AN EXPERIMENT IN DALL SHEEP MANAGEMENT: PROGRESS REPORT 1/

by

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ABSTRACT

Abstract

This paper reports progress on a continuing experiment which was begun in 1970 to compare results of three management programs involving three nearby but isolated herds of Dall sheep (Ovis dalli dalli) on the Kenai Peninsula, Alaska. One herd on Slaughter Mountain had been essentially closed to all hunting since before statehood and was to remain closed; a herd on Surprise Mountain had been hunted traditionally and intensively for rams with horns of 3/4-curl or larger and would continue to be so managed. A third herd on Crescent Mountain, which in the past had been hunted as intensively for rams as had that on Surprise Mountain, would be reduced deliberately through either-sex harvest and maintained for several years at a level approximately 30 percent lower than its pre-experiment size.

All three herds had exhibited roughly similar growth patterns from low levels in the 1940's until about 1968, when those on Surprise and Crescent mountains appeared to level off. The Slaughter Mountain herd continued to increase until 1973 when it, too, reached a peak. During the winter of 1969-70, the Suprise Mountain herd declined by some 40 percent due to an extremely unfavorable winter.

Between the falls of 1970 and 1974, approximately 124 sheep of both sexes were removed from Crescent Mountain during three public hunting seasons and a winter collecting program. An additional 40 or so animals emigrated from the study area in 1974. During the same period, an estimated 14 rams were taken by hunting from Surprise Mountain and possibly as many as 22 rams from the Slaughter Mountain herd when they moved beyond the closed area boundaries.

Biological information obtained from the Crescent Mountain collection is being reported elsewhere as are reproductive and food habits data gathered during field observations, collections, and aerial surveys.

Winter ranges were compared on all three areas in 1971 and 1972. Forage production was found to be highest on Slaughter Mountain and lowest on Crescent Mountain. However, production of primary sheep forage species (grasses and sedges) increased on Crescent Mountain in 1972 despite a general reduction in forage production on all areas that summer, suggesting decreased grazing pressure following the initial herd reduction.

Winter conditions, as indicated by temperature, wind velocity, snow depth, and snow hardness, appear to be harshest on Crescent Mountain and mildest on Slaughter Mountain, although the significance of these factors in relation to sheep survival is not yet clear.

Population models for each herd and year of study have been constructed based upon replicate aerial surveys. Reproductive success and over-winter mortality were estimated from observed changes in each population.

Despite an apparently more inhospitable habitat, reproductive success has averaged higher, while over-winter lamb mortality has averaged lower on Crescent Mountain than on the other two areas for the past three years. Although additional data are needed before statistically significant conclusions can be drawn, it does appear at this time that herd reduction on Crescent Mountain has stimulated reproduction and lowered mortality while providing more animals for harvest than in similar herds under ram-only hunting.

INTRODUCTION

Background

Dall sheep (Ovis dalli dalli) have traditionally been hunted in Alaska only for rams with horns of 3/4-curl or larger. Such trophy hunting, although generally accepted by the public, has not been shown to control sheep populations and is therefore of little value as a management tool when population manipulation is desired. Sheep populations in Alaska have been controlled largely by the effects of winter weather. The species has become adapted to a relatively stable, climax habitat, and so can probably be expected to remain relatively stable in numbers under "normal" conditions, with natural mortality more or less balancing natality to keep numbers in approximate balance with the carrying capacity of winter habitat. Sharp but comparatively minor variations in

[1]Study supported by Alaska Department of Fish and Game under Federal Aid in Wildlife Restoration Project W-17-R.

herd sizes should reflect "normal" variations in winter severity, which, in turn, affect snow cover and hence available winter forage.

However, large population declines have been know to occur in the past, the best documented occurred in McKinley National Park in the 1930's and 1940's (Murie, 1944). Exceptionally severe winter weather in the form of deep and persistent snows appeared to be the causative factor. Apparently, similar population crashes occurred in many other sheep herds in the state at about the same time, although no documentary evidence is available. Old residents have told me of sheep having been very numerous in the Kenai Mountains in the late 1930's, but declining to remnant herds sometime in the early 1940's. Aerial surveys of various herds in the state begun in the late 1940's by the U.S. Fish and Wildlife Service and, following statehood, continued by the Alaska Department of Fish and Game, indicated very low populations at first, followed by increases until the late 1960's. Some of the best historical population data available are for three herds on the Kenai Peninsula, the Surprise Mountain herd, the Crescent Mountain herd and the herd in the Cooper Landing Closed Area on Slaughter Mountain (Alaska Dept. Fish Game and U.S. Fish Wildl. Serv., numerous unpubl. progress reports; Pitzman, 1970). All of these estimates indicate increasing populations from low points in the early 1940's (Figs. 1, 2, 3).

Local severe winter conditions in 1969-70 were believed responsible for the decline of about 40 percent in the Surprise Mountain herd. In this case, "severe" consisted of above normal temperatures and precipitation resulting in deep, heavy snow cover which could not be blown free by the wind from usual winter feeding areas. Population data were not adequate to determine the effects of this winter on the remaining sheep herds of the area, but it did not appear to affect so severely the herds on Crescent and Slaughter Mountains.

In 1970, the Alaska Department of Fish and Game began a study to determine whether herd control through either-sex hunting would improve reproductive and survival rates by relieving grazing pressure on winter range. It was also hoped to learn whether maintaining a herd well below the known carrying capacity of its winter range would reduce the effects of exceptionally severe winters which might otherwise cause drastic herd reductions. A third objective of the study was to obtain as much life history information as possible about a relatively unknown species. This study is still in progress and is expected to continue until it is evident that statistically sound conclusions can be drawn regarding the primary objective. This paper is thus a progress report of results to date rather than a final report on a concluded project.

STUDY DESIGN

Three nearby but relatively isolated herds of Dall sheep in the Kenai Mountains were chosen for study: that on Crescent Mountain, that on Surprise Mountain, and the herd occupying Cooper Landing Closed Area which winters largely on Slaughter Mountain. These herds were selected for several reasons: historical data were available on population sizes; each occupied a comparatively isolated mountain or series of mountains with no known interchange of animals; all were accessible from the highway and by light aircraft for study purposes; all were situated along the Kenai Lake-Kenai River drainage and within a few miles of each other and hence assumed to be subject to similar climatic influences; each contained a herd of sheep adequate in size for study; and all were within the southern extremity of Dall sheep range in Alaska which appears to be limited by maritime climate and thus could be expected to be subject to more frequent and severe winter-related fluctuations than interior herds.

Both the Crescent Mountain and the Surprise Mountain herds had been hunted so intensively for rams with horns of 3/4-curl or larger that few, if any, survived the annual hunting seasons. The Slaughter Mountain herd had been closed to hunting since before statehood and was essentially regulated by nature alone, except for the removal of a few rams which occasionally wandered outside the closed area boundaries during the hunting season.

Furthermore, the three sheep herds had exhibited approximately similar growth rates (despite intensive ram-only hunting in two of them) from low points in the 1940's until reaching what appear to have been density-dependent peaks in the late 1960's. Least-squares growth curves were fitted to the observed population data (Figs. 1, 2, 3) and have been plotted to the same scale in Fig. 4 to illustrate the similarity of growth rates, rates which approximated 11-14 percent average annual increases. These data suggest fairly similar environmental pressures and population responses, making the three herds suitable for comparison during the intended study.

It was planned to reduce the Crescent Mountain herd by public either-sex hunting and scientific collecting from its pre-experiment level of some 287 sheep to about 200 sheep before lambing each year. This plan was later changed to aim for a pre-winter level of approximately 200 animals. The Surprise Mountain herd would remain open to hunting for legal rams only, as before, while the Slaughter Mountain herd would continue closed to hunting. Thus, three separate "management" plans could be compared: herd reduction through either-sex hunting, intensive ram-only hunting, and essentially-complete protection.

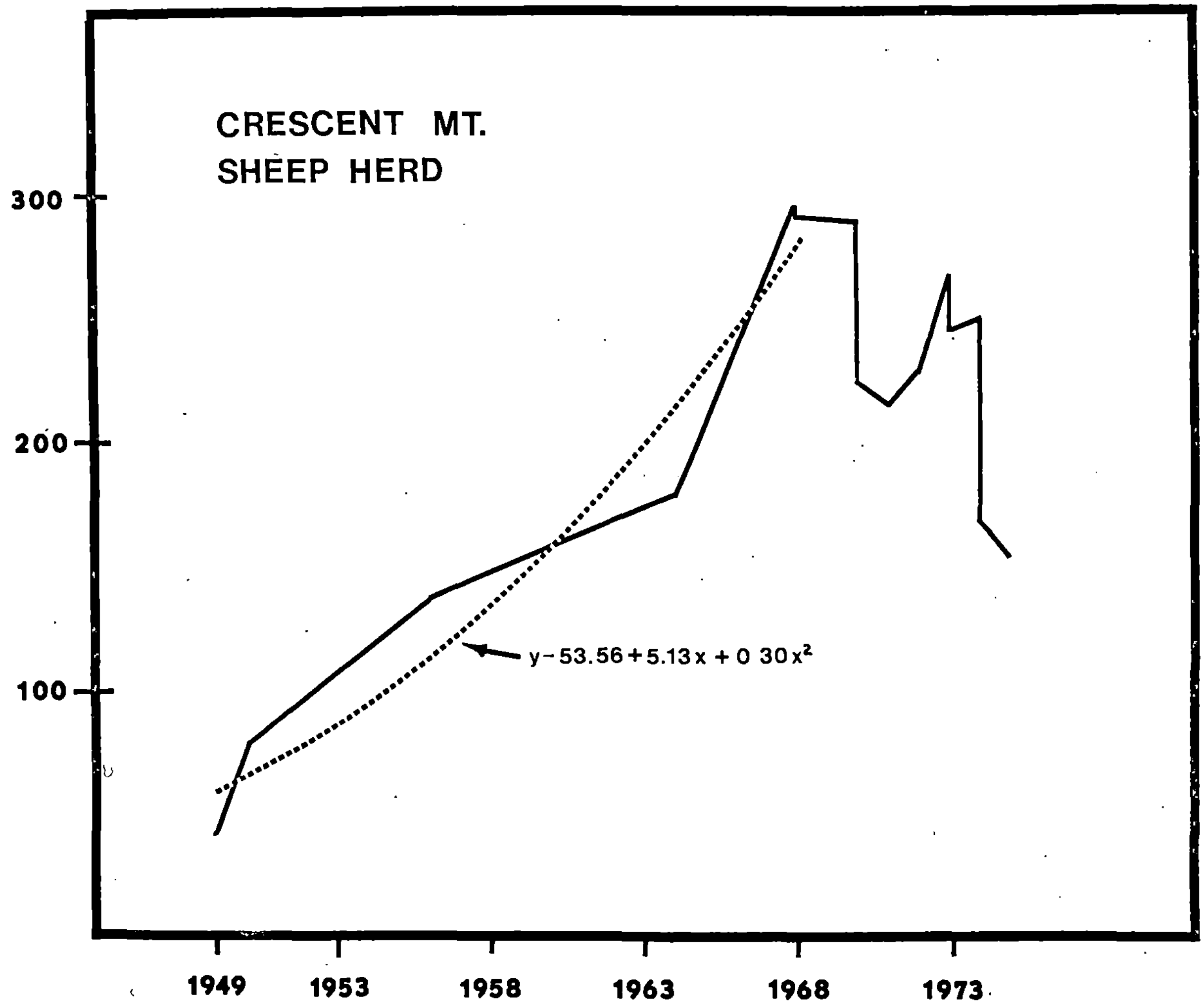

Fig. 1. Growth of Crescent Mountain Dall sheep herd as estimated from aerial surveys, and fitted growth curve (vertical displacements represent known removals by hunting, collection and emigration).

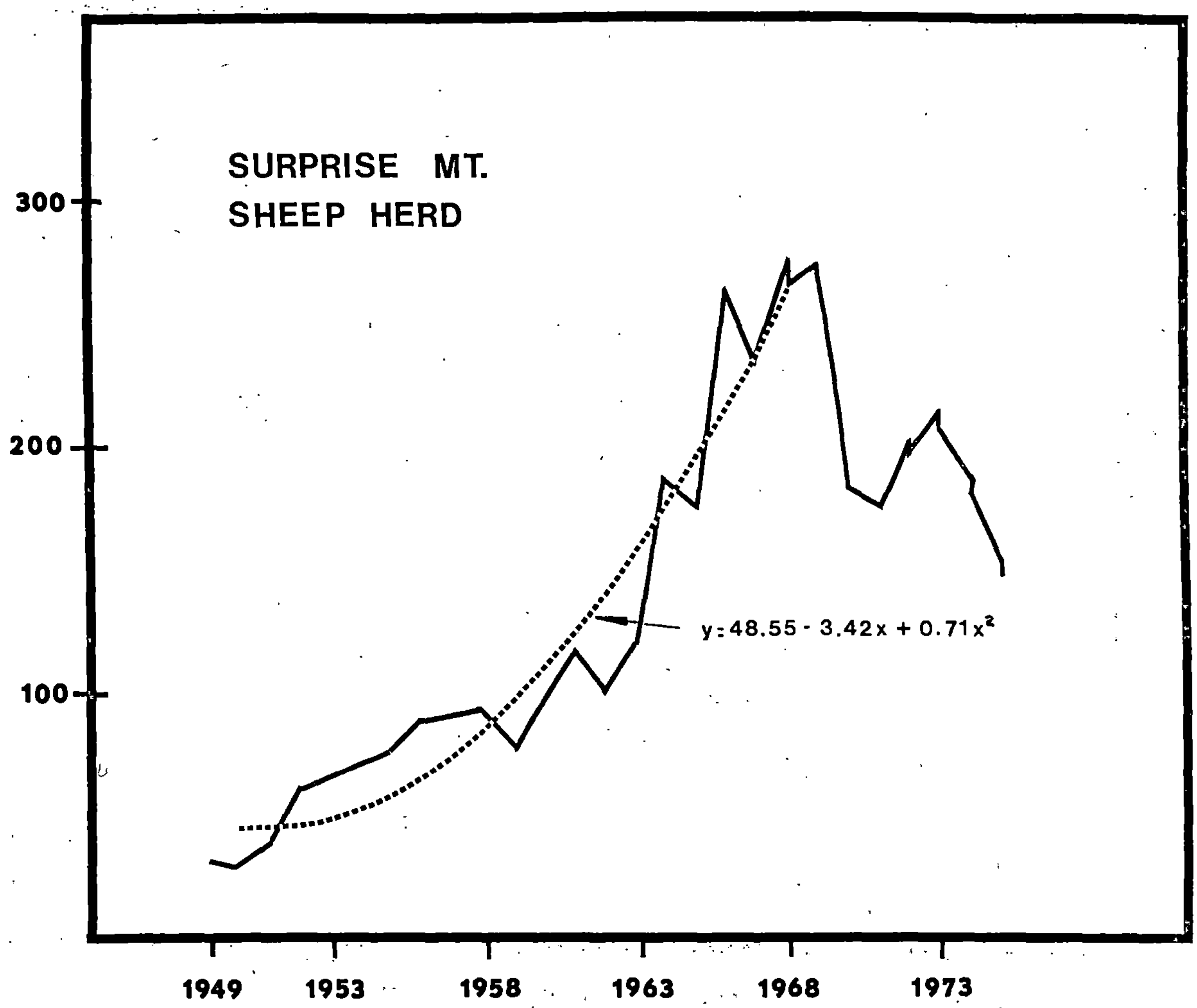

Fig. 2. Growth of Surprise Mountain Dall sheep herd as estimated from aerial surveys, and fitted growth curve (vertical displacements represent known removal by hunting).

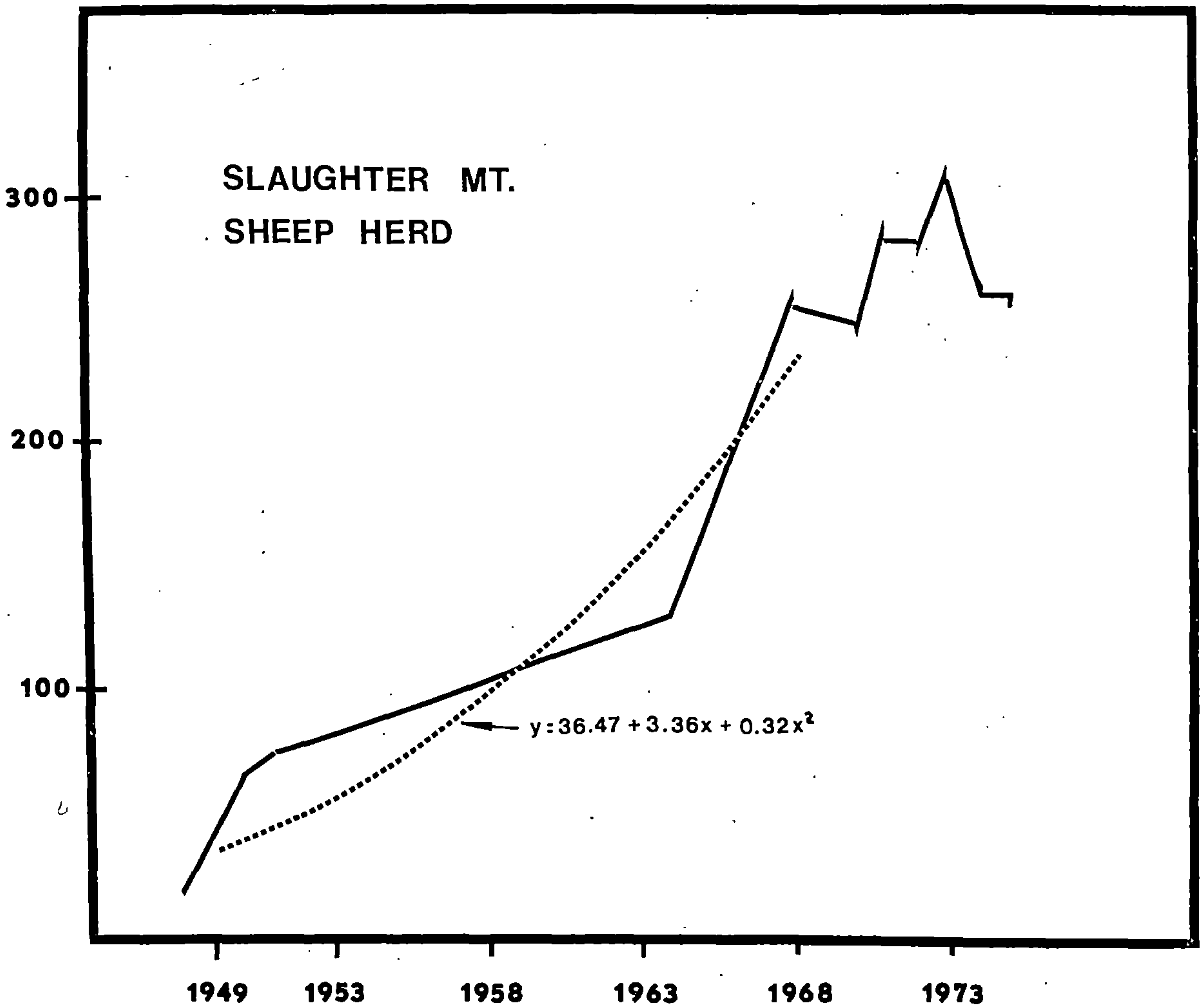

Fig. 3. Growth of Slaughter Mountain Dall sheep herd as estimated from aerial surveys, and fitted growth curve (vertical displacements represent estimated removal by hunting).

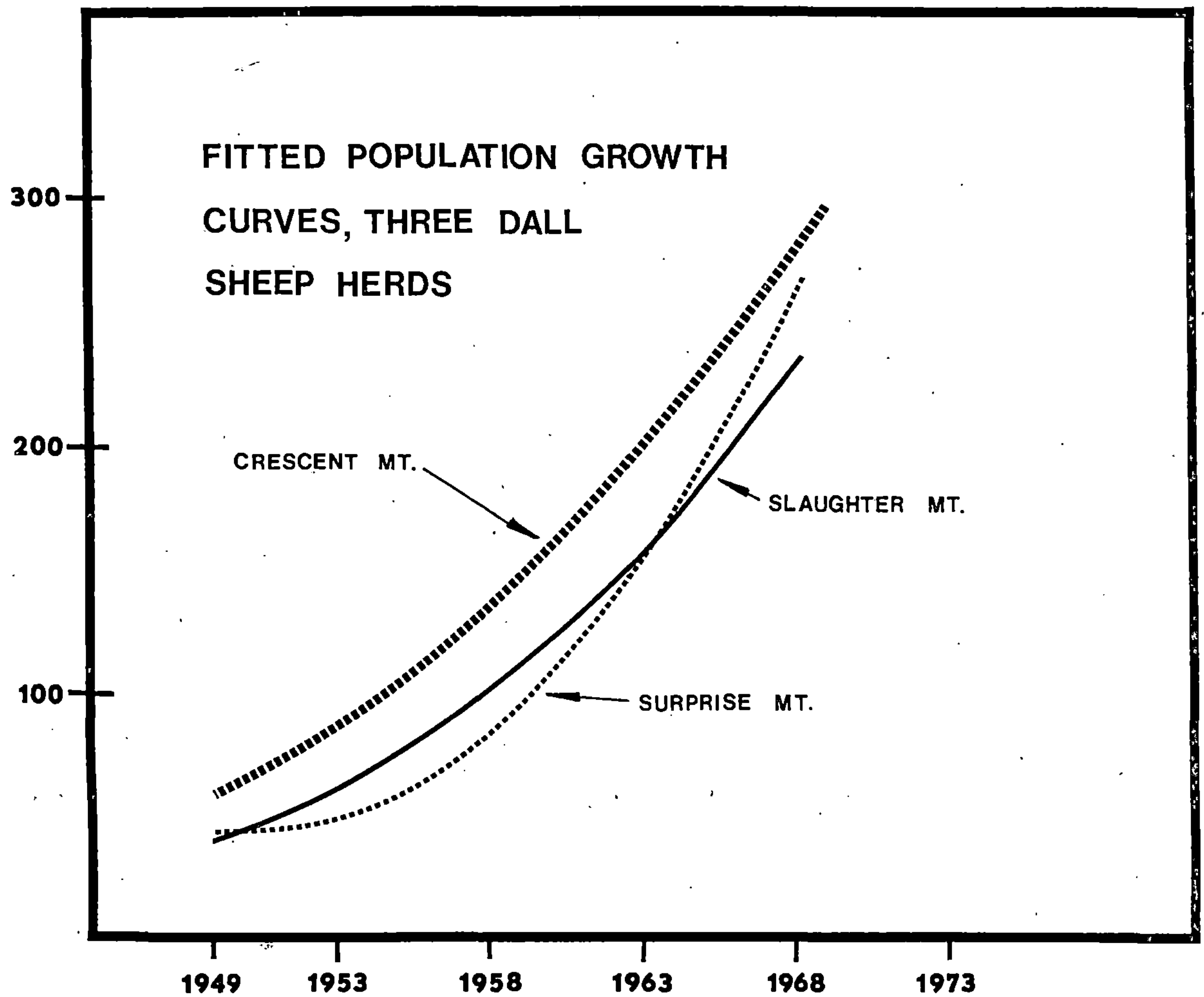

Fig. 4. Calculated growth curves of three Dall sheep herds (least squares fit).

Thereafter, population changes, lamb production, and survival would be monitored for the duration of the study. At the same time weather and snow conditions would be recorded, and initially forage production would be determined on all areas. Thus, any changes occurring in each population could be interpreted in light of both management technique applied and habitat conditions.

This report covers the comparison of habitats and populations, and population responses to the three management techniques. The study phases including reproduction, food habits, and physiological changes will be reported elsewhere.

METHODS

Herd Reduction and Control

The original reduction of the Crescent Mountain herd began in August, 1970, with a public hunt; 60 permits were issued for the taking of one sheep of either sex with horns of 1/2-curl or less. The remaining reudction was accomplished during the following winter by Department personnel utilizing helicopters and shotguns. Approximately 10 animals were taken at a time during each of the winter months except December (November, January, February, March and April). All were removed promptly by helicopter to a laboratory for necropsy and provided data on weights and measurements, physiological changes throughout winter, reproduction, parasites and disease, and food habits.

Another public hunt with similar restrictions was held in the fall of 1973. In August, 1974, a similar hunt was held except that there were no restrictions on the number of persons participating, the only requirement being to check in and out at a hunter checking station. In addition to the hunt for either-sex sheep with horns of 1/2-curl or less, a limited, permit-only hunt was held for rams with horns of full curl or larger.

Weather Conditions

Three Model 1071 self-contained, mechanical weather stations were obtained from Meterorology Research, Inc., Altadena, California. These stations continuously record wind velocity, wind direction and temperature. They are well suited to remote locations as charts and batteries need be changed but about every two months. One station was located in sheep winter range on each of the mountains under study. All were accessible by light aircraft or by helicopter if conditions made the latter method of transportation necessary. Data from the charts were later reduced to tabular form, providing a comparison of wind and temperature between the three sites.

Snow Conditions

A simple technique for comparing gross snow conditions was developed. A jointed aluminum alloy avalanche probe (Mountain Safety Research, Inc., Seattle) was coated with light-colored epoxy paint and marked with a scale to measure snow depth. A Chatillon Model 719-40 "push-pull" scale, registering from 0 to 40 lbs. (0 - 18.1 kg) was used to measure snow hardness. It was used with either of two extension rods, one with a circular flat tip of 1.0 cm area, and the other with a tip of 0.5 cm area, and both with sockets on the upper ends into which the push probe of the scale could be inserted. The rods were made long enough for the operator to begin pushing down with the scale held at about chest height.

In practice, the chosen rod was placed on the surface of the snow and held vertically with one hand. The scale was inserted in the socket and carefully pressed down with the other hand while watching the pressure indicator. Thus, the force in lb/cm^2 required to penetrate the snow could be measured directly. A recording slider on the scale simplified reading the maximum pressure applied. When snow conditions were too hard for penetration of the 1.0 cm^2 tip with 40 lbs pressure, the 0.5 cm^2 tip was used, enabling pressure to be read to 80 lb (36.3 kg)/cm^2.

Transects were laid out in sheep winter range in as similar sites as could be found. Each transect consisted of five lines, each of which had 10 points 10 paces apart. At each point, one depth measurement was made, around which four hardness measurements were made. Thus, each transect consisted of 50 depth measurements and up to 200 hardness measurements. No hardness measurement could be made on bare ground. Hardness was measured to a maximum depth of 18 in (46 cm) below the surface.

This method was easy to use under adverse winter conditions and the entire transect could be completed without removal of snowshoes or gloves (data were recorded in a casette recorder). The method was tested for accuracy by running three simultaneous transects with the points of each approximately one meter apart; no statistically significant difference could be detected between transects. The method was considered sufficiently accurate, therefore, to detect real differences in gross snow conditions.

Winter Range Conditions

In late winter, Dall sheep are often restricted by snow conditions to feeding only on windblown, open ridgetops. A number of such sites, known to be used by sheep in winter, were staked out on each mountain during the winter of 1970-71 so that they could be located for study during the summer growing season. Dr. R. M. Hansen, Colorado State University was contracted to determine winter range forage production on each of the three study areas. Ten transects of 100, 100-cm^2 plots each were established on the previously-marked ridges in each study area during the summer of 1971. Forage production of each plant species encountered was estimated by the weight-estimation method developed by Pechanec and Pickford (1937) and later converted to oven-dry weight by drying and re-weighing samples of each species collected and weighed during the surveys. Correction factors for each estimator were determined by periodically clipping and weighing previously-estimated samples of each species.

The range survey was repeated during the summer of 1972, again by Dr. Hansen and his team, to obtain two years of forage production data from each area.

Sheep Populations

Sheep in each herd were counted and classified from the air by the method described by Nichols (1970). A Piper PA-18-150 Supercub was used for all counts, each of which was conducted under as nearly ideal flying conditions as could be encountered to make possible the best accuracy. In some cases, replicate counts were conducted to assess accuracy, which, in the case of total numbers and lambs-of-the-year, approached 100 percent. Counts were made of each herd in each year prior to the spring lambing season to determine adult sex ratios and the proportion of lambs surviving the winter. Counts after completion of lambing enumerated total numbers and lambs. Additional aerial surveys were flown whenever necessary to obtain post-hunting season herd status, winter distribution, lambing progression and size classification of rams. Annual population models were then constructed from the aerial count data. Production and mortality data were determined from these models.

RESULTS

Herd Reduction and Control

All sheep known to have been removed from Crescent Mt. during the course of this study are listed in Table 1. It is interesting to note that during the first two public hunts when the number of permittees and their hunting time was limited, hunting success was only 25 percent, which was lower than the average statewide hunting success of 36 percent for rams, only. Harvest was lower than anticipated or desired in both hunts despite the either-sex option and the accessibility of the area, suggesting that it may be difficult to achieve a desired level of either-sex harvest under similar conditions in future hunts, and particularly in more remote areas. Success in the 1974 hunting season increased to 44 percent, slightly higher than the statewide average of 42 percent for that year. The increase is attributed to the length of hunting time and number of trips each individual could make as well as to exceptional weather. During that season, 81 hunters participated, many making several trips.

The more intensive hunting pressure was encouraged because of the previous difficulty in reaching the desired harvest under tighter control of hunters, and by the change in plan to bring the herd to a pre-winter level of about 200 animals rather than a spring level of that magnitude. Included in that hunt was a special-permit hunt wherein permittees were allowed the option of taking either a ram with full-curl horns or larger or a sheep of either sex with horns of half-curl or less. It was expected that these permittees, who were allowed to hunt prior to the general either-sex hunt, would take about 10 of the known 14 full-curl rams in the herd. Only three were taken, including one wounded and lost.

Had the herd reduction on Crescent Mountain been limited to the hunting harvest in 1974, the desired population level would have been approximated except for a sex-ratio imbalance which was enlarged by the failure to harvest enough old rams. However, at some time during the hunting season, about 42 sheep left the mountain, resulting in a remaining pre-winter population of only 170 animals. The sex and age composition of the emigrants was unknown, but was believed to have been mostly ewes and lambs which further unblanced the remaining sex-ratio in favor of males. It is believed that the emigration was a direct result of too much hunting pressure: too many hunters for too long a period in this relatively small area.

During this same period from 1970 through 1974, 14 rams with horns of 3/4-curl or larger were reported taken from Surprise Mountain and approximately 22 from the closed area. The latter were taken outside the boundaries of the area closed to hunting, but probably came from the Slaughter Mountain herd.

Table 1. Known numbers of sheep removed from Crescent Mountain by hunting, wounding, scientific collection and emigration.

Date	Method of Removal	Rams	Ewes	Lambs	Total
Fall, '70	Public Hunt	6	9	-	15
Winter, '70-'71	Collection	9	28	11	48
Winter, '70-'71	Wounding		1		1
Sub-total		15	38	11	64
Fall, '73	Public Hunt	5	13	1	19
Fall, '73	Wounding		3		3
Sub-total		5	16	1	22
Fall, '74	Public Hunt	16	19	1	36
Fall, '74	Wounding	1		1	2
Fall, '74	Emigration	?	?	?	42
Sub-total		17 +	19 +	2 +	80
Grand total		27 +	73 +	14 +	166

Weather Conditions

Adequate wind and temperature data were obtained for comparison during the winters of 1971-72, 1972-73, and 1973-74. Sufficient data were not obtained during the winter of 1974-75 due to mechanical problems with the weather instruments.

Average winter (October through April) wind and temperature data are listed in Table 2. The average maximum wind is the mean of maximum recorded winds each month.

Table 2. Average winter temperatures and winds by area and year.

Average winter temperature, degrees C.

Year	Crescent Mt.	Surprise Mt.	Slaughter Mt.
1971-72	-12.2	-8.2	-7.8
1972-73	- 5.8	-6.5	-5.0
1973-74	- 8.1	-5.3	-8.0
$\bar{x}$ =	- 8.7	-6.7	-6.9

Average winter wind, km/hr.

Year	Crescent Mt.	Surprise Mt.	Slaughter Mt.
1971-72	25.8	25.3	16.4
1972-73	28.3	20.6	15.1
1973-74	27.5	20.6	15.8
$\bar{x}$ =	27.2	22.2	15.8

Average winter maximum wind, km/hr.

Year	Crescent Mt.	Surprise Mt.	Slaughter Mt.
1971-72	111.0	74.4	53.0
1972-73	147.4	68.7	52.8
1973-74	105.6	65.3	73.7
$\bar{x}$ =	121.3	69.5	59.9

Analysis of variance of these data indicated that there were no statistically significant differences in mean winter temperature between sites (F = 0.70/2,6), but significant differences (P<.001) existed between sites in both average wind (F = 31.36/2,6) and average maximum wind (F = 14.43/2,6). Average winter wind was found (by Student-Newman-Keuls' test) to be significantly higher (P<.05) on Crescent Mountain than on Slaughter Mountain, but not significantly higher than on Surprise Mountain, which in turn, was similar to Slaughter Mountain. Average Maximum winter wind was similar on Slaughter and Surprise Mountains, but significantly higher (P<.05) on Crescent Mountain than on either of the other two.

To see whether significant differences existed between the three years, wind and temperature data were pooled by year and compared. No significant difference between years could be detected.

Snow Conditions

Snow surveys were conducted once each winter on each area at as near the beginning of February as conditions permitted. Lack of time prevented more than one annual survey; however, I believe that comparisons based upon the one annual survey at that time and used as an indicator of gross annual snow conditions are valid. Replicate surveys were conducted throughout the winter of 1973 on Surprise Mountain to determine changes in snow conditions. Results indicated that snow depth increased from November through early December, then remained approximately the same through mid-March regardless of additional snowfall during the interim. Apparently, the snow became crusted or packed by December from thawing and refreezing or wind action; additional snow did not accumulate in significant amounts, but blew away from the stabilized, early-winter surface. Snow hardness increased until late January, then remained approximately the same through March. Thus, surveys conducted in late January or early February could be expected to reflect average mid-winter conditions.

Average snow depth and hardness data are listed in Table 3 by area and year. Mean annual depths and hardnesses were pooled by area to find out whether differences existed between the three mountains. Analysis of variance showed that significant differences did, indeed, occur between sites in both depth (F = 40.1/2, 747 P<.01**) and hardness (F = 235.6/2,2525 P<.01**). When examined individually, it was found that depth was significantly less on Crescent Mountain (P<.01**) than on Surprise or Slaughter Mountains, but the latter two were not significantly different from each other. Crescent Mountain had significantly harder snow (P .01**) than did Surprise Mountain, which had significantly harder snow (P<.01**) than did Slaughter Mountain.

Table 3. Average snow depth and hardness data by area and year.

Year	Crescent Mt.	Surprise Mt.	Slaughter Mt.
Snow Depth in cm.			
1972	14.0	32.5	50.3
1973	11.9	29.0	43.7
1974	16.0	43.7	40.6
1975	24.6	45.2	43.9
1976	16.8	25.4	40.1
$\overline{x}$ =	16.7	35.2	43.7
Snow Hardness in kg/cm^2			
1972	9.0	4.9	3.3
1973	14.6	7.3	2.7
1974	7.6	10.4	3.1
1975	18.6	14.2	5.9
1976	8.8	4.3	3.1
$\overline{x}$ =	11.7	8.2	3.6

With mean snow depths and hardnesses pooled by area and compared between years, no significant difference could be found in average depth (F = 1.80/4,745), while average hardnesses were significantly different (F = 79.62/4,2523 P<.01**). Mean annual hardnesses were compared individually by the Student-Newman-Keuls test with the following results:

Year:	1972	1976	1974	1973	1975
$\overline{x}$ Hardness:	5.1	5.5	7.0	7.4	13.0

Years connected by underline were similar to each other; those not connected by underline were significantly different (P<.05).

When examined between areas within years, it was found that snow depth on Crescent Mountain was significantly less, in general, than on Surprise or Slaughter Mountains, which were usually similar to each other. Snow hardness was significantly different between all areas each year, with that on Crescent Mountain being hardest and that on Slaughter Mountain being softest. These results, which are too lengthy for inclusion, agree for the most part with the pooled data.

Winter Range Conditions

Detailed forage production data by plant species will be reported elsewhere. For purposes of this report, forage production has been summarized by plant class (total grass and grasslike plants, total forbs and browse, total herbaceous vegetation) in Table 4. Chi-squared tests indicate significant differences (P<.01) between areas each year. Area by area comparisons by forage class were made using Student's t-tests; results are summarized in Table 5. It may be seen that significant differences (P<.01) between each area for each forage class were found in 1971, with Crescent Mountain producing the least and Slaughter Mountain producing the most vegetation.

Table 4. Forage production on sheep winter range in kg/ha, oven-dry weight.

	Area	TOTGR 1/	TOTFB	TOTHB
1971	Crescent Mt.	60.3	335.2	395.6
	Surprise Mt.	112.0	985.0	1097.0
	Slaughter Mt.	254.2	1191.5	1445.7
	Between areas $X^2 = 27.54/4$ P<.01**			
1972	Crescent Mt.	81.4	247.8	329.3
	Surprise Mt.	74.9	624.6	699.5
	Slaughter Mt.	95.4	704.7	800.1
	Between areas $X^2 = 41.12/4$ P<.01**			

1/ TOTGR = Total grass and grasslike plants.
TOTFB = Total forbs and browse.
TOTHB = Total herbaceous vegetation (TOTGR + TOTFB)

Table 5. Forage production comparisons between areas, 1971 and 1972.

	Areas compared	Forage class	t-value and DF	Significance
1971				
	Crescent vs. Surprise	TOTGR 1/	-6.69/1998	P<.01**
		TOTFB	-14.46/1998	P<.01**
		TOTHB	-15.25/1998	P<.01**
	Crescent vs. Slaughter	TOTGR	-12.52/1998	P<.01**
		TOTFB	-21.24/1998	P<.01**
		TOTHB	-23.82/1998	P<.01**
	Surprise vs. Slaughter	TOTGR	-8.45/1998	P<.01**
		TOTFB	-4.21/1998	P<.01**
		TOTHB	-6.66/1998	P<.01**
1972				
	Crescent vs. Surprise	TOTGR	0.91/1998	No difference
		TOTFB	-15.43/1998	P<.01**
		TOTHB	-14.37/1998	P<.01**
	Crescent vs. Slaughter	TOTGR	-1.96/1998	P<.05*
		TOTFB	-17.67/1998	P<.01**
		TOTHB	-17.31/1998	P<.01**
	Surprise vs. Slaughter	TOTGR	-1.80/1998	No difference
		TOTFB	-2.56/1998	P<.05*
		TOTHB	-3.10/1998	P<.01**

1/ TOTGR = Total grass and grasslike plants.
TOTFB = Total forbs and browse.
TOTHB = Total herbaceous vegetation (TOTGR + TOTFB).

In 1972, the same relationships continued except for the total grass and grasslike plants class, which showed no difference in production between Crescent and Surprise Mountains, nor between Surprise and Slaughter Mountains. Forage production on all three areas decreased significantly (P<.01) from 1971 to 1972 (precipitation was greater during the summer of 1971 than 1972) except for grasses and grasslike plants, which increased significantly (P<.01) in 1972 on Crescent Mountain only (Table 6).

Table 6. Forage production comparisons, 1971 vs 1972.

Area	Comparison	t-value and DF	Significance
Crescent Mt.	1/ TOTGR (increased)	-3.91/1998	P<.01**
	TOTFB (decreased)	4.50/1998	P<.01**
	TOTHB (decreased)	3.18/1998	P<.01**
Surprise Mt.	TOTGR (decreased)	4.10/1998	P<.01**
	TOTFB (decreased)	9.43/1998	P<.01**
	TOTHB (decreased)	10.11/1998	P<.01**
Slaughter Mt.	TOTGR (decreased)	9.81/1998	P<.01**
	TOTFB (decreased)	11.12/1998	P<.01**
	TOTHB (decreased)	13.61/1998	P<.01**

1/ TOTGR = Total grass and grasslike plants.
TOTFB = Total forbs and browse.
TOTHB = Total herbaceous vegetation (TOTGR + TOTFB).

Sheep Populations

Population models, based on the results of replicate aerial surveys of each herd each year, have been constructed for each herd and are presented in Table 7. Each annual model represents an estimate of herd composition and size during the summer after lambing has been completed. One recognized anomaly is the unexplained disappearance of a number of rams between 1973 and 1974 in the Slaughter Mountain model. A miscount is not believed responsible since the proportion of rams in the herd remained approximately similar from 1974 to 1975. It is possible that a group of rams emigrated from the area entirely or departed for a distant summer range before counts were completed. Since no explanation can be offered, this apparent loss to the herd has been included in "mortality."

Table 7. Sheep population models based upon replicate aerial surveys.

Area	Year	Rams	Ewes	Yearlings	Lambs	Total
Crescent Mt.	1970	70	143	30	44	287
	1971	72	101	22	20	215
	1972	78	103	13	35	229
	1973	74	113	31	50	268
	1974	73	99	31	47	250
	1975	57	61	14	23	155
Surprise Mt.	1970	19	141	5	20	185
	1971	27	120	9	21	177
	1972	25	117	14	45	201
	1973	24	118	25	46	213
	1974	27	109	24	29	189
	1975	22	106	8	18	154
Slaughter Mt.	1970	78	121	21	28	248
	1971	88	133	17	50	288
	1972	94	112	22	50	282
	1973	86	134	25	67	312
	1974	54	145	28	39	266
	1975	59	146	21	34	260

Annual lamb production, calculated as the ratio of viable, observed lambs per 100 ewes, is presented in Table 8 with results of statistical comparisons. Data have been separated into two time periods: "before treatment" and "after treatment". Although the initial herd reduction on Crescent Mountain took place during the winter of 1970-71, no recognizable response occurred until 1973. Therefore, lamb production and survival data up through 1972 are considered to be indicative of the period before this herd was reduced, while the period beginning with 1973 is considered indicative of that after herd reduction.

Chi-squared analyses denote significant differences in lamb production between herds both before and after treatment. However, the only differences that could be demonstrated between herds were merely suggestive ($P<.10$) when examining the herds individually.

Table 8. Lambs per 100 ewes.

Year		Crescent Mountain	Surprise Mountain	Slaughter Mountain
1970		31	14	23
1971		20	18	38
1972		34	38	45
	$\bar{x}$ =	28.3	23.3	35.3
1973		44	39	50
1974		47	27	27
1975		38	17	23
	$\bar{x}$ =	43.0	27.7	33.3

Between herds <u>before</u> treatment: $X^2 = 10.11/2$ $P<.01$**

CM ($\bar{x}$ = 28.3) vs SM ($\bar{x}$ = 23.3) t = 0.801/2
SM ($\bar{x}$ = 23.3) vs SL (x = 35.3) t = -2.969/2 $P<.10$
CM ($\bar{x}$ = 28.3) vs SL (x = 35.3) t = -0.901/2

Between herds <u>after</u> treatment: $X^2 = 7.25/2$ $P<.05$*

CM ($\bar{x}$ = 43.0) vs SM ($\bar{x}$ = 27.7) t = 2.963/2 $P<.10$
SM ($\bar{x}$ = 27.7) vs SL ($\bar{x}$ = 33.3) t = -1.782/2
CM ($\bar{x}$ = 43.0) vs SL ($\bar{x}$ = 33.3) t = 1.214/2

Within herds, <u>before vs after</u> treatment:

CM before ($\bar{x}$ = 28.3) vs after ($\bar{x}$ = 43.0) t = -2.927/4 $P<.05$*
SM before ($\bar{x}$ = 23.3) vs after ($\bar{x}$ = 27.7) t = -0.443/4
SL before ($\bar{x}$ = 35.3) vs after ($\bar{x}$ = 33.3) t = 0.188/4

Average lamb production before herd reduction on Crescent Mountain was compared with that afterwards for each herd by t-test. No changes between "before" and "after" could be detected for the Surprise Mountain or Slaughter Mountain herds. However, a significant ($P<.05$) increase was apparent for the Crescent Mountain herd in which the mean number of lambs per 100 ewes increased approximately 52 percent.

Lamb survival over winter, calculated by comparing the number of yearlings observed in the spring with the number of lambs observed the previous summer, and taking into consideration any lambs removed by hunting or collecting, is listed by herd and year in Table 9 along with statistical comparisons. As with lamb production, chi-squared tests indicated significant differences in lamb survival between herds both before and after treatment, but comparison of individual herds suggested only ($P<.10$) that mean lamb survival on Crescent Mountain may have been higher than that on Surprise Mountain after the Crescent Mountain herd was reduced.

"Before" vs "after" comparisons for each herd failed to show significant changes in lamb survival. Nevertheless, it may be seen that the trend in survival is slightly up on Crescent Mountain, while it appears to be downwards on both other mountains.

The ratios of lambs per 100 ewes, and the percent lamb survival by herd and year are presented graphically in Fig. 5 and Fig. 6 as an aid in visualizing changes.

Table 9. Lamb survival over previous winter.

Year		Percent Survival	
	Crescent Mountain	Surprise Mountain	Slaughter Mountain
1971	67	45	61
1972	65	67	44
$\bar{x}$ =	66.0	56.0	52.5
1973	89	56	50
1974	62	52	42
1975	48	28	54
$\bar{x}$ =	66.3	45.3	48.7

Between herds <u>before</u> treatment: $X^2 = 7.079/2$ P<.05*

CM ($\bar{x}$ = 66.0) vs SM ($\bar{x}$ = 56.0) t = 0.833/1
SM ($\bar{x}$ = 56.0) vs SL ($\bar{x}$ = 52.5) t = 0.179/1
CM ($\bar{x}$ = 66.0) vs SL ($\bar{x}$ = 52.5) t = 1.800/1

Between herds <u>after</u> treatment: $X^2 = 12.482/4$ P<.05*

CM ($\bar{x}$ = 66.3) vs SM ($\bar{x}$ = 45.3) t = 3.154/2 P<.10
SM ($\bar{x}$ = 45.3) vs SL ($\bar{x}$ = 48.7) t = -0.293/2
CM ($\bar{x}$ = 66.3) vs SL ($\bar{x}$ = 48.7) t = 1.355/2

Within herds, <u>before vs after</u> treatment:

CM before ($\bar{x}$ = 66.0) vs after ($\bar{x}$ = 66.3) t = -0.021/3
SM before ($\bar{x}$ = 56.0) vs after ($\bar{x}$ = 45.3) t = 0.765/3
SL before ($\bar{x}$ = 52.5) vs after ($\bar{x}$ = 48.7) t = 0.491/3

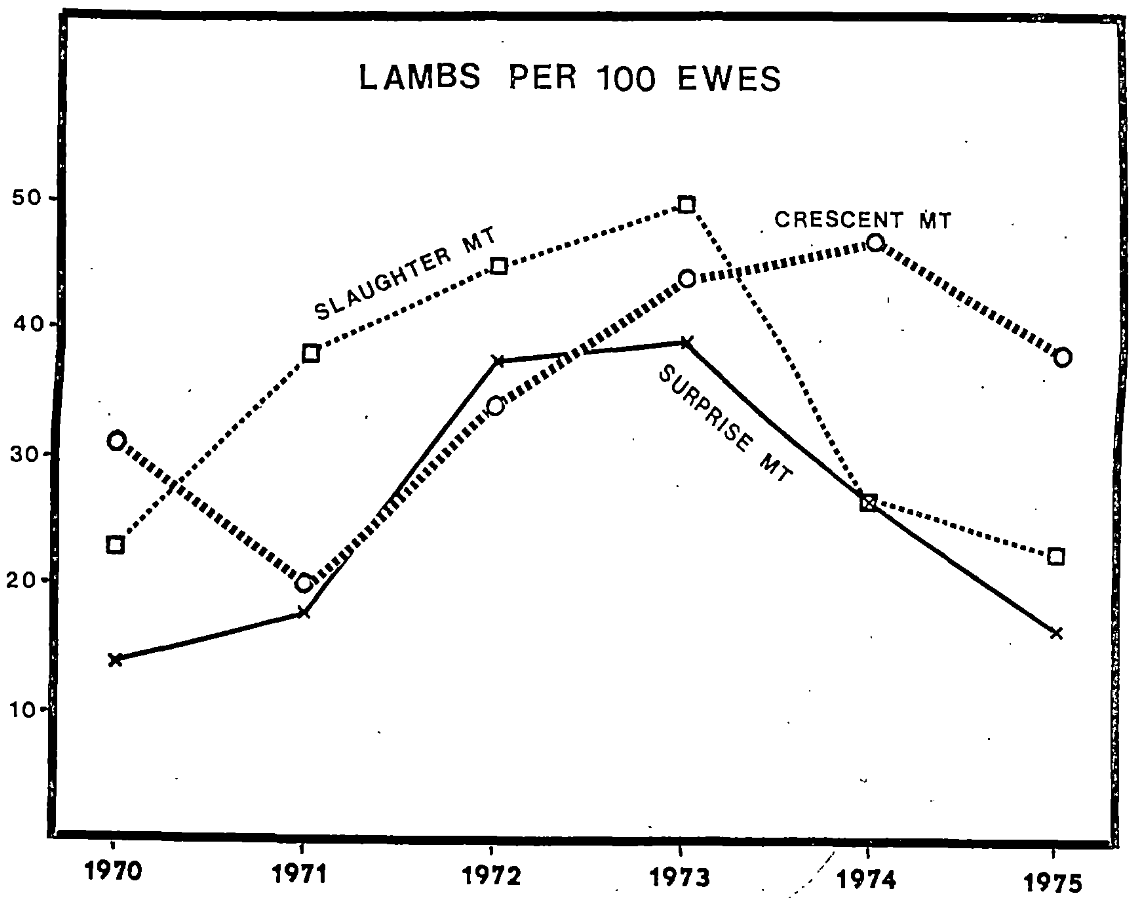

Fig. 5. Ratios of lambs per 100 ewes in three Dall sheep herds.

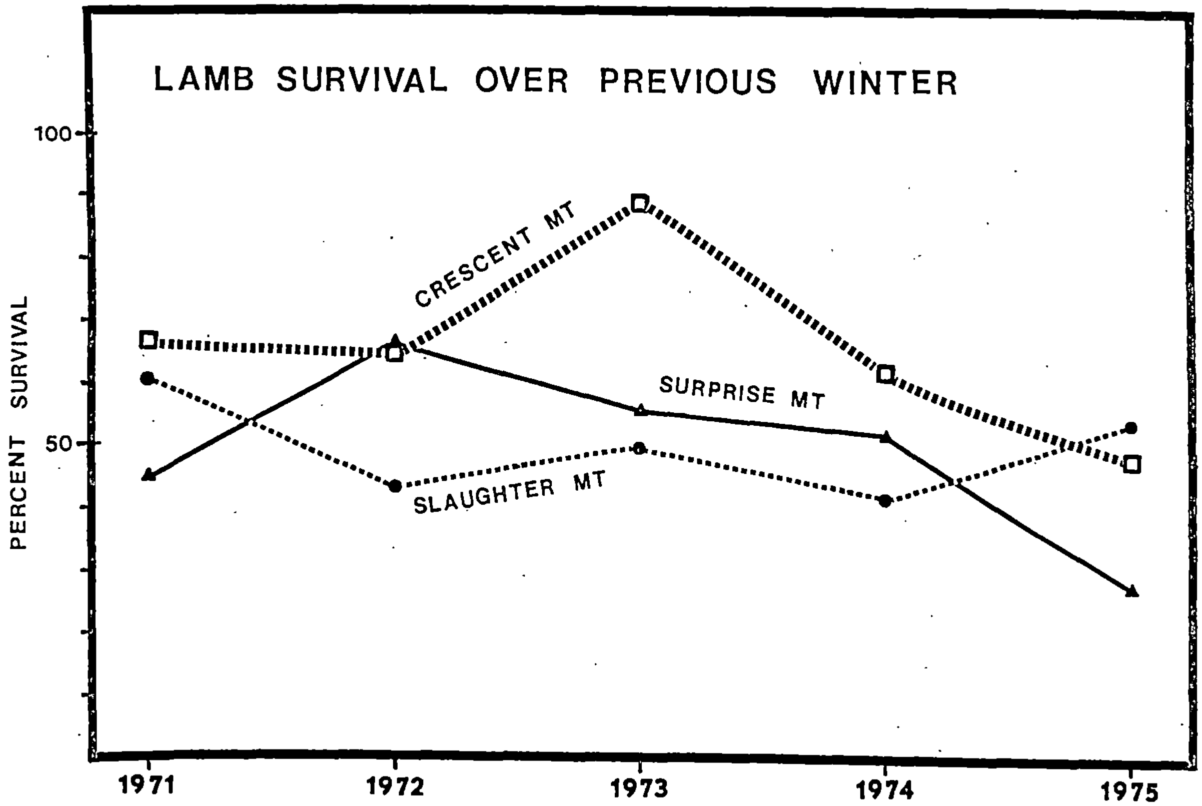

Fig. 6. Percent survival of lambs over the previous winter in three Dall sheep herds.

Overall herd survival over winter has been calculated from the total number of sheep counted in the summer compared with the total number of "non-lambs" observed the following summer. These figures, which take into account those animals removed by hunting, collection and emigration, are presented in Table 10. No significant nor suggestive differences could be demonstrated by statistical analyses either between herds or within herds before vs after treatment.

Table 10. Herd survival over previous winter.

Year		Percent Survival	
	Crescent Mountain	Surprise Mountain	Slaughter Mountain
1971	87	85	97
1972	90	89	82
$\bar{x}$ =	88.5	87.0	89.5
1973	95	84	88
1974	83	76	74
1975	78	75	87
$\bar{x}$ =	85.3	78.3	83.0

No significant differences between or within herds before or after treatment.

DISCUSSION

Before discussing the results of the study, itself, it might be valuable to summarize briefly the problems and benefits associated with reducing and maintaining the Crescent Mountain sheep herd at a given level. If the emigration of some 40 sheep had not occurred, the objectives of the control program would have been approximately met through controlled public hunting and scientific collecting. Sheep removed by the latter method could be considered for purposes of argument, as part of the "hunting harvest," since they could have been removed as well by hunters had that been the objective. Initial reduction and continuing control thus provided 124 sheep (including wounding loss) for "harvest" while Surprise Mountain under ram-only hunting, and Slaughter Mountain, largely protected, provided about 36 rams during the same period. In the meantime, large rams were protected on Crescent Mountain so that by 1974, about 14 full-curl rams were present and available as trophies. By now, more rams have undoubtedly reached that size, a size rarely attained in previous years under intensive ram-only hunting.

The experiment has brought to light several obvious problems. An imbalanced sex-ratio has resulted from not removing an adequate number of rams while ewe numbers were being reduced, was well as from the departure of a number of ewes from the area. The emigration, itself, reduced the herd by an unwanted amount, eliminating potential producers and their progeny, and necessitating several years of hunting closure to allow the herd to recover to the desired level of about 200 sheep.

It was found difficult to attain sufficient harvest without allowing too many hunters into the area for too long a period and thus forcing the emigration. A pressure-induced emigration was considered when the experiment began, but was discounted because of the isolated nature of the mountain. Having occurred under these conditions, such movements probably could be expected from even less hunting pressure in other habitats which are less restrictive to sheep movement. Management of either-sex hunts should thus be approached with this possibility in mind. Perhaps an extended season with less hunters allowed in an area at one time and with "rest" periods interspersed with hunting periods might reduce the psychological pressure on the animals while allowing the desired harvest to be attained.

The Crescent Mountain sheep herd did not appear to have any identifiable habitat advantage which would contribute to higher reproductive success or to survival compared with the other two herds under study. All had been increasing at approximately the same rate prior to 1968, and all three appeared to have reached a population peak at about the same time, suggesting similar environmental pressures. Weather conditions during the critical winter period were found relatively similar among the three areas with the exception that winds were higher in general on Crescent Mountain.

Snow conditions varied between areas with the snow in mid-winter averaging harder but shallower on Crescent Mountain than on the other mountains. The effect of snow depth and hardness on reproductive success and over-winter survival was not clearly demonstrated, but there does appear to be a relationship. A significant inverse correlation was found between snow depth and lamb production the following summer ($r = -0.986/2$ $P<.05*$) and between snow depth and lamb survival during the winter ($r = -0.982/2$ $P<.05*$). Murphy (1974) found a similar relationship between snow depth and lambing success in Mt. McKinley National Park. In his study, snow depth was measured at park headquarters, not in sheep range, and so reflected general winter conditions rather than those encountered specifically in sheep winter habitat.

Similar, but non-significant correlations were found between snow hardness and lamb production ($r = -0.765/2$) and lamb survival ($r = -0.767/2$). Strong, but non-significant correlations occurred between snow depth and mean maximum winter winds ($r = -0.991/1$), between snow hardness and mean winter temperature ($r = 0.984/1$), and between mean maximum winter winds and both lamb production ($r = 0.988/1$) and lamb survival ($r = 0.980/1$).

Thus, it would appear that colder, windier areas should have softer, shallower snow and consequently be more favorable for lamb production and survival. This may be even more apparent in Alaska's interior mountain ranges which are not as subject to maritime-induced temperature fluctuations in winter as are sheep habitats near the southern extremes of Dall sheep range such as in the Kenai Mountains. With the colder winter temperature, the snow is fluffier and the wind can remove it more easily. Also, the sheep can dig through it for forage. Warmer temperatures bring on thawing, refreezing and crusting, solidifying the snow pack.

On Crescent Mountain, the situation is not clear. Since it has shallower snow (as a consequence of higher winds), this should enhance lamb production and survival, but at the same time, it has harder snow than the other two areas which should serve to depress both lambing and survival. Data accumulation for a longer period may help clarify the relationships between winter weather, snow and herd response. With the information available, it cannot be shown that snow conditions on Crescent Mountain were more or less favorable than on Surprise or Slaughter Mountain.

Before the herd reduction took place, forage production on winter range was found to be significantly lower on Crescent Mountain than on the others. After the initial herd reduction took place, and after the range had time to show response, it was found that production of grasses and grasslike plants (which make up the bulk of Dall sheep diets) had actually increased on Crescent Mountain despite a general decrease in production of other forage plants on that mountain and a general decline of all forage production on both other mountains. This is assumed to have been a direct result of reduced grazing pressure on Crescent Mountain as a consequence of reducing the size of the herd.

A very rough approximation of grazing pressure and forage availability was obtained by estimating the area of winter range on each mountain, dividing that by the number of sheep on each mountain to obtain the amount of winter range per sheep, and then multiplying that figure by the kilograms of forage produced per hectare. In this case, only the class of grasses and grasslike plants (TOTGR in Table 4) was used since that contains the most important plants eaten by sheep. By using the pre-reduction herd size on Crescent Mountain (287 in 1970) and the 1971 herd sizes on Surprise and Slaughter Mountains (177 and 288 respectively), it was calculated that about 570 kg of TOTGR were available per sheep on Crescent Mountain, about 725 kg per sheep on Surprise Mountain, and about 1031 kg per sheep on Slaughter Mountain. By 1972, the Crescent Mountain herd had been reduced to 229 sheep while TOTGR had increased, so that about 964 kg were available per sheep. At the same time, the Surprise Mountain herd had increased to 201 sheep while the Slaughter Mountain herd had remained approximately the same, 282 animals. Forage production on both areas had decreased so that the amount of grasses and grass-likes per sheep had declined to 427 and 425 kg respectively. It is of interest that both the latter herds showed little reaction to the increased grazing pressure for one more year, then both declined sharply in numbers and reproductive success.

In overall topography appearance, winter ranges on both Crescent and Surprise Mountains give the impression of being less favorable to sheep than that on Slaughter Mountain. The Slaughter Mountain winter habitat consists of a series of cliffs and shoulders, broken by many small benches, most of which seem to be well vegetated. This habitat extends to a lower elevation than does acceptable habitat on the other areas, and sheep winter at a mean elevation of about 2000 ft. (610 m) or less. These cliffs face almost directly south, gaining maximum benefit from heat reflected by the surrounding cliffs; they become partially snow-free before adjacent areas.

On Surprise Mountain, part of the winter range is roughly similar to that on Slaughter Mountain, but the many small benches are generally absent from the cliffs, or are much smaller in size. Sheep spend more time in winter feeding on the upper, windblown ridgetops than among the lower cliffs. The overall aspect of the winter habitat is south through east. Mean elevation of sheep wintering habitat is about 2,500 ft (760 m). Crescent Mountain winter habitat faces generally southwesterly, and consists largely of steeply sloping ridges used for feeding, broken by cliffy canyons used for escape terrain rather than feeding. This habitat seems to depend on wind action to expose forage more than upon solar radiation. The sheep here winter at an average elevation of some 3,000 ft (914 m) or higher.

Thus, all data obtained to date, as well as general appearance, imply that sheep winter habitat is no less harsh on Crescent Mountain than on Surprise or Slaughter Mountains. In fact, the opposite may well be true: that winter habitat is less favorable to sheep on Crescent Mountain, particularly when compared with that on Slaughter Mountain. Therefore, favorable population responses in the Crescent Mountain herd can be related to the management method applied rather than to inherent habitat advantage. Reduced population size relieved grazing pressure and induced increasing production of important winter forage plants. This, in turn, stimulated reproductive success by a significant amount, and appears to have improved over-winter survival of lambs.

Although it is planned to continue the experiment for several more years to obtain data over a longer period and to assure observed trends, it appears at the present time that herd reduction and control through controlled either-sex harvest of Dall sheep is a beneficial management technique.

LITERATURE CITED

Murie, A. 1944. The wolves of Mount McKinley. U.S. Natl. Park Serv. Fauna Ser. 5. 238 pp.

Murphy, E. C. 1974. An age structure and reevaluation of the population dynamics of Dall sheep (*Ovis dalli dalli*). MS Thesis, Univ. of Alaska, College.

Nichols, L. 1970. Aerial inventory and classification of Dall sheep in Alaska. Trans. Northern Wild Sheep Council. B. C. Fish Wildl. Br. Publ.:25-33.

Pechanec, J. F. and G. D. Pickford. 1937. A weight estimate method for determination of range or pasture production. Agron. J., 29:894-904.

Pitzman, M. S. 1970. Birth behavior and lamb survival in mountain sheep in Alaska. MS Thesis, Univ. of Alaska, College.

DISCUSSION

QUESTION: Are there Dall sheep in the McKinley National Park and what has been done about the enlargement of the park?

REPLY BY NICHOLS: There are Dall sheep, plenty of them, in McKinley National Park. We have nothing to do with the Park itself. The Park has proposed a very large enlargement under the D-2 Native Lands Claim Act.

QUESTION: How did you establish your initial carrying capacity estimates on which to establish your harvest recommendations?

REPLY BY NICHOLS: It was fairly arbitrary as evidenced from the growth curves, all of these herds climbed and peaked out. We assumed that that was the carrying capacity of the range. We arbitrarily reduced that Crescent Mountain herd to a round figure of 200 animals which brought it down enough that we figured we would get some response from the herd. It did respond. It was an arbitrary number, but we wanted to reduce it enough to get some response rather than just fool around with it.

QUESTION: What was the public reaction to ewe harvest?

REPLY BY NICHOLS: We had some adverse reaction at first and a little antagonism. Nevertheless we had about 1,100 applications for the 60 or 70 permits, showing that there was considerable support for it. Once we explained the program and the reason for it, opposition dwindled and we had no opposition later on. I think we can show that it is an effective tool.

The people that go after ewes or that want to hunt ewes are mostly the meat hunters and the amateurs that want to go out and think they can get a sheep the easy way. The trophy hunters don't. They don't want to go out for an ewe. The hunt turns out to be just as sporting and probably a little more difficult in these mountains than going after rams. The success ratio for the ewe hunt was lower than the statewide ram-only success ratio, which is interesting. The ewes were just as hard to get as the rams. They live in the same area.

QUESTION: If I understand your previous answer, your carrying capacity was based on population figures. Are you doing any work determining range carrying capacities?

REPLY BY NICHOLS: Yes, but only by determining the forage quantity on the area over the two winters. By dividing the number of acres of sheep winter habitat into the pounds per acre we could come up with an average very rough figure of pounds of forage per sheep. But we haven't done it over enough years to really determine the carrying capacity; we've got a rough estimate and that's all.

QUESTION: In your bad winters, what causes the mortality?

REPLY BY NICHOLS: I was able to get a correlation in just a few years with snow depth and both lambing percentage and lamb mortality. I think probably it's snow hardness as much as depth.

QUESTION: How about the adult mortality?

REPLY BY NICHOLS: This doesn't seem to affect the adults nearly as much. The first mortality is lambs and old animals and then the yearlings get it the next year. In the bad years that we had on Pride's Mountain when we lost about 40% of the animals, we were able to collect a few that spring that had survived and none of the females were pregnant. They apparently either aborted or resorbed. However, all of the females that we collected throughout that winter on Crescent Mountain were pregnant. So, I assumed that we lose considerable lambs that way as well as at lambing season when the females are weak and the lambs are stillborn.

QUESTION: Have you seen a response in lamb growth from keeping the population down?

REPLY BY NICHOLS: We have no way to measure this without collecting some animals, but it is probably there.

I forgot to mention that between the first and second year of the range study, forage production fell off on all three areas because the second year was much drier than the first year. This happened except for the grasses and sedges on Crescent Mountain which increased statistically over the 2 years, following the reduction of sheep. Grasses and sedges are the main forage species used by sheep. So by reducing that herd we took the pressure off the winter range and forage did increase, which presumably enabled the sheep to reproduce successfully.

QUESTION: Were there any vegetational comparisons made between these ridge areas that are clear in the winter and some of the surrounding areas that are used under more favorable conditions?

REPLY BY NICHOLS: We did that and of course there was a significant difference between summer range and winter range as far as forage production. Summer range was much higher.

QUESTION: Do you have any estimate of sheep impact on the vegetation on these ridge areas?

REPLY BY NICHOLS: No, we haven't; we have to go over it for a number of years to determine that and we just did the 2 areas. Obviously there is considerable impact. Also there is a very strong climatic impact on the open ridges as winter winds, dessication, sand blast effect by snow and gravel really does in that vegetation on those open ridges once it dries out. Quality falls way off, as you would expect.

QUESTION: Should this land become national park, what options will you have, if any, in herd management?

REPLY BY NICHOLS: We in the state game departments will have no options. The national park is up in the interior, but this area is down on the Kenai portion and shouldn't be effected. The Park Service conducts no management within the park area and there would be no way to reduce the animals. Also we don't intend to do this type of management in all areas, as it is impractical. Some are just too remote and we couldn't get the hunting pressure to reduce the herds if we wanted to.

Transactions of the Second North American Wild Sheep Conference

Denver, Colorado
April 22-23, 1976

Edited by Eugene Decker

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Colorado State University, Fort Collins, Colorado 80523