual population growth rate lambda (λ) by constructing a three stage (lamb, yearling, adult) matrix model to describe the population dynamics of Sierra bighorn of the following form (Johnson 2010, Johnson et al. 2010, Cahn et al. 2011). Equations are formulated based on the timing of the annual population survey:

Summer survey equation matrix Fecundity = lamb/ewe ratio (Jul-Aug)

$$N(t+1) = \begin{vmatrix} N_L(t+1) \\ N_Y(t+1) \\ N_A(t+1) \end{vmatrix} = \begin{bmatrix} 0 & S_A F(0.5) & S_A F \\ S_Y & 0 & 0 \\ 0 & S_A & S_A p \end{bmatrix} \begin{vmatrix} N_L(t) \\ N_Y(t) \\ N_A(t) \end{vmatrix}$$

Winter survey equation matrix Recruitment = lamb/ewe ratio (Mar-Apr)

$$N(t+1) = \begin{bmatrix} 0 & R(0.5) & R \\ S_Y & 0 & 0 \\ 0 & S_A & S_A p \end{bmatrix} \begin{vmatrix} N_L(t) \\ N_Y(t) \\ N_A(t) \end{vmatrix}$$

Where N = number of individuals, F = fecundity, S = survival, R = recruitment, p = 1% senescent

We then solve this linear series of simultaneous equations using eigenvectors and eigenvalues to get the ratio of N(t+1)/N(t), or λ, the annual population growth rate.

MOUNTAIN LION POPULATION ESTIMATION

We monitor mountain lions throughout the range of Sierra bighorn to understand which herds may be experiencing impacts from predation and the degree to which these impacts may hinder recovery. We use all available evidence to create minimum counts of mountain lions in each count zone, following techniques described in McBride et al. (2008). Minimum counts encompass the total number of individual collared animals, the number of uncollared mortalities documented, and the number of distinct unmarked animals that can be identified. Minimum counts are conducted within four separate count zones; the northern, central, southern, and Olancha count zones (Figure App. 1). We also create a minimum count for mountain lions in the eastern Sierra outside of the count zones, but within the count zones we attempt to count every animal present when possible. Lion minimum counts in this report reflect animals counted May 1, 2023 – April 30, 2024.

We used GPS locations from collared lions in conjunction with remote cameras to count the minimum number of collared and uncollared lions in the study area. Our cameras were placed with two goals: 1) capturing photographs of every lion in the study area, and 2) obtaining photos of proper angle and quality to discern unique marks on individual lions. Cameras were not placed in accordance with a grid or any other sampling scheme. We used scent-lure and/or naturally occurring mountain lion scent at scrape sites as an attractant for the purpose of enticing lions to linger in front of the camera and offer multiple angles of view as they turn their heads and bodies to investigate the scent, as described by McBride and Sensor (2015). Lions in photographs were identified as individuals by 1) GPS collar location data, 2) unique collar features, 3) unique ear shapes due to healed lacerations, and 4) age of dependent subadults. GPS-collared animals were identified by GPS locations placing animals in proximity to cameras at the time of camera detections, and

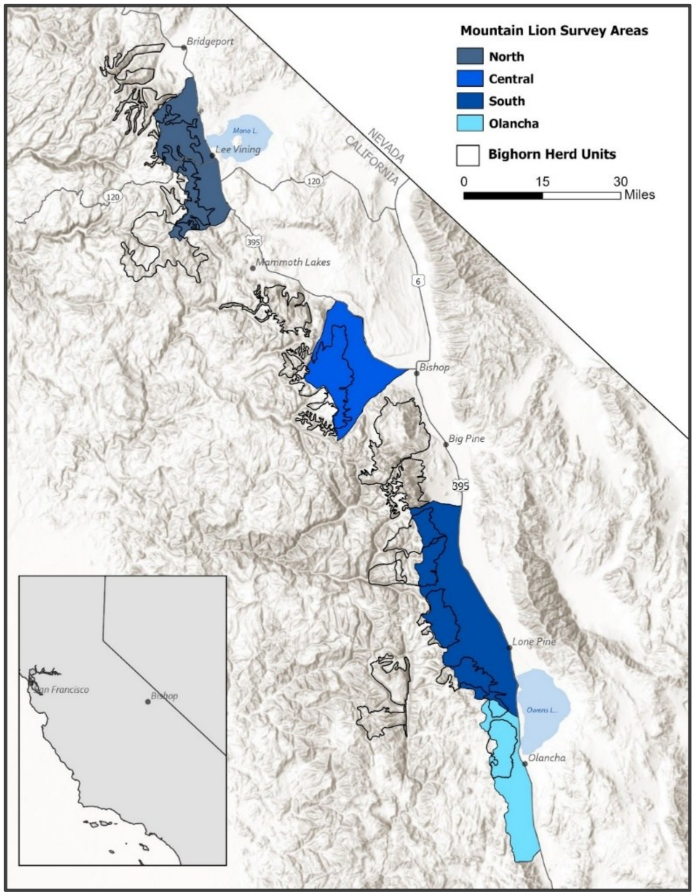

Figure App. 1. Mountain lion count zones in the eastern Sierra Nevada, with Sierra bighorn herd units for reference.

by unique features of collars such as model, color, unit symmetry, and spacer modifications. Collared lions were classified as adults if they were greater than 24 months of age and traveling independently of their mother and siblings. A detection was defined by a lion visiting a camera site yielding any number of photos. A new detection was counted if any one of the following criteria were met: 1) greater than two hours elapsed between photos, 2) different individual lions sequentially triggered a camera regardless of elapsed time, and 3) different camera sites triggered by lion regardless of elapsed time or distance between cameras. Detections of adult females with dependent subadults were classified as one detection of a family group rather than multiple detections for the individual lions.

Identification of uncollared lions was based on unique scar patterns on ears and age of subadults. Uncollared lions were also distinguished based on simultaneous detections separated by sufficient distance such that it would have been impossible for one lion to trigger the two distant cameras within the timespan between detections. Tears, notches, holes, and missing parts of ears are common in mountain lions, and while the bleeding edges will heal, they do not regrow missing flesh. A lion may accumulate these scars as time goes on, but they do not lose them. If a lion passes a remote camera in January with no ear scars, then a lion passes the same camera in February with many ear scars this is counted as one lion because the scars could have been accumulated between the detections. However, if a lion passes a camera in January with many ear scars, then a lion passes the same camera in February with no ear scars, these photographs represent two individual lions. All lions within a gender with no ear scars are counted as one individual. Female lions with no ear scars or other unique marks can be identified by the age of their dependent young that appear in photos with them. For example, if a camera detects a female lion with a group of 4-month-old subadults and the following week the same camera detects a female lion with a group of 12-month-old subadults than that would yield a count of two adult females.

Uncollared subadult lions were classified as individuals by the adult female which they were photographed with, by the number of animals visible in a single frame, and by the gender of those animals. Subadults photographed by themselves with no adult female present were counted as one of the known subadults belonging to a known adult female unless the age of the unknown animal was not consistent with that of the known animals.

Uncollared lions were classified as adults if they were photographed with dependent young, or if they met all of the following criteria: 1) had no juvenile pelage or morphological characteristics, 2) had unique ear notches which distinguished them from all known lions, and 3) were photographed repeatedly over a period of months indicating residency. Collared and uncollared lions that could not be identified as individuals by the methods described above were classified as unknown.

Mountain Lion Survival Analysis

Mountain lion annual survival probabilities were calculated with a standard Kaplan-Meier survival analysis for each age and sex class individually. This analysis allows for censoring of animals whose collars failed as well as for staggered time entry of animals who were captured for the first time during the monitoring period. This yields survival probability estimates for individuals of a given age and sex class based on observed mortalities within those groups. Uncollared mountain lions were not included in the analysis.

Appendix C: Genetic Identification of Source Population for Unknown Ram Observed in Southern Sierras

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Report prepared June 8, 2026

Introduction and Methods

After a reported sighting of a bighorn sheep in the southern Sierra Nevada, near Inyokern, California, the Epps Population and Conservation Genetics Laboratory at Oregon State University received several sets of fecal pellets from CDFW. The ram was sighted by a member of the public on February 2, 2025. That member of the public showed CDFW where the ram was located for pellet collection on February 5th, 2025; at or near 35.71974 N, -117.92944 E.

We attempted to extract DNA from 8 sets of fecal pellets, genotyped pellets at 9 loci to resolve species and individual identity, and genotyped an additional 7 loci for confirmed bighorn individuals. One male bighorn sheep was detected and genotyped by this process (genotypes from samples 1-5 and 7 appeared to be from the same individual bighorn despite some missing data); two fecal samples appeared to be from deer.

We compiled data from relevant (Sierra, Death Valley, selected north-central Mojave) populations of bighorn sheep in California, including Sierra bighorn sheep (54 individuals from the 2022 and 2023 captures), and desert bighorn including the ram killed near Clovis in 2023 (previously determined to originate in the Panamint Mountains), and bighorn genotypes from Tin Mountain, White Mountains, Panamint Buttes, Panamints, Owlsheads, Old Dad/Kelso/Marl, Last Chance, Inyo, Grapevine, Funeral, Black Mountains/Greenwater, Cady Mountains, and Avawatz (total 637 desert bighorn individuals). We used STRUCTURE to assign the unknown genotype to genetic clusters evident within this dataset, using K = 1-15, 10,000 runs as burn-in, 50,000 for estimation, and using sampling location (population) as prior. We set the program to infer Alpha, using an initial value of 0.083. We did not distinguish within Sierra Nevada bighorn populations during this analysis. We used 5 replicate runs for each value of K and inspected assignments for all runs.

Results and Discussion

Population assignments at all values of K with multiple genetic clusters (i.e., K = 2-15) clearly indicated that the single male bighorn sheep genotype recovered near Inyokern was from the Sierra Nevada bighorn populations, assigning it at probabilities ranging from ~95-100% to the same cluster as known Sierra Nevada bighorn. No genetic substructure was evident within the Sierra Nevada bighorn samples included. K = 8 or 9 appeared to be the most appropriate cluster numbers for the mix of desert and Sierra Nevada populations included in this dataset.

Thus, we conclude with very high confidence that the fecal pellets recovered in February 2025 originated from a single Sierra Nevada bighorn ram.

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