

## MORTALITY PATTERNS IN A BIGHORN SHEEP POPULATION

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### ABSTRACT

Natural mortality patterns of a native Rocky Mountain bighorn sheep (Ovis canadensis canadensis) population were studied over a nine-year period. Lamb mortality averaged 27% during the first six months of life and 10%, thereafter. Yearling mortality averaged 41 for ewes and 33% for rams. Ewe mortality was low between two and four years of age and increased thereafter. Ram mortality remained high for two-year-olds (31%), then declined to a low level through seven years of age. Few rams survived past their eighth year. No relationship was detected between dominance and ram mortality. Management implications are discussed.

## INTRODUCTION

Knowledge of natural mortality patterns and rates is essential to understanding population trends and dynamics and ultimately effective management of any animal species. Efforts to provide this information for North American mountain sheep populations generally have centered on development of life tables and/or survivorship curves based on the ages of animals found dead (Murie 1944, Woodgerd 1964, Geist 1971, Bradley and Baker 1967, Hansen 1967). Some have also attempted to "age" live animals in the field, using horn-ring counts, and directly document mortality within cohorts (Murphy and Whitten 1976). Both of these approaches have important limitations. The former in that the probability of finding skulls of dead animals is not the same for all sex and age classes; the latter in that it applies only to males and may not be accurate for animals older than 8 years. Lamb mortality has been particularly difficult to assess, and often has been ignored. Thus, neither the accuracy of existing mortality data nor the extent to which they may be generalized for all wild sheep populations is known.

This paper examines mortality patterns in a native population of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) that winters in the Stillwater River valley of southcentral Montana. Data were obtained from intensive population studies over a 9-year period, 1971-79.

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## STUDY AREA AND BIGHORN POPULATION TRENDS

Detailed descriptions of the study area, including land usage, are provided by Stewart (1975) and Stoneberg (1977).

Annual counts and classifications of bighorns were highly consistent with each other within and between years. This plus frequent observation of marked bighorns and our ability to accurately follow several cohorts over a 9-year period indicated that annual population estimates and classifications were extremely accurate, with

for if any animals being missed in any census period. Due perhaps to the small size and accessibility of the winter range and the behavior of the bighorns, this herd apparently can be accurately censused during the rut in late November, December and early January and again during green-up in late March and April.

Population size increased from 33 bighorns in the winter of 1971-72 to an average of 45 during the next four winters, 1972-73 through 1975-76, 50 animals in 1976-77 and 60 in 1977-78 (Table 1). From 51 to 52 sheep have been on the range each of the last two winters. Much of the population increase resulted from a four-fold increase in ram numbers between 1971-72 and 1979-80. Ewe numbers increased about 50% between 1971-72 and 1974-75, then remained relatively stable. Lamb numbers fluctuated annually but averaged about 12 animals.

#### METHODS

Observations of bighorns on the winter range were recorded almost daily between December and early May from 1971-72 through 1975-76. Thereafter, through 1978-79, observations were made at approximately weekly intervals. All observations were made from a highway which crosses the winter range. Bighorns were classified into sex and age classes, with rams being aged by counting annual horn rings (Geist 1966) using a 15-60X spotting scope. Ewes captured during the study were aged by incisor replacement for ages 1 through 4 and by counting annual rings thereafter. Annual ring counts may underestimate the actual age of older ewes (Geist 1971); however, 70% of the ewes captured were 4 years old or less, and only 10% were over 6 years old. Thus, this bias probably had only negligible effects on the results.

Approximately 20-30% of the ewes and some rams have been marked with individually recognizable neckbands throughout the study. Capture was by darting using a Cap-Chur gun manufactured by Palmer Co. The immobilizing agent was xylazine (Rompun) at dosages varying from 1 to 3 cc (100 mg/ml concentration).

The annual age structure of adult ewes was calculated with yearling recruitment added as necessary to account for both the total number of ewes present on the winter range and known mortality from each previous year (Table 2). Thus, the

Table 1. Size of the Stillwater bighorn population, post-hunting season, 1971-72 to 1979-80

Year	Rams	Ewes	Lambs	Total
1971-72	4	18	11	33
1972-73	8	22	14	44
1973-74	7	25	15	47
1974-75	7	28	11	46
1975-76	7	28	9	44
1976-77	11	27	12	50
1977-78	13	31	16	60
1978-79	12	25	15	52
1979-80	17	26	8	51

Table 2. Number of yearlings, two and three-year-old and older ewes in the Stillwater population during winter, 1971-72 to 1979-80

Year	Yearlings	Two	Three +
1971-72	1	?	17
1972-73	4	1	17
1973-74	7	4	14
1974-75	6	6	16
1975-76	1	6	21
1976-77	2	1	24
1977-78	4	2	25
1978-79	1	2	22
1979-80	2	1	23

Minimum number of yearling ewes present is indicated. Since more mortality may have occurred among adult ewes than was detected, the number of yearling ewes probably was underestimated, at least in some years. Lacking specific data I estimated only one yearling ewe in the 1971-72 population, based on the fact that only one yearling ram was present. The effect of this arbitrary decision was canceled by 1974.

Attempts to classify yearling ewes were not successful and were discontinued early in the study. Neck collared yearling ewes could not consistently be differentiated from mature ewes on the basis of horn growth or facial characteristics; and some neckbanded 2 and 3-year-old ewes resembled yearlings.

Attempts to determine the number of yearling ewes based on the number of yearling rams were also unsuccessful (Table 3). In 4 of the 9 years the sex ratio varied substantially from 50:50. However, over the total 9 years the sex ratio was relatively even.

Age specific mortality rates for yearling and 2-year-old ewes were calculated from the data in Table 2. For older ewes, mortality rates were based on the annual survival of neckbanded ewes.

#### RESULTS - Lamb Mortality

Lambing grounds, nursery areas and summer ranges of Stillwater ewes have not been located; therefore, lamb production and early survival can only be estimated. A lambing rate of 90 lambs/100 ewes 3 years old and older was assumed to be a reasonable average for most years and was probably exceeded in 1973. Based on this average a total of 142 lambs was expected between 1971 and 1978. Of these, 103 survived to winter (Table 1). This suggested an average mortality rate of 27% during the first 6 months of life. At least 93 of the 103 lambs that arrived on the winter range were known to survive until spring, indicating an average winter mortality of only 10%. Overall, annual lamb mortality averaged 35%. This rate included both male and female lambs, as no attempt was made to detect differential mortality.

Table 3. Numbers of yearling rams and ewes in the Stillwater population, 1971-72 to 1979-80

	1971- 1972	1972- 1973	1973- 1974	1974- 1975	1975- 1976	1976- 1977	1977- 1978	1978- 1979	1979- 1980	Total
Rams	1	5	2	3	2	6	5	3	6	33
Ewes	1	4	7	6	1	2	4	1	2	28

### Ewe Mortality

Yearlings incurred the highest annual mortality among ewes older than lambs, averaging 41% during the study (Table 4). Relatively low mortality was characteristic of ewes 2 to 4 years of age, averaging only 16%. Higher mortality, averaging 30%, prevailed between 5 and 9 years of age, with few ewes surviving past 10 years. The oldest known ewe in the population will be 13 years old in June 1980.

Survivorship curves for Stillwater bighorn ewes, desert (Nelson) bighorn ewes and Dall ewes are compared in Figure 1. These data indicate lower mortality of lambs, much higher mortality of yearlings, and somewhat higher mortality among 2 and 3-year-old ewes in the Stillwater population. After four years mortality rates appear to be similar for all three populations. Maximum longevity also appears to be similar.

### Ram Mortality

Mortality patterns and rates among rams in the Stillwater population have been greatly influenced by hunting and changes in hunting regulations since 1975. In that year the Stillwater winter range was closed to hunting and a quota was set on the number of rams that could be harvested from the population. These regulations resulted in a decline in harvest and a corresponding increase in the number of rams over 4 years old (Table 5).

Under the unlimited three-quarter-curl harvest in effect through 1974, most rams were being harvested as they reached three-quarter-curl as 3-year-olds and all were killed before they reached 5 years of age (Table 5). Because of this, my data primarily represent natural mortality patterns and rates to 3 years of age. Only after 1975, when ram survival increased, were data for older animals obtained.

Among eight cohorts followed between their second and third winters, numbers declined in 5, remained the same in 2 and increased in 1 (Table 5). This indicated either a significant mortality or emigration during the third summer. In either case a substantial net loss of rams from the population occurred which can only be treated as mortality in terms of general population dynamics.



Table 4. Average annual natural mortality of Stillwater ewes by age class, 1971-72 to 1979-80

	Age Classes												
	Lambs	1	2	3	4	5	6	7	8	9	10	11	12
No. of ewes entering age class	71 <sup>1/2</sup>	46	25	7	6	8	5	6	5	3	1	1	1
No. of ewes entering next age class	46	27	21	6	5	6	4	4	3	2	1	1	1
Percent mortality	35	41	16	14	17	25	20	33	40	33	0	0	0

<sup>1/2</sup> Number of ewe lambs projected to be born 1971-1978 - based on ratio of 90 lambs/100 3+-year-old ewes and a 50:50 lamb sex ratio.

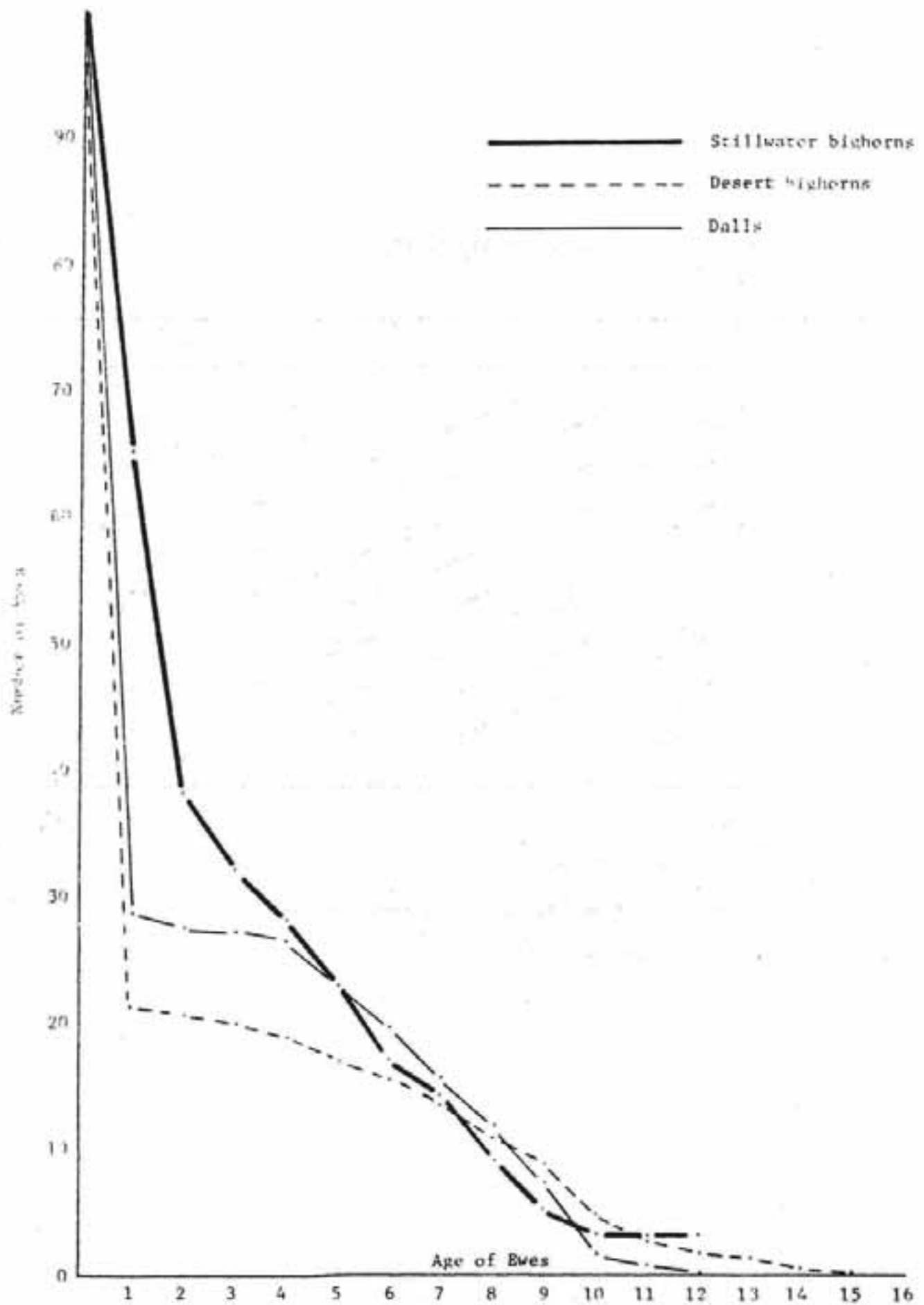


Figure 1. Comparative survivorship curves for Stillwater bighorns, desert bighorns and Dall ewes.

Table 5. Post-hunting season age distribution of Stillwater ram population, 1971-72 to 1979-80

Year	Yrlg.	Two	Three	Four	Five	Six	Seven	Eight
1971-72	1	$\frac{1^1/}{3}$	$\frac{2H^2/}{0}$	0	0	0	0	0
1972-73	5	$\frac{W \& S^2/}{2}$	$\frac{W \& I}{1}$	$\frac{H}{0}$	0	0	0	0
1973-74	2	$\frac{3}{3}$	$\frac{2H}{2}$	$\frac{H}{0}$	0	0	0	0
1974-75	3	$\frac{S}{2}$	1	1	$\frac{H}{0}$	0	0	0
1975-76	2	$\frac{S}{2}$	$\frac{H}{2}$	1	0	0	0	0
1976-77	6	$\frac{2S}{1}$	1	2	$\frac{S^4/}{1}$	0	0	0
1977-78	5	$\frac{3S}{4}$	$\frac{H}{1}$	1	1	1	0	0
1978-79	3	2	3	1	1	1	1	0
1979-80	6	3	2	3	1	1	1	$\frac{S}{0}$

$\frac{1}{1}$  = immigration.

$\frac{2}{H}$  = hunting mortality.

$\frac{2}{W}$  = known winter mortality, S = summer mortality or emigration.

$\frac{4}{4}$  This was a known mortality.

Calculated average annual natural mortality rates indicate that from the time a ram cohort is born until it is 3 years old, it is subjected to average annual mortality of about 33% (Table 6). Between 3 and 7 years of age natural mortality averaged only 4% annually. To date no rams have survived until their ninth birthday.

A comparison of survivorship curves for Stillwater, desert bighorn (Bradley and Baker 1967), and Dall rams (data from Murie 1944 as analyzed in Bradley and Baker 1967) shows two sharp differences (Figure 2). First, mortality remains high through the yearling and 2-year-old age classes in the Stillwater, whereas only insignificant mortality is indicated for desert and Dall rams of these age classes. Second, maximum longevity for Stillwater rams is substantially less than for the other populations. Geist (1971) showed minimal mortality in the yearling and 2-year-old age classes for bighorns in Banff National Park and documented a maximum longevity of 20 years.

#### DISCUSSION AND CONCLUSIONS

Mortality studies of North American mountain sheep have generally indicated insignificant mortality of yearling and 2-year-old animals (Beuchner 1960, Woodgerd 1964, Bradley and Baker 1967, Geist 1971). However, in this study substantial "mortality" apparently occurred among yearlings of both sexes and 2-year-old rams. This mortality occurred largely during the summer and/or early fall. Only one yearling and one 2-year-old, both rams, have died on the winter range during the study.

These disappearances could be explained by either emigration or death. Geist (1971) observed that yearlings of both sexes migrated to summer range with their maternal ewe groups. Little, if any, emigration was noted. Two-year-old rams tend to wander independently of ewe and ram groups and emigration may be more likely. Indeed, one 2-year-old ram was known to immigrate into the Stillwater population.

For the most part, however, the disappearance of yearling and 2-year-old rams from the Stillwater population was thought to be the result of their death. Geist (1971) suggested that yearlings may wander into strange areas if they fail to attach themselves to barren females when pregnant females withdraw for lambing in the spring.

Table 6. Average annual natural mortality of Stillwater rams by age class, 1971-72 to 1979-80

	Age Classes								
	Lambs	Yearlings	Two	Three	Four	Five	Six	Seven	Eight
No. of rams entering age class	71 <sup>1/2</sup>	46	26	12	9	5	3	2	1
No. of rams entering next age class	46	31	18	12	9	4	3	2	0
Percent mortality	35	33	31	0	0	20	0	0	100

<sup>1/2</sup> Number of ram lambs projected to be born 1971-1978 - based on ratio of 90 lambs/100 3+-year-old ewes and a 50:50 lamb sex ratio.

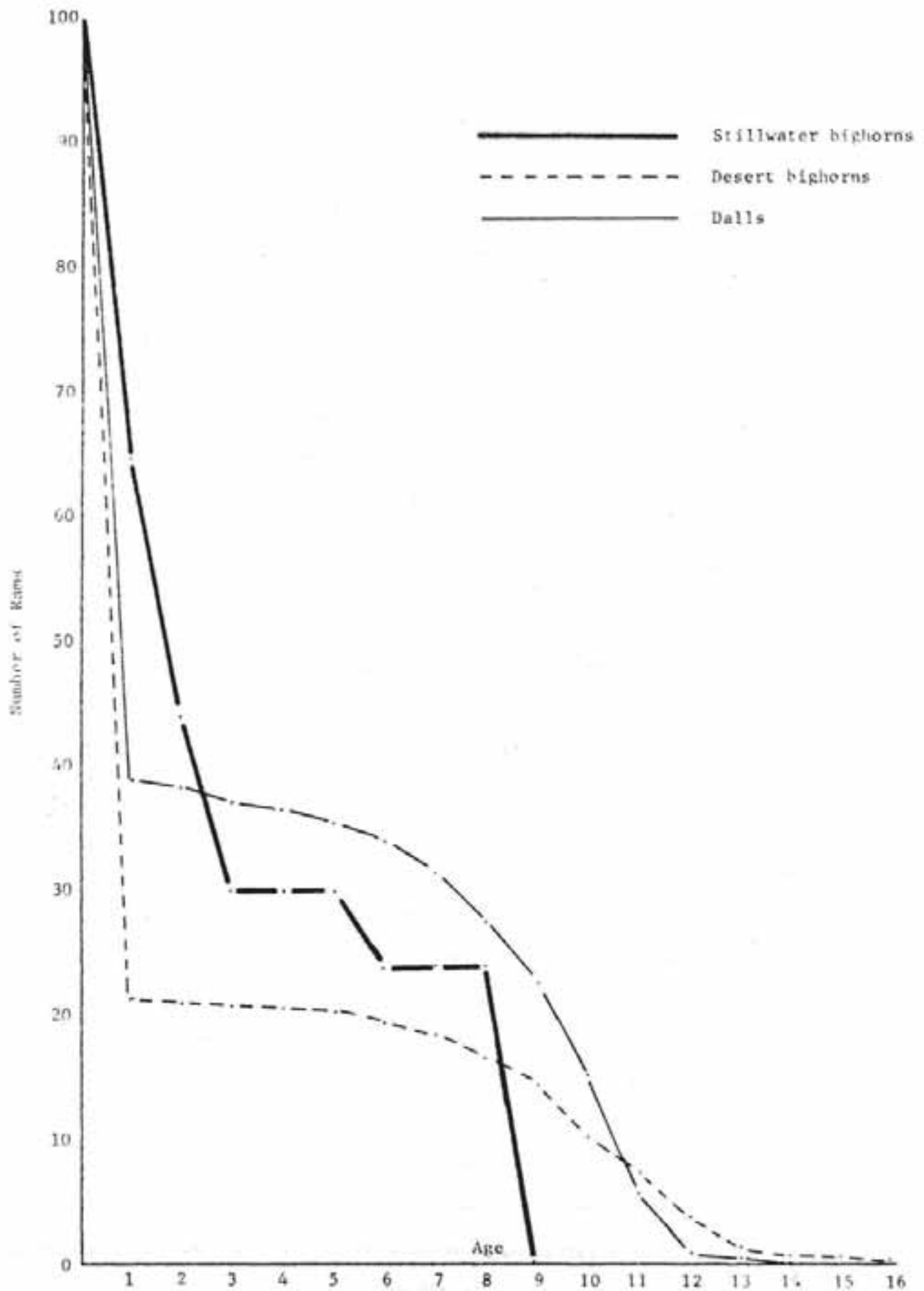


Figure 2. Comparative survivorship curves for Stillwater bighorns, desert bighorns and Dall rams.

Wandering in strange areas is likely to result in the sheep's death. Wishart (1958) found yearling remains in areas not normally visited by bighorns. Similarly, wandering by 2-year-old rams in areas not normally occupied by sheep may result in their death. This may be especially true in areas like the Beartooth Mountains where wandering sheep are unlikely to find other bighorns, due to the extremely low density of sheep in the area. Emigration in such cases would eventually result in death.

It is possible that mortality of yearlings of both sexes and perhaps 2-year-old rams as well was also high in other studies but could not be detected by the techniques employed; i.e. examination of bighorn remains found on traditional winter-spring ranges. If these sheep were lost during summer or fall or by wandering into normally unoccupied areas before their death, their remains would go undetected. Murphy and Whitten (1976) documented substantial yearling and 2-year-old mortality for several cohorts of Dall rams in McKinley Park using the data based on field aging of living rams. It is also possible that different mortality rates and patterns may be characteristic of different populations or subspecies/races of mountain sheep.

The relatively short longevity of rams in the Stillwater probably is an artifact of heavy hunting pressure prior to 1975. Because all rams that achieved legal status prior to 1975 were shot, few now occur in older age classes. However, even under a more natural age structure, it is unlikely that many rams will live past 10-12 years. Of 384 rams killed in Montana since 1974 from both low and high-quality populations, only one (0.2%) has been over 12 years old and only 6 (1.6%) have been 10 years old or older (Montana Department of Fish, Wildlife and Parks files). It is unlikely that exceedingly old rams can be found outside of low-quality unhunted populations.

Geist (1971) suggested that mortality increased when rams reached their ultimate body and horn size and became dominant breeding animals at approximately 8 years of age. He further predicted that mortality of young rams would increase if they were allowed to participate in breeding at the same level as older rams.

ty results do not support this conclusion. Young rams (7 years old or less) have been dominant throughout the study, yet they have had the same natural mortality rate (4%) reported by Geist (1971) for young mature age classes. No relationship could be detected between dominance and mortality.

All rams on the Stillwater winter range as 2-year-olds returned to that winter range each year until death. Thus, declines in the number of animals in a cohort after that age can be attributed to natural or hunting mortality and not to emigration. Geist (1971) suggested that ram home ranges were fixed by 4½ years of age and documented seasonal home range fidelity of 86-89%, although this figure may have included younger rams.

Ewe fidelity to the winter range also appears to be close to 100%; no marked ewes 2 years old and older have ever failed to return to the winter range one year and then returned in following years. Thus, the disappearance or nonreturn of adult ewes was considered to represent their death. Geist (1971) suggested that ewe fidelity to seasonal home ranges was in excess of 90%.

#### MANAGEMENT IMPLICATIONS

The three-quarter-curl law employed to restrict the harvest of bighorns to old-age animals should be reconsidered. As shown here, it does not accomplish that objective. To mimic natural mortality, hunting mortality should be directed to yearling and 2-year-old rams and animals older than 8 years. The three-quarter-curl law puts hunting pressure on prime-age (3 to 7-year-old) animals. Within these age classes, hunting mortality is additive and not compensatory and it may be detrimental to a population if the total harvest is not strictly controlled so that some rams are kept in each age class.

Harvest regulations need not protect yearling and 2-year-old rams if prime-aged rams are not protected. This only results in an artificial establishment of "trophy" status. A tightly controlled hunt where the hunter is allowed to take any ram or any sheep would be biologically preferable to a three-quarter-curl hunt. The other alternative is to restrict hunters to the harvest of rams in excess of 8 years old.



Such regulations are plagued with enforcement problems and are unrealistic and unnecessary in most cases.

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## QUESTIONS - RESPONSES

Jim Bailey: Why did you decide it was desirable to change your harvest so that you could have older rams in the population?

Shawn Stewart: Basically with young rams; I guess everybody knows young rams use the winter range as ewe groups do. Because it is a small winter range, we felt it would be more desirable to try to get an older age class structure and try to have a different ram pattern and ewe pattern and thus take some of the competition away from the ewes on the winter range. That did result. As soon as we got 5 year old rams on the winter range, all of the rams, with the exception of yearlings, began using areas away from the areas that the ewes used.

Jim Bailey: Did you notice any difference in reproduction?

Shawn Stewart: We've had high reproduction all the way through with the exception of this year. Reproduction is high, survival is high so we can't say.

Nike Goodson: You said you didn't know where the summer ranges of these sheep were. Are you certain that there aren't any other sheep range that they are using?

Shawn Stewart: We've got a suspicion that it's that. Some of the rams do mingle with rams of another summer. The ewes, as near as we can tell; there is no mixing with ewes. We've just begun radio studies this year and, hopefully, that's going to be straightened out, but I don't feel that there is any mix with ewes on the summer range. The marked sheep that we have had in the past have not shown up on other areas. They have come back to the winter range. We've never lost any sheep, or had them show up in another place, less say.

John Youds: How did you estimate numbers in each age class?

Shawn Stewart: For rams or for ewes?

John Youds: For both.

Shawn Stewart: Rams just by counting; we know how many sheep are out there. They're right alongside the road and we can count annual rings, so we know.

John Youds: You were capturing every animal?

Shawn Stewart: No, just counting from the road. We look at them with a spotting scope and count how many annual rings they got, you know how many rams you got and you know what age each ram is. The ewes, everything from 3 years old on, they are marked animals, we aged them at the time of capture and we just follow the mortality through; when they disappear from the population.