# SIERRA NEVADA BIGHORN HERDS:1983 STATUS

by

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## INTRODUCTION

Detailed annual monitoring of the Mount Baxter bighorn herd in the Sierra Nevada has been an ongoing process due to intensive harvesting of this population as reintroduction stock since 1979. While the primary purpose of this report is to summarize winter census information on that herd for 1983, I have taken the opportunity to include two related subjects. One is the question of the influence of mountain lion predation on the Mount Baxter herd. Census efforts were intense during the winter of 1983 in order to the compare predation level with that of 1982.

Secondly, I have included current census data on the other three bighorn herds (1 native, 2 reintroduced) in the Sierra Nevada in order to assess the overall success of the reintroduction program now in effect since the first successful trapping in March of 1979. The reason for making an assessment at this time is that heavy snowfall in 1983 provided ideal census opportunities analogous to 1978, allowing comparison with data from that year.

This report summarizes findings for 45 field days I spent investigating bighorn in the Sierra Nevada over the past year (Mount Baxter herd: 10 in summer/fall, 27 in winter; Mount Williamson herd: 3 in winter; Wheeler Crest: 5 in winter), as well as many days contributed by Tom Blankinship, Robin Hamlin, Rob Ramey, and Terry Russi. I have relied entirely on data collected by Tom Blankinship and Robin Hamlin for the Mount Langley herd. My work on these herds was supported by contract #53-9JC9-2-46 from Inyo National Forest and a grant from Foundation for North American Wild Sheep.

## MOUNT BAXTER HERD

Six entire censuses of the Mount Baxter herd (excluding Goodale Creek) were conducted from early January to early April, and three days were spent censusing the Goodale Creek area. With the exception of the mid-February census that missed a large group of sheep, these censuses demonstrated the need to conduct censuses in February and March. Counts in early January and early April were notably incomplete (Table 1). This corresponds with experiences in all previous years except the drought year of 1977, when the best census was made March 31 - April 2). For the 3 good mid winter-censuses, the total count varied little (157 - 159), but the composition varied greatly (Table 1). Many rams were missed in February and early March (thus the low sex ratio), whereas numerous ewes were missed in late March when previously missing rams were counted (high sex ratio; Table 1). This pattern also corresponds

TABLE 1 - Census results for the Mount Baxter herd from 1983.

| DATE(S) | LOCATION | ADULT EWES | YEARLING EWES | TOTAL EWES | LAMBS | YEARLING RAMS | ADULT RAMS | TOTAL RAMS | TOTAL SHEEP | RAMS PER 100 EWES | LAMBS PER 100 EWES | LAMBS PER 100 ADULT EWES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/5 | Sawmill Can. | 13 | 2 | 15 | 6 | 0 | 12 | 12 | 33 | | | |
| 1/6,8 | s. of Sawmill Cr. | 33 | 6 | 39 | 9 | 3 | 29 | 32 | 80 | | | |
| 1/5-8 | census total | 46 | 8 | 54 | 15 | 3 | 41 | 44 | 113 | 81 | 28 | 33 |
| 2/1 | Sawmill Can. | 18 | 2 | 20 | 6 | 0 | 11 | 11 | 37 | | | |
| 2/4,5 | s. of Sawmill Cr. | 54 | 13 | 67 | 15 | 10 | 30 | 40 | 122 | | | |
| 2/1-5 | census total | 72 | 15 | 87 | 21 | 10 | 41 | 51 | 159 | 59 | 24 | 29 |
| 2/19 | Sawmill Can. | 19 | 5 | 24 | 7 | 1 | 12 | 13 | 44 | | | |
| 2/15,16 | s. of Sawmill Cr. | 41 | 13 | 54 | 10 | 8 | 16 | 24 | 88 | | | |
| 2/15-19 | census total | 60 | 18 | 78 | 17 | 9 | 28 | 37 | 132 | 47 | 22 | 28 |
| 3/6 | Sawmill Can. | 19 | 5 | 24 | 7 | 1 | 0 | 1 | 32 | | | |
| 3/4,5 | s. of Sawmill Cr. | 56 | 13 | 69 | 14 | 8 | 35 | 43 | 126 | | | |
| 3/4-6 | census total | 75 | 18 | 93 | 21 | 9 | 35 | 44 | 158 | 47 | 23 | 28 |
| 3/25 | Sawmill Can. | 16 | 4 | 20 | 6 | 0 | 17 | 17 | 43 | | | |
| 3/27,28 | s. of Sawmill Cr. | 47 | 7 | 54 | 13 | 10 | 37 | 47 | 114 | | | |
| 3/25-28 | census total | 63 | 11 | 74 | 19 | 10 | 54 | 64 | 157 | 86 | 26 | 30 |
| 4/7 | Sawmill Can. | 15 | 4 | 19 | 4 | 1 | 15 | 16 | 39 | | | |
| 4/5,6 | s. of Sawmill Cr. | | | 44 | 7 | 8 | 30 | 38 | 89 | | | |
| 4/5-7 | census total | | | 63 | 11 | 9 | 45 | 54 | 128 | 87 | 19 | |
| 4/25 | Sawmill Can. | | | 17 | 7 | 0 | 15 | 15 | 39 | | | |
| 2/17 | Goodale Creek | 3 | 0 | 3 | 1 | 1 | 0 | 0 | 5 | | | |
| 4/9 | Goodale Creek | 3 | 0 | 3 | 0 | 1* | 1* | 2 | 5 | | | |
| 4/21 | Goodale Creek | 0 | 0 | 0 | 0 | 1* | 6* | 7 | 7 | | | |
| Maximal | | | | | | | | | | | | |
| | Sawmill Can. | 19 | 5 | 24 | 7 | 1 | 17 | 18 | 49 | | | |
| | s. of Sawmill Cr. | 56 | 13 | 69 | 15 | 10 | 37 | 47 | 131 | | | |
| | subtotal | 75 | 18 | 93 | 22 | 11 | 54 | 65 | 180** | 70 | 24 | 29** |
| | Goodale Creek | 3 | 0 | 3 | 1 | 2* | 7* | 9 | 13 | | | |
| | total | 78 | 18 | 96 | 23 | 13 | 61 | 74 | 193** | 77 | 24 | 29** |

* the yearling ram and (7-yr old) ram seen 4/9 north of Goodale Creek were not among those seen 4/21; thus the minimum total. This agrees exactly with the 13 seen 1/4 by Tom Blankinship from a helicopter except for yearling rams classified as ewes.

**a ewe that died in early January and a lamb killed in late January would bring the early winter subtotal to 182, the total to 195, and both ratios of lambs per 100 adult ewes to 30.

add 6 rams in Union Valley

with past experiences, and emphasizes the need for multiple censuses to provide a good total count. Best ram counts have always been made in late winter when some ewes are already dispersing to higher areas prior to lambing. When maxima of various sex and age classes are combined, the total for 1983 comes to 193 including Goodale Creek. Mortalities of two sheep prior to the early February census indicate that at least 195 sheep were present at the beginning of winter. Given the optimal census conditions this winter (heavy snow), this may be the actual total or be very close to it.

The number of sheep wintering in Goodale Creek this winter was approximately half the number there the previous two winters. The high number of ewes that wintered in the remainder of the winter range indicates a shift in distribution. Apparently the Goodale Creek winter range remains a connected offshoot of the Mount Baxter herd.

At the beginning of April in 1982 (after removals for reintroduction), the number of ewes (including yearlings) known to exist in the Mount Baxter herd (including Goodale Creek) was 75. The number of adult ewes known to exist at the beginning of winter in 1983 was 79. To account for mortality, more than 4 ewes were necessarily missed in 1982. In years when snow does not accumulate sufficiently, it is probable that in the neighborhood of 10% of ewes and possibly other age classes are not accounted for in censuses. Heavy snowfall years thus serve the important function of allowing some accounting of this slack.

The sex biased removal of sheep for reintroduction prior to 1982 caused a skewing of the sex ratio in the Mount Baxter herd. Consequently, a large number of rams were removed and relocated to reintroducted herds in 1982. This action has been effective in returning the sex ratio to about its pretrapping level (Table 1).

Mortality

The lamb crop in 1982 was low, with an early winter ratio of 30 lambs per 100 adult ewes and 24 per 100 total ewes (Table 1). Summer sampling in 1982 netted 5 lambs, 19 adult ewes, 1 yearling ewe, 7 yearling males, and 4 unsexed yearlings. This yields a ratio of 26 lambs per 100 adult ewes and 23 per 100 total ewes if half of the unsexed yearlings are assumed to be female. These ratios are very close to those for early winter, indicating negligible lamb mortality prior to winter. This is the usual pattern for this herd, the reasons for which have been discussed elsewhere (Wehausen 1980).

Winter mortality in the Mount Baxter herd appears to be almost entirely from mountain lion predation. The only exception found this winter was an old ewe with teeth worn down to gum level. She apparently walked out from the base of the Black Canyon range in early January and died, as there was no sign of predation associated with her carcass when found during the early January census.

This first census in January also produced two ram carcasses (4 and 5 year olds) on Sand Mountain that were lion kills from 1982.

New horn growth indicated that they were killed in spring after censusing had ceased.

One adult sheep carcass was found in 1983 that was a probable lion kill during that winter. This was the collared ewe that escaped from the trailer during the 1982 capture. She was last recorded in field notes as alive on 1 February in Sawmill Canyon. However, her collar may have been overlooked in later censuses, since it had lost all bright colors. In mid-March her collar was encountered in the sand at the base of the north side of Sawmill Ridge by Tom Kucera. On a subsequent investigation of the site I located her hair and rumen contents in a pile typical of lion kills, and her well-chewed backbone a short distance above. Although the skull has not been located to check for tooth marks, all other signs suggest a lion kill.

Three lambs were killed by lions on Sand Mountain during the census period in 1983. The first was found as a very recent kill on 2 February. The second was killed sometime in February and found March 14. The third was killed about March 18 and was first encountered by Steve Yeager of Bishop before the lions had finished consuming it. No lamb kills were found in Sawmill Canyon. It is noteworthy that these kill data are exactly corroborated by census data. The number of lambs counted south of Sawmill Creek dropped by one between early February and early March and by an additional one between early and late March, whereas all lambs known in Sawmill Canyon in February were observed in late April (Table 1).

Remains of lambs killed by lions during the winter of 1982 were clealy identifiable by leg bones with hooves in all cases, as well as part of the skull in some. Consumption of lambs killed in 1983 was notably more complete with nothing but hair, rumen contents, and an occasional bone chip remaining in all cases. Most killing in 1982 was by an adult female lion with one juvenile, whereas tracks clearly indicated two juveniles with an adult female in 1983. This additional lion may account for the more complete consumption of carcasses in 1983.

Remains of two additional lion kills (a 3 year old ewe and a lamb) were picked up in Goodale Creek in April by Bill McIntyre. Deterioration of the lamb hoof and weathering of the ewe skull suggest that these were either killed very early this past winter or more probably in the winter of 1982.

Mountain lion predation on the Mount Baxter herd (ignoring Goodale Creek) was relatively light in 1983, with only 3 lambs and one adult known to be taken between late January and late March. During the same time period in 1982, 8 lambs disappeared along with at least one adult. These differences in predation parallel differences in the abundance of lion tracks in the winter range during these two years. In both years, tracks indicated the presence of a female and juvenile(s) and a less frequent larger lion, presumably a male. Thus in 1982 these totalled three, whereas in 1983 the presence of a second juvenile brought the total to

four. Yet, tracks were far less frequent in 1983, and fewer sheep were killed. Why?

In 1982, the high level of predation resulted in the removal of the adult female lion on the assumption that she had become a specialist as a sheep hunter. Thus one possible explanation for the above results is that this was in fact true and lion removal was an effective action.

A second hypothesis is that (1) adult sheep are very difficult to catch, (2) lambs are much easier to catch due to little or no exposure to lions prior to winter, and (3) lions are opportunists; thus the intensity of their predation on bighorn is dependent on their success in catching them, i.e. on the number of lambs on the winter range. This could take two forms: (1) an approximately fixed percentage of lambs caught each year, or (2) a density dependent relationship where a higher percent of the lambs are killed at higher lamb densities.

In 1982, 42 lambs entered the winter range, of which 8 or 19% disappeared in a 2 month period. In 1983, 23 lambs entered the winter range and 3 or 13% disappeared in the same time period. These various hypotheses can be tested only through additional winters of similar intense data collection.

While the level of lion predation in 1982 was considered heavy, it by no means prevented a population increase. For the entire Mount Baxter herd (including Goodale Creek), 47 lambs entered the

winter range in 1982 and 31 yearlings did so in 1983; thus 67% survived that winter and the subsequent year (accounting for the lamb trapped and removed from the population). The total ewe population rose 29% - from 75 after trapping removals to 97 at the beginning of winter in 1983. This is an overestimate due to ewes missed in the 1982 census; but even if as many as 10 were missed in 1982, the increase rate is still 14% - a substantial rate despite predation.

Average Rate of Population Increase

The excellent census conditions in 1983 paralleled those in 1978; results from both years are probably very close to the actual number of bighorn existing at the time. This allows a calculation of the average rate of increase of the Mount Baxter herd during the intervening years. The actual change in population size has been a decline from 220 to 193 (Table 2), representing an average annual decline of 2.6%. This decline results from the difference between natural increase by the population and removals for reintroduction, which have totalled 60 sheep during this interval (Table 3).

In order to calculate the natural rate of increase of the population, it is necessary to formulate an equation that corrects for sheep trapped and removed from the population. This was done using an average annual finite increase rate ($\lambda$), such that $N_t = N_o \lambda^t$, where $N_o$ is the initial population size and $N_t$ is the population size t years later. Since each sheep removed would have

TABLE 2 - Summary of census data for 1978 and 1983.

| YEAR | HERD | EWES | LAMBS | RAMS | TOTAL |
|---|---|---|---|---|---|
| 1978 | MOUNT BAXTER | 108 | 38 | 74 | 220 |
| | MOUNT WILLIAMSON | 14 | 5 | 11 | 30 |
| | TOTAL | 122 | 43 | 85 | 250 |
| 1983 | MOUNT BAXTER | 96 | 23 | 74 | 193 |
| | MOUNT WILLIAMSON | 14 | 8 | 7 | 30* |
| | WHEELER CREST | 14 | 6 | 11 | 31 |
| | MOUNT LANGLEY | 7 | 2 | 7 | 16 |
| | TOTAL | 131 | 39 | 99 | 270 |

* includes one unclassified adult

TABLE 3 - Bighorn removed from the Mount Baxter herd as part of the reintroduction program, 1979 - 1982.

| YEAR | ADULT EWES | YEARLING EWES | FEMALE LAMBS | MALE LAMBS | YEARLING RAMS | ADULT RAMS | TOTAL |
|---|---|---|---|---|---|---|---|
| 1979 | 4 | 0 | 0 | 2 | 1 | 2 | 9 |
| 1980 | 16 | 1 | 5 | 2 | 1 | 6 | 31 |
| 1982 | 5 | 0 | 1 | 0 | 0 | 14 | 20 |
| TOTAL | 25 | 1 | 6 | 4 | 2 | 22 | 60 |

contributed to the population at the same annual increase rate, these are simply tacked on as negative sums. The value of $\lambda$ for these equations can be determined using the Newton approximation method or very quickly using trial and error with a programmable calculator.

For the ewe population, female lambs removed were treated as equivalent to adult (including yearling) ewes removed the following year. The resulting equation is

$$96 = 108\lambda^5 - 4\lambda^4 - 17\lambda^3 - 5\lambda^2 - 5\lambda - 1,$$

the solution of which is $\lambda = 1.041$ or a 4.1% average annual increase rate. This will be a slight overestimate in that a female lamb removed is actually equal to less than a ewe removed the following year because of less than 100% survivorship during the intervening year. It was previously calculated that survivorship of lambs from early winter to the next winter was 67%. This will be an underestimate relative to the above equation, since trapping has generally taken place later in winter after lion predation has already accounted for about half of this mortality. Estimating survivorship of female lambs removed at 85% changes the equation to

$$96 = 108\lambda^5 - 4\lambda^4 - 17\lambda^3 - .85x5\lambda^2 - 5\lambda - .85,$$

the solution of which is $\lambda = 1.038$, or an average annual increase rate of 3.8%.

When calculated for the population as a whole, the equation is

$$193 = 220\lambda^5 - 9\lambda^4 - 31\lambda^3 - 20\lambda,$$

for which the solution is $\lambda = 1.033$, or a 3.3% average annual increase rate.

For the years 1978-1982, the average winter ratio of lambs per 100 ewes has been 39.8, which has resulted in an average annual increase of 3.8% for the ewe population. Assuming an approximately equal sex ratio of lambs, 2 lambs per 100 ewes above the population maintenance ratio (where $\lambda = 1.0$) will be necessary for each percent increase of the ewe population. Thus 3.8x2 = 7.6 lambs per 100 ewes above the maintenance ratio are needed to account for the calculated 3.8% increase in the ewe population. Subtracting this from the average ratio of 39.8 for this period yields approximately 32 lambs per 100 ewes (including yearlings) needed for a static population in this herd. For the 1983 ratio of 24 lambs per 100 ewes (Table 1), this means that the ewe population can be expected to decline by about 4% over the next year. The average increase rate calculated for the entire population was lower than that for ewes alone because it already accounted for this low lamb recruitment in 1983.

The average annual increase rates calculated for the Mount Baxter herd are certainly lower than would be expected for a population being maintained below the level where density effects on individual nutrition and reproduction are discernable (Wehausen 1980). The reason for this is that during the period in question lamb

production was strongly influenced by years of poor primary production due to scant precipitation. This has occurred through the two year time lag in the influence of precipitation on recruitment rate (Wehausen 1980). Thus low recruitment in 1978 and 1979 (35 and 29 lambs per 100 ewes respectively) reflected the drought years of 1976 and 1977; the value of 34 for 1981 reflected low precipitation in 1979 (and probably also some density effects); and the low value for 1983 reflected a dry year in 1981, perhaps especially a very dry summer. The heavy winters of 1982 and 1983 should yield high recruitment rates the next two years.

## MOUNT WILLIAMSON HERD

Three days were spent censusing the Mount Williamson herd in late January of 1983 after a series of heavy snow storms. These produced considerable snow depths in the mountains, forcing bighorn to the base of Mount Williamson. Bighorn were located in the same three locations at which they wintered during 1978 (both forks of Bairs Creek and the rock outcrops north of Georges Creek). The census netted 30 bighorn, one of which was a large eartagged six-year old ram released at Lubkin Creek in 1982. No other sheep had eartags, with the possible exception of two adults that were not carefully scrutinized. Both the total number and the number of ewes were identical to respective totals in 1978 (Table 2). The low number of rams (2 yearlings, 1 two- year, 1 three-year, 1 four-year, 2 six-year), suggests the possiblity that a few more may exist; one unclassified adult in North Bairs Creek may have been a ram.

Overall, these data indicate that the Mount Williamson herd is a static population at carrying capacity.

## WHEELER CREST HERD

The Wheeler Crest population is largely divided into two winter ranges - one in Pine Creek and one in the Wells Meadow area. One ram (#7) was documented to move from the latter to the former in late fall, but he remained in Pine Creek throughout the winter. Nine sheep were known to be present in Pine Creek in late fall, and Terry Russi documented that they remained there all winter. They were a ewe with 2 lambs (apparently twins) by the mine and 2 ewes (both collared - #2 and presumably #3) with 4 rams in a side canyon further east. The rams were a yearling and a two-year old born on Wheeler Crest and 2 collared rams (original #1 and #7).

On 7 December 1982, 17 sheep were seen above Wells Meadow, composed of 9 ewes (2 collared - #6, #7), 1 yearling ewe, 3 lambs, and 5 rams (1 collared - new #1). On 18 January 1983, 18 were seen in the same location composed of 6 ewes (2 collared - #6, #7), 1 yearling ewe, 4 lambs, and 7 rams. Of these rams, 5 were born on Wheeler Crest (2 yearlings, 1 two-year, 2 three-year) and 2 were collared (#9 and new #1). If we assume that the additional lamb seen on this January count was with a ewe when the December count was made, a minimum of 10 ewes, 1 yearling ewe, 4 lambs, 2 yearling rams, and 5 adult rams wintered in the Wells Meadow area. When added to those in Pine Creek, the minimum population on Wheeler

Crest was 14 ewes, 6 lambs, and 11 rams for a total of 31 (Table 2).

Ewe #7 was observed on several occasions during this past winter, but was not recorded in the census of the previous winter. Since she was seen with a lamb just prior to that winter, it is reasonable to add 2 sheep to the 1982 minimum population, bringing it to 25.

## MOUNT LANGLEY HERD

The only sheep recorded in the Mount Langley herd wintered in Diaz Creek. They were 7 ewes, 2 lambs, and 7 rams. Five of the ewes (all collared) were those released in 1982, one was released in 1980 (eartagged), and one was born there.

## DISCUSSION

The bighorn reintroduction program in the Sierra Nevada has been in effect for 4 years. Has it produced a discernable increase in the total population? Examination of Table 2 indicates an overall increase of 20 sheep since 1978. This represents an average annual increase of only 1.6%. A number of factors underlie this apparently low rate: (1) it does not take into account the sheep exported from the Sierra Nevada to the Warner Mountains, where they have increased well; (2) while the census total for Wheeler Crest is probably close to the actual total, this cannot be stated for the Mount Langley herd, where an additional pocket of sheep may exist; (3) the Mount Williamson herd appears to be a naturally static herd at carrying capacity, thus cannot be expected to contribute to the overall

population increase; and (4) reintroduced populations can be expected to exhibit an initial lag in population growth until they establish home range patterns that strike an optimal balance between mortality risks and nutrient intake (and consequent reproducton). This has been apparent in both reintroduced populations in the Sierra Nevada in the form of high initial mortality rates due to snow avalanches and mountain lion predation.

Given these factors, the actual measured increase rate for the total population in the Sierra Nevada underestimates the success of the reintroduction program. As such it is a very positive sign. Reproduction in 1983 will probably put the Wheeler Crest population over 40 and on a clear path to success. The future of the Mount Langley herd remains less certain; it clearly warrants some close monitoring over the next couple of years.

The ratio of 32 lambs per 100 ewes necessary for population maintenance in the Mount Baxter herd is higher than commonly assumed. McQuivey (1978) provided a figure of 26 for Nevada, but did not indicate how it arrived at; thus underlying assumptions cannot be evaluated. The existence of a measurable level of predation in the Mount Baxter herd would predict a higher recruitment ratio necessary for population maintenance than in more predation free environments.

The 1982 reintroduction proposal produced by the Sierra Nevada bighorn interagency advisory group provided an approximate

expectation of harvestable sheep from the Mount Baxter herd for different population levels. This analysis was based on data indicating that density effects depressed reproduction when the population numbered 220, suggesting that maximum sustained yield occurs at a population of about 200. Calculations of approximate harvest expectations assumed (1) 26 lambs per 100 ewes needed for population maintenance, (2) an average recruitment ratio of 43 lambs per 100 ewes (based on data), and (3) a sex ratio of 70 rams per 100 ewes that existed before trapping began. The table in that report can now be recalculated using 32 lambs per 100 ewes needed for population maintenance. It is evident from Table 4 that the previous estimate of harvestable sheep was a substantial overestimate. Under the revised schedule, a reintroduction of 20 sheep every other year will on average be possible only if the population is maintained at an average of 200 (excluding Goodale Creek). Under circumstances when the recruitment ratio averages less than 43 lambs per 100 ewes, as has been the case since 1978, it will be necessary to allow 3 years to elapse between some transplants. The removal of 60 sheep since 1978 has consequently been a slight overharvest relative to maximum sustained yield.

The remaining question is whether the removal of mountain lions from the winter range of the Mount Baxter herd will increase the potential sheep harvest by lowering the lamb:ewe ratio necessary for population maintenance. The female lion removed in 1982 was replaced in 1983 by another female, resulting in an actual increase

in lions due to an added juvenile. Experience elsewhere suggests that continual replacement of lions removed can be expected (Munoz 1982). A program of regular lion removal from the Mount Baxter herd winter range is not justifiable on this ground and on the ground that the reintroduction program can continue in their presence.

Table 4 - Approximate harvest expectations for the Mount Baxter herd at different population levels. Previous estimates assumed 26 lambs per 100 ewes needed for population maintenance; the revised values used the ratio of 32:100 calculated in this report.

| TOTAL* POPULATION | NUMBER OF EWES | AVERAGE NO. OF LAMBS | AVERAGE ANNUAL SURPLUS TO MAINTAIN POPULATION PREVIOUS | REMOVABLE REVISED |
|---|---|---|---|---|
| 200 | 94 | 40 | 16 | 10 |
| 190 | 89 | 38 | 15 | 9.5 |
| 180 | 85 | 36 | 14 | 9 |
| 170 | 80 | 34 | 13 | 8.5 |
| 160 | 75 | 32 | 12 | 8 |
| 150 | 70 | 30 | 11 | 7.5 |

*excluding Goodale Creek

## LITERATURE CITED

McQuivey, R. 1978. The desert bighorn sheep of Nevada. Nevada Dept. of Fish and Game Biol. Bull. No. 6. 81pp.

Munoz, R. 1982. Movements and mortalities of desert bighorn of the San Andres Mountains, New Mexico. Des. Bigh. Counc. Trans. 26:107-108.

Wehausen, J. D. 1980. Sierra Nevada bighorn sheep: history and population ecology. Ph.D. diss., Univ. of Mich., Ann Arbor. 240 pp.