

Sierra Nevada Bighorn Sheep: 2008-09 Status
July 2008-June 2009

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This report synthesizes population information for bighorn sheep herds in the Sierra Nevada developed over the past year beginning in July 2008 as part of the Sierra Nevada Bighorn Sheep Recovery Program lead by the California Department of Fish and Game. As in previous such reports, this one is organized by herd units from south to north and first reviews pertinent prior information needed to interpret data developed during this time period for each herd unit. While data were collected for some herd units through this past winter, for consistency the numbers of sheep are presented for the first half of the sampling year prior to winter.

Where possible, efforts are made every year to develop some data on every herd in the Sierra Nevada. Over the years these efforts have used knowledge of habitat use patterns of each herd to attempt to count as many sheep as possible when they were most concentrated. Such counts all represent minimum numbers present by population, which is a primary criterion in the recovery plan for these sheep. Those minima, however, can vary considerably in what percentage of the population was accounted for. It has been our experience that, for most bighorn sheep herds, it will be difficult to develop consistent good minimum counts once the number of females has increased beyond 30, unless aided by extra technology like telemetry; however, in some cases there can also be a high variability at much lower population sizes. There is a continuing effort to improve counts, and we report some successes here.

Rapid increases in sizes of some populations this decade, while very desirable, have made population monitoring more difficult in some herd units because of expanding ranges and higher numbers of sheep that need to be found in a short time period for a complete or nearly complete count. Telemetry collars have been deployed in part to help with such counts. These collars increase minimum population counts by helping us find otherwise missed groups of sheep. They also allow us to develop independent estimates of population sizes using mark-resight methods. Depending on their statistical resolution, these estimates can help in the evaluation of the completeness of minimum counts. Consequently, a sampling approach that is now often employed for some larger herd units involves multiple observers first finding as many sheep as possible without the aid of telemetry for mark-resight estimates, followed by the use of telemetry to find sheep groups not yet sampled to maximize the minimum count. McClintock and White (2007) suggested that the Bowden estimator (Bowden and Kufeld 1995) was more appropriate for mark-

resight estimates of bighorn sheep. Consequently, we present only Bowden estimates with 95% confidence intervals in parentheses.

Some judgment is usually made on the completeness of minimum counts based on recorded numbers and reproduction in previous years tempered by potential mortalities, and sometimes coupled with interpretation of field evidence of additional groups of sheep not seen (including collared sheep). Better counts in subsequent years also have been used to evaluate and sometimes correct past counts to higher minimum numbers present by sex and age categories. These are known as reconstructed counts.

Our population surveys focus primarily on females because they are the reproductive base of the population. However, in the Mono Basin it has been possible to track numbers of males for many years. The same has been true for the Wheeler Ridge herd in most years.

We were greatly assisted in the collection of data by Karl Chang, Kelsey Ellis, Joy Ehrlenbach, Jonathan Fusaro, Lacey Greene, and Kathleen Knox. Tim Glenner took photos of Mount Baxter sheep at high elevation from a helicopter that allowed accurate classification.

Table 1. Changes by herd unit in numbers of bighorn sheep (females/males) in the Sierra Nevada that carried telemetry collars, July 2008 through June 2009. Mortalities and additions do not include new sheep caught that died due to capture.

	Langley	Williamson	Baxter	Sawmill	Wheeler	Gibbs	Warren	Total
1 July 2008	13/1	3/1	5/0	4/1	16/14	3/2	2/6	46/25
additions	3/0	2/1	7/1	6/1	3/4	1/0	1/0	22/7
re-collarings	2/0	0/0	2/0	0/0	3/0	1/1	0/2	8/3
mortalities	4/0	3/0	5/0	2/0	0/4	0/0	0/1	14/5
translocations	-2/0				-3/0		+5/0	
30 June 2009	10/1	2/2	7/1	8/2	16/14	4/2	8/5	55/27

Highlights of the Past Year

Bighorn Sheep Collaring

During multiple collaring efforts, 40 bighorn sheep (30 females, 10 males) were captured in 7 herd units in the Sierra Nevada between October 2008 and April 2009 (see Table 1 for details). Because 11 of the successful captures involved re-collaring, and 19 collared bighorn died during the monitoring year, the total number of marked bighorn sheep increased only from 71 to 82. There was only 1 capture related mortality this past year.

Translocations

In early April the Mount Warren herd unit received 2 augmentations totaling 6 females released in Lundy Canyon. Three each came from the Mount Langley and Wheeler Ridge herds. All were pregnant

by ultrasound at capture. Five of these were previously collared females selected for translocation on the basis of age, reproductive history, and individual levels of heterozygosity.

Population Dynamics

In 2008 excellent data were collected for the Mount Williamson herd for the second consecutive summer. The number of females counted in the Sawmill Canyon herd more than doubled due to much more complete counts. More complete counts for the Mount Baxter and Mount Warren herds verified some past undercounting. Respectively, more telemetry collars coupled with the focused use of a helicopter, and fecal genotyping allowed the better counts of those 2 herds.

Earlier this decade the population dynamics among herd units varied widely from one herd showing slow decline (Mount Warren) to varying rates of increase (Figure 1). In recent years this variance has declined as an increasing number of herds have shifted from increasing trends to static or declining status. Increasing data quality (better counts) associated in part with more telemetry collars has in some cases masked actual static to declining population trends. This was particularly true this past year, when better counts for 3 herds resulted in a modest 5% increase in the total numbers of females in the Sierra Nevada, when the actual population trend appears to be a slow decline. A combination of minimum counts and a couple of mark-resight estimates put the total number of adult and yearling females at 194, which is 64% of the recovery goal. Three years ago we comfortably projected that the total population of bighorn sheep in the Sierra Nevada had crossed 400. For the second half of 2008 we can barely project that it might be close to 400.

Rate of known mortality for all Sierra Nevada bighorn sheep during this reporting period (6.5%) was only slightly lower than the previous 18 months (7.3%), but foci of mortality appear to have shifted among herd units, with a particularly high rate in the Mount Baxter herd.

Two herds are currently of greater concern: (1) the Mount Baxter herd because of its importance to future reintroduction efforts and its continuing lack of significant population increase apparently due to high predation losses; and (2) the Mount Warren herd because of its recent long history of small size and lack of sustained population increase.

Mount Langley Herd Unit

While this herd utilizes low elevation winter range areas, a substantial proportion of the population has remained at high elevations every year. Consequently, population surveys are conducted in summer. This herd unit exhibited strong population increases for numerous years this decade, but those increases have tapered off in recent years (Fig. 1). A minimum of 45 adult and yearling females and 91 total sheep were accounted for in 2006, when the population undoubtedly exceeded 100. In 2007 a minimum of 44 adult and yearling females could be accounted for, and the Bowden estimate was 47 (95% CI:38-60).

Three sampling efforts were carried out in 2008 (July, August, and September) of which the August attempt produced poor data due to extensive thunderstorms. Minimum counts were 35 adult females, 3 yearling females, 8 lambs, 5 yearling males, and 19 adult males. The Bowden estimate of adult and yearling females for the July survey was 49 (34-72), and 42 (29-61) for the September sample; combined they produced an estimate of 48 (32-71), which exceeds the 2007 estimate by 1.

Reproductive and recruitment ratios were low at 0.235 lambs per adult female and 0.176 yearlings per adult female. Four collared females died between summer surveys in 2007 and 2008, which would constitute 8.5% mortality, and exceeded the measured recruitment of 3 yearling females. Given the

likelihood of some additional mortality of uncollared females, the number of females at Mount Langley undoubtedly declined from summer 2007 to 2008, suggesting that the September 2008 estimate of 42 total females may be closer to the actual population size.

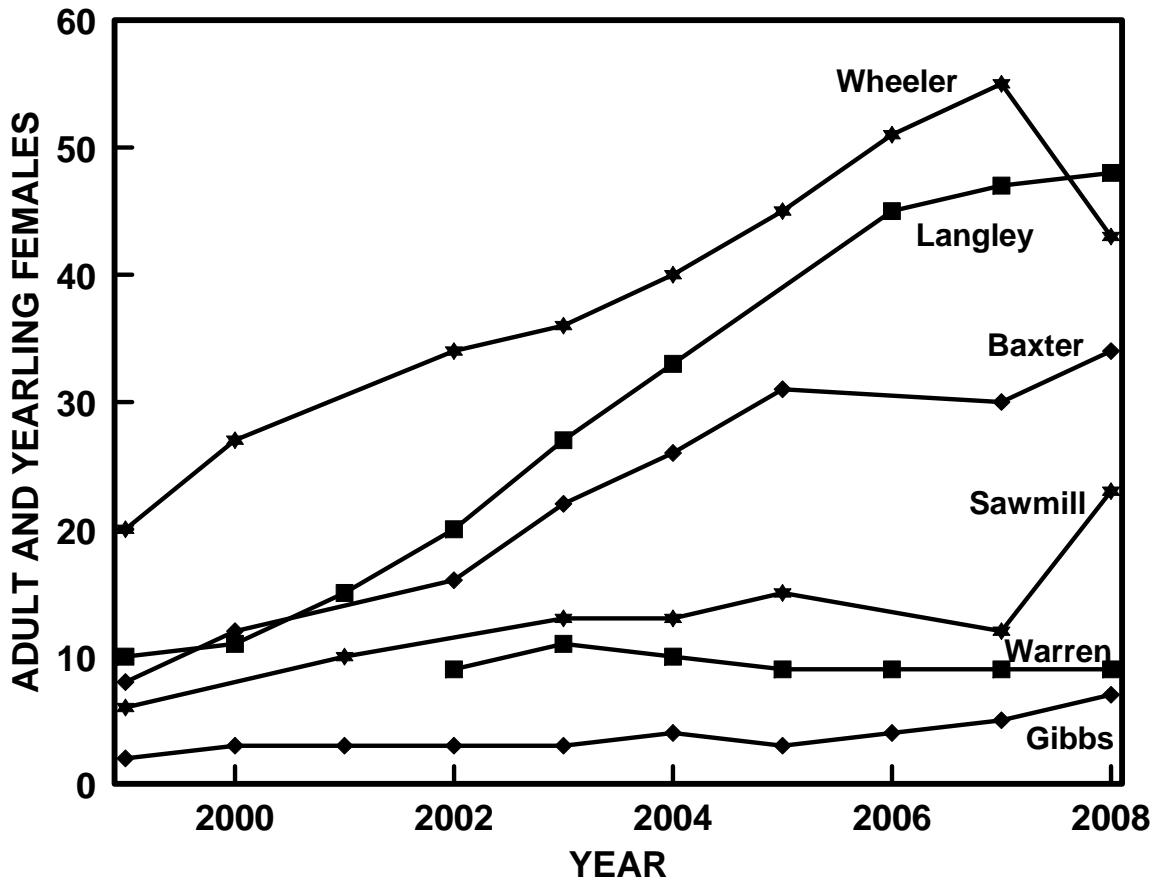


Figure 1. Recent reproductive base histories for 6 herd units of bighorn sheep in the Sierra Nevada for which adequate data exist. Data are all minimum counts except for mark-resight estimates for the Mt. Langley herd unit after 2006 and the Wheeler Ridge herd unit after 2005.

There was also further known mortality after summer 2008: 3 females and an adult male. For the July 2008-June 2009 sampling period, 4 adult collared females and 1 adult uncollared male are known to have died. One female died in early summer of unknown cause, another died in winter at high elevation of unknown cause, and the third female was euthanized following a capture injury, and the remaining female and the male were killed on low elevation winter ranges by two different lions.

Mount Williamson Herd Unit

After 11 years of mostly failed attempts to monitor this population directly from the ground or a helicopter, in 2007 28 sheep (10 adult females, 3 yearling females, 7 lambs, 1 yearling male, and 7 adult males) were counted in summer. During the summer of 2008, 28 sheep again were counted in this herd unit (11 adult females, 3 yearling females, 4 lambs, 2 yearling males, and 8 adult males). As in the previous year, these sheep were found in the more southern canyons of Mount Williamson – an area also used extensively during 1976-79, but only occasionally during 1996-2006 when the highest count made was 11.

During 1976-85 this herd was counted on escarpment base winter ranges, which have not been used since then. In that time period the highest counts (29-31) were very similar to results from the past couple of summers, as were compositions by sex and age classes. During that earlier time period the highest counts were obtained in three winters, 1978, 1983, and 1985, of which the first 2 had very high snowfall. Those appeared to be total or near total counts, and suggested that the herd was static at about 30 sheep.

In March of 2008, the first radio collars were installed in this herd, and a few were added in October that year. Additionally, in the late summer of 2007 a telemetered ewe from the Mount Baxter herd, that was translocated there from Wheeler Ridge in 2005, migrated to the Symmes Creek area, which we treat here as part of the Mount Williamson herd unit; indeed, rams from the Mount Williamson herd used that habitat regularly in the 1970s. In the short time that there have been radio collars at Mount Williamson, 3 of 7 collared sheep have died, 2 from mountain lion predation and 1 from an apparent fall. All losses were females, constituting 60% mortality in a one year period. While the sample size is too small to put any weight on that percentage (95% CI = 14-95% mortality), these initial data suggest that high adult mortality may be keeping this herd at its small size. The dynamics of a population of such small size will be very sensitive to the loss of relatively few sheep each year. Clearly, mountain lion predation is not limited to low elevation winter ranges. Among the lion kills was the migrant from the Mount Baxter herd, who was killed in summer at 11,000 feet elevation. There was hope that she might be the beginning of a new home range pattern utilizing habitat just north of what the Mount Williamson herd currently uses. A lamb and a young male accompanied that female the winter prior to her death. Depending on the gender and fate of that lamb, a new deme may yet emerge in this area.

Data from GPS collars placed on some of the Mount Williamson sheep have provided important data on seasonal patterns of habitat use. It has been known for most of this decade that some of these sheep occasionally utilize a pocket of south-facing winter range in Shepherd Creek at the confluence with Williamson Creek. The GPS location data indicate a much broader utilization of habitat in this region, including considerable use of habitat with dense vegetation cover. This may explain the failure of some earlier thorough winter helicopter surveys to find any sheep, or even tracks of sheep in snow.

Bubbs Creek Herd Unit

A helicopter survey in mid January of 2008 produced the highest count of this herd to date, totaling 27 sheep in 5 groups (13 adult females, 1 yearling female, 6 lambs, 1 yearling male, 1 2-yr old male, and 5 older males). In a January 2009 helicopter survey 23 sheep were counted in 4 groups (14 adult females, 3 yearling females, 1 lamb, 1 yearling male, 2 2-year old males, 1 3-year old male, and 1 older male). While this was fewer sheep than the previous year, the difference was largely in adult males and lambs. The 14 adult females seen in 2009 matched the number of adult and yearling females seen in 2008. The 4 yearlings seen in 2009 are consistent with 6 lambs seen the previous year. The 2 2-year old males seen in 2009 are one more than the number of yearling males seen the previous year.

Mount Baxter Herd Unit

This herd has shown increasing use of low elevation winter ranges beginning in 2003, including Sand Mountain, where most of the sheep translocated during 1979-88 were caught. Those winter ranges have provided the only good opportunities to assess the total size of this herd in recent years. With the exception of the particularly dry winter of 2006-07, good winter range counts have been made annually. A major wild fire in July 2007 burned most of the winter range. Nevertheless, numerous sheep used that range in the 2007-08 winter and re-growth of forage species appeared to make it attractive to sheep as the

growing season progressed. However, only 29 total females, 9 lambs, and 13 total males could be accounted for, totaling 51, of which 2 adult females and a lamb died on the winter range, 2 of which were lion kills. This suggested that the population had ceased growing when it was less than half the size it once was (Fig. 1).

To help develop better data on various aspects of this herd, 7 additional females and 1 yearling male were collared in October 2008 (Table 1), bringing the total collared females to 12. Subsequent winter range counts suggested a continuing relatively static population trend based on comparison with similar census efforts of prior years, and identified lion predation as the apparent factor limiting growth. Counts of sheep on the winter range during March totaled only 43 sheep: 18 adult females, 3 yearling females, 9 lambs, 2 yearling males, and 11 older males (Table 2), to which could be added 3 collared sheep that remained at higher elevations: 2 adult females and 1 yearling male.

The mark-resight estimate from March winter range sampling was 27 total females (18-40), suggesting yet more sheep at high elevations. Photos taken from a helicopter in March allowed accurate classification of sheep at high elevation that accompanied the remaining collared sheep. Two groups were found high on Mount Mary Austin (including the summit) and 1 group was SW above Sawmill Lake for a total of 5 adult females (including the 2 with collars), 1 yearling female, 2 yearling males (including the collared one), and 2 lambs. These brought the minimum count to 23 adult females, 4 yearling females, 11 lambs, 4 yearling males, and 11 older males, for a total of 53, which is about the same total counted on the winter range in 2008. To this can be added 4 collared adult females, 2 uncollared adult females, and a male of unknown age that had already died by the time these counts took place. One of those collared females died of an apparent fall at higher elevation, while the remaining mortalities were known (4 females) or likely (1 female, 1 male) lion kills on the winter range. These increase the number of adult females that used the winter range through March to 28, and the early winter minimum female count to 29 adults and 4 yearlings. This is 2 more adult females than adult and yearling females known to be alive at the end of the previous winter, a finding attributable to additional radio collars.

An additional minimum count was made in mid April because large numbers of sheep remained on the winter range and the 3 telemetered sheep previously at high elevations had descended to winter range areas. That count totaled 21 adult females, 5 yearling females, 13 lambs, 5 yearling males, and 9 adult males, for a total of 53, and included all telemetered sheep except one female who remained somewhat higher south of Black Canyon. Noteworthy are the gains of 1 yearling female, 2 lambs, and 1 yearling male relative to earlier counts. The lack of an associated increase in the number of adult females apparently reflects some females counted earlier that had already moved from low elevation winter ranges to higher elevation lambing ranges prior to these additional sheep first appearing on the winter range. The 10 total yearlings counted on the winter range in April are 2 more than the number of lambs at the end of winter the previous year. This is consistent with a higher minimum female count this winter facilitated by more telemetry collars.

The finding of 10 additional sheep in 3 groups at high elevations in March with the aid of telemetry collars indicates that more than that number also should have existed at those altitudes in groups with no collars. The additional 2 lambs and 2 yearlings recorded in mid April would have been part of those groups. If they occurred in groups with the same lamb:ewe and yearling:ewe ratios recorded in the rest of the population prior to low elevation predation losses, 5-7 additional uncollared adult ewes would have been present. These and additional adult males likely not using the winter range would probably put the total population over 75.

Lions killed an additional adult male in March and another collared female in late April, bringing the total known winter deaths to 7 adult females, including 5 with radio collars, and 2 males. For the

second consecutive year this puts the minimum number of adult and yearling females at the end of winter below 30, which is 1 fewer than the count in the winter of 2005-06. The 2008-09 winter minimum mortality rate for females alone was about 19%, of which most was due to lion predation. That 4 collared females were killed suggests that a considerable number of additional uncollared sheep met similar fates. Only a few such mortalities were encountered and were tested genetically to determine gender and verify that they were unique genotypes. There were probably more that went undetected this year, as well as in recent years when there were fewer radio collars. The population trend and mortality data developed in recent years together strongly suggest that lion predation has been a major factor limiting growth of this population.

Sawmill Canyon Herd Unit

The size of the Sawmill Canyon herd also has been assessed on its low elevation winter ranges, where this herd has shown increasing use of low elevation winter ranges in recent years, including Goodale Creek, where 13 sheep were seen in 2006. The total count of adult and yearling females in this herd unit had grown to 15 in the winter of 2005-06 (Fig. 1), including 3 of 5 adult females that were translocated from Wheeler Ridge to the Mount Baxter herd unit in 2005, but took up residence in the Sawmill Canyon herd unit. Similar to the Mount Baxter herd unit, few sheep were observed on winter ranges in 2006-07; thus, no new information on population size was obtained. However, considerable mountain lion predation on this herd beginning in 2007 suggested that predation might be limiting this population. Known lion predation removed 5 females from this herd in less than a year in 2007-08, and the minimum known remaining females at the end of winter in 2008 was only 9. That figure included 2 collared females that did not descend to low elevation winter ranges that winter; thus there remained the question of how many others might similarly have remained at high elevations. Data collected over the past year have shed considerable light on that question due to two factors: a particularly good high elevation count in late summer, and the addition of numerous telemetry collars in October 2008 (Table 1) that facilitated an even better winter count.

The summer effort yielded a total of 14 adult females, 1 yearling female, 6 lambs, 3 yearling males, 3 2-year old males, and 3 older males, to which can be added 2 unseen collared males for a total of 32. This past winter saw considerable use of low elevation winter ranges in Sawmill Canyon as well as some use of Goodale Creek. Counts on those winter ranges totaled 17 adult females, 0 yearling females, 9 lambs, 1 yearling male, 1 3-year old male, and 1 unclassified sheep that likely was a collared yearling male, for a total of 29.

To this winter count 2 lone collared females found with a helicopter can be added, as can 2 collared males not seen and an additional collared female whose signal was not even heard from the helicopter, but was heard periodically from the Owens Valley during winter. This yields a total winter count of 20 adult females, 9 lambs, 1 yearling male, 3 older males, and 1 unclassified sheep that likely was a collared yearling male, for a total of 34.

Further sheep need to be added to produce a minimum count during summer 2008: a yearling of each sex seen in summer but not in winter, 5 more adult males seen in summer, and 2 more adult collared females that died during winter (the only known winter mortalities), one from bobcat predation at 9600 feet elevation, and another from a fall high in Goodale Canyon, bringing the summer total to 22 adult females, 1 yearling female, 9 lambs, 3 yearling males, 3 2-year old males, 1 3-year old male, and 4 older males, for a total of 43. The yearlings seen in summer but missing in the winter count and the collared females seen alone at higher elevations from a helicopter all suggest the existence of yet more uncollared sheep than are included in this minimum count. These new population figures indicate that the 5 females recently killed in a one year period in 2007-08 probably represented only a maximum of 20% of the

reproductive base; but that is still a significant loss. The collared female that died of a fall in upper Goodale Canyon was another of the 5 females translocated from Wheeler Ridge in 2005 that ended up in 3 different herd units. Three others have been killed by mountain lions, and the last survivor is part of the Mount Baxter herd.

Wheeler Ridge Herd Unit

The Wheeler Ridge herd has offered excellent opportunities to track population growth via direct counts on low elevation winter ranges in most years since it re-colonized those ranges in the late 1990s. This population has shown an increasing trend for many years (Fig. 1) and first exceeded 100 in 2004-05. Mark-resight estimates in April 2007 were 49 adult and yearling females (37-61) and 59 adult and yearling males (26-92), both of which were very close to mark-resight estimates from surveys the previous summer. Summer surveys in 2007 yielded an estimate of 55 adult and yearling females (43-70) and minimum totals of 36 adult females, 6 yearling females, 15 lambs, 4 yearling males, and 21 adult males. Sampling the following winter yielded a Bowden estimate of 50 (38-65) and a minimum count of 36 adult females, 4 yearling females, 10 lambs, 3 yearling males, and 35 adult males, the last of which would put the summer total population estimate at 109. Considerable mortality was documented during 2007-08, including the loss of about 64% of the lambs born in 2007 and 14 adults of which 8 were known or probable lion kills, but mostly males. During 2007-08 this population appeared to have transitioned from an increasing phase to a decreasing trend with loss of males substantially driving that change.

One summer range survey in 2008 failed to produce an adequate sample. Winter sampling in 2009 produced a minimum count of 36 adult females, 2 yearling females, 14 lambs, 2 yearling males, and 20 adult males for a total of 74. Best mark-resight estimates were 43 (33-56) adult and yearling females and 31 adult males (19-53). These figures are consistent with the projected declining population trend (Figure 1).

Six adult males are known to have died during the past year of which one was a lion kill, one due to old age, and four of unknown cause. Four were telemetered.

Mount Gibbs Herd Unit

The Mount Gibbs herd has very limited low elevation winter range; thus population data are collected primarily in summer. However, this herd has been observed using lower elevations above Walker Lake during the past two springs (Figure 2). This herd has grown steadily from a reproductive base of only a single female in the middle of the last decade (Fig. 1). In 2006 it consisted of 3 adult females, 1 yearling female, 2 lambs, and 3 adult males. In the summer of 2007 this herd grew significantly to 4 adult females, 1 yearling female, 4 lambs, 1 yearling male, and 3 adult males, for a total of 13. One of those lambs did not survive; the herd composition in the summer of 2008 was 5 adult females, 2 yearling females, 3 lambs, 1 yearling male, 1 2-year old male, and 2 older males, for a total of 14.

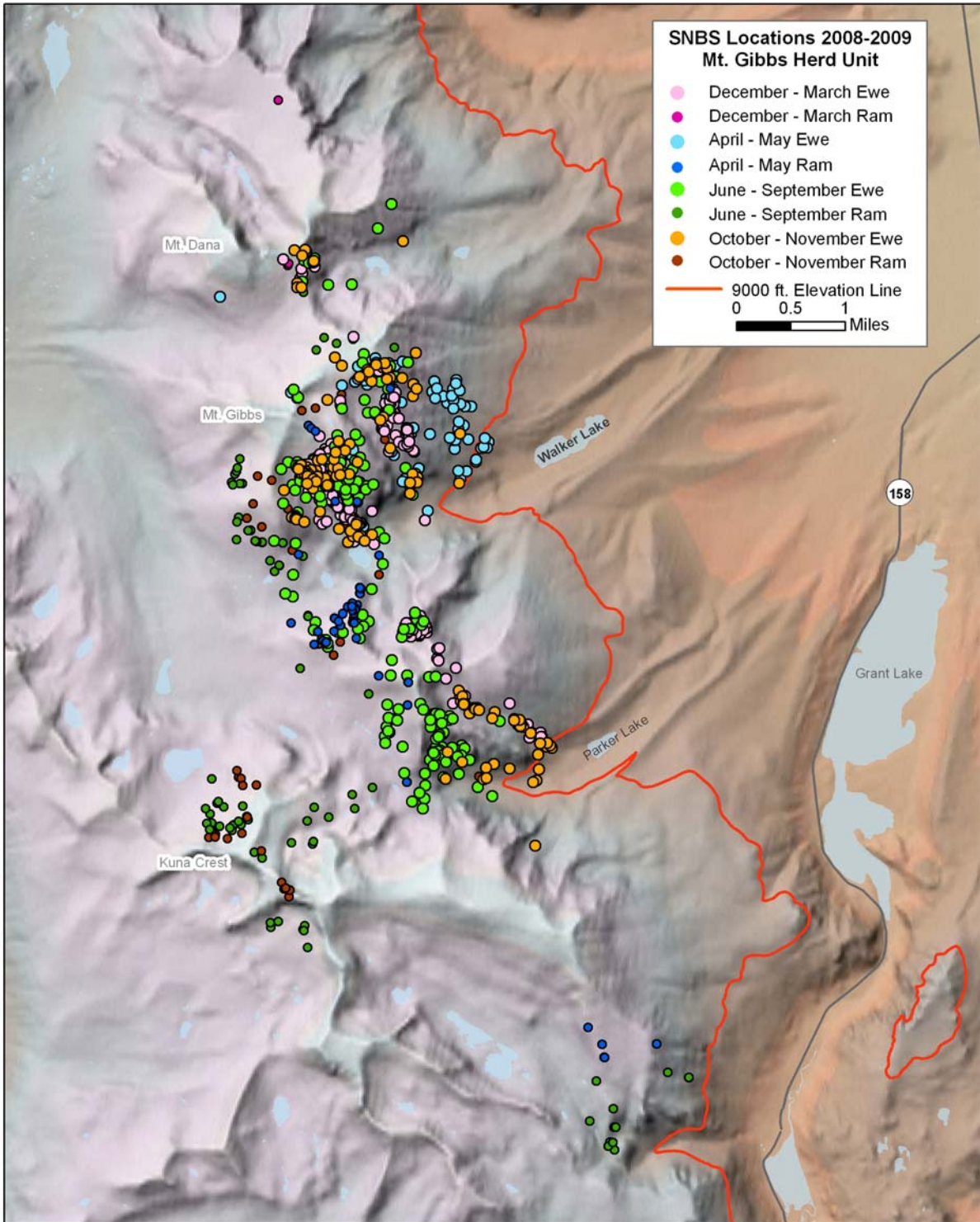


Figure 3. GPS collar locations for the Mt. Gibbs herd unit.

Mount Warren Herd Unit

In recent years this population has been documented to move regularly between Mount Warren, Tioga Crest, and the north side of Lundy Canyon. The summer of 2008 was no exception. While these sheep sometimes use lower elevations back in Lundy Canyon later in spring, females in this population have not been documented to use of low elevation winter ranges since they abandoned use of Lee Vining Canyon after a lion was hunting them there in 1998. Consequently, population data are collected primarily in summer.

The total number of bighorn sheep in the Mount Warren herd unit from 2003 to 2006 was a pattern of steady slow decline: 28, 27, 25, 23; however, the reproductive base of adult and yearling females changed only from 10 in 2004 to 9 in 2005 and 2006 (Fig. 1). That reproductive base remained the same in 2007, at 7 adult females and 2 yearling females, along with 4 lambs, and 13 adult males, for a total of 26, but was followed by considerable winter mortality that dropped the known herd size to only 16 sheep: 4 adult females, 1 yearling female, 2 lambs, and 9 adult males. Both surviving lambs proved to be female, but counts in the summer of 2008 found an additional adult female: 6 adult females, 2 yearling females, 4 lambs, and 7 adult males. The 7 males were collared ones. No uncollared males were seen, but 1-2 may exist. The additional adult female seen suggested an undercount the previous year. Similarly, fecal genotyping of samples from the 2008 lamb cohort identify a fifth lamb, which implies yet another adult female missed in the 2008 count. This would put the reproductive base at 9 adult and 2 yearling females in 2007, and 7 adult and 2 yearling females in 2008. It is possible that some females have been missed in all counts between 2005 and 2008.

The only known mortality this past winter was one adult male.

Discussion

Total Population and Trend

Data compiled here for the summer of 2008 total a minimum of 179 adult and yearling females, 57 lambs and 100 adult and yearling males, for a total of 336 bighorn sheep. With mark-resight estimates this increases to 194 adult and yearling females, 57 lambs, and 111 adult and yearling males, for a total of 362 sheep (Table 2). Additional uncollared females not counted in the Mount Baxter herd unit will bring the female total to about 200. Our data on numbers of males are certainly low for some herds. Earlier data from the Sierra Nevada found a male:female ratio of about 0.7 (Wehausen 1980), which if applied to 200 total females would suggest the existence of about 30 more males, and would put the total population close to 400. We first reported the total population to have crossed 400 for the summer of 2005, but three years later it appears not to have increased further and probably has declined a bit.

On the surface, this is not consistent with the trend in numbers of females, which shows a continuing increase (Figure 3). Our report from a year ago projected a likely decline in the number of females for this year, which has not been realized; instead, it increased by 9. A couple of factors explain the apparent contradictory trends for total sheep vs females. First, the past year was a particularly good year for counts, which focus primarily on adult females and the yearlings and lambs that accompany them. A notably better count of the Sawmill herd alone accounts for more than the increase in total

numbers. In the absence of those better data that total would have declined. We also uncovered evidence of undercounting for 2007-08 in the Mount Baxter and Mount Warren herds. In short, the data are consistent with a small population decline.

Table 2. Summary of population data for all herd units of Sierra Nevada bighorn sheep in summers 2007 and 2008.

Herd unit	Year	Adult ewes	Yrlg ewes	Min. total ewes	Est. total ewes	Lambs	Adult rams	Yrlg rams	Min. total rams	Est. total rams	Min. total	Total with ests.
Langley	2007	34	10	44	47	17	16	6	22		83	86
	2008	35	3	38	48	8	19	5	24		70	80
Williamson	2007	10	3	13		7	7	1	8		28	
	2008	11	3	14		4	8	2	10		28	
Bubbs	2007	13	1	14		6	6	1	7		27	
	2008	14	3	17		1	4	1	5		23	
Baxter	2007	27	3	30		10	9	4	13		53	
	2008	29	5	34		13	12	5	17		64	
Sawmill	2007	11	1	12		1	3	2	5		18	
	2008	22	1	23		9	8	3	11		43	
Wheeler	2007	36	6	42	55	15	35	4	39		96	109
	2008	36	2	38	43	14	20	2	22	31	74	88
Gibbs	2007	4	1	5		4	3	1	4		13	
	2008	5	2	7		3	3	1	4		14	
Warren	2007	7	2	9		4	13	0	13		26	
	2008	6	2	9		5	7	0	7		21	
Total	2007	142	27	169	185	64	92	19	111	111	344	360
	2008	158	21	179	194	57	81	19	100	111	336	362

There is a second reason to expect a declining total population trend in recent years. The Wheeler Ridge and Mount Warren herd units have had an unexpectedly high ratio of males to females. High male mortality in both herd units in recent years has led to more normal sex ratios. At Wheeler Ridge alone it appears that about 25 males have died in the past couple of years. Those losses would significantly affect the total Sierra Nevada population trend.

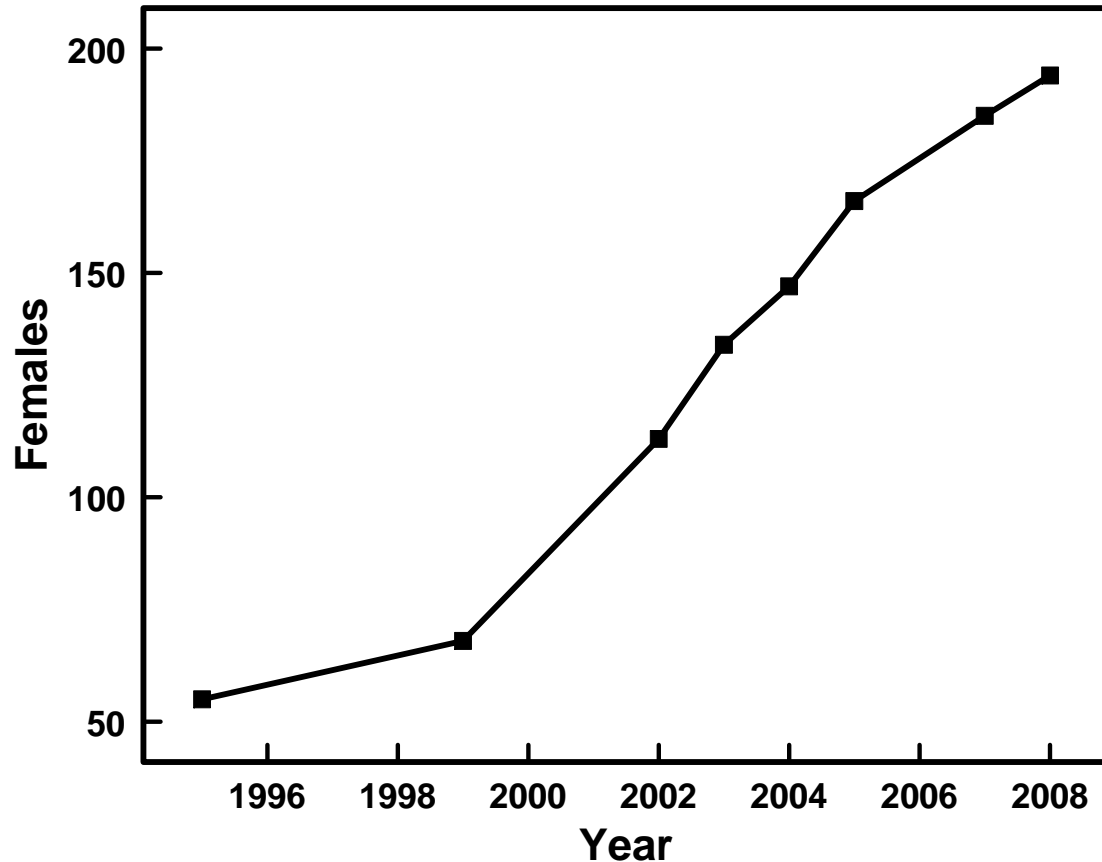


Figure 3. Numbers of adult and yearling female bighorn sheep in all herd units in the Sierra Nevada in summer, 1995-2007.

Mortality Patterns

In our compilation a year ago we reported 44 known mortalities of bighorn sheep in the Sierra Nevada in an 18 month period from the beginning in 2007. For a total population of about 400 that was an annual rate of about 7.3%. In the subsequent 1 year period from 1 July 2008 to 30 June 2009 we documented 26 additional mortalities, which is a similar annual rate of 6.5%. This year's known mortalities were all adults (61.5% female and 38.5% male); this is to be expected given that almost all collars are deployed on adults. Predation accounted for 13 (50%), 3 (11.5%) were due to accidents (falls), 1 resulted from capture, and the rest (35%) were of unknown cause.

On the surface these recent overall annual mortality rates are not excessive. However, this mortality is not a uniform rate across herds and is a significant impediment to population growth in areas like the Mount Baxter herd, where much higher mortality rates appear to be limiting population growth. Also, this documented mortality is the minimum rate of loss detected substantially from telemetered sheep; the amount of additional unrecorded mortality could be considerable. The number of telemetered bighorn has increased substantially over the past six years, increasing the opportunity for detection of mortalities (Figure 4). This is reflected in an increasing trend in recorded mortalities; however, predation losses have considerably outpaced other categories of mortality in that trend (Figure 4). This appears to reflect a notable increase in lion predation in 2008 that is independent of increasing detection opportunity.

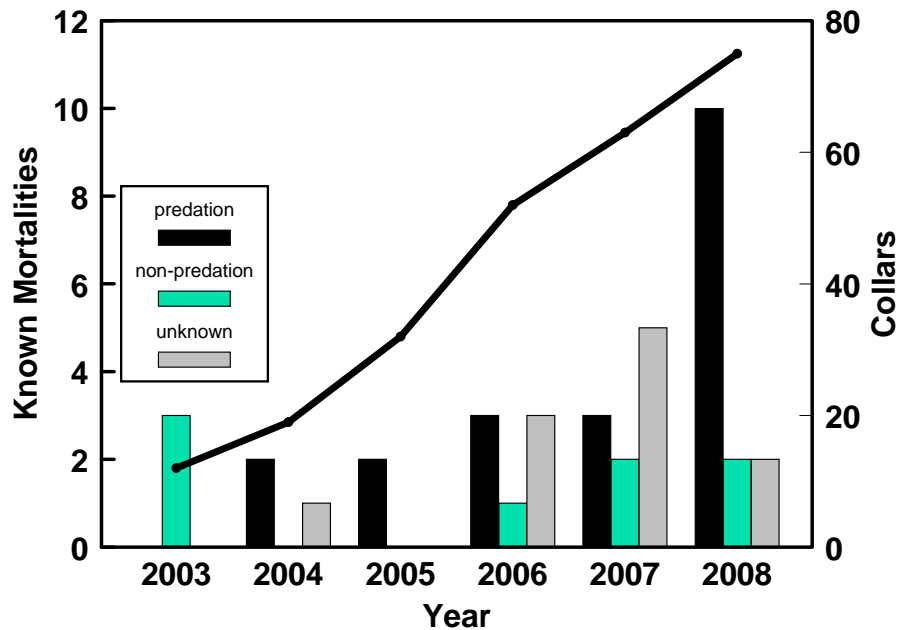


Figure 4. Total recorded mortalities of bighorn sheep in the Sierra Nevada by year and three categories (bars), and the number of telemetry collars on bighorn sheep at the beginning of the winter season (line).

Conclusions

Two herd units stand out as situations of concern. One is the Mount Warren herd unit, where the population has exhibited numerous years of declining or static dynamics (Figure 1) at a low population level. It is hoped that the augmentation program initiated this year will help rectify that situation.

Mount Baxter is the other herd unit of concern. The major impact on population growth rate of high mortality rates driven largely by predation has significant implications for recovery goals. Key future recovery program actions are dependent on that population attaining a much larger size where it again can serve as a source of translocation stock. Each year of delay in the growth of the Mount Baxter herd translates to at least a year delay in attaining recovery goals. It appears that management of lions is necessary in the Mt. Baxter region to prevent continued losses of bighorn sheep to predation and to permit population growth.

Literature Cited

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