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JUNEAU, ALASKA

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SHEEP REPORT

by
Lyman Nichols

and

SHEEP DISEASE REPORT

by
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and
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Volume XIV
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-4, Jobs 6.3R, 6.4R, 6.5R, 6.6R and 6.7R (2nd half) and
Project W-17-5, Jobs 6.3R, 6.4R, 6.5R, 6.6R and 6.7R (1st half)

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Lyman Nichols		
Project Nos.:	W-17-4 & W-17-5	Project Title:	Big Game Investigations
Job No.	6.3R	Job Title:	Dall Sheep Food Habits and Body Condition During Winter
Job No.:	6.4R	Job Title:	Productivity in Unhunted and Heavily Exploited Dall Sheep Populations
Job No.:	6.5R	Job Title:	Dall Sheep Population Trends and Composition on the Kenai Peninsula
Job No.:	6.7R	Job Title:	Dall Sheep Winter Range and Climate

Period Covered: January 1, 1972 to December 31, 1972

SUMMARY

A series of seasonal sheep pellet collections from each of the three herds under study was begun; analyses to determine diets have not been completed. Measurements to determine what snow conditions limit Dall sheep feeding ability were begun.

In October, 1972, 42 sheep on Surprise Mountain and nine in the Crescent Mountain were aerially marked with red dye. Dye markings were visible for up to four months. Early winter movements of marked rams were observed.

Lambing began prior to May 12, 1972 in the Cooper Landing Closed Area herd, and between May 12 and May 22 in the herds on Surprise and Crescent mountains. The apparent peak of lambing occurred about May 25-28 on the Closed Area and Surprise Mountain, and about 2-5 days later on Crescent Mountain. Lamb production increased from about 14 lambs:100 ewes to 38 lambs:100 ewes on Surprise Mountain between 1970 and 1972, and from 23 lambs:100 ewes to 45 lambs:100 ewes in the Closed Area during the same period. In 1972, 34 lambs:100 ewes were observed on Crescent Mountain.

Lamb mortality during the first winter dropped from 50 percent to 33 percent during the three-year period on Surprise Mountain, but remained

fairly stable at about 45 percent in the Closed Area. No data are available for the Crescent Mountain herd.

Aerial counts indicate approximately stable populations on the three areas during the study period. Observed total populations on each of the areas after lambing in 1972 were: 229 on Crescent Mountain, 201 on Surprise Mountain, and 282 in the Cooper Landing Closed Area. Population models were constructed to show the sex and age composition of each herd.

Forage production was sampled in the late summer of 1972 on both winter and summer feeding sites in each area. Production was significantly higher on summer than on winter feeding sites. Total production on winter feeding sites was highest on Slaughter Mountain and lowest on Crescent Mountain, and was significantly lower in 1972 than in 1971. However, production of grasses on Crescent Mountain was higher in 1972 than in 1971, possibly reflecting the reduced sheep population on that mountain.

Analyses of summer-collected samples of major forage species for content of nitrogen, total available carbohydrate and gross energy were undertaken.

Sheep were found to be using the rootstocks of the false hellebore plant (*Veratrum* spp.) in certain locations. Samples of this species were analyzed and the literature examined concerning its poisonous effects on domestic sheep.

Self-contained weather stations in each of the three study areas showed that in 1972 Crescent Mountain was the windiest and coldest, while Slaughter Mountain was the warmest and least windy. Average annual winds on Crescent, Surprise and Slaughter mountains were 16.9, 13.4 and 9.6 m.p.h., respectively, while average annual temperatures were 25.8, 27.6 and 29.4 degrees F.

Measurements made in early 1972 showed snow conditions to be significantly different on all three areas. The snow was deepest but softest on Slaughter Mountain and shallowest but hardest on Crescent Mountain. In early 1973, the same relationship applied except there was no significant difference in depth between Surprise and Slaughter mountains. Between 1972 and 1973, there was no significant difference in depth on any area, but on Surprise and Crescent mountains, the snow was significantly harder in early 1973.

CONTENTS

BACKGROUND

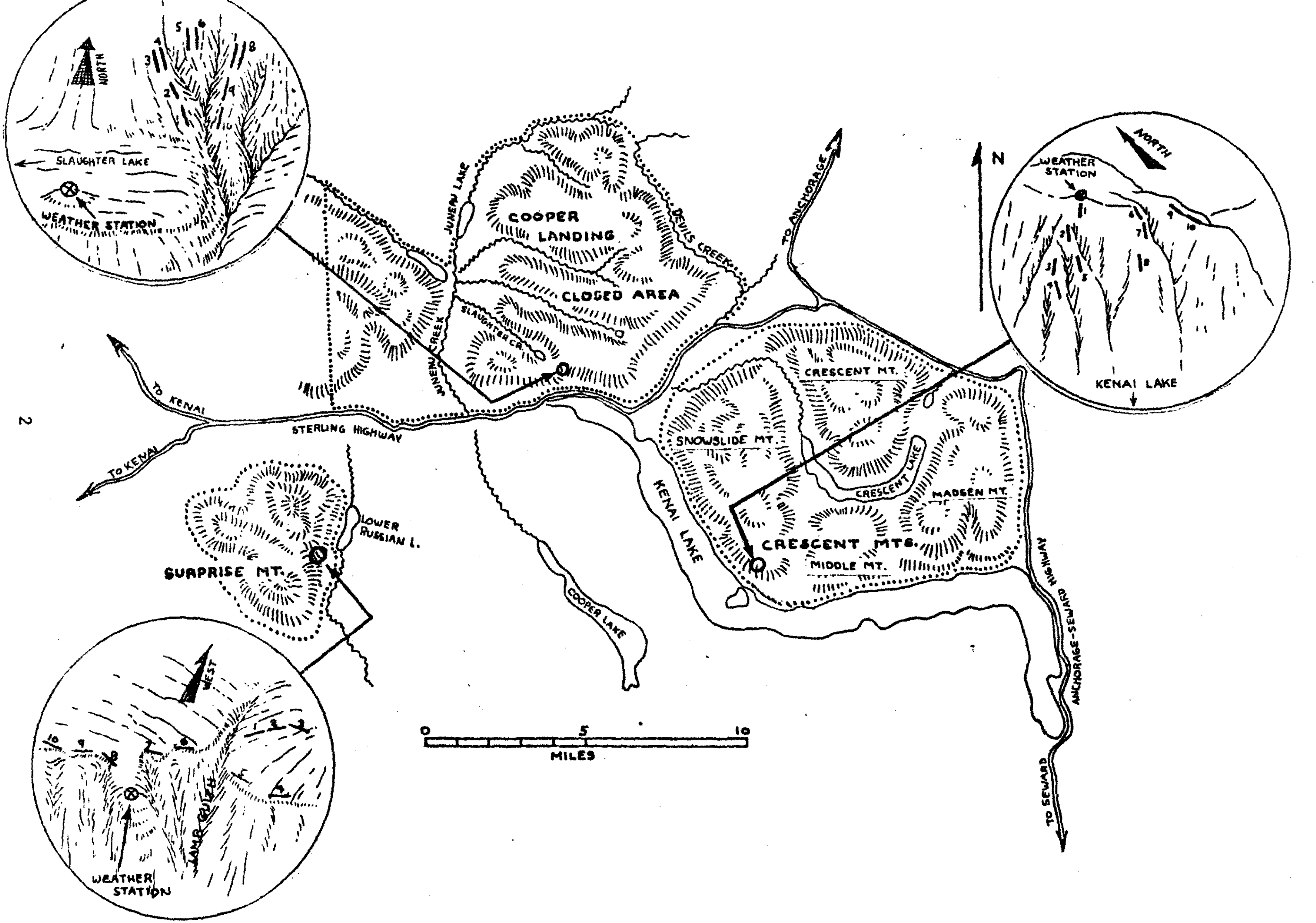
The Dall sheep (*Ovis dalli*) in Alaska has been managed traditionally for the harvest of mature rams only. Such harvest has not controlled herd growth and sheep numbers have increased or declined due to natural causes alone. Populations have apparently been increasing during the past decade or longer and, in some areas, may be approaching their maximum safe level.

One herd on Surprise Mountain on the Kenai Peninsula is known to have declined by about 20 percent because of a harsh winter in 1969-70. Similar or more serious declines may face this and other populations which have been allowed to reach overabundance through lack of control.

The main objective of this study, in addition to obtaining basic life history data, is to determine whether such natural declines can be reduced by maintaining sheep populations at a level below the carrying capacity of their winter range through either-sex hunting. The secondary objective is to learn whether intensive hunting for 3/4-curl and larger rams has a detrimental effect on reproduction or survival. Three herds on the Kenai Peninsula were chosen for study: the Crescent Mountain herd, the Surprise Mountain herd and the Cooper Landing Closed Area herd (see Fig. 1). These herds are near each other but appear to be isolated because of topographical features; no significant movement is known to occur between them. The habitats seemed initially to be similar, but subsequent investigation has shown significant differences. These herds had been increasing at approximately the same rate prior to the winter of 1969-70 when that on Surprise Mountain declined as stated previously.

Both the Surprise and Crescent mountain herds are readily accessible to hunters from nearby highways. Both have been hunted heavily during past years with almost every ram being harvested as soon as its horns reached the legal status of 3/4-curl. The Cooper Landing Closed Area is,

Figure 1. Sheep study areas, Kenai Peninsula, Alaska, showing weather station and range stand locations.



as its name implies, closed to sheep hunting. The herd within its boundaries has been, for practical purposes, unhunted.

The study called for the reduction of the Crescent Mountain herd by some 30 percent during the first year, with maintenance at this lowered level for at least four more years. This reduction was accomplished through a public either-sex hunt in August, 1970 and a collecting program during the winter of 1970-71. Poor lambing success in the springs of 1971 and 1972, combined with natural mortality, have served to hold the herd at this level through 1972. The Surprise Mountain herd will be hunted for rams only, as it has been, and the Cooper Landing herd will remain protected. Production and survival of young, herd size and herd response to winter stress are being monitored on the three areas. A comparative study of winter range trend and climate on the three areas is underway. Thus, the effects of either-sex hunting and consequent herd control will be compared with those of ram-only hunting and complete protection.

OBJECTIVES

To determine the forage plants eaten by Dall sheep, their feeding habits and changes in their body condition throughout the winter.

To compare the various factors relating to reproduction in Dall sheep, including: body condition, chronology of breeding and parturition, minimum breeding age, pregnancy rate, prenatal sex ratio, fetal growth rate, rutting behavior and differences in rutting behavior between a population which is relatively unhunted and one which is heavily exploited.

To determine the population compositions and trends on Crescent Mountain, Surprise Mountain and Cooper Landing Closed Area, Kenai Peninsula.

To compare Dall sheep winter range composition, trend and availability and gross winter climate on Crescent Mountain, Cooper Landing Closed Area and Surprise Mountain, Kenai Peninsula.

PROCEDURES

Winter Food Habits and Body Condition

A series of collections of sheep fecal pellets was begun on each of the three study areas. Two pellets from each of up to 50 fresh pellet groups were obtained during the summer (July and August, 1972), during midwinter (January and February, 1973) and during late winter (April, 1973). These were dried and submitted to Dr. Richard Hansen of Colorado State University for microanalysis to determine herd diet by season and area.

A series of snow depth and hardness measurements was begun adjacent to sheep feeding craters in an effort to learn what snow conditions limit digging, and hence feeding ability. Snow depth in inches was determined by using a marked probe. Hardness measurements utilized a Chatillon "push-pull" scale with a capacity to 40 pounds, a rod with a 1.0 cm^2 tip and another rod with a 0.5 cm^2 tip. Hardness of the snow was indicated by the force required to push the rod through snow layers to the surface of the ground, and was recorded in pounds-per-cm^2. Measurements were made within six inches of the edge of a number of craters in undisturbed snow. Depth and hardness measurments were made in pairs approximately one foot apart around each crater's edge. The number of measurements depended upon the size of the crater. When writing was impractical due to the cold, data were listed on appropriate forms or recorded in a portable tape recorder for later transcription.

Productivity

As an aid in identifying individual sheep during the breeding behavior study, a number were dye-marked in late October, 1972, by the method described by Simmons (1971). A Piper PA-18-150 Supercub airplane with a modified Sorensen belly tank was used to drop a dye-water mixture on sheep from low altitude. The red dye (Calcocid Scarlet 2RIL - American Cyanamid Co.) was mixed at a rate of 5 pounds per 20 gallons of water; approximately 20 gallons were carried per plane load. With the tank loaded, sheep were located in a suitable area, then herded by air into as compact a group as they would form. The load of dye was then dropped, all at once, during a low pass by means of the quick-release outlet.

The planned continuation of the rutting behavior study on Surprise Mountain was not conducted during this segment due to illness of the principal investigator.

A series of replicate aerial counts was conducted from May 12 to June 18, 1972 on the three study areas to determine chronology of lambing. These counts were flown in the same manner as described in the previous progress report (Nichols and Heimer, 1972), with all sheep seen classified as "adults" (nonlambs) or "lambs" (new lambs). Data were later converted to lambs per 100 adults to enable lambing chronology to be compared between areas.

Population Trends

Aerial classification counts of sheep herds on Surprise Mountain, Crescent Mountain and Cooper Landing Closed Area were conducted as previously described (Nichols, 1970; Nichols and Heimer, 1972). A Piper PA-18-150 airplane was used for all surveys. Population models were constructed mathematically from the count data.

Winter Range and Climate

A contract was again let to Dr. R. M. Hansen, Department of Range Science, Colorado State University, to conduct a survey of sheep winter range on the three areas to obtain information on annual variation in forage production. This survey was conducted on the same sites and in the same manner as that done during the summer of 1971. The method has been described previously (Nichols and Heimer, 1972).

Forage production by plant species was also estimated for summer range sites on the three areas by the same method.

Survey data were then analyzed by computer at Colorado State University and the results sent to me for statistical comparison.

Samples of forage plants which had been previously determined to be important in the diet of sheep were collected from winter range sites at the peak of the growing season. These were analyzed under another contract with Dr. Hansen for their content of nitrogen, total available carbohydrates and gross energy. Samples of false hellebore (*Veratrum* spp.) which were being utilized by sheep at "pseudo-mineral licks", were also analyzed for chemical content.

The three self-contained weather stations installed under the previous segment were maintained. Recorded data on wind direction, velocity and temperature were reduced from the instrument charts to a usable form on a piecework basis by nonemployee technicians. Climatological data were then examined and compared by area and season.

Snow surveys were conducted on sheep winter range on each area during the winters of 1971-72 and 1972-73. Five transects were established on each area with 10 plots per transect. One depth and four hardness measurements were made at each plot by the previously-described method. Hardness was measured to a maximum of 18 inches. Data were examined and compared statistically between areas and years.

FINDINGS

<u>Winter Food Habits and Body Condition</u>

Although pellet collections by season and area were begun during this segment, analyses to determine herd diet have not been completed. Therefore, no results are available at this time.

The ability of sheep to obtain forage during winter depends upon snow cover and conditions. Where the wind or thawing temperature expose vegetation, sheep can graze directly upon it. During much of the winter, however, they are able to dig through soft or shallow snow cover to reach buried forage. As long as they are able to do so, these animals appear to prefer digging for their feed rather than feeding exclusively on exposed plants. This is probably because snow-covered vegetation remains more succulent than that on exposed sites which is subject to the desiccating effects of wind and cold.

In digging for forage under the snow, Dall sheep typically paw out feeding craters with their front feet. These craters average about two to three feet in diameter. Each animal generally paws its own crater, feeds in it a while, then moves on to dig another. This feeding behavior forms the characteristic spiderweb patterns of craters and interconnected trails which are readily visible on snow-covered mountainsides.

The ability of sheep to dig through snow to buried forage is dependent upon a combination of snow depth and hardness. These, in turn, are dependent upon snowfall, temperature and wind. Precipitation deposits the initial cover and directly affects the initial depth. Wind then removes snow from exposed areas and deposits it in more protected sites such as gully bottoms or behind ridges or bushes. Wind may be more important in regulating snow depth on a given site than is original precipitation.

Temperatures below freezing allow the snow to remain soft and powdery. Not only does this make the digging easier, but it also allows the wind to move it. Thawing temperatures melt upper snow layers which later freeze into crusts of varying hardness. Once the snow is crusted, wind effects are much reduced and the layer may remain in place all winter. Wind appears to harden crusts by further packing action. Snow cover is usually made up of alternating layers of hard and soft snow which show considerable variation from site to site depending on the surface wind and exposure pattern.

As long as the snow is shallow and soft enough, sheep are able to paw through it to feed. But beyond some point of depth or hardness, or a combination of the two, they are unable or unwilling to dig. Snow depth and hardness, therefore, control in part the amount of winter forage available to sheep. Where snow is too deep or hard, they are restricted to the relatively small area and poor forage available on exposed, windblown ridges. Soft and shallow snow expands the size and probably the quality of their winter range. These factors undoubtedly play an important part in influencing the animals' physical condition and their ability to withstand winter conditions.

Table 1 lists the mean depth and hardness obtained at each crater measured to date. The method of measurement used proved both simple and fast despite the difficulties imposed by wind and cold. Digging ability depends upon a combination of depth and hardness as well as upon each factor independently. A sheep can probably dig through hard snow that is shallow more easily than through equally hard snow that is deeper. Therefore, the sum and product of each mean depth and hardness pair, and the product of the depth and hardness squared are also listed in Table 1 for future use in determining, if possible, the relationship of the two parameters to digging ability.

No conclusions can be drawn at this time regarding specific snow conditions and digging ability. Many more measurements around feeding craters under varied snow conditions are needed before analysis can be undertaken.

Productivity

During the breeding behavior study in 1971, it was difficult to follow the behavior of individual animals in the shifting groups of

Table 1. Random snow measurements within six inches of sheep feeding craters.

Area	Date	$\bar{x}D$ [1/]	$\bar{x}H$ [2/]	$\bar{x}D + \bar{x}H$	$(\bar{x}D)(\bar{x}H)$	$(\bar{x}D)(\bar{x}H^2)$	$(\bar{x}D)^2(\bar{x}H)$
Surprise Mt.	11/30/71	3.8	4.3	8.1	16.3	70.3	62.1
		5.3	8.8	14.1	46.6	410.4	247.2
	2/4/73	4.8	7.0	11.8	33.6	235.2	161.3
		4.6	9.2	13.8	42.3	389.3	194.7
		4.0	10.0	14.0	40.0	400.0	160.0
		3.8	9.8	13.6	37.2	364.9	141.5
		4.8	7.0	11.8	33.6	235.2	161.3
		4.6	9.6	14.2	44.2	423.9	203.1
	2/17/73	2.7	11.5	14.2	31.1	357.1	83.8
		2.8	7.0	9.8	19.6	137.2	54.9
		4.0	5.2	9.2	20.8	108.2	83.2
		5.0	4.0	9.0	20.0	80.0	100.0
		2.4	3.4	5.8	8.2	27.7	19.6
		3.0	3.0	6.0	9.0	27.0	27.0
		3.4	3.4	6.8	11.6	39.3	39.3
		5.8	6.2	12.0	36.0	223.0	208.6
		2.8	7.6	10.4	21.3	161.7	59.6
		2.2	7.0	9.2	15.4	107.8	33.9
		2.2	5.4	7.6	11.9	64.2	26.1
		3.4	7.8	11.2	26.5	206.9	90.2
		4.8	6.5	11.3	31.2	202.8	149.8
		3.4	4.4	7.8	15.0	65.8	50.9
		4.4	2.0	6.4	8.8	17.6	38.7
		3.0	12.8	15.8	38.4	491.5	115.2
		3.8	6.0	9.8	22.8	136.8	86.6
		5.8	6.6	12.4	38.3	252.6	222.0
		6.0	4.6	10.6	27.6	127.0	165.6
	2/22/73	5.0	6.8	11.8	34.2	231.2	170.0
		4.0	11.0	15.0	44.0	484.0	176.0
		4.8	10.8	15.6	51.8	559.9	248.8
		4.3	12.0	16.3	51.6	619.2	221.9
		4.8	4.4	9.2	21.1	92.9	101.4
		2.6	4.8	7.4	12.5	59.9	32.4

1/ $\bar{x}D$ = average depth in inches.
2/ $\bar{x}H$ = average hardness in pounds per cm^2.

sheep. The pairing bond between ewes in estrous and rams was of particular interest but was difficult to ascertain without marked animals. Therefore, it was decided to dye-mark a number of sheep on Surprise Mountain prior to the rut to make it possible to recognize individuals by the pattern of dye on their coats.

During two days of flying on October 27 and 30, 1972, I was able to mark approximately 42 sheep by dropping a water-dye mixture on them from the air. Some problems were encountered with the release mechanism on the dye tank at first, but the method generally worked well. The cost, exclusive of practice and including aircraft rental and dye, amounted to approximately $5.23 per sheep marked. The red dye marked animals with various shades of red from almost completely scarlet to small pink splotches. Most appeared to have acquired distinctive patterns which would have made them recognizable during the study.

No segregation of the dyed sheep was observed either right after marking or at later dates. Dyed animals were frequently seen throughout the winter feeding and traveling in the close company of unmarked sheep. There appeared to be no adverse social or physical effects of the marking. During winter, the dye gradually faded. Pink sheep were seen during February and early March, but not in late March or thereafter. Thus, the dye lasted on some of the animals for approximately four months.

Unfortunately, a protracted illness prevented me from carrying out the breeding behavior study on Surprise Mountain as planned.

In addition to those marked on Surprise Mountain, nine rams were dyed on Snowslide Mountain in the Crescent Mountains complex (see Fig. 1). The same dye and method were used. The purpose in dying these animals was to make it possible to observe ram dispersion between the four main mountains of the complex during winter. Marking was accomplished on October 30, 1973 before the rut, which influences ram movement, and before snow accumulated to sufficient depth to prevent movement through the intermediate valleys.

All nine rams were accounted for during flights made later in the winter. On December 19, 1972, five were seen scattered among the 54 sheep counted on Snowslide Mountain. On the same date, three others were seen among the 25 sheep which were found on Middle Mountain. Madsen Mountain was not flown until January 15, 1973, at which time, one red ram was observed there with 30 other sheep. By the time these flights were made, the intervening valleys were covered with snow too deep for sheep movement and I believe that no intermountain movement occurred for the remainder of the winter. No marked animals were found among the 73 sheep counted on Crescent Mountain on Janaury 23, 1973, and it is not known whether there is any interchange between the herd here and those on the other three mountains of the complex.

Results of the lambing progression counts conducted in the spring of 1972 are listed in Table 2. The irregularity of these aerial counts resulted from variations in flying weather between areas and dates. The ratios of lambs per 100 "adults" (nonlambs) by area and date are plotted

Table 2. Aerial lambing progression counts, 1972.

Area	Date	"Adults"*	New Lambs	Lambs per 100 "Adults"
Surprise Mt.	5/12/72	154	0	0.0
	5/22/72	144	10	6.9
	5/27/72	148	29	19.6
	5/30/72	161	38	23.6
	6/3/72	126	33	26.2
	6/5/72	161	45	28.0
	6/9/72	143	37	25.9
	6/13/72	156	45	28.8
	6/18/72	152	45	29.6
Crescent Mt.	5/13/72	166	0	0.0
	5/22/72	167	2	1.2
	5/27/72	164	6	3.7
	5/30/72	193	16	8.3
	6/6/72	190	17	8.9
	6/13/72	194	30	15.5
	6/18/72	200	30	15.0
Cooper Landing Closed Area	5/12/72	184	9	4.9
	5/14/72	184	10	5.4
	5/26/72	201	31	15.4
	5/30/72	201	43	21.4
	6/5/72	215	42	19.5
	6/9/72	225	43	19.1
	6/12/72	226	45	19.9
	6/15/72	223	45	20.2
	6/18/72	248	49	19.8

* "Adults" includes all nonlambs.

in Fig. 2. Since complete classification by sex and age class was not accomplished during each of these flights, progressive lamb/ewe ratios could not be plotted. The lamb/adult ratios are sufficient to indicate chronological progression of lambing but not necessarily magnitude of lambing which can be shown meaningfully only by the ratio of lambs to ewes.

The lambing progression curves were then fitted by eye with smooth curves which, in turn, were converted to rate-of-increase curves. These are illustrated in Fig. 3, and make it possible to more readily visualize the chronology of lambing on each area.

The first flight was made on May 12, 1972. Lambing had already commenced in the closed area at that time, and nine new lambs were seen. None were observed on Surprise Mountain on that date, nor on Crescent Mountain the following day. By May 22, lambing was underway on Surprise Mountain with 10 lambs counted, but had barely started on Crescent Mountain where only two were seen. Thus, lambing began sometime prior to May 12 in the closed area herd, sometime after May 12 but before May 22 in the Surprise Mountain herd, and sometime just before May 22 in the Crescent Mountain herd.

Fig. 3 shows that the peak of lambing occurred at approximately the same time (May 25-28) on both the closed area and Surprise Mountain, but not until May 30-June 1 on Crescent Mountain. This apparent two- to five-day delay on Crescent Mountain may have been a true delay in lambing rate of increase, or may have been the result of a harsher climate having removed a larger proportion of early lambs, thus skewing the observed chronology. A snow storm hit all areas on June 1 and 2. Although weather data are scanty on Crescent and Slaughter (in the closed area) mountains because of instrument breakdown during May, a drop in mean daily temperature and an increase in mean and maximum daily wind velocity were recorded during this storm. The effects were stronger on Snowslide Mountain (location of the weather station in the Crescent Mountains complex), with the average daily temperature dropping below freezing and remaining there for three days and the mean and maximum daily winds reaching 40 and 50 m.p.h., respectively. At the same time, the mean daily temperature dropped barely below freezing for one day only on Surprise Mountain where mean and maximum daily wind velocities reached only 15 and 20 m.p.h., respectively. On Slaughter Mountain, the temperature remained well above freezing and the wind did not exceed 20 m.p.h.

The effects of this storm are probably responsible for the dip in the lambing progression curve on Crescent Mountains (Fig. 2) as well as the delay of the apparent timing of the peak in lambing. Loss of newly-born lambs during this storm may well have been responsible for the reduced ratio of lambs to ewes in this herd after completion of lambing.

In Fig. 4, lambing progression curves are illustrated for each of the three main subherds within the Crescent Mountains unit. The Middle Mountain herd contained only 8-10 sheep and is not included. Madsen Mountain is the most exposed to storms originating to the east and southeast in Prince William Sound, and appears to receive considerably heavier

Figure 2. Lambing progression by observed lambs per 100 "adults" and date, 1972.

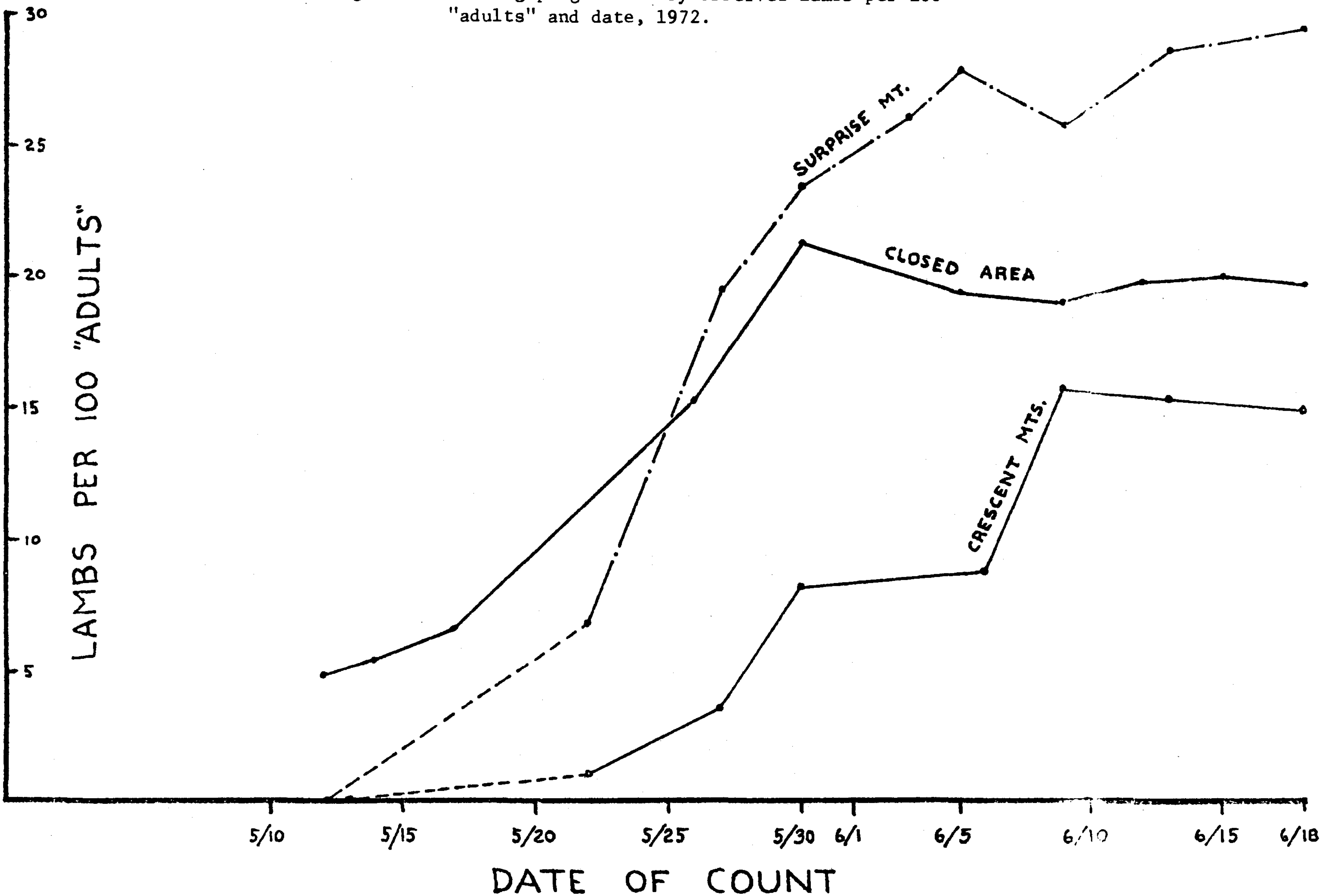


Figure 3. Estimated lambing progression by rate of increase in lambs per 100 "adults" in 1972. (from fitted curve)

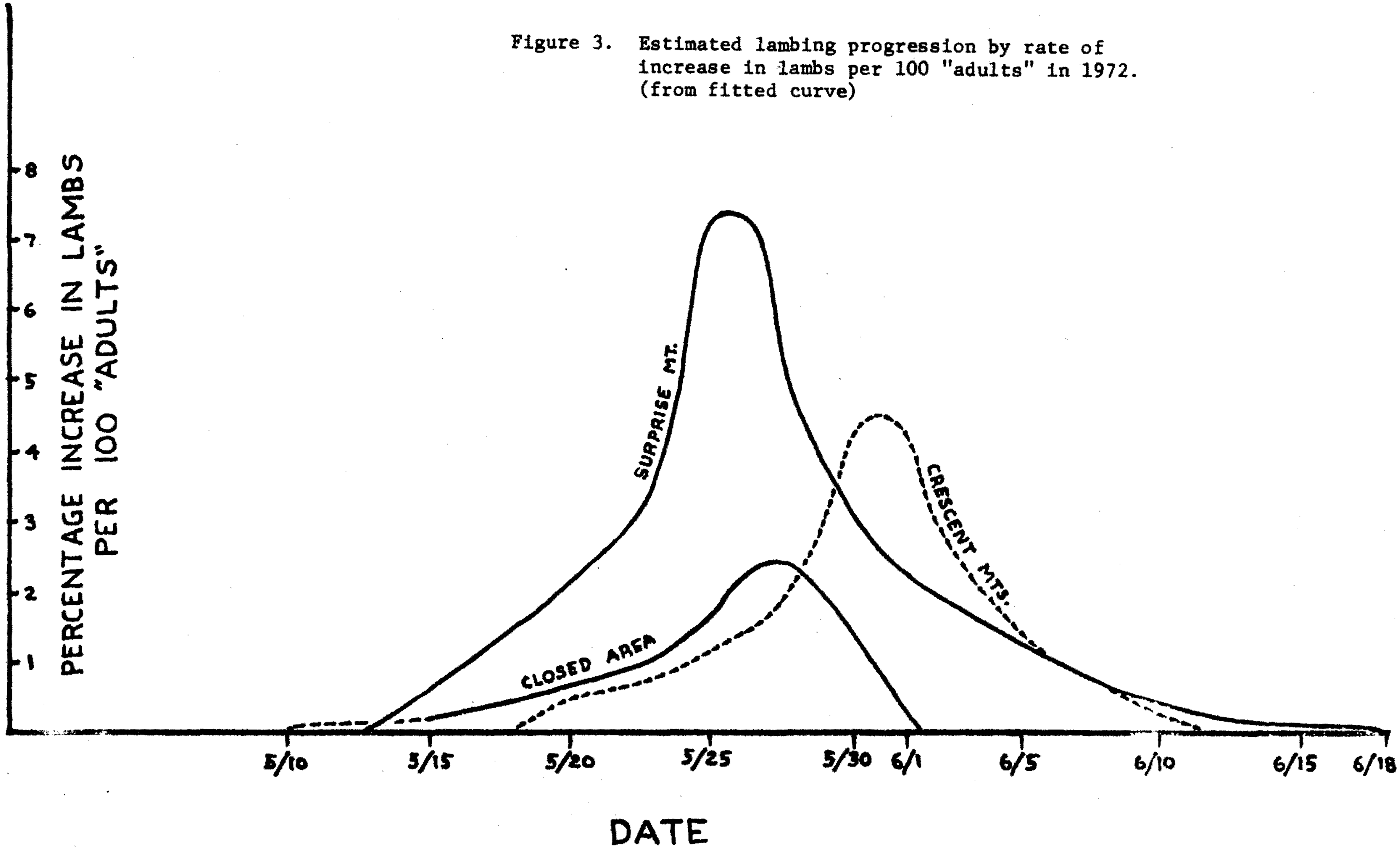
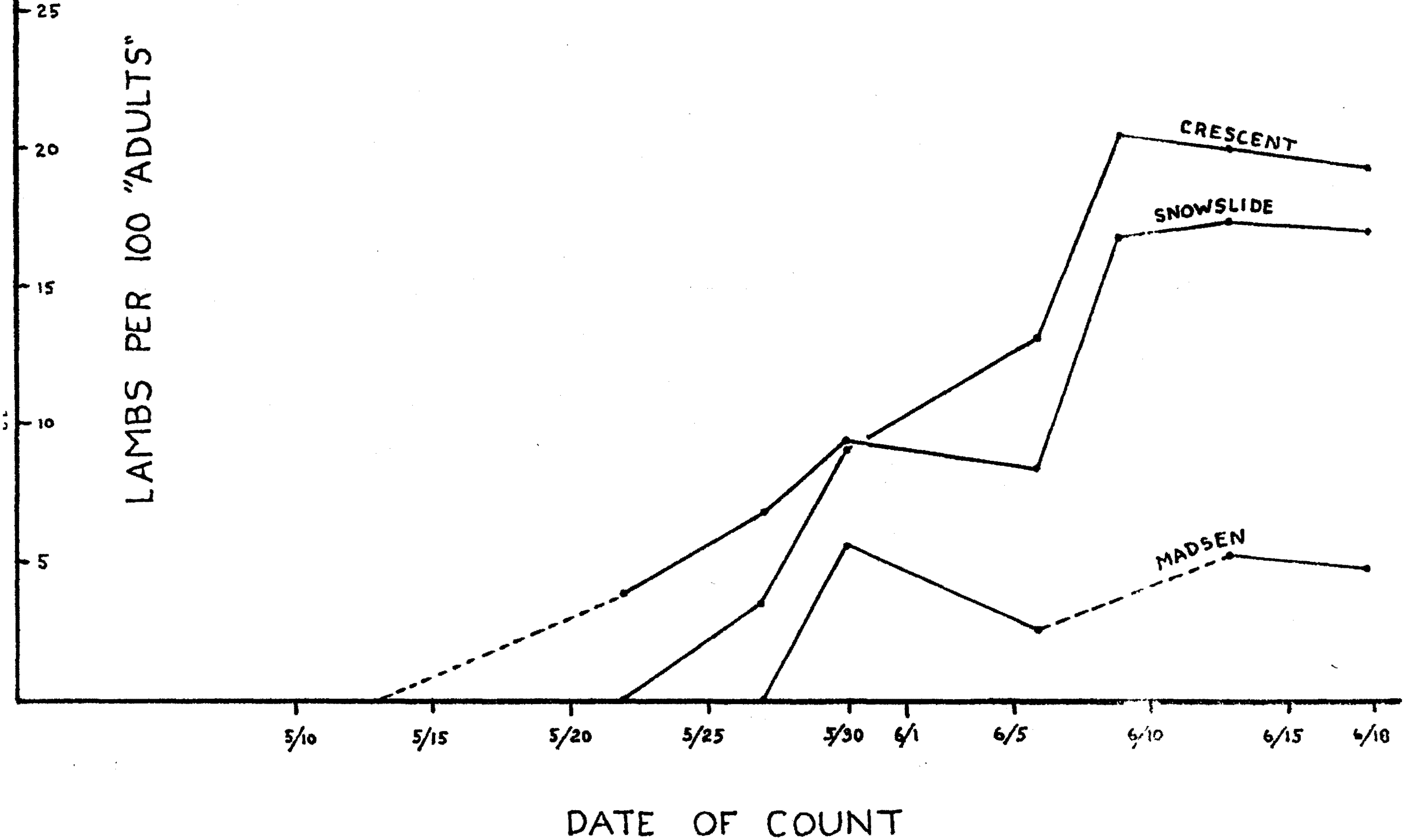


Figure 4. Lambing progression by observed lambs per 100 "adults" and date, 1972, Crescent Mountain Complex, only.



precipitation than the other mountains. Snowslide Mountain is intermediate in exposure while Crescent Mountain is the least exposed. Lambing progression appears to reflect this exposure to the early June snowstorm and probably the general differences in winter severity as well.

Population Trends

Listed in Table 3 are the dates and results of the various aerial surveys conducted during 1972 and early 1973. Bad weather, distance and other duties again prevented completion of planned ram classification surveys in the winter of 1971-72.

Population models, based on data from the several counts of each herd, were constructed as previously described (Nichols, 1970) and are shown in Table 4. Examination of Table 4 shows that the nonlamb portion of the Crescent Mountain herd, following the initial reduction by hunting and collection during the fall and winter of 1970-71, showed a net loss of less than seven percent from 1971 to 1972. That on Surprise Mountain decreased less than 6 percent from 1970 to 1971, then remained the same until 1972. The herd in Cooper Landing Closed Area gained slightly over 8 percent from 1970 to 1971, then lost less than 3 percent from 1971 to 1972. Considering possible errors in counting, these small fluctuations probably indicate that the three herds were more or less stable during the period under study.

Lamb production on Surprise Mountain more than doubled during the three-year period, and in the closed area almost doubled. Mortality of lambs over their first winter was approximately 50 percent on Surprise Mountain between 1970 and 1971, and 33 percent between 1971 and 1972. In the closed area herd, mortality was 43 percent and 47 percent, respectively, over the two winters. Lamb production and survival cannot be compared prior to 1972 on Crescent Mountains due to lack of data.

In the summer of 1972, lamb production was greatest in the closed area, intermediate on Surprise Mountain and lowest on Crescent Mountains.

The ratio of rams to ewes is highest in the closed area, a bit lower on Crescent Mountains, and considerably lower on Surprise Mountain. These ratios are related to the three types of management involved; complete protection in Cooper Landing Closed Area, no hunting of adult rams since 1969 on Crescent Mountains, and intensive harvest of adult rams each year on Surprise Mountain.

Winter Range and Climate

Dr. Richard Hansen and his team of graduate students conducted range surveys on the three study areas in late July and early August, 1972 at the height of the growing season when forage production was presumably at its peak. Winter range sites (those sites previously determined to be used by sheep in winter) were sampled in the same manner as in 1971, utilizing the same 10 transects on each area (Nichols and Heimer, 1972). Each transect again contained 100 plots.

Table 3. Results of aerial sheep classification surveys, 1972-73.

Area	Date	Young Rams	Legal Rams	All Rams	Ewes plus Yrlgs.[1]	Ewes	Yrlgs.[2]	Lambs[3]	Total
Crescent Mt.	4/5/72	-	-	60	89	79	10	-	149
	6/13/72	-	-	-	-	-	-	30	224
	9/13/72	31	26	75	119	-	-	35	229
	12/19/72 } 1/15-23/73 }	43	18	61	-	95	29	-	185
Surprise Mt.	4/7/72	-	-	22	118	105	13	-	140
	6/13/72	-	-	-	-	-	-	45	201
	8/3/72	-	-	24	129	-	-	40	193
	9/22/72	-	-	-	-	-	-	-	163
	3/16/73	11	12	23	-	115	25	-	163
Cooper Landing Closed Area	6/18/72	-	-	94	134	112	22	50	282
	9/13/72	-	-	66	154	-	-	42	262
	3/4/73	31	21	52	-	119	27	-	198

1/ This cagetory may include young rams mis-identified as "ewes" and is the main source of error in aerial classifications.

2/ "Yearlings" is used to distinguish lambs of the previous summer from new lambs.

3/ "Lambs" includes those born in the summer of the survey year.

Table 4. Computed population models and ratios, 1970-72.

Area	Date	Rams	Ewes	Yearlings	Lambs	Nonlambs	Total
Crescent Mt.	7/70	-	-	-	44	243	287[1/]
	6/71	-	-	-	20	208	228
	6/72	78	103	13	35	194	229
		76:100 ff		13:100 ff	34:100 ff		
Surprise Mt.	7/70	19	141	5	20	165	185
		13:100 ff		4:100 ff	14:100 ff		
	8/71	27	120	9	21	156	177
		23:100 ff		7:100 ff	18:100 ff		
	6/72	25	117	14	45	156	201
		21:100 ff		12:100 ff	38:100 ff		
Cooper Landing Closed Area	8/70	78	121	21	28	220	248[2/]
		64:100 ff		17:100 ff	23:100 ff		
	6/71	88	133	17	50	238	288
		66:100 ff		13:100 ff	38:100 ff		
	6/72	94	112	22	50	232	282
		84:100 ff		20:100 ff	45:100 ff		

1/ Observed data; computed models not available for Crescent Mt. in 1970 or 1971.

2/ Includes only closed area. Previous model (Nichols and Heimer, 1972) included those counted on Gilpatrick Mt. outside the closed area.

Although not called for in the contract, Dr. Hansen also sampled sites being utilized by sheep in the summer on each area. These sites were chosen after observations indicated where sheep were feeding at this season. The summer range sites appeared to have been protected by snow during the winter and were generally on better soil than the rocky, wind-scoured winter range sites. Sampling consisted of 400 0.01 m^2 plots on each mountain.

The computer printout, showing complete results of the forage production surveys on both winter and summer sites, is included as Appendix 1. To save space, computer symbols for plant species and categories will generally be used in the following discussions rather than complete species names. A list of these species symbols is attached as Appendix 2. The symbol TOTGR indicates production of all grasses and grasslike species; TOTFB indicates production of all forbs and browse; TOTHB means total herbaceous production including all grasses, forbs and browse.

Tables 5 and 6 summarize forage production of major plant species on each area and site and list them by rank. Of the grasses and grasslikes, CAREX (*Carex* spp.), FEAL (*Festuca altaica*), and HIAL (*Hierochloe alpina*) are the top three species in production on each area on winter range sites. CAREX and FEAL are also in the three top-ranking producers on all summer feeding sites, but HIAL is replaced by the rushes LUSP (*Luzula* spp.) and JUSP (*Juncus* spp.).

Table 7 summarizes the mean annual forage production by forage classes and compares production between summer and winter sites on each study area. It can be seen that in all cases, production was significantly higher on the summer sites.

Table 8 shows results of the analysis of variance in comparing mean annual forage production by forage classes between areas on both winter and summer feeding sites as measured in the summer of 1972. Production of TOTGR on winter sites was not significantly different between Surprise and Crescent mountains (to be specific, on Snowslide Mountain within the Crescent Mountains complex) or between Crescent and Slaughter mountains, but was significantly less on Surprise Mountain than on Slaughter Mountain. Production of TOTFB and TOTHB was highest on Slaughter Mountain and lowest on Crescent Mountains, with significant differences between all three areas.

On the summer feeding sites, production of TOTGR was not significantly different between Crescent and Slaughter mountains, but was significantly lower on Surprise Mountain than on either of the other two. Surprisingly, production of TOTFB and TOTHB was higher on Surprise Mountain than on Slaughter Mountain and lowest on Crescent Mountains, with significant differences between all areas.

In Table 9, forage production by forage classes and by area is compared between 1971 and 1972 on the winter feeding sites (no data on summer feeding sites were obtained in 1971). Significant differences in mean annual production between years are shown on each area. The

Table 5. Summary of forage production by rank of major species in lbs. dry weight per acre from winter range sites, 1972.

Area		Species Rank 1	2	3	4	5	6	7
Grasses and Grasslikes								
Surprise Mt.	Species:	CAREX	FEAL	HIAL	FEBR	TRSP	POAS	FERU
	Mean ($\bar{x}$):	34.7	15.9	9.1	2.9	2.3	1.8	0.2
Slaughter Mt.	Species:	FEAL	HIAL	CAREX	BRSP	POAS	TRSP	FEBR
	Mean ($\bar{x}$):	44.8	15.5	9.1	6.0	5.0	2.5	1.5
Crescent Mt.	Species:	CAREX	FEAL	HIAL	FEBR	TRSP	BRSP	POAS
	Mean ($\bar{x}$):	40.5	10.4	7.3	7.2	3.9	1.4	1.2

Area		Species Rank 1	2	3	4	5	6	7	8	9
Forbs and Browse										
Surprise Mt.	Species:	DRIN	ARRU	VAVI	BENA	VAUL	EMNI	SALIX	MOSS	LEPA
	Mean ($\bar{x}$):	102.1	97.4	76.1	59.7	59.1	38.6	31.3	30.8	27.7
Slaughter Mt.	Species:	DRIN	EPAN	VAVI	ARRU	BENA	ARAR	SALIX	GEER	LEPA
	Mean ($\bar{x}$):	306.4	44.7	35.0	28.3	26.8	24.0	22.9	17.6	14.9
Crescent Mt.	Species:	DROC	SALIX	SATR	POUN	SABR	OXYTR	CALA	MOSS	ANNA
	Mean ($\bar{x}$):	57.5	45.6	24.0	18.0	12.1	7.7	7.4	7.4	6.9

Table 6. Summary of forage production by rank of major species in lbs. dry weight per acre from summer range sites, 1972.

Area		Species Rank 1	2	3	4	5	6	7	8	9
Grasses and Grasslikes										
Surprise Mt.	Species:	CAREX	LUSP	FEAL	UNKG	PHLE	TRSP	POAS	AGSP	-
	Mean ($\bar{x}$):	113.0	13.3	8.0	2.3	1.3	1.3	0.9	0.1	-
Slaughter Mt.	Species:	CAREX	JUSP	FEAL	TRSP	FESP	POAS	LUSP	-	
	Mean ($\bar{x}$):	170.7	79.2	31.6	13.1	8.2	3.5	1.2	-	
Crescent Mt.	Species:	CAREX	LUSP	FEAL	TRSP	HIAL	JUSP	CACA	POAS	FEBR
	Mean ($\bar{x}$):	238.7	35.0	6.1	4.7	4.6	2.5	2.4	0.7	0.05
Forbs and Browse										
Surprise Mt.	Species:	EMNI	VAUL	MOSS	BENA	CAST	VAVI	SALIX	LYCO	LUPE
	Mean ($\bar{x}$):	798.9	304.3	223.1	172.5	145.8	110.4	85.1	66.9	66.8
Slaughter Mt.	Species:	GEER	SAST	LUPE	VERA	RAES	EPLA	ABCO	PYSP	RUSP
	Mean ($\bar{x}$):	425.7	158.9	98.9	71.7	56.8	34.7	26.9	17.1	15.6
Crescent Mt.	Species:	SALIX	MOSS	LUPE	VAVI	ARAR	THSP	DILA	UNKF	SATR
	Mean ($\bar{x}$):	90.4	69.6	63.6	57.8	40.5	21.5	12.4	9.9	9.4

Table 7. Comparison of mean annual forage production in pounds per acre dry weight between summer and winter feeding sites by area, 1972.

SURPRISE MT.

Forage Class	Summer	Winter
TOTGR		
$\bar{x}$ =	140.18	66.85
SE =	9.061	4.908
N =	400	1000
Summer vs. winter t = 7.6016 Highly Signif. Difference at .01%		
TOTFB		
$\bar{x}$ =	2090.99	557.25
SE =	70.287	18.977
N =	400	1000
Summer vs. winter t = 28.6061 Highly Signif. Difference at .01%		
TOTHB		
$\bar{x}$ =	2231.18	624.11
SE =	68.828	19.719
N =	400	1000
Summer vs. winter t = 30.0224 Highly Signif. Difference at .01%		

CRESCENT MT.

Forage Class	Summer	Winter
TOTGR		
$\bar{x}$ =	294.80	72.66
SE =	16.272	4.092
N =	400	1000
Summer vs. winter t = 18.2790 Highly Signif. Difference at .01%		
TOTFB		
$\bar{x}$ =	416.86	221.11
SE =	18.945	10.705
N =	400	1000
Summer vs. winter t = 9.4393 Highly Signif. Difference at .01%		
TOTHB		
$\bar{x}$ =	711.66	293.78
SE =	24.257	11.810
N =	400	1000
Summer vs. winter t = 17.2933 Highly Signif. Difference at .01%		

Table 7. (continued) Comparison of mean annual forage production in pounds per acre dry weight between summer and winter feeding sites by area, 1972.

SLAUGHTER MT.

Forage Class	Summer	Winter
TOTGR		
$\bar{x}$ =	307.52	85.13
SE =	23.105	4.880
N =	400	1000
Summer vs. winter t = 13.4636 Highly Signif. Difference at .01%		
TOTFB		
$\bar{x}$ =	955.80	628.67
SE =	55.477	20.429
N =	400	1000
Summer vs. winter t = 6.8607 Highly Signif. Difference at .01%		
TOTHB		
$\bar{x}$ =	1263.32	713.79
SE =	60.105	21.191
N =	400	1000
Summer vs. winter t = 10.8471 Highly Signif. Difference at .01%		

* Legend of terms and figures used

Winter feeding sites: available to and used by sheep in winter

Summer feeding sites: used by sheep in summer; generally unavailable in winter

TOTGR: total grass and grasslike plants

TOTFB: total forbs and browse

TOTHB: total herbaceous plants

$\bar{x}$: mean annual forage production in pounds per acre, dry weight.

SE: standard error

N: number of plots in sample.

Table 8. Comparison of mean annual forage production in pounds per acre dry weight between areas and sites.

* WINTER FEEDING SITES, 1972

Forage Class	(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTGR			
$\bar{x}$ =	66.85	72.66	85.13
SE =	4.908	4.092	4.880
N =	1000	1000	1000

No. (1) vs. No. (2) t = -.9088 NO Signif. Difference at .05%
No. (2) vs. No. (3) t = -1.9570 NO Signif. Difference at .05%
No. (1) vs. No. (3) t = -2.6399 Highly Signif. Difference at .01%

Forage Class	(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTFB			
$\bar{x}$ =	557.25	211.11	628.67
SE =	18.977	10.705	20.429
N =	1000	1000	1000

No. (1) vs. No. (2) t = 15.4275 Highly Signif. Difference at .01%
No. (2) vs. No. (3) t = -17.6709 Highly Signif. Difference at .01%
No. (1) vs. No. (3) t = -2.5613 Significant Difference at .05%

Forage Class	(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTHB			
$\bar{x}$ =	624.11	293.78	713.79
SE =	19.719	11.810	21.191
N =	1000	1000	1000

No. (1) vs. No. (2) t = 14.3719 Highly Signif. Difference at .01%
No. (2) vs. No. (3) t = -17.3137 Highly Signif. Difference at .01%
No. (1) vs. No. (3) t = -3.0985 Highly Signif. Difference at .01%

Table 8. (continued) Comparison of mean annual forage production in pounds per acre dry weight between areas and sites.

SUMMER FEEDING SITES, 1972

Forage Class		(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTGR				
	$\bar{x}$ =	140.18	294.80	307.52
	SE =	9.061	16.272	23.105
	N =	400	400	400

No. (1) vs. No. (2) t = -8.3015 Highly Signif. Difference at .01%
No. (2) vs. No. (3) t = -.4505 No Difference
No. (1) vs. No. (3) t = -6.7428 Highly Signif. Difference at .01%

Forage Class		(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTFB				
	$\bar{x}$ =	2090.99	416.86	955.80
	SE =	70.287	18.945	55.477
	N =	400	400	400

No. (1) vs. No. (2) t = 22.9978 Highly Signif. Difference at .01%
No. (2) vs. No. (3) t = -9.1933 Highly Signif. Difference at .01%
No. (1) vs. No. (3) t = 12.6776 Highly Signif. Difference at .01%

Forage Class		(1) Surprise Mt.	(2) Crescent Mt.	(3) Slaughter Mt.
TOTHB				
	$\bar{x}$ =	2231.18	711.66	1263.32
	SE =	68.828	24.257	60.105
	N =	400	400	400

No. (1) vs. No. (2) t = 20.8218 Highly Signif. Difference at .01%
No. (2) vs. No. (3) t = -8.5114 Highly Signif. Difference at .01%
No. (1) vs. No. (3) t = 10.5917 Highly Signif. Difference at .01%

* Legend of terms and figures used
Winter feeding sites: available to and used by sheep in winter
Summer feeding sites: used by sheep in summer; generally unavailable in winter
TOTGR: total grass and grasslike plants
TOTFB: total forbs and browse
TOTHB: total herbaceous plants

$\bar{x}$: mean annual forage production in pounds per acre, dry weight.
SE: standard error
N: number of plots in sample.

Table 9. Comparison of mean annual forage production on winter feeding sites in pounds per acre dry weight between years by area.

SURPRISE MT.

Forage Class	1971	1972
TOTGR		
$\bar{x}$ =	99.92	66.85
SE =	6.412	4.908
N =	990	1000

1971 vs. 1972 t = 4.1003 Highly Signif. Difference at .01%

Forage Class	1971	1972
TOTFB		
$\bar{x}$ =	878.76	557.25
SE =	28.342	18.977
N =	990	1000

1971 vs. 1972 t = 9.4437 Highly Signif. Difference at .01%

Forage Class	1971	1972
TOTHB		
$\bar{x}$ =	978.68	624.11
SE =	29.017	19.719
N =	990	1000

1971 vs. 1972 t = 10.1252 Highly Signif. Difference at .01%

CRESCENT MT.

Forage Class	1971	1972
TOTGR		
$\bar{x}$ =	53.78	72.66
SE =	2.556	4,092
N =	1000	1000

1971 vs. 1972 t = -3.9139 Highly Signif. Difference at .01%

Forage Class	1971	1972
TOTFB		
$\bar{x}$ =	299.00	221.11
SE =	13.608	10.705
N =	1000	1000

1971 vs. 1972 t = 4.4987 Highly Signif. Difference at .01%

Table 9. (continued) Comparison of mean annual forage production on winter feeding sites in pounds per acre dry weight between years by area.

TOTHB

$\bar{x}$ =	352.78	293.78
SE =	14.331	11.810
N =	1000	1000

1971 vs. 1972 t = 3.1773 Highly Signif. Difference at .01%

SLAUGHTER MT.

Forage Class	1971	1972
TOTGR		
$\bar{x}$ =	226.80	85.13
SE =	13.587	4.880
N =	980	1000

1971 vs. 1972 t = 9.8898 Highly Signif. Difference at .01%

TOTFB

$\bar{x}$ =	1063.05	628.67
SE =	33.300	20.429
N =	980	1000

1971 vs. 1972 t = 11.1691 Highly Signif. Difference at .01%

TOTHB

$\bar{x}$ =	1289.84	713.79
SE =	36.633	21.191
N =	980	1000

1971 vs. 1972 t = 13.6793 Highly Signif. Difference at .01%

* Legend of terms and figures used
Winter feeding sites: available to and used by sheep in winter
Summer feeding sites: used by sheep in summer; generally unavailable in winter
TOTGR: total grass and grasslike plants
TOTFB: total forbs and browse
TOTHB: total herbaceous plants

$\bar{x}$: mean annual forage production in pounds per acre, dry weight.
SE: standard error
N: number of plots in sample.

summer of 1972 was noticeably drier than that of 1971 which was wet and rainy. In all but one case, forage production reflected the difference in precipitation and was lower in 1972.

Production of TOTGR, however, was significantly higher on Crescent Mountain in 1972 than in 1971 despite the generally lowered forage growth. No explanation can be offered for this anamoly at present except to hypothesize that reduction of the sheep herd on this mountain resulted in increased production of those species most utilized in their diet. Further comparisons in future years will be needed to see whether such a trend has indeed begun.

In order to see what changes in forage value take place between summer and winter in plants on sheep winter feeding sites, a series of plant specimens was collected during the summer and again during late winter on each study area. Species were selected on the basis of the previous diet study (Nichols and Heimer, 1972). Summer-collected plants were analyzed at Colorado State University under Dr. Hansen's contract. Analyses were conducted to determine the amounts of nitrogen (N), total available carbohydrates (TAC) and gross energy (GE) available in each species. Results of these analyses are listed in Table 10. The amount of crude protein (CP) present (N x 6.25) is also shown.

Crude protein is listed at 6-10 percent in timothy hay, and 12-16 percent in alfalfa hay according to the Yearbook of Agriculture (U.S.D.A., 1948), and Quinton (1972) lists 8.22 percent crude protein in meadow hay and 16.75 percent in alfalfa hay. He found gross energy values of 4055 and 4651 cal/g in meadow hay and alfalfa hay, respectively. I was unable to locate any comparable TAC values.

Examination of the values listed in Table 10 shows that several species of Dall sheep forage plants from winter feeding sites approach or exceed alfalfa hay in crude protein and gross energy, and a number exceed meadow hay. These specimens were picked at the peak of their growing season, of course; the same species collected from the same sites in winter have not yet been analyzed.

Budgetary limitations precluded analyses of sufficient specimens of each species to enable comparisons by species and area. However, a comparison of forage components by area was accomplished by lumping the species within each area. Results are shown in Table 11. No significant difference could be demonstrated between areas except that gross energy was significantly higher in Surprise Mountain specimens than in Crescent Mountain specimens.

During the breeding behavior study in November and December of both 1970 and 1971, sheep were observed utilizing what appeared to be small mineral licks at the head of Slaughter Gulch. Investigation showed that they were seeking the exposed rootstocks of the false hellebore plant (*Veratrum* spp.). Animals were spending considerable time and effort to merely lick the frozen rootstocks which were partially exposed but frozen solidly into the soil of a small cutbank.

Table 10. Analyses of forage plants collected from winter range sites during summer, 1972.

Species	Surprise Mt.				Slaughter Mt.				Crescent Mt.			
	N	CP	TAC	GE	N	CP	TAC	GE	N	CP	TAC	GE
HIAL	1.07	6.69	234	4784	1.41	8.81	190	5682	1.40	8.75	205	3709
CAREX	2.23	13.94	172	4873	2.46	15.38	184	4814	2.20	13.75	173	4725
FEBR	1.88	11.75	141	5099	2.86	17.88	164	5023	1.08	6.75	196	5188
FEAL	1.79	11.19	239	4992	2.28	14.25	153	4953	1.57	9.81	161	4694
DRYAS	1.27	7.94	145	5621	1.60	10.00	164	5111	2.19	13.69	196	5659
EMNI	1.09	8.65	145	5959	1.58	9.88	136	5886	1.11	6.94	172	5300
SALIX	2.12	13.25	152	5696	1.86	11.63	124	5586	2.69	16.81	168	4335
VAVI	1.34	8.38	146	5600	1.65	10.31	193	5145	1.69	10.56	133	5494
VAUL	1.96	12.25	118	5618	1.49	9.31	100	4963	1.89	11.81	148	5208
MOSS	1.07	6.69	75	4688	1.04	6.50	66	4725	1.17	7.31	79	4738

N = percent nitrogen
CP = percent crude protein = N x 6.25
TAC = total available carbohydrates in mg/g
GE = gross energy in kcal/g

Table 11. Comparison of forage components from summer-collected samples from winter feeding sites between areas in 1972.

N (Nitrogen in percent)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
$\bar{x}$ = 1.582	$\bar{x}$ = 1.699	$\bar{x}$ = 1.823

Surprise vs. Crescent t = -.0834 No Difference
Crescent vs. Slaughter t = -.5533 No Difference
Surprise vs. Slaughter t = -1.953 No Difference

TAC (Total available carbohydrates in mg/g)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
$\bar{x}$ = 156.7	$\bar{x}$ = 163.1	$\bar{x}$ = 147.4

Surprise vs. Crescent t = -.5368 No Difference
Crescent vs. Slaughter t = 1.6282 No Difference
Surprise vs. Slaughter t = .8163 No Difference

GE (gross energy in kcal/g)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
$\bar{x}$ = 5293.0	$\bar{x}$ = 4905.0	$\bar{x}$ = 5188.8

Surprise vs. Crescent t = 2.5932 Signif. Difference at .05%
Crescent vs. Slaughter t = -1.2014 No Difference
Surprise vs. Slaughter t = .8178 No difference

During the late summer of 1972, I examined what I had believed in the past to be small mineral licks high on the slopes of Slaughter Gulch and on the slope of an alpine cirque above Crescent Lake. In both cases, it was obvious that sheep had been seeking the lower stems and rootstocks of *Veratrum*. Sheep had been observed frequenting these "pseudo-mineral licks" throughout the summer, but particularly in August and September. They behaved much like they do at real mineral licks, and the associated trail systems appear similar.

Although this plant is common on the lower slopes, sheep seem to select it only on certain sites at the upper limit of its growth. In both cases examined, the utilized plants were associated with old marmot (*Marmota caligata*) colonies and burrows. It appeared that the marmot burrows might have first exposed the roots, after which, sheep enlarged the pits by pawing and eating. At any rate, focal points of the sheep trails and activities were small pits about two to three feet across dug into the sides of the hills, with *Veratrum* roots exposed in the uphill cutbanks.

Several specimens of *Veratrum* roots were collected and sent to Colorado State University for analysis. Results of the analyses are listed in Table 12. Significance of the components is not understood at present.

Veratrum has long been known as a plant poisonous to domestic sheep (Samson, 1952). Ingestion in sufficient quantities causes death within six to eight hours (Binns, pers. comm.). Sublethal doses cause excess salivation and urination, weakness, irregular gait, rapid respiration and irregular heartbeat. Very small amounts over a long period seem to have no effect upon domestic sheep; however, if ingested at about the 14th day of gestation, it causes congenital cyclopian-type malformations in lambs. Continued ingestion caused spontaneous abortion in many ewes (Binns, et al, 1963).

The toxic agent from *V. californicum* has been identified and given the name, cyclopamine. It was found to be highly concentrated in the roots, particularly after the middle of August in Utah specimens (Keeler and Binns, 1971).

Further investigation is needed to determine the significance of these *Veratrum* "licks" to Dall sheep. It may be that they form a substitute in the absence of true mineral licks and supply sheep with required trace elements or nutrients. It is possible that late season use in December could lead to reduced success in lambing.

Climatological data in the form of wind speed and direction and temperature were obtained from the charts as recorded by each of the three self-contained weather stations. Data have been reduced to tabular form and are available in the files on an hourly or daily basis. For the purpose of this report, it was deemed unnecessary to include this information in such lengthy form. Table 13 lists monthly wind and temperature data by area for each month in which the instruments were functioning. Instrument breakdown caused the loss of data for at least

Table 12. Analysis of *Veratrum* roots and crown from Slaughter Mt., summer, 1972.

Minerals	Percent of Dry Weight
Nitrogen	2.69
Crude protein (Nitrogen x 6.25	16.81
Phosphorus	0.407
Calcium	0.028
Magnesium	0.174
Sodium	0.024
Potassium	0.011
Cobalt	0.0004
Manganese	0.008
Zinc	0.0097
Iron	0.019
Silver	0.0002
Total Ash	5.16
Others	
Cellulose	15.70
Organic matter	94.84

Total available carbohydrates (TAC) = 104.03 ± 7.00 mg/g

Gross energy = 4082 kcal/g

Table 13. Average monthly wind velocities in miles per hour and temperatures in degrees Fahrenheit by area.

	Crescent Mt.					Surprise Mt.					Slaughter Mt.				
	Wind		Temperature			Wind		Temperature			Wind		Temperature		
Month	Max.	Aver.	Max.	Min.	Aver.	Max.	Aver.	Max.	Min.	Aver.	Max.	Aver.	Max.	Min.	Aver.
10/71	-	-	-	-	-	40	16.1	36	8	22.8	30	11.7	11	9	27.4
11/71	80	14.8	22	-12	11.4	40	15.8	30	-5	18.1	30	9.0	33	-4	18.5
12/71	55	17.9	34	-17	9.2	70	19.0	34	-9	16.4	40	12.1	33	-6	16.4
1/72	-	-	15	-25	1.0	30	14.0	20	-13	13.1	30	10.4	33	-20	14.7
2/72	-	-	-	-	-	45	14.4	37	2	17.3	30	10.1	35	-11	14.1
3/72	70	15.0	46	-10	9.7	52	14.6	41	-2	15.6	30	9.3	35	-6	13.7
4/72	71+	16.2	38	5	18.7	-	-	-	-	-	40	9.0	42	5	20.6
5/72	82+	22.6	53	19	31.5	30	11.7	51	19	31.8	30	10.5	56	20	34.4
6/72	50	18.0	56	19	37.4	30	10.3	62	27	38.6	30	8.4	63	30	42.6
7/72	40	10.6	78	38	54.1	30	9.5	79	38	53.3	20	6.2	83	43	55.9
8/72	57	19.6	69	38	47.1	20	8.8	65	40	48.6	20	8.2	73	40	51.3
9/72	60	17.7	50	20	38.2	-	-	-	-	-	30	10.2	54	26	43.3
10/72	76	20.4	44	20	24.7	30	13.9	40	18	28.8	30	10.1	48	13	30.3
11/72	100+	17.8	40	13	25.4	55	11.5	32	10	21.6	-	-	-	-	-

one month at each site, and for a number of shorter periods. Thus, not all monthly figures are based on a full month of data.

When considering these climatological data, it must be remembered that the weather instruments sampled wind and temperature at only one site on each mountain. Each station was located as near as possible to other centers of study--such as range and snow transects--and was situated to sample as much as possible the gross unobstructed wind flow. Many variables, such as slope-aspect, gully-depth, wind-exposure, etc., affect the microclimates of individual portions of the habitats. Consideration must be given to differences in elevation above sea level, too. The weather stations at Slaughter Mountain, Surprise Mountain and Snowslide Mountain are at elevations of 2200 feet, 2600 feet, and 4200 feet, respectively. On the first two mountains, these are approximately the average elevations used by sheep in the winter. On Snowslide Mountain, the station is located at about the upper limit of sheep winter range.

Wind and temperature data during the winter period (October, 1971 through April, 1972) are summarized and presented in Fig. 5. Similar data for the summer period (May through September, 1972) are shown in Fig. 6. Average monthly temperatures, and the maximum and minimum temperatures recorded each month are shown in Fig. 7 for each location. Fig. 8 shows the average and maximum-recorded winds by month.

It can be seen that Crescent Mountain (actually Snowslide Mountain within the Crescent Mountains complex) was the coldest and windiest of the three sites, while Slaughter Mountain (in Cooper Landing Closed Area) was the warmest and calmest during the year examined. This relationship applied to both the winter and summer periods. Average and maximum winds were only a little higher on Crescent Mountain than on Surprise Mountain during the winter period, but were a great deal higher during the summer period. In October and November, 1972, (not included in Figs. 5 and 6) the wind blew steadily between 60 and 70 m.p.h. for over five hours each during two periods recorded, and once blew over 80 m.p.h. for over six hours, including three hours of winds over 100 m.p.h. with much higher gusts. Winds on Slaughter Mountain were significantly lower.

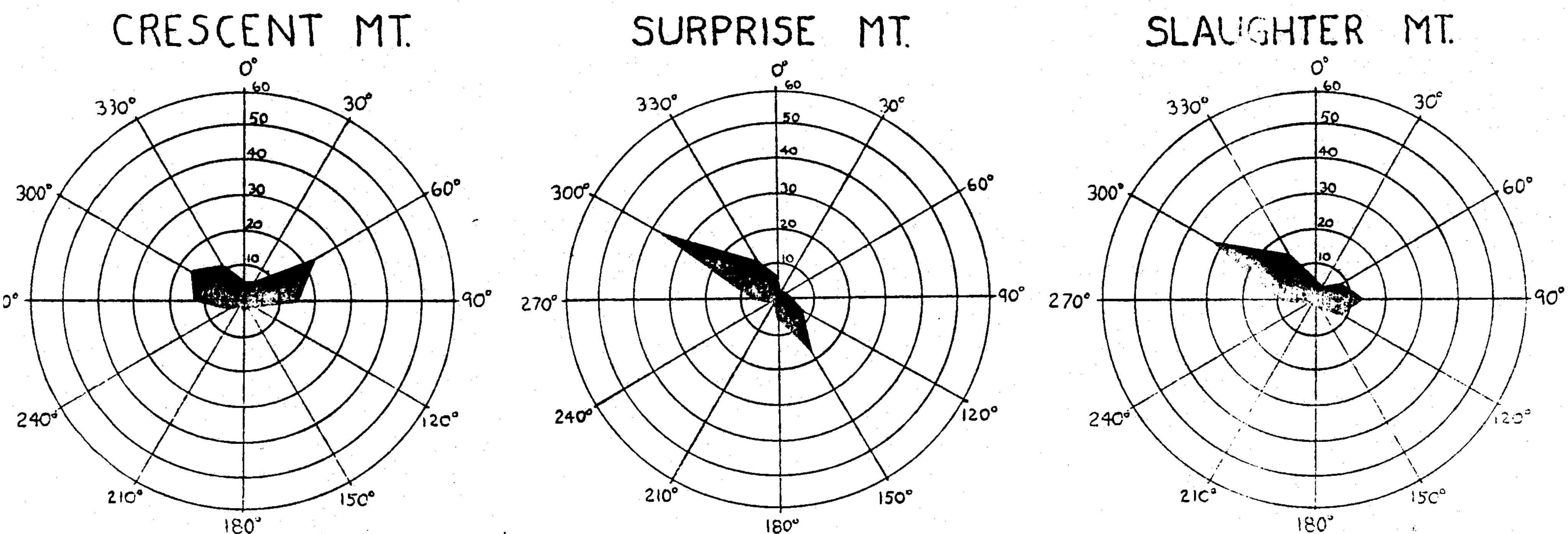
Although winter winds blew mostly from the northeast and east, and northwest and west on Crescent Mountain, the strongest winds invariably came from the east. Northeast and east winds predominated in summer. On Surprise Mountain, the winter winds as well as the strongest winds came from the northwest, while the less powerful summer winds blew predominantly from the southeast. The winter winds on Slaughter Mountain blew largely from the northwest and the summer winds from the east and southeast.

Winter temperatures averaged lower on Crescent than on Surprise or Slaughter mountains, while summer temperatures were not too dissimilar on the three areas.

Snow surveys were conducted on each mountain during midwinter in early 1972 and 1973. Although sheep generally utilize the brinks of plateaus and steep mountain slopes during winter (except on Surprise

Figure 5. Summary of wind and temperature data during the winter (October through April) period, 1971-72.

Average wind direction by degrees magnetic from which it blows and by percent of time.



CRESCENT MT.

WIND (MPH)
MAX. RECORDED
80
AVER. SEASONAL
16.0

TEMP. (DEG. F)
MAX. RECORDED
46°
MIN. RECORDED
-25°
AVER. SEASONAL
10.0°

SURPRISE MT.

WIND (MPH)
MAX. RECORDED
70
AVER. SEASONAL
15.7

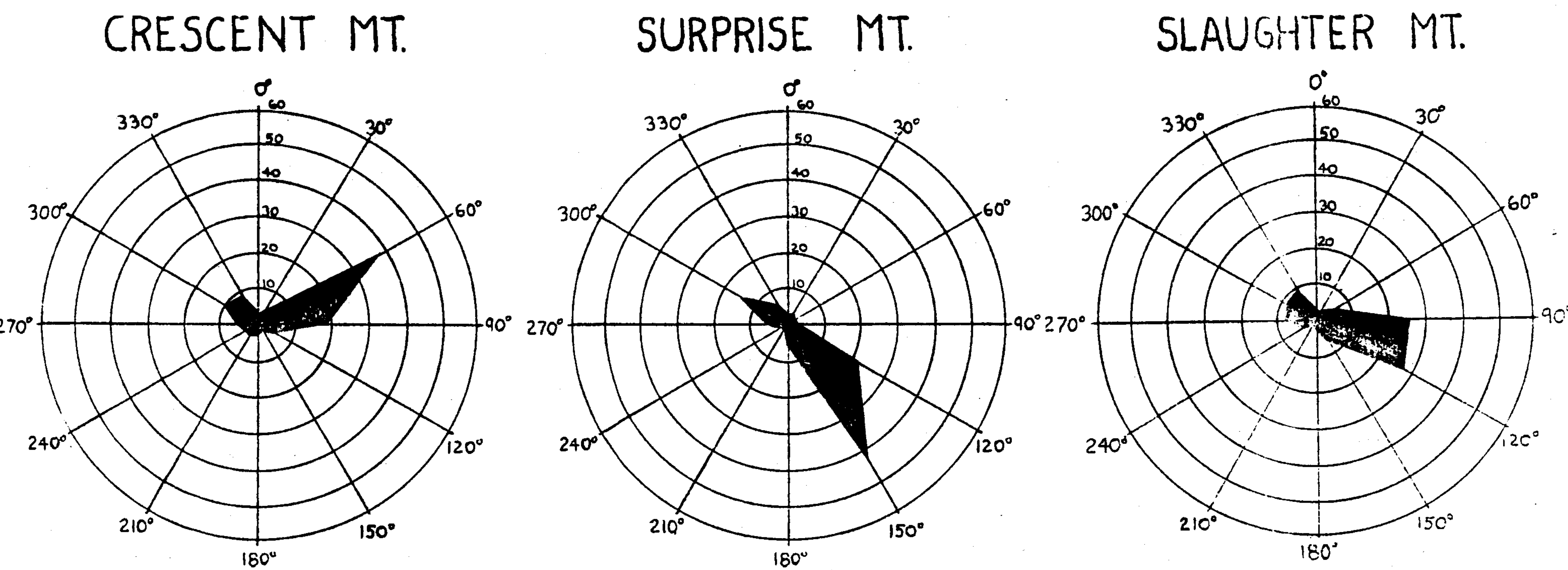
TEMP. (DEG. F)
MAX. RECORDED
41°
MIN. RECORDED
-13°
AVER. SEASONAL
17.2°

SLAUGHTER MT.

WIND (MPH)
MAX. RECORDED
40
AVER. SEASONAL
10.2

TEMP. (DEG. F)
MAX. RECORDED
42°
MIN. RECORDED
-20°
AVER. SEASONAL
17.9°

Figure 6. Summary of wind and temperature data during the summer (May through September) period, 1972. Average wind direction by degrees magnetic from which it blows and by percent of time.



	CRESCENT MT.	SURPRISE MT.	SLAUGHTER MT.
WIND (MPH)			
MAX. RECORDED	82+	30	30
AVER. SEASONAL	17.7	10.1	8.7
TEMP. (DEG. F)			
MAX. RECORDED	78°	79°	83°
MIN. RECORDED	19°	19°	20°
AVER. SEASONAL	41.7°	43.1°	45.5°

Figure 7. Average, maximum and minimum monthly temperatures by area.

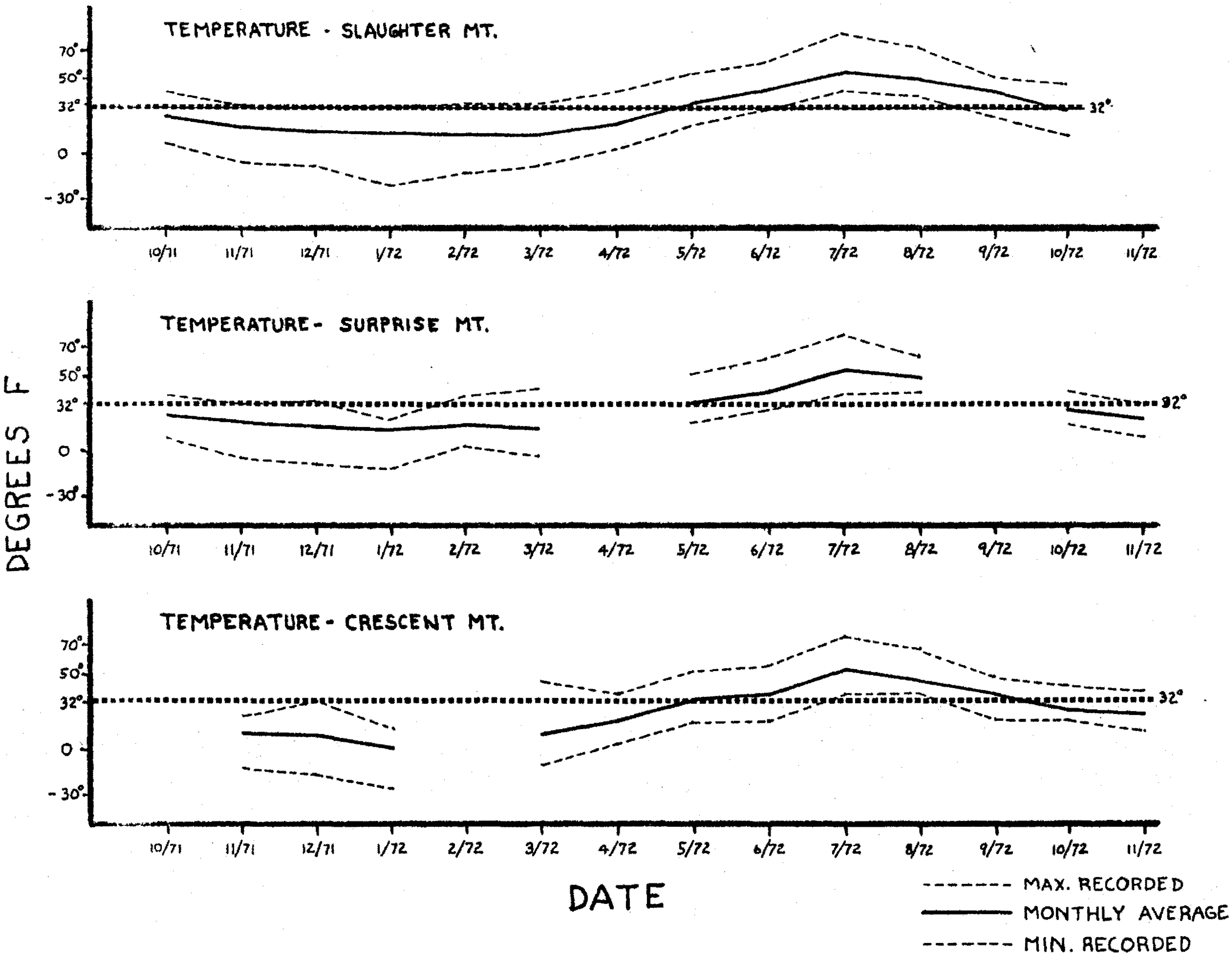
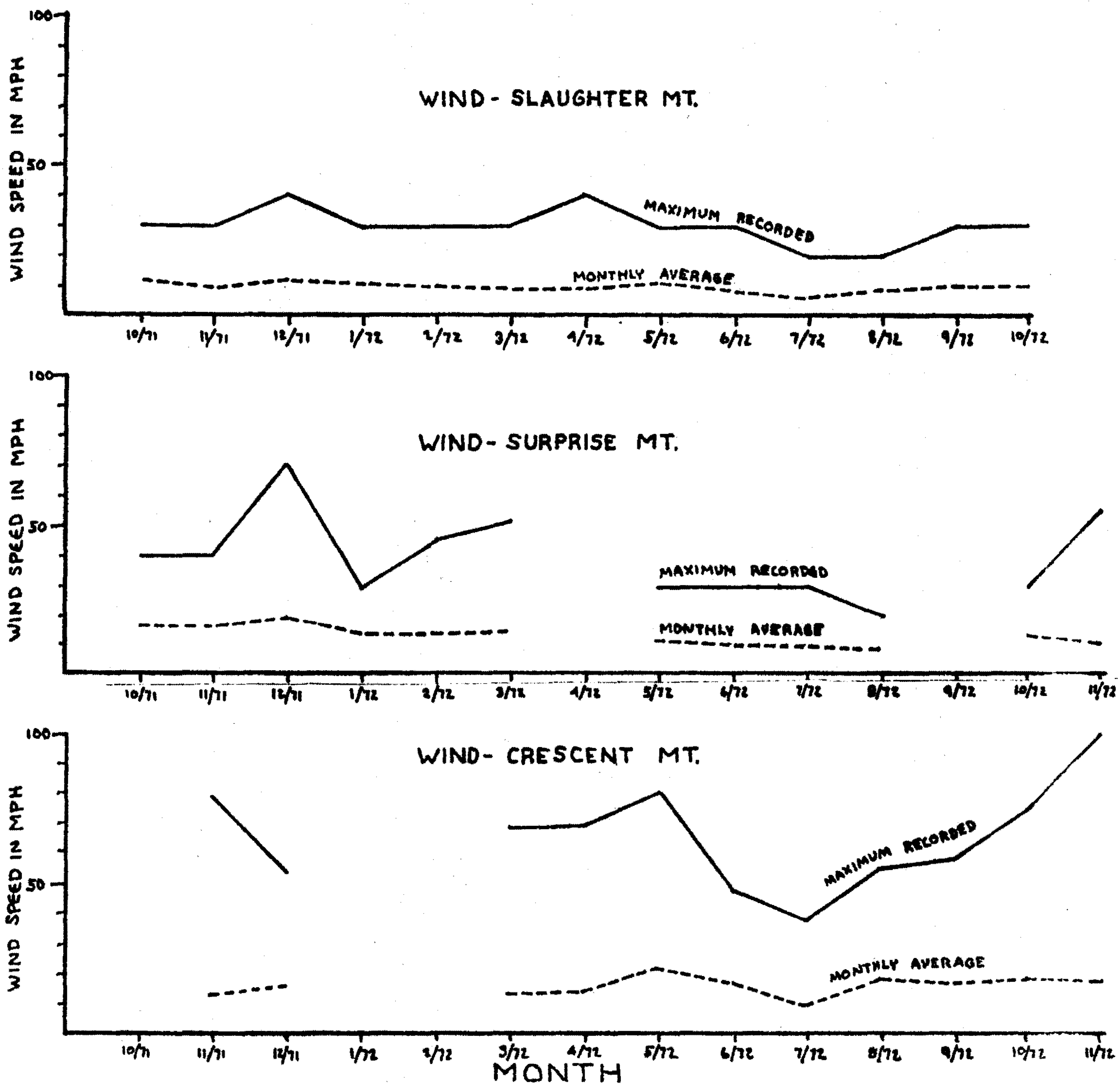


Figure 8. Average and maximum monthly winds by area.



Mountain where the plateau, itself, is also much used), it did not appear practicable to attempt to measure and compare snow on the slopes. Therefore, snow transects were laid out near the weather stations and range transects on reasonably level ground and running "inland" from the brink of the slope in each case. The sites are thus more or less comparable and should indicate gross snow conditions on each mountain.

Snow transects were run on the following dates and areas:

	1972	1973
Slaughter Mountain	Feb. 23	Feb. 5
Surprise Mountain	Feb. 22	Feb. 4
Crescent Mountain	Mar. 3	Jan. 25

The mean snow depth and hardness of each transect are presented in Table 14 with results of an analysis of variance in comparing the three areas for each year tested. Table 15 shows a comparison of the depth and hardness means between years by area.

Examination of Table 14 shows that both depth and hardness were significantly different between all areas in 1972, with the depth being least on Crescent Mountain and greatest on Slaughter Mountain, and hardness being greatest on Crescent and least on Slaughter. In 1973, there were significant differences between all areas except between depths on Surprise and Slaughter mountains. Again, average depth was greatest and average hardness least on Slaughter Mountain, while hardness was greatest and depth least on Crescent Mountain. The snow was over five times harder and less than one-third as deep on Crescent than on Slaughter Mountain.

Table 15 shows that there was no significant difference in snow depth between years on any of the three areas, but that there was a significant increase in hardness from 1972 to 1973 on both Surprise and Crescent mountains.

The mean hardness of the snow was probably greater than shown on Crescent Mountain, particularly in 1973, due to a weakness in the measurement method. With the system used, no greater hardness could be measured than 80 $lbs./cm^2$. Hardpacked snow was often encountered on Crescent Mountain which could not be penetrated with this maximum force. In such cases, hardness could only be listed as the maximum readable, thus lowering the true mean an unknown amount.

A summary of gross annual weather, snow, forage production and lambing data is presented in Fig. 9. It can be seen that in 1972, climatic conditions were harsher and forage production and lambing success were lower on Crescent Mountain than on the other two areas. Slaughter Mountain had the most benevolent climate, highest forage production and best lambing success, while Surprise Mountain was intermediate in all factors.

Table 14. Comparison of snow depth (in inches) and hardness (in pounds per cm^2) between areas in the winters of 1972 and 1973.

Year	Snow Condition	Comparison		t	DF	Difference
1972		<u>Crescent vs. Surprise</u>				
	Depth	($\bar{x}D$=5.5)	($\bar{x}D$-12.8)	2.975	98	Highly significant at .01%
	Hardness	($\bar{x}H$=19.9)	($\bar{x}H$=10.7)	7.301	254	Highly significant at .01%
		<u>Surprise vs. Slaughter</u>				
	Depth	($\bar{x}D$=12.8)	($\bar{x}D$=19.8)	2.668	98	Highly significant at .01%
	Hardness	($\bar{x}H$=10.7)	($\bar{x}H$=7.2)	4.163	334	Highly significant at .01%
		<u>Crescent vs. Slaughter</u>				
	Depth	($\bar{x}D$=5.5)	($\bar{x}D$=19.8)	5.230	98	Highly significant at .01%
	Hardness	($\bar{x}H$=19.9)	($\bar{x}H$=7.2)	11.723	262	Highly significant at .01%
1973		<u>Crescent vs. Surprise</u>				
	Depth	($\bar{x}D$=4.7)	($\bar{x}D$=11.4)	2.762	98	Highly significant at .01%
	Hardness	($\bar{x}H$=32.2)	($\bar{x}H$=16.0)	7.096	310	Highly significant at .01%
		<u>Surprise vs. Slaughter</u>				
	Depth	($\bar{x}D$=11.4)	($\bar{x}D$=17.2)	1.945	98	No significant difference
	Hardness	($\bar{x}H$=16.0)	($\bar{x}H$=5.9)	9.175	366	Highly significant at .01%
		<u>Crescent vs. Slaughter</u>				
	Depth	($\bar{x}D$=4.7)	($\bar{x}D$=17.2)	5.393	98	Highly significant at .01%
	Hardness	($\bar{x}H$=32.2)	($\bar{x}H$=5.9)	12.855	302	Highly significant at .01%

$\bar{x}D$ = average depth in inches

$\bar{x}H$ = average hardness in pounds per cm^2

Table 15. Comparison of snow depth (in inches) and hardness (in pounds per cm^2) between the winters of 1972 and 1973 by areas.

Area	Snow Condition	Comparison	t	DF	Difference
Crescent		1972 vs. 1973			
	Depth	($\bar{x}D$=5.5) ($\bar{x}D$=4.7)	0.382	98	No significant difference
	Hardness	($\bar{x}H$=19.9) ($\bar{x}H$=32.2)	4.188	214	Highly significant at .01%
Surprise		1972 vs. 1973			
	Depth	($\bar{x}D$=12.8) ($\bar{x}D$=11.4)	0.506	98	No significant difference
	Hardness	($\bar{x}H$=10.7) ($\bar{x}H$=16.0)	4.277	350	Highly significant at .01%
Slaughter		1972 vs. 1973			
	Depth	($\bar{x}D$=19.8) ($\bar{x}D$=17.2)	0.894	98	No significant difference
	Hardness	($\bar{x}H$=7.2) ($\bar{x}H$=5.9)	1.861	350	No significant difference

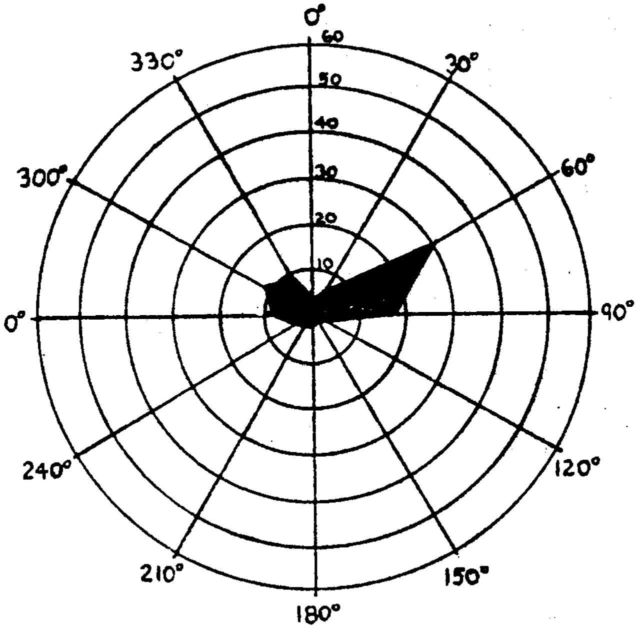
$\bar{x}D$ = average depth in inches

$\bar{x}H$ = average hardness in pounds per cm^2

Figure 9. Summary of annual weather, snow, forage production and lambing data by area.

Average wind direction by degrees magnetic from which it blows and by percent of time.

CRESCENT MT.



WIND (MPH)

MAX. RECORDED
82+

AVER. ANNUAL
16.9

TEMP. (DEG. F)

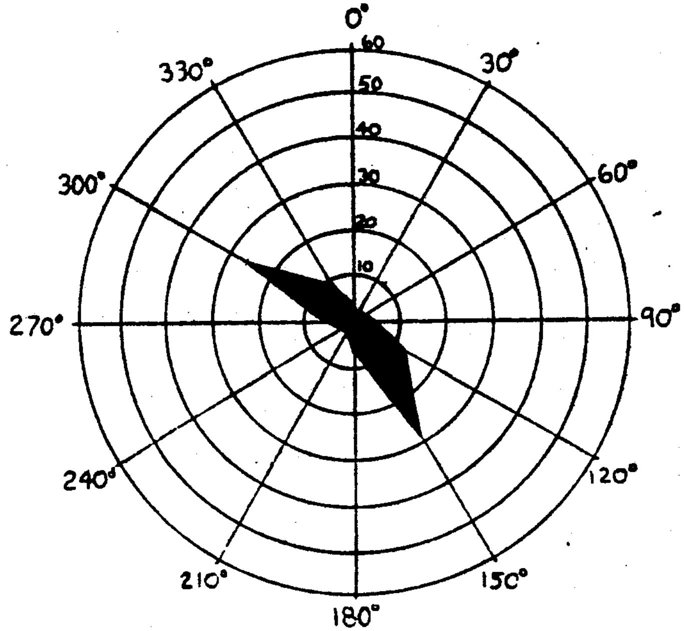
MAX. RECORDED
78°

MIN. RECORDED
-25°

AVER. ANNUAL
25.8°

AVER. SNOW DEPTH: 5.5 IN.
AVER. SNOW HARDNESS: 19.9 LB/CM²
FORAGE PRODUCTION
TOTHB: 293.8 LB./ACRE
LAMB PRODUCTION:
34 LAMBS PER 100 EWES

SURPRISE MT.



WIND (MPH)

MAX. RECORDED
70

AVER. ANNUAL
13.4

TEMP. (DEG. F)

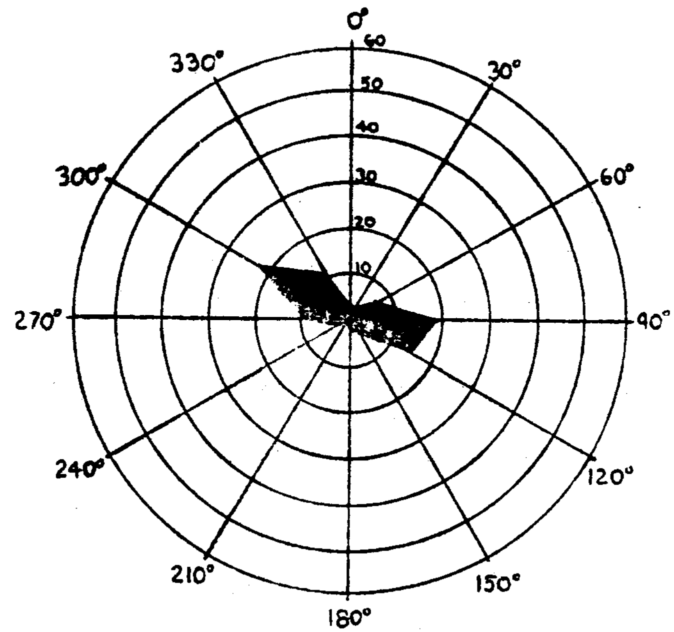
MAX. RECORDED
79°

MIN. RECORDED
-13°

AVER. ANNUAL
27.6°

AVER. SNOW DEPTH: 12.8 IN.
AVER. SNOW HARDNESS: 10.7 LB/CM²
FORAGE PRODUCTION
TOTHB: 624.1 LB./ACRE
LAMB PRODUCTION:
38 LAMBS PER 100 EWES

SLAUGHTER MT.



WIND (MPH)

MAX. RECORDED
40

AVER. ANNUAL
9.6

TEMP. (DEG. F)

MAX. RECORDED
83°

MIN. RECORDED
-20°

AVER. ANNUAL
29.4°

AVER. SNOW DEPTH: 19.8 IN.
AVER. SNOW HARDNESS: 7.2 LB/CM²
FORAGE PRODUCTION
TOTHB: 713.8 LB./ACRE
LAMB PRODUCTION:
45 LAMBS PER 100 EWES

RECOMMENDATIONS

No specific recommendations for sheep management can be made at this time except that the Crescent Mountain herd be maintained at approximately 200 animals by public hunting and scientific collecting for the duration of this study.

I recommend that Job No. 6.5, "Dall Sheep Population Trends and Composition on the Kenai Peninsula" be extended until the end of the study. Final data on range trends will be relatively meaningless without comparable data on sheep populations.

Forage production on winter feeding sites should be measured again in three or four years to determine range trends on each of the three areas under study.

Further study is needed to determine the significance of sheep use of *Veratrum* spp. in "pseudo-mineral licks" on the Kenai Peninsula.

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Appendix 1

Table 1. Summary of plant biomass for winter range sites of Dall Sheep, Surprise Mountain, Alaska (page 1 of two summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
CAREX	288.	.1232	.0382	.0026	34.7124	2.3851
FEBR	29.	.0127	.0032	.0007	2.8789	.6197
FERU	1.	.0008	.0002	.0002	.2073	.2073
HIAL	116.	.0333	.0100	.0011	9.0859	1.0055
*POAS	90.	.0555	.0194	.0044	17.6543	4.0272
TRSP	8.	.0029	.0025	.0009	2.3158	.8272
TOTGR	532.	.2283	.0735	.0054	66.8545	4.9083
ANNA	37.	.0162	.0032	.0006	2.9516	.5691
ANSP	6.	.0025	.0005	.0002	.4256	.1858
ARAR	12.	.0148	.0025	.0012	2.2914	1.0992
ARRU	180.	.3060	.1071	.0086	97.3662	7.8322
ARUU	1.	.0009	.0002	.0002	.1957	.1957
BRSP	5.	.0034	.0012	.0009	1.0914	.8004
BENA	95.	.1684	.0657	.0088	59.6913	8.0303
CALA	117.	.0422	.0046	.0007	4.2196	.6571
CACA	2.	.0007	.0003	.0003	.2673	.2343
CESP	5.	.0008	.0002	.0001	.1461	.0668
COCA	5.	.0022	.0002	.0001	.2172	.1139
DILA	53.	.0447	.0170	.0027	15.4408	2.4100
DRIN	245.	.3035	.1123	.0080	102.0897	7.3122
EMNI	59.	.0965	.0425	.0065	38.5976	5.9078
EPLA	2.	.0008	.0002	.0001	.1371	.1142
GEER	2.	.0005	.0001	.0001	.1037	.0733
LEPA	66.	.0782	.0305	.0082	27.7180	7.4185
MIMA	1.	.0007	.0002	.0002	.1614	.1614
MOSS	100.	.0377	.0339	.0041	30.8422	3.7357
OXYTR	38.	.0149	.0020	.0006	1.8416	.5158

*Note error: POAS mis-identified and is approximately 90% FEAL, 10% POAS as listed; all areas.

Table 1 (con't). Summary of plant biomass for winter range sites of Dall Sheep, Surprise Mountain, Alaska (page 2 of two summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
PELA	21.	.0073	.0012	.0003	1.0682	.2806
PESP	8.	.0029	.0005	.0002	.4204	.1559
POUN	2.	.0078	.0026	.0019	2.3490	1.7501
POVI	2.	.0010	.0002	.0002	.2110	.1565
SABR	4.	.0048	.0005	.0003	.4830	.2500
SALIX	114.	.1379	.0345	.0038	31.3493	3.4475
SATR	2.	.0009	.0001	.0001	.0858	.0639
STSP	3.	.0013	.0003	.0002	.2280	.1384
VAUL	173.	.1667	.0650	.0053	59.1162	4.8017
VAVI	302.	.1994	.0837	.0060	76.1239	5.4713
UNKF	1.	.0001	.0000	.0000	.0209	.0209
TOTFR	1663.	1.6478	.6130	.0209	557.2511	18.9769
********** SUMMARY TOTALS **********						
	2195.	1.8962	.6865	.0217	624.1056	19.7185

Table 2. Summary of plant biomass for summer feeding sites of Dall Sheep, Surprise Mountain, Alaska (page 1 of two summary pages). 1972

SPECIES	NO. OCCURRENCES ~~1000~~ 400 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
AGSP	1.	.0004	.0001	.0001	.0807	.0807
CAREX	210.	.3551	.1243	.0083	112.9800	7.5728
LUSP	29.	.0638	.0147	.0035	13.3400	3.1494
PHLE	3.	.0059	.0015	.0009	1.3312	.7939
POAS	24.	.0257	.0098	.0025	8.8955	2.3049
TRSP	3.	.0055	.0014	.0008	1.2506	.7649
UNKG	7.	.0072	.0025	.0011	2.3068	.9926
TOTGR	277.	.4636	.1542	.0100	140.1848	9.0610
ACBO	1.	.0024	.0008	.0008	.7091	.7091
ANNA	64.	.0912	.0137	.0023	12.4364	2.0650
ANPA	1.	.0010	.0001	.0001	.1225	.1225
ANSP	5.	.0056	.0008	.0004	.7175	.3310
APAR	70.	.0616	.0111	.0019	10.0820	1.7057
APRU	1.	.0009	.0002	.0002	.1690	.1690
ARSP	6.	.0080	.0005	.0002	.4364	.1957
BENA	92.	.5127	.1897	.0227	172.4511	20.6527
CACA	20.	.0210	.0084	.0026	7.6500	2.3778
CALA	3.	.0011	.0000	.0000	.0409	.0255
CAST	79.	.3411	.1603	.0245	145.7620	22.2956
CESP	1.	.0003	.0000	.0000	.0338	.0338
COCA	5.	.0096	.0025	.0018	2.2667	1.6533
DILA	2.	.0029	.0011	.0008	.9712	.6996
DRIN	1.	.0008	.0003	.0003	.2530	.2530
EMNI	260.	1.9972	.8787	.0507	798.8620	46.0974
EPAN	6.	.0163	.0029	.0013	2.6632	1.2073
EQSP	2.	.0044	.0024	.0022	2.1600	1.9729
GEGL	1.	.0033	.0004	.0004	.3627	.3627

Table 2 (con't). Summary of plant biomass for summer feeding sites of Dall Sheep, Surprise Mountain, Alaska (page 2 of two summary pages). 1972

SPECIES	NO. OCCURRENCES ~~1000~~ 400 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
GESP	13.	.0054	.0003	.0001	.2455	.0706
MIAL	11.	.0050	.0014	.0005	1.2829	.4928
MITR	18.	.0103	.0010	.0004	.9336	.3473
LEPA	23.	.0310	.0130	.0039	11.8211	3.5504
LIBO	6.	.0126	.0040	.0021	3.6655	1.9453
LUPE	51.	.2296	.0735	.0136	66.7964	12.3564
LYCO	69.	.1987	.0735	.0147	66.8523	13.3418
LYSP	0.	0.0000	0.0000	0.0000	0.0000	0.0000
MOSS	207.	.4544	.2454	.0210	223.0691	19.1205
OXYTR	2.	.0009	.0002	.0001	.1460	.1087
PESP	4.	.0156	.0031	.0017	2.8445	1.5897
POVI	6.	.0071	.0008	.0005	.7110	.4452
PYSP	8.	.0318	.0102	.0047	9.2509	4.2593
RAES	9.	.0148	.0001	.0001	.1350	.0518
RUCH	23.	.0618	.0136	.0036	12.3525	3.3063
SALIX	114.	.3020	.0936	.0104	85.1140	9.4431
SAST	11.	.0260	.0073	.0035	6.6303	3.1955
SATR	1.	.0005	.0002	.0002	.1423	.1423
SERO	8.	.0065	.0005	.0002	.4128	.1520
SPBE	11.	.0224	.0083	.0031	7.5211	2.7828
STSP	9.	.0074	.0009	.0006	.8116	.5186
TSME	0.	0.0000	0.0000	0.0000	0.0000	0.0000
VAUL	164.	.8584	.3348	.0294	304.3489	26.6912
VAVI	114.	.2248	.1214	.0135	110.3625	12.3171
VERA	1.	.1135	.0136	.0136	12.3818	12.3818
UNKF	21.	.0394	.0055	.0017	5.0114	1.5781
TOTFB	1524.	5.7616	2.3001	.0773	2090.9925	70.2868
	■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■	SUMMARY TOTALS	■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■ ■			
	1801.	6.2252	2.4543	.0757	2231.1773	68.8281

Table 3. Summary of plant biomass for winter range sites of Dall Sheep, Slaughter Mountain, Alaska (page 1 of 3 summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT. LB/ACRE
AGSP	3.	.0019	.0004	.0002	.3265	.1981
BRSP	29.	.0349	.0066	.0016	6.0225	1.4484
CACA	1.	.0022	.0004	.0004	.4009	.4009
CAREX	71.	.0356	.0100	.0014	9.0542	1.2575
FERR	6.	.0047	.0017	.0008	1.5221	.7250
HIAL	91.	.0631	.0170	.0022	15.4904	2.0209
POAS	264.	.2284	.0548	.0043	49.8380	3.8911
TRSP	9.	.0031	.0027	.0010	2.4716	.9071
TOTGR	474.	.3738	.0936	.0054	85.1261	4.8800
ACRO	12.	.0043	.0006	.0002	.5123	.1597
ACDE	12.	.0109	.0020	.0006	1.7877	.5772
ALIN	8.	.0206	.0064	.0030	5.8032	2.7265
ANNA	10.	.0122	.0022	.0009	1.9947	.8345
ANPA	1.	.0011	.0002	.0002	.1400	.1400
ANSP	2.	.0013	.0003	.0002	.2284	.1739
ANSE	5.	.0018	.0004	.0002	.3360	.1540
APAR	106.	.1550	.0264	.0035	23.9552	3.1619
APRU	17.	.0384	.0104	.0029	9.4279	2.6714
ARUU	83.	.1244	.0311	.0042	28.2723	3.7798
BENA	50.	.0953	.0295	.0050	26.8491	4.5528
CALA	13.	.0061	.0007	.0003	.6136	.2483
CARO	25.	.0172	.0017	.0004	1.5615	.3288
CEAR	11.	.0034	.0007	.0003	.6153	.2422
CESP	10.	.0051	.0010	.0003	.8816	[illegible]967
DILA	7.	.0148	.0056	.0024	5.0989	2.1650
DRIN	421.	1.2038	.3371	.0183	306.4132	16.6167
DRSP	4.	.0030	.0007	.0003	.5928	.3160

Table 3 (con't). Summary of plant biomass for winter range sites of Dall Sheep, Slaughter Mountain, Alaska (page 2 of 3 summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
EMNI	2.	.0052	.0022	.0016	2.0045	1.4311
EPAN	147.	.2237	.0492	.0055	44.7492	5.0128
EPLA	9.	.0174	.0031	.0012	2.8440	1.1133
ERSP	1.	.0013	.0003	.0003	.2418	.2418
FERN	5.	.0045	.0008	.0004	.6888	.3497
GEER	92.	.0842	.0194	.0027	17.6048	2.4943
JUCO	2.	.0085	.0033	.0026	3.0278	2.3285
LEPA	8.	.0443	.0164	.0080	14.9107	7.2547
LIBO	8.	.0045	.0014	.0006	1.3056	.5061
LUNO	3.	.0023	.0005	.0004	.4809	.3708
MIMA	1.	.0010	.0002	.0002	.2259	.2259
MOSS	56.	.0229	.0062	.0011	5.6239	.9891
MYAL	9.	.0121	.0008	.0003	.7672	.3059
OXYTR	78.	.0365	.0051	.0007	4.6514	.6713
PEFL	1.	.0015	.0005	.0005	.4185	.4185
PELA	4.	.0015	.0002	.0001	.2225	.1132
PESP	12.	.0065	.0010	.0003	.9471	.3043
POSP	1.	.0010	.0003	.0003	.3150	.3150
POUN	12.	.0127	.0042	.0015	3.8205	1.3900
POVI	40.	.0252	.0061	.0012	5.5045	1.0659
PYSP	16.	.0072	.0017	.0005	1.5685	.4151
ROSA	26.	.0437	.0149	.0036	13.5169	3.2988
SABR	1.	.0003	.0000	.0000	.0345	.0345

Table 3 (con't). Summary of plant biomass for winter range sites of Dall Sheep, Slaughter Mountain, Alaska (page 3 of 3 summary pages). 1972

SALIX	35.	.0813	.0252	.0053	22.9253	4.8376
SATR	72.	.0842	.0095	.0014	8.6178	1.2275
SFRO	2.	.0035	.0002	.0002	.2215	.1572
SIAC	2.	.0023	.0006	.0005	.5127	.4849
SOMU	36.	.0529	.0106	.0021	9.6138	1.9217
STSP	23.	.0150	.0028	.0007	2.5840	.5978
TRIF	2.	.0003	.0001	.0000	.0601	.0433
UPGR	2.	.0017	.0004	.0003	.3607	.2687
VAUL	9.	.0125	.0046	.0019	4.2025	1.7165
VAVI	129.	.1132	.0385	.0044	34.9749	4.0298
VEWO	1.	.0017	.0003	.0003	.3136	.3136
UNKF	28.	.0265	.0041	.0017	3.7218	1.5619
TOTFB	1672.	2.6779	.6915	.0225	628.6671	20.4286
	* * * * * * * * * * * * * * * * * * * *	SUMMARY TOTALS	* * * * * * * * * * * * * * * * * * * *			
	2146.	3.0518	.7852	.0233	713.7932	21.1906

Table 4. Summary of plant biomass for summer feeding sites of Dall Sheep, Slaughter Mountain, Alaska (page 1 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES ~~1000~~ 400 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
CAREX	275.	1.1047	.1878	.0121	176.7310	10.9862
FESP	6.	.0282	.0090	.0042	8.2065	3.8030
JUSP	29.	.3631	.0871	.0204	79.2120	18.5114
LUSP	2.	.0048	.0013	.0010	1.2218	.9098
POAS	32.	.1244	.0386	.0095	35.0695	8.6619
TRSP	18.	.0480	.0144	.0044	13.0841	4.0203
TOTGR	362.	1.6732	.3383	.0254	307.5249	23.1045
ACBR	66.	.2274	.0296	.0054	26.8781	4.9202
ANNA	12.	.0262	.0047	.0017	4.2840	1.5907
ARAR	37.	.0750	.0098	.0023	8.8684	2.0618
EMNI	4.	.0160	.0067	.0048	6.0938	4.3275
EPLA	24.	.1820	.0382	.0092	34.7455	8.3475
EPPA	14.	.0140	.0029	.0014	2.6727	1.2372
FERN	10.	.0084	.0011	.0005	.9927	.4821
GEGI	1.	.0064	.0005	.0005	.4636	.4635
GEER	208.	2.2300	.4683	.0374	425.7187	33.9851
LUPE	68.	.3885	.1088	.0157	98.8795	14.2531
LYCO	27.	.0230	.0062	.0029	5.6455	2.6261
OXYTR	1.	.0003	.0001	.0001	.0483	.0483
POUN	0.	0.0000	0.0000	0.0000	0.0000	0.0000
RAES	91.	.4169	.0625	.0083	56.8445	7.5800
PYSP	56.	.1711	.0188	.0031	17.1130	2.8543
RUSP	34.	.0744	.0171	.0037	15.5564	3.3947
SALIX	1.	.0100	.0031	.0031	2.8182	2.8182
SAST	144.	.6991	.1748	.0171	158.8920	15.5597
THSP	7.	.0214	.0045	.0019	4.0807	1.7080
TREU	12.	.0245	.0024	.0015	2.2273	1.3673

Table 4 (con't). Summary of plant biomass for summer feeding sites of Dall Sheep, Slaughter Mountain, Alaska (page 2 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
VAUL	6.	.0104	.0039	.0021	3.5150	1.8759
VAVI	8.	.0182	.0066	.0029	5.9695	2.6742
VFRA	11.	.6576	.0789	.0392	71.7382	35.6221
VESP	11.	.0050	.0007	.0002	.6364	.2083
VISP	3.	.0082	.0012	.0008	1.1168	.7386
TOTFB	866.	5.3140	1.0514	.0610	955.7986	55.4773
SUMMARY TOTALS						
	1228.	6.9872	1.3897	.0661	1263.3235	60.1054

Table 5. Summary of plant biomass for winter range sites of Dall Sheep, Crescent Mountain, Alaska (page 1 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
BRSP	10.	.0054	.0015	.0005	1.3745	.4598
CAREX	303.	.1536	.0445	.0034	40.4919	3.0896
FEBR	58.	.0215	.0080	.0013	7.2426	1.2080
HIAL	110.	.0187	.0080	.0010	7.3077	.8893
LUSP	9.	.0028	.0008	.0004	.7593	.3563
POAS	73.	.0455	.0127	.0021	11.5874	1.8763
TRSP	36.	.0204	.0043	.0015	3.8989	1.3608
TOTGR	599.	.2679	.0799	.0045	72.6623	4.0924
ACDE	1.	.0005	.0001	.0001	.1289	.1289
ANNA	81.	.0280	.0076	.0011	6.8764	1.0328
ANSP	1.	.0005	.0001	.0001	.0864	.0864
ARAR	66.	.0261	.0057	.0009	5.2152	.8291
ARRU	5.	.0070	.0025	.0012	2.2945	1.0623
ARSP	7.	.0043	.0013	.0006	1.1738	.5293
CALA	136.	.0356	.0082	.0008	7.4399	.7500
CEAR	10.	.0011	.0002	.0001	.2045	.0706
CESP	9.	.0027	.0005	.0002	.4909	.1950
DILA	2.	.0006	.0002	.0002	.2204	.1534
DROC	140.	.1861	.0633	.0065	57.5373	5.8648
EPAN	20.	.0287	.0066	.0019	5.9959	1.7349
EPLA	7.	.0110	.0025	.0013	2.3071	1.1490
FERN	1.	.0002	.0000	.0000	.0332	.0332
GEER	12.	.0071	.0019	.0006	1.7525	.5442
MIMA	42.	.0238	.0059	.0012	5.4036	1.1081
MOSS	59.	.0091	.0082	.0021	7.4103	1.8698
MYAL	1.	.0010	.0003	.0003	.2577	.2577
OXYTR	92.	.0313	.0085	.0016	7.6852	1.4858

Table 5 (con't). Summary of plant biomass for winter range sites of Dall Sheep, Crescent Mountain, Alaska (page 2 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES 1000 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
PEFL	4.	.0098	.0029	.0017	2.6659	1.5107
PCUN	70.	.0660	.0198	.0040	17.9926	3.5984
PCVI	11.	.0018	.0004	.0001	.3309	.1323
SABR	23.	.0302	.0133	.0042	12.0728	3.8127
SALIX	183.	.1729	.0501	.0050	45.5869	4.5761
SATR	91.	.1200	.0264	.0035	24.0042	3.1847
SERU	2.	.0026	.0002	.0001	.1632	.1281
SIAC	5.	.0039	.0010	.0006	.8775	.5266
STSP	27.	.0106	.0021	.0007	1.9345	.5950
VAUL	5.	.0020	.0007	.0003	.6454	.3055
VAVI	12.	.0062	.0022	.0014	2.0432	1.2831
UNKF	3.	.0012	.0003	.0002	.2835	.1688
TOTFB	1119.	.8319	.2432	.0118	221.1144	10.7051

= SUMMARY TOTALS =

	1718.	1.0999	.3232	.0130	293.7768	11.6095

Table 6. Summary of plant biomass for summer feeding sites of Dall Sheep, Crescent Mountain, Alaska (page 1 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES ~~1000~~ 400 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
CACA	4.	.0092	.0027	.0018	2.4287	1.6717
CAREX	290.	.9056	.2626	.0155	238.7458	14.0603
FEBR	1.	.0002	.0001	.0001	.0486	.0466
HIAL	28.	.0182	.0051	.0016	4.6327	1.4101
JUSP	15.	.0087	.0027	.0007	2.4553	.6752
LUSP	73.	.1674	.0385	.0052	35.0018	4.6874
POAS	24.	.0249	.0075	.0016	6.8011	1.4779
TRSP	15.	.0178	.0051	.0016	4.6809	1.4810
TOTGR	440.	1.1520	.3243	.0179	294.7950	16.2716
ANNA	34.	.0434	.0087	.0020	7.8932	1.8100
ANSP	10.	.0068	.0008	.0003	.7440	.3043
ARAR	92.	.2473	.0445	.0057	40.4624	5.1718
CALA	7.	.0024	.0001	.0000	.0886	.0365
CEAR	3.	.0015	.0002	.0001	.1691	.1012
CESP	0.	0.0000	0.0000	0.0000	0.0000	0.0000
DILA	13.	.0370	.0137	.0049	12.4320	4.4596
DROC	4.	.0139	.0049	.0031	4.4267	2.6201
EMNI	0.	0.0000	0.0000	0.0000	0.0000	0.0000
EPPA	0.	0.0000	0.0000	0.0000	0.0000	0.0000
GEGL	2.	.0076	.0009	.0007	.8343	.6160
LUPE	81.	.2412	.0699	.0100	63.5891	9.0727
LYCO	2.	.0035	.0013	.0012	1.1953	1.0561
MIMA	5.	.0100	.0054	.0031	4.9091	2.8453
MOSA	0.	0.0000	0.0000	0.0000	0.0000	0.0000
MOSS	116.	.2015	.0766	.0091	69.6246	8.3118
OXYTR	20.	.0180	.0031	.0008	2.7749	.7078
PESP	1.	.0093	.0019	.0019	1.6932	1.6932

Table 6 (con't). Summary of plant biomass for summer feeding sites of Dall Sheep, Crescent Mountain, Alaska (page 2 of 2 summary pages). 1972

SPECIES	NO. OCCURRENCES ~~1000~~ 400 PLOTS	MEAN FIELD WT/PLOT GM/100 CM SQ	MEAN DRY WT/PLOT GM/100 CM SQ	+/- S.E. OF MEAN DRY WT/PLOT GM/100 CM SQ	MEAN DRY WT LB/ACRE	+/-S.E. OF MEAN DRY WT LB/ACRE
POAC	6.	.0104	.0018	.0009	1.6065	.8131
POUN	1.	.0007	.0001	.0001	.1350	.1350
POVI	42.	.0409	.0045	.0009	4.0882	.8533
PYSP	2.	.0010	.0001	.0001	.0987	.0814
RAES	1.	.0003	.0001	.0001	.0675	.0675
SALIX	142.	.3314	.0994	.0104	90.3907	9.4597
SATR	6.	.0333	.0103	.0051	9.3930	4.6199
SERO	40.	.1163	.0081	.0015	7.4036	1.3325
TAOF	4.	.0027	.0002	.0001	.1500	.0804
THSP	42.	.0846	.0237	.0052	21.5244	4.7472
VAVI	86.	.1818	.0636	.0076	57.8439	6.8977
VAUL	4.	.0082	.0032	.0019	2.8931	1.7263
VEWO	13.	.0116	.0006	.0002	.5274	.1859
UNKF	45.	.0778	.0109	.0020	9.9025	1.8121
TOTFB	824.	1.7445	.4585	.0208	416.8608	18.9452
SUMMARY TOTALS	1264.	2.8966	.7828	.0267	711.6559	24.2567

Appendix II

List of symbols and names for plants from Surprise Mountain, Slaughter Mountain, and Crescent Mountain, Alaska, as used in 1972 data.

Symbols	Scientific Names	Surprise Mountain	Slaughter Mountain	Crescent Mountain
ACBO	*Achillea borealis*	X	X	0
ABDE	*Aconitum delphinifolium*	0	X	X
AGSP	*Agropyron spicatum*	X	X	0
ALIN	*Alnus incana*	0	X	0
ANNA	*Anemone narcissiflora*	X	X	X
ANPA	*Antennaria pallida*	X	X	0
ANSE	*Androsace septentrionalis*	0	X	0
ANSP	*Antennaria* sp.	X	X	X
ARAR	*Artemisia arctica*	X	X	X
ARRU	*Arctostaphylos rubra*	X	X	X
ARSP	*Arnica* sp.	X	0	X
ARUU	*Arctostaphylos uva-ursi*	X	X	0
BENA	*Betula nana*	X	X	0
BRSP	*Bromus* sp.	X	X	X
CACA	*Calamagrostis canadensis*	X	X	0
CALA	*Campanula lasiocarpa*	X	X	X
CAREX	*Carex* sp.	X	X	X
CARO	*Campanula* sp.	0	0	0
CAST	*Cassiope* sp.	X	X	X
CEAR	*Cerastium arvense*	0	X	X
CESP	*Cetraria* sp.	X	X	X
COCA	*Cornus canadensis*	X	0	0
DILA	*Diapensia lapponica*	X	X	X
DRIN	*Dryas integrifolia*	X	X	0
DROC	*Dryas octopetala*	0	0	X
DRSP	*Dryas* sp.	0	X	0
EMNI	*Empetrum nigrum*	X	X	X
EPAN	*Epuilobium angustifolium*	X	X	X
EPLA	*Epilobium latifolium*	X	X	X
EPPA	*Epilobium palustre*	0	X	X
EQSP	*Equisetum* sp.	X	0	0
FEAL	*Festuca altaica*	X	X	X
FEBR	*Festuca brachyphylla*	X	X	X
FERN	Fern	0	X	X
FERU	*Festuca rubra*	X	X	0
FESP	*Festuca* sp.	0	X	0
GEER	*Geranium erianthum*	X	X	X
GEGL	*Gentiana glauca*	X	X	X
GESP	*Geum* sp.	X	0	0
HEMLOCK	*Tsuga mertensiana*	0	0	0
HIAL	*Hierochloe alpina*	X	X	X
HITR	*Hierocium triste*	X	0	0
JUCO	*Juniperus communis*	0	X	0

Appendix II (cont'd.)

Symbols	Scientific Names	Surprise Mountain	Slaughter Mountain	Crescent Mountain
JUSP	*Juncus* sp.	0	X	X
LEPA	*Ledum palustre*	X	X	X
LIBO	*Linnaea borealis*	X	X	0
LUNO	*Lupinus nootkantensis*	0	X	0
LUPE	Unknown forb 7	X	X	X
LUSP	*Luzula* sp.	X	0	X
LYCO	*Lycopodium* sp.	X	X	X
LYSP	*Lycopodium* sp.	X	0	0
MIMA	*Minuartia macrocarpa*	X	X	X
MOSA	*Montia sarmentosa*	0	0	X
MOSS	Moss	X	X	X
MYAL	*Myosotis alpestris asiatica*	0	X	X
OXYTR	*Oxytropis* sp.	X	X	X
PEFL	*Pentaphylloides floribunda*	0	X	X
PELA	*Pedicularis labridorica*	X	X	0
PESP	*Pedicularis* sp.	X	X	X
PHLE	*Phleum* sp.	X	0	0
POAC	*Polemonium acutifolum*	0	0	X
POAS	*Poa* sp.	X	X	X
POUI	*Potentilla uniflora*	0	0	0
POVI	*Polygonum viviparum*	X	X	X
PYSP	*Pyrola* sp.	X	X	X
RAES	*Ranunculus eschscholtzii*	X	X	X
RANU	*Ranunculus* sp.	0	0	0
ROSA	*Rosa* sp.	0	X	0
ROSP	*Rosa* sp.	0	X	0
RUCH	*Rubus chamaemorus*	X	0	0
RUSP	*Rubus* sp.	0	X	0
SABR	*Saxifraga bronchialis*	X	X	X
SALIX	*Salix* sp.	X	X	X
SAST	Unknown forb 3	X	X	0
SATR	*Saxifraga tricuspidata*	X	X	X
SERO	*Sedum rosea*	X	X	X
SIAC	*Silene accaulis*	0	X	X
SOMU	*Solidago multiradiata*	0	X	0
SPBE	*Spiraea beauverdiana*	X	0	0
STSP	*Stereocaulon* sp.	X	X	X
TAOF	*Taraxicum officinale*	0	0	X
THSP	*Thalictrum sparsiflorum*	0	X	X
TOTFB	Total forbs	X	X	X
TOTGR	Total grasses	X	X	X
TREU	Unknown forb 4	0	X	0
TRIF	*Trifolium* sp.	0	X	0
TRSP	*Trisetum spicatum*	X	X	X
TSME	*Tsuga mertensiana*	X	0	0
UNKF	Unknown forb	X	X	X

Appendix II (cont'd.)

Symbols	Scientific Name	Surprise Mountain	Slaughter Mountain	Crescent Mountain
UNKFB	Unknown forb	0	0	0
UNKG	Unknown grasses	X	0	0
URGU	*Urtica gracilis*	0	X	0
VAUL	*Vaccinium uliginosum*	X	X	X
VAVI	*Vaccinium vitus-idaea*	X	X	X
VERA	*Veratrum* sp.	X	X	0
VESP	*Veronica* sp.	0	X	0
VEWO	*Veronica wormskjoldii*	0	X	X
VISP	*Viola* sp.	0	X	0

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Carol Ericson and Kenneth A. Neiland

Project Nos.: W-17-4 & W-17-5

Project Title: Big Game Investigations

Job No.: 6.6R

Job Title: Dall Sheep Diseases and Parasites

Period Covered: January 1, 1972 to December 31, 1972

SUMMARY

Thirteen Dall sheep were collected from the vicinity of the Dry Creek mineral lick in the central Alaska Range during 1972. Detailed examination of their gastrointestinal tracts revealed nearly 22,000 nematodes: 17,000 trichostrongylids (Strongylorida:Trichostrongylidae), 4,670 pinworms (Ascaridorida:Oxyuridae) and 160 whipworms (Dorylaimorida: Trichuridae). The burdens of individual animals ranged from 250 to 7,550 nematodes. One of ten sheep examined for lump jaw displayed abcesses, and all six sheep examined for lungworm infection were positive. Further work on specimens from these animals will be continued in 1973.

CONTENTS

BACKGROUND

The parasites of Alaska's Dall sheep (*Ovis dalli*) have been examined in very few studies; these studies are listed in Neiland's 1971 Sheep Disease Studies Progress Report. In previous progress reports (1962, 1965, 1968, 1969 and 1971) Neiland has discussed various disease conditions and parasites he has found in sheep, including lump jaw, lungworm pneumonia and coccidia. Collected but still unidentified are numerous trichostrongylid worms and also some whipworms from Wrangell and Chugach Mountains sheep and from Kenai Peninsula sheep.

While trichostrongylids are known to be the most important and most pathogenic parasites of domestic sheep and goats (Levine, 1968), their effect on wild sheep populations has not been investigated. Trichostrongylids have also been collected from caribou (*Rangifer tarandus*), moose (*Alces alces*), bison (*Bison bison*), black-tailed deer (*Odocoileus hemionus sitchensis*), muskoxen (*Ovibos moschatus*) and arctic hares (*Lepus othus*) in Alaska. It is important that these parasites be precisely identified so as to ascertain their current and potential impact on Alaskan wildlife populations and particularly on productivity and mortality of Dall sheep.

OBJECTIVES

To identify the species and determine the incidence and distribution of potential pathogens in Dall sheep.

To develop efficient techniques for recovering, identifying and estimating the population of these potential pathogens.

To determine the extent to which these potential pathogens contribute to mortality or lower productivity of Dall sheep.

PROCEDURES

This year a total of 13 Dall sheep were collected at or in the vicinity of the Dry Creek mineral lick in the central Alaska Range. One sheep was taken in March, one in April, four in May, two in June, three in July and two in November. All sheep were necropsied and the gastrointestinal tract of each animal was examined in detail. The lungs and jaws were grossly examined; the lungs, livers and hearts were stored for further, more detailed, examination.

FINDINGS

Recovery Techniques

The gastrointestinal contents of six sheep (Table 1) were washed carefully from the organs and preserved and dilutions were examined under a strong light against a black background so that any tiny helminths could be washed out and recovered. Since this procedure involved nearly ten working days to examine the entire tract contents of one sheep, a new, faster technique was developed and evaluated. The remaining seven sheep (Table 1) were examined utilizing this "separate spray sieve technique".

While the abomasum and duodenum can easily be examined directly, as described above, the separate spray sieve technique is more efficient for recovering small helminths from the voluminous, bulky contents of the small intestine, caecum and colon of large herbivores. Part of the preserved contents of each organ are poured into the first sieve, #10 (mesh 2.0 mm) and washed with a gentle spray of water while the sieve and its contents, partially immersed in the through-wash, are swirled around. The through-wash is successively passed in the same way through sieves #18 (mesh 1.0 mm) and #45 (mesh 0.335 mm). Then it is only necessary to carefully examine the semi-clear, diluted backwashes of each sieve under a strong light against a black background to find the small helminths. For the seven sheep examined with this technique, the recovery rate was greater than approximately 90 percent of the total helminths present (i.e. less than 10 percent of the parasites pass through all three sieves in the series). This recovery rate is in agreement with Soulsby's (1965) statements about sieve sizes for helminth work.

If these sieve backwashes are sampled as described by Clark et. al. (1971), the number of nematodes can quickly be estimated with known standard deviation. Such estimates of total numbers will be valuable in future monitoring of sheep gastrointestinal parasite burdens once the identities of the species commonly involved have been determined by examining the specimens collected this year. Since no work has been done previously on the gastrointestinal fauna of Dall sheep, it was felt that all helminths present should be recovered and identified in this pilot study, rather than taking samples and estimating the entire burden, so as to detect species which happened to be present in very low numbers in 1972.

Gastrointestinal Parasite Burdens

A total of about 22,000 small helminths, all nematodes (17,000

Table 1. Gastrointestinal helminth burden, 1972 Dry Creek sheep.

No.	Autopsy No.	Date Collected	Sex	Age Yrs.	Body Wt. (lbs.)	Repro. Condition	Exam** Technique	Number of Tricho-strongylids	*Skrjabinema* sp.	*Trichuris* sp.	Other Parasites	Total Helminths
1	3559	Mar 20	F	4	88	lactate	direct	740	–	0	lungworms	740
2	3575	Apr 1	F	1	?*		direct	(70)*	–	17	?	(90)*
3	3581	May 4	F	1	62	non-preg.	sieve	905	360	44	lungworms	1310
4	3578	May 5	F	4	80	non-preg.	direct	855	140	28	lungworms	1005
5	3579	May 5	F	7	92	non-preg.	sieve	2060	290	4	lungworms	2350
6	3580	May 5	F	7	109	pregnant	sieve	5170	2390	3	lungworms	7560
7	3623	Jun 5	F	1	67	non-preg.	direct	320	140	2	lump jaw, ?	465
8	3624	Jun 5	F	13	105	pregnant	direct	650	545	6	lungworms	1200
9	3695	July 11	M	1	55		sieve	1575	55	36	?	1670
10	3697	July 11	F	4	80	non-lactate	sieve	2435	600	13	?	3050
11	3696	July 11	F	11	107	lactate	direct	125	125	0	ectoparasites, ?	250
(All July animals collected while utilizing mineral lick.)												
12	3868	Nov 17	F	3	?*	non-lactate	sieve	500	2	5	kidney cyst, ?*	510
13	3870	Nov 18	F	5	132	non-lactate	sieve	1550	15	3	?	1570
											Total:	21,770

* Only part of carcass available for necropsy.
**Method used for recovering helminths from gastrointestinal tract contents.

trichostrongylids, 4,670 pinworms and 160 whipworms), were found in the 13 gastrointestinal tracts. The burdens of individual animals ranged from 250 to 7,550 nematodes (Table 1). No clear relationships were noted between size of the burden and sheep age or condition, or mineral lick utilization. Becklund and Senger (1967), in the only rigorous investigation of small helminth numbers in wild sheep prior to this study, found similar numbers (range 307 to 5,300) of similar species in 12 Rocky Mountain bighorns (*Ovis canadensis canadensis*) in Montana.

In terms of number of individual nematodes, trichostrongylids (Strongylorida:Trichostrongylidae) accounted for 54 percent to 99 percent of the gastrointestinal nematode burdens observed, pinworms (Ascaridorida: Oxyuridae) for less than 1 percent to 45 percent, and whipworms (Dorylaimorida:Trichuridae) for 0 percent to 3 percent. While the "impact" of one larger nematode (i.e. a whipworm) is often equivalent to that of numerous individual small ones (i.e. trichostrongylids), the pathogenicity of the species involved is of far greater importance than the number of nematodes. Therefore, some time during 1973 will be spent sorting the 22,000 nematode specimens to species.

The trichostrongylids are of particular potential importance (Table 2); not only because they accounted for the majority of the infections, but also because certain species are highly pathogenic to domestic sheep, especially lambs. While trichostrongylids have been widely reported from wild sheep in both North America and Eurasia, very little work has been done to monitor their numbers in wild populations or to determine their chronic or acute effects in conjunction with range condition, climate and other parasites.

There are a few reports of both pinworms (*Skrjabinema* sp., Table 3), and whipworms (*Trichuris* sp., Table 4), in North American wild sheep. The actual species of pinworm involved has not been identified. Pinworms in particular are usually overlooked at necropsies because of their extremely small size, and prior to this investigation only a single count of the number present in one wild sheep (*Ovis canadensis*) has been reported in the literature (Allen, 1955). Recent studies by Knight and Uhazy (1973) have identified the whipworm species infecting Canadian bighorn sheep in British Columbia and Alberta. Interestingly, the only previous report of this whipworm (*Trichuris schumakovitschi*) is from domestic sheep in eastern Siberia. The effect of these nematodes on wild sheep has thus far not been studied anywhere.

Other Infections

Lump jaw and lungworm infections are common disease factors in Dall sheep, and investigations begun in previous years were continued this year to a limited extent. Of 10 of the 13 Dry Creek sheep examined for gross lesions of lump jaw in 1972, one was positive: a yearling ewe taken in July. Bacterial cultures of the extensive lesions were not made. All six Dry Creek sheep superficially examined for evidence of lungworm infection (nodules, adhesions, etc.) were apparently affected to varying degrees. Volumetric determinations of the percentages of affected lung tissue, as well as identification of the lungworm larvae

Table 2. Number of trichostrongylids, 1972 Dry Creek sheep.

No.	Autopsy No.	Month Taken	Sex	Age Yrs.	Abomasum				Duodenum				Sm. Intestine, Caecum, Colon				Total, G.I. Tract			
					M	F	Im.	Total	M	F	Im.	Total	M	F	Im.	Total	M	F	Im.	Total
1	3559	Mar	F	4	150	540	0	700	15	25	0	0	0	0	0	0	265	565	0	740
2	3575	Apr	F	1				*	10	30	1	40	10	20	0	*	20	50	2	(70)*
3	3581	May	F	1	310	300	0	610	140	85	0	220	30	45	0	75	480	430	0	905
4	3578	May	F	4	300	400	0	700	45	60	0	105	30	20	0	50	375	480	0	855
5	3579	May	F	7	750	830	75	1660	240	55	70	365	15	10	10	35	1005	895	155	2060
6	3580	May	F	7	930	1000	100	2030	250	370	5	620	720	900	900	2521	1900	2270	1005	5170
7	3623	June	F	1	120	110	0	230	20	25	1	50	15	25	0	40	155	160	1	320
8	3624	June	F	13	200	300	0	500	60	35	10	110	15	20	2	40	275	355	12	650
9	3695	July	M	1	600	870	20	1500	25	30	0	60	15	5	0	20	640	905	20	1575
10	3697	July	F	4	1010	1015	10	2040	55	30	7	90	240	40	30	310	1305	1085	47	2435
11	3696	July	F	11	40	85	0	120	1	5	0	5	0	0	0	0	41	90	0	125
12	3868	Nov	F	3	190	275	15	480	0	0	0	0	0	0	23	23*	275	190	15	(500)*
13	3870	Nov	F	5	315	420	0	735	30	35	8	75	350	250	150	740	695	705	158	1550
																			Total:	16,960

* Only part of carcass available for necropsy.
**Totals are not actual sums because of rounding off.

Table 3. Number of pinworms (*Skrjabinema* sp.), 1972 Dry Creek sheep.

No.	Autopsy No.	Month Taken	Sex	Age Yrs.	Duodenum, Sm. Intestine			Caecum			Colon			Total**		
					M	F	Total	M	F	Total	M	F	Total	M	F	Total
1	3559	March	F	4												) *Skrjabinema* unnoticed
2	3575	April	F	1												)
3	3581	May	F	1	0	0	0	140	135	270	60	30	90	200	160	360
4	3578	May	F	4	0	0	0	?*	90	90	?*	50	50	?*	140	(140)*
5	3579	May	F	7	4	2	6	150	60	210	40	35	75	200	90	290
6	3580	May	F	7	2	3	5	1880	360	2240	60	80	140	1940	450	2390
7	3623	June	F	1	0	0	0	0	130	130	0	11	11	0	140	140
8	3624	June	F	13	0	4	4	45	440	485	0	60	60	45	500	545
9	3695	July	M	1	0	0	0	8	30	35	5	15	20	10	45	55
10	3697	July	F	4	1	8	10	3	180	180	0	415	415	4	600	605
11	3696	July	F	11	0	0	0	50	15	70	30	30	60	80	45	125
12	3868	Nov	F	3	0	0	0	1	1	2	0	0	0	1	1	2
13	3870	Nov	F	5	0	0	0	7	7	15	0	0	0	7	7	15
															Total:	4,670

* *Skryabinema* males were not noticed.
**Totals are not actual sums because of rounding off.

Table 4. Number of whipworms (*Trichuris* sp.), 1972 Dry Creek sheep.

No.	Autopsy No.	Month Taken	Sex	Age Yrs.	Caecum	Colon	Total
1	3559	March	F	4	0	0	0
2	3575	April	F	1	0	17	(17)*
3	3581	May	F	1	34	10	44
4	3578	May	F	4	8	20	28
5	3579	May	F	7	1	3	4
6	3580	May	F	7	2	1	3
7	3623	June	F	1	2	0	2
8	3624	June	F	13	6	0	6
9	3695	July	M	1	32	4	36
10	3697	July	F	4	11	2	13
11	3696	July	F	11	0	0	0
12	3868	Nov	F	3	0	5	5
13	3870	Nov	F	5	2	1	3
						Total:	161

*Entire carcass not available for autopsy.

and adults involved, will be made in 1973.

Fecal pellets were removed from the rectums of 12 of the sheep and will be evaluated in 1973 for their content of nematode eggs, coccidia and lungworm larvae.

CONCLUSIONS

The "separate spray sieve technique" is a rapid and efficient means of recovering small helminths from the contents of the intestines and caecae of large herbivores.

Dall sheep at Dry Creek are supporting light to medium gastro-intestinal helminth burdens of trichostrongylids, whipworms and pinworms. The species involved should be identified to determine their current and potential effect on the health of the population.

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