72-74

ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

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SHEEP REPORT

by
Lyman Nichols

Volume XV
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-5, Jobs 6.3R, 6.4R, 6.5R and 6.7R (2nd half) and
Project W-17-6, Jobs 6.3R, 6.4R, 6.5R and 6.7R

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Lyman Nichols		
Project No.:	W-17-5 W-17-6	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 June 30, 1974.

SUMMARY

The Dall sheep herd on Crescent Mountain was reduced by a known 21 animals through a public either-sex hunt in the fall of 1973. Adult-ram-only hunting continued on Surprise Mountain, and no hunting occurred in the Cooper Landing Closed Area.

Analyses of seasonally-collected sheep fecal pellets from each of the three herds under study are presented as an indicator of herd food habits. The grasses *Festuca altaica* and *F. rubra* and sedges, *Carex* spp., were found to be the most important plant species in the gross annual diets.

Measurements of snow depth and hardness around sheep feeding craters have enabled the preliminary determination of the limits of these parameters which affect sheep digging, and hence feeding ability in snow. These data are presented.

Attempts to further document sheep breeding behavior on Surprise Mountain met with failure due to early snow cover which adversely affected herd movements. Lambing progression was effectively charted by replicate aerial surveys. Lambing commenced just before May 5 in Cooper Landing Closed Area and probably just after that on Crescent Mountain, while not until about May 10 on Surprise Mountain. It appeared to peak between May 15 and 20 on Surprise Mountain, between May 18 and 25 on Crescent Mountain, and about May 22 or 23 in the closed area.

Population models, based on replicate aerial surveys, were constructed for each herd. Lamb production, shown by the ratio of lambs per 100 females, was found to be as follows: Crescent Mountain - 44:100; Surprise Mountain - 39:100; Cooper Landing Closed Area - 50:100. Total herd sizes, estimated in the same order, were: 268, 213 and 312. Over-winter lamb and herd mortalities from 1972 to 1973 were found to be lower on Crescent Mountain than in either of the other areas. Lowered mortality and increased lamb production on Crescent Mountain may be related to deliberate herd reduction on that mountain.

Specimens of forage plants collected during the winter from sheep winter feeding sites were analyzed for their nitrogen, total available carbohydrates and gross energy content. Composite values for all components declined significantly from those found in plants collected from the same sites during the summer. No differences could be found in composite values for the three components between areas.

Wind and temperature data were obtained from recording weather stations in each of the three areas and were analyzed on a monthly and seasonal basis. The average annual climate was characterized by higher winds and lower temperatures on Crescent Mountain than on Surprise Mountain, with even lower winds and higher temperatures on Slaughter Mountain in the closed area.

Snow surveys were conducted on each area in January 1974, and analysis of these data showed that snow was significantly shallower on Crescent Mountain than on the other mountains, which were similar to each other in depth. Snow was significantly harder on Surprise Mountain than on Crescent Mountain, and harder on Crescent than on Slaughter Mountain. These data were also compared with those found during the previous winter.

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 sustainable 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 additon 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 initially seemed 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

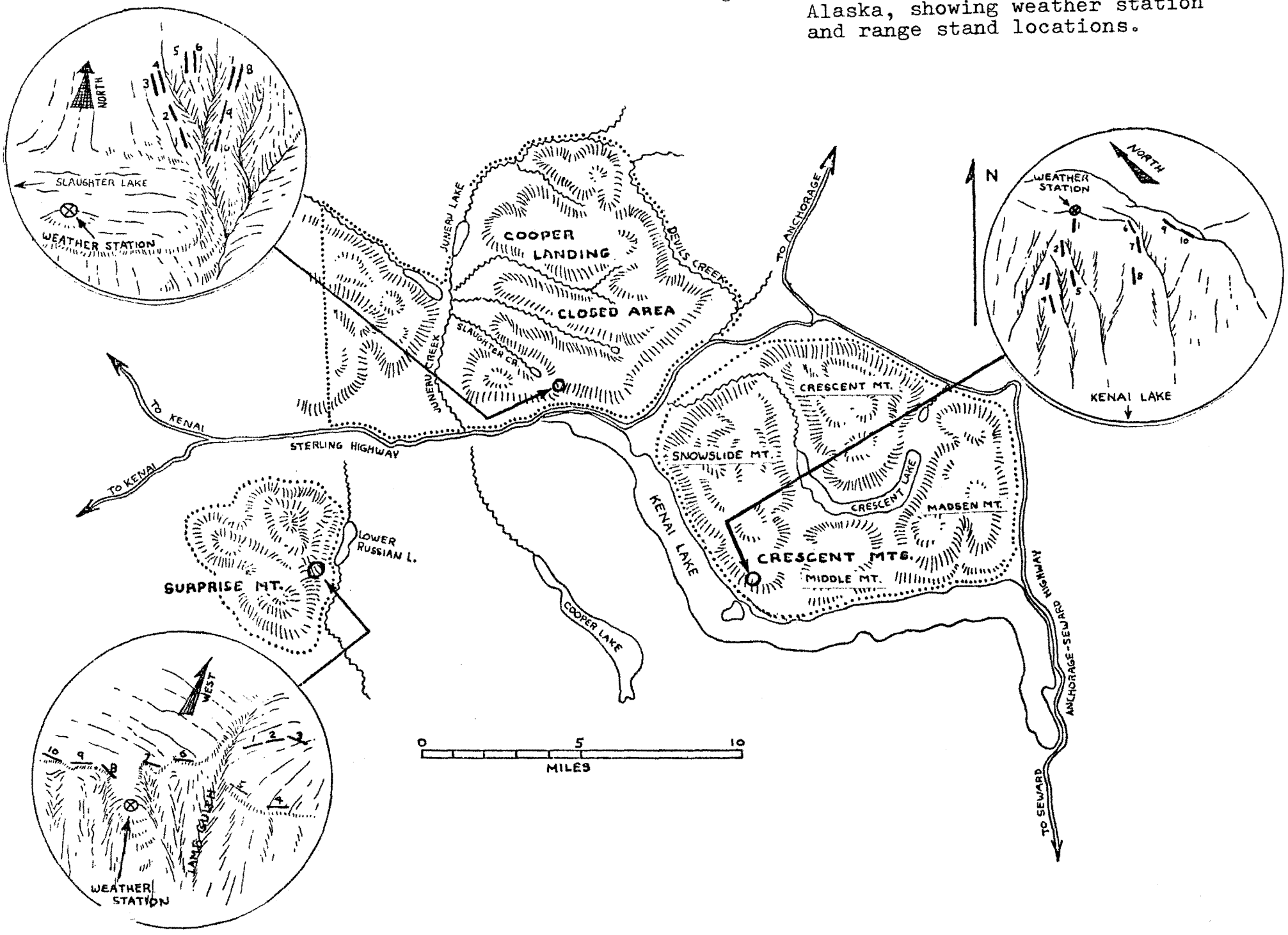


Fig. 1. Sheep study areas, Kenai Peninsula, Alaska, showing weather station and range stand locations.

reached the legal status of 3/4-curl. The Cooper Landing Closed Area is, 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, served to hold the herd at the desired level of about 200 sheep through 1972.

Low mortality during the winter of 1972-73, and a good lamb crop in the spring of 1973 allowed the herd to increase to over 260 animals. Another public hunt was held in the fall of 1973 in an attempt to reduce the herd. Seventy-five permits for one sheep with horns of 1/2-curl or less were issued, and 19 sheep were taken (14 females and 5 males). Two more animals were known to have been killed illegally bringing the pre-winter population to approximately 247 animals.

The Surprise Mountain herd will continue to be hunted for rams only 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.

Portions of the study (Jobs No. 6.3R and 6.4R) have been completed but will be continued one more year for the writing of final reports only. It is anticipated that several more years will be required before conclusions can be drawn with reasonable certainty about the effects of either-sex hunting and herd reduction on the Crescent Mountain sheep herd. Jobs No. 6.5R and 6.7R will be continued to enable monitoring of the populations and habitats involved until the experiment is ended.

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 Mountian, Cooper Landing Closed Area and Surprise Mountain, Kenai Peninsula.

PROCEDURES

Winter Food Habits and Body Condition

Sheep fecal pellets, collected from each of the three study areas during the last segment and submitted to Dr. R.M. Hansen, Colorado State University, were analyzed by the method described by Sparks and Malechek (1968) and Todd and Hansen (1973). Gross seasonal herd diets are indicated by the results of these analyses.

Snow measurements adjacent to sheep feeding craters were continued as described in the previous progress report (Nichols 1973), with emphasis on those craters where sheep appeared unable or only partially able to paw through to the vegetation beneath. Data were then examined graphically to assess the relationship between snow condition and feeding ability.

Productivity

A camp was manned on Surprise Mountain from November 15 to December 14, 1973, and observations of sheep breeding behavior were attempted throughout the period. The method used to describe and record behavior was described previously (Nichols and Heimer 1972).

Replicate aerial counts were again conducted throughout May and June 1973 on the three study areas to determine chronology of lambing. These counts were flown in the same manner as described previously (Nichols and Heimer 1972). All sheep were classified as "adults" (non-lambs) or "lambs" (new lambs) with the data 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

Specimens of plants found to be important in Dall sheep diets were collected in late winter on each of the study areas from sites used by sheep in winter. These were shipped to Dr. Hansen and analyzed under special contract for their content of nitrogen, total available carbohydrates and gross energy.

The three self-contained weather stations installed under a previous segment were maintained. Recorded data on wind direction and 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 winter of 1973-74. 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

Winter Food Habits and Body Condition

Results of the microhistological analyses of the seasonally collected sheep fecal pellets from each study area are presented in Tables 1, 2 and 3. Samples were compounded from up to 50 pellet groups in each collection and the diets as listed represent gross herd food habits by area and season: summer, mid-winter, late-winter and early spring.

Errors in plant identification were found in earlier rumen/fecal analyses (Nichols and Heimer 1972) and results of the current work are not directly comparable with them as yet. Further laboratory work is underway to correct these errors if possible, and complete data and discussions will be presented in the final report covering this job.

Examination of Table 1 shows that on Crescent Mountain grasses and grass-like plants (primarily *Festuca altaica, Carex* spp. and *Festuca rubra*) made up most of the animals' diet except in mid-winter when they were replaced in importance by lichens. Browse and forbs (mostly *Salix, Erigeron* and *Dryas* spp.) comprised a relatively small portion of the diet in this area.

On Surprise Mountain (Table 2), grasses and grass-likes again formed the major portion of the diet except in mid-winter when overshadowed by the consumption of lichens and mosses. *F. altaica, F. rubra* and *Carex* spp. appear to be the most important of the grasses and grass-like plants. In late winter, consumption of grasses increased somewhat and consumption of lichens decreased, but mosses made up almost one-fifth of the diet. It is possible that mosses were taken incidentally to other species during feeding since many of the choice forage plants protrude through moss. When selected species are grazed close to their bases, as they often are in late winter, considerable moss may be consumed accidentally. Browse and forbs (again mostly *Salix, Dryas* and *Erigeron* spp.) were more important in the diet than on Crescent Mountain, making up almost 30 percent of the forage eaten in late summer and late winter, and 20 percent in mid-winter.

Table 3 shows that the same three grasses and grass-likes were the most important of the plants eaten throughout the year on Slaughter Mountain in the closed area, with browse - primarily *Salix* spp. augmented by *Dryas* spp. in mid-winter - being of lesser importance. Lichens were eaten more in late winter than in other seasons.

Table 1. Foods of Dall sheep from Crescent Mt. as determined by microhistological examination of fecal samples.

Species	Percent in diet			
	Aug. 1972	Feb. 1973	Apr. 1973	June 1973
Carex spp.	66.12	8.69	17.37	23.14
Festuca rubra	7.04	2.61	9.77	14.99
Festuca altaica	11.02	25.37	50.14	56.95
Trisetum spicatum	--	.09	--	--
Other grasses/grass likes	--	.64	.46	.40
Total grasses/grass likes	84.18	37.40	77.74	95.48
Dryas spp.	1.10	2.31	3.63	--
Empetrum nigrum	.77	--	.11	--
Erigeron spp.	--	1.00	4.87	.50
Salix spp.	5.79	9.26	4.62	1.31
Tsuga mertensiana	--	.09	--	.20
Vaccinium vitis-idaea	1.43	.44	.46	--
Other forbs & browse	1.32	1.64	.57	1.20
Total forbs & browse	10.41	14.74	14.26	3.21
Mosses	4.09	5.52	4.37	1.31
Lichens (*Cladonia* spp.)	1.32	42.35	3.63	--

Table 2. Foods of Dall sheep from Surprise Mt. as determined by microhistological examination of fecal samples.

Species	Percent in diet			
	Aug. 1972	Feb. 1972	Apr. 1973	June 1973
Carex spp.	31.80	11.37	12.04	6.54
Festuca rubra	10.40	9.72	7.05	10.93
Festuca altaica	14.39	14.20	24.26	65.42
Poa spp	--	.68	--	--
Other grasses/grass likes	--	.10	--	--
Total grasses/grass likes	56.59	36.07	43.35	82.89
Dryas spp.	6.40	4.50	2.07	--
Empetrum nigrum	2.44	--	.56	--
Erigeron spp.	2.70	1.18	4.24	2.93
Salix spp.	15.43	12.43	19.54	8.83
Tsuga mertensiana	--	.58	1.72	.18
Vaccinium vitis-idaea	1.78	.29	1.37	--
Other forbs & browse	.38	.58	.34	.35
Total forbs & browse	29.13	19.56	29.84	12.29
Mosses	8.44	14.90	19.37	3.02
Lichens (*Cladonia* spp.)	5.84	29.47	7.44	1.80

Table 3. Foods of Dall sheep from Slaughter Mt. as determined by microhistological examination of fecal samples.

Species	Percent in diet			
	July 1972	Dec. 1972	Apr. 1973	May 1973
Carex spp.	70.61	4.71	7.66	6.34
Festuca rubra	3.09	8.02	2.92	9.95
Festuca altaica	4.48	56.39	40.02	64.81
Poa spp.	.19	1.60	2.25	--
Trisetum spicatum	--	.36	--	--
Other grasses/grass likes	--	.24	.10	.10
Total grasses/grass likes	78.37	71.32	52.95	81.20
Artemisia arctica	--	.12	--	--
Dryas spp.	.75	6.89	--	--
Empetrum nigrum	1.14	.12	1.06	--
Erigeron spp.	.44	.98	1.06	.39
Salix spp.	4.09	15.58	17.05	12.41
Tsuga mertensiana	--	.36	.42	--
Vaccinium vitis-idaea	.63	.98	1.17	--
Other forbs & browse	.06	2.18	.21	.20
Total forbs & browse	7.11	27.21	20.97	13.00
Mosses	5.44	1.23	9.19	4.00
Lichens (*Cladonia* spp.)	9.08	.24	16.89	1.80

During winter, Dall sheep obtain much of their food by pawing craters through the snow and exposing the underlying vegetation. Later in the winter, the snow packs too hard for them to dig through and they then become dependent upon the scant forage exposed by the wind on open ridgetops. This vegetation is dessicated and wind-scoured and probably provides little nutrition. That covered early by snow often remains green and succulent all winter; green leaves are common in the basal clumps of *F. altaica,* for example. Thus, as long as they are able to dig through snow to the more protected and probably more nutritious forage beneath, sheep remain on a better diet and undoubtedly maintain their body reserves in reasonable condition. Once the snow hardens and they are forced to subsist only on the dried forage of windblown ridges, stored body fat is used at an accelerated rate due to a below-maintenance-level diet. The animals become less able to withstand the rigors of climate, eventually becoming weak enough to succumb to malnutrition should such winter conditions persist.

In order to learn what snow conditions limit sheep's ability to dig through to ground vegetation, a series of depth and hardness measurements were made around the perimeters of a number of feeding craters. Measurements were made around craters where sheep were able to penetrate the snow and around craters where they obviously tried to dig but were unsuccessful. Measurements were made of the snow depth in inches and the snow hardness as indicated by the force in pounds per square centimeter required to push a probe through to ground level.

Since susceptibility to digging is a function of both depth and hardness, the resulting measurements were combined for examination. With even very soft snow there is undoubtedly some point at which depth alone limits foraging ability, but no feeding attempts were found in snow deep enough to indicate that this had occurred. Most digging was in relatively shallow snow, less than one foot deep.

The sums of average depth plus average hardness of each crater measured were plotted in Fig. 2 by the number of occurrences and by whether the animal was able or unable to penetrate the snow to the ground. It can be seen that a combined depth/hardness index of less than 15 did not deter foraging. At an index between 15 and about 27, digging became more difficult, and after 27, sheep were unable to reach the ground vegetation.

Hardness of the snow appeared to be more important than depth in limiting digging in the craters observed, so the data were plotted in Fig. 3 with hardness squared to give it added weight. The resultant indices were computed by multiplying the average depth by the average hardness squared of each crater. The interface between "able to dig" and "unable to dig" appears slightly better defined with this method. Below an index of some 1200, sheep appear to have little difficulty in digging; above 2400, they were unable to do so.

Work on this method has been limited to date, and more field measurements are needed to confirm and refine its accuracy. It does seem to offer a possible means of estimating the direct effects of snow upon a sheep herd's ability to survive a given winter, however.

Fig. 2. Sheep ability and inability to dig through snow as indicated by measurements of depth and hardness (Depth + Hardness).

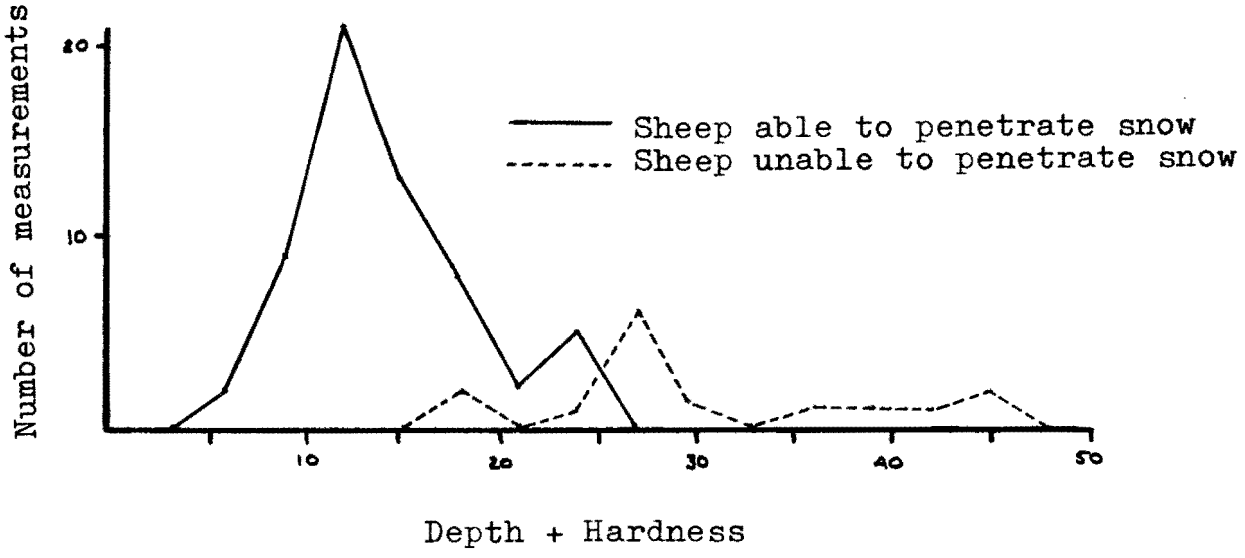
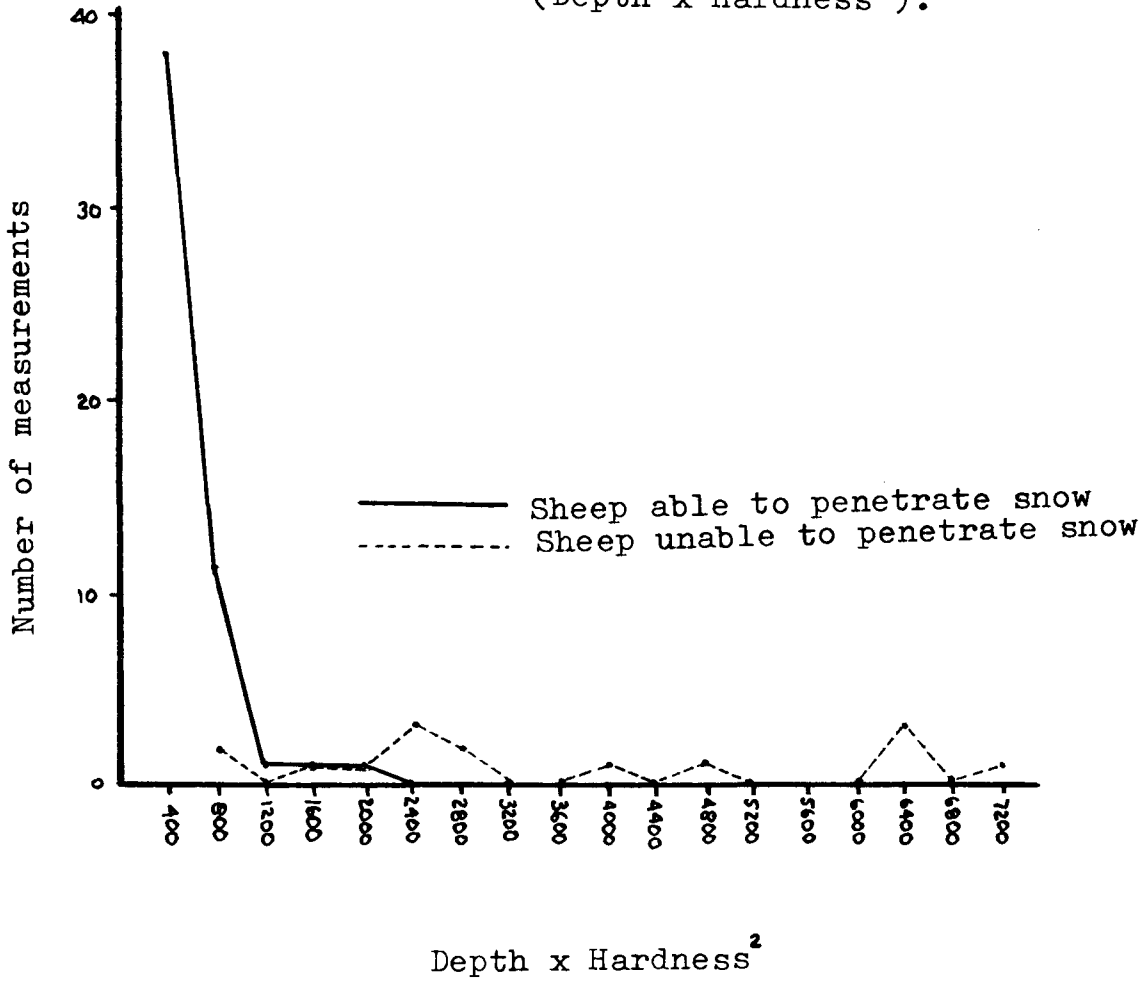


Fig. 3. Sheep ability and inability to dig through snow as indicated by measurements of depth and hardness (Depth x Hardness^2).



Productivity

A winter camp was set up and manned on Surprise Mountain throughout the sheep rutting season in 1973 and attempts were made to obtain more data on the rutting behavior of a herd in which only young rams (less than 3/4-curl horns) were present. Unfortunately, because the upper feeding ridges normally used by sheep at this time of year were covered by an unusually heavy and early snow, the sheep remained low in cliffs where forage was more available, but where the animals were not visible to an observer on the ground. Observation sites were set up almost daily from various points on the mountain, but too few sheep were ever visible to provide usable behavioral data.

Results of the lambing progression counts conducted in the spring of 1973 are listed in Table 4. 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 in Fig. 4. Since complete classification by sex and age class could not be 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 make it possible to more readily visualize the chronology of lambing on each area (Fig. 5).

The first flight was made over the closed area on May 5, at which time, two new lambs were seen indicating that lambing had just commenced. Surprise Mountain and Crescent Mountain were not flown until May 12 and 13, respectively, due to weather problems. During these flights, three lambs were seen on Surprise and seven on Crescent Mountain. Lambing had probably commenced on Surprise Mountain within a day or two, but may have commenced nearly as early on Crescent Mountain as it did in the closed area.

Fig. 5 shows that the peak in lambing was probably between May 15 and 20 on Surprise Mountain, between May 18 and 25 on Crescent Mountain, and about May 22 or 23 in the closed area. Most lambs were born by the end of May but a few stragglers arrived during the following week.

Fig. 6 presents the lambing progression curves as observed within the Crescent Mountains complex, only. The four mountains within the complex, each with its sub-herd of sheep, appear to be subject to different climatic influences during winter, which in turn, affect lambing success. Crescent and Snowslide Mountains seem to receive about the same amount of winter snowfall and wind effect. The sheep on these two mountains must have the easiest time in winter as evidenced by the timing and magnitude of lambing. Those on Middle Mountain are restricted into a smaller area due to heavier snows, and seem to have lambed later, although the sample size of the herd involved (18) may be too small for meaningful conclusions to be drawn. Madsen Mountain receives the heaviest snowfall

Table 4. Aerial lambing progression counts, 1973.

Area	Date	"Adults"*	New Lambs	Lamps per 100 "Adults"
Crescent Mt.	5/13/73	197	7	3.6
	5/23/73	176	30	17.0
	5/29/73	211	46	21.8
	6/2/73	209	48	23.0
	6/6/73	211	47	22.3
	6/10/73	217	50	23.0
	6/13/73	218	50	22.9
Surprise Mt.	5/12/73	155	3	1.9
	5/19/73	146	21	14.4
	5/23/73	156	30	19.0
	5/29/73	163	44	27.0
	6/2/73	166	44	26.5
	6/6/73	166	46	27.7
	6/10/73	167	46	27.5
	6/13/73	167	46	27.5
Closed Area	5/5/73	216	2	0.9
	5/12/73	216	9	4.2
	5/19/73	211	25	11.9
	5/23/73	218	43	19.7
	5/29/73	228	48	21.1
	6/2/73	217	51	23.5
	6/6/73	229	63	27.5
	6/9/73	223	58	26.0
	6/13/73	245	67	27.3

* "Adults" includes all non-lambs.

Fig. 4. Lambing progression by observed lambs per 100 "adults" and date, 1973.

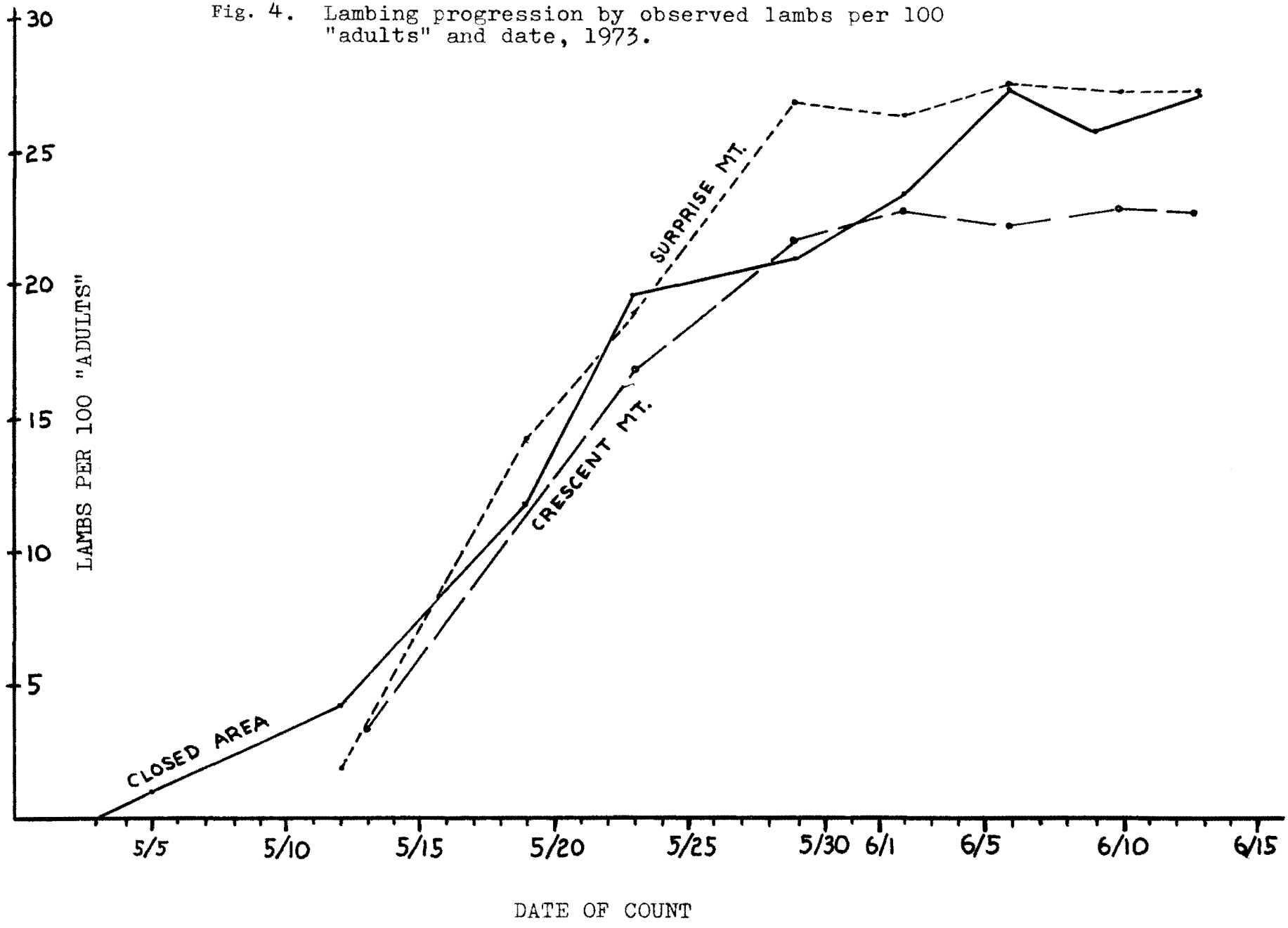


Fig. 5. Estimated lambing progression by rate of increase in lambs per 100 "adults" in 1973. (from fitted curves)

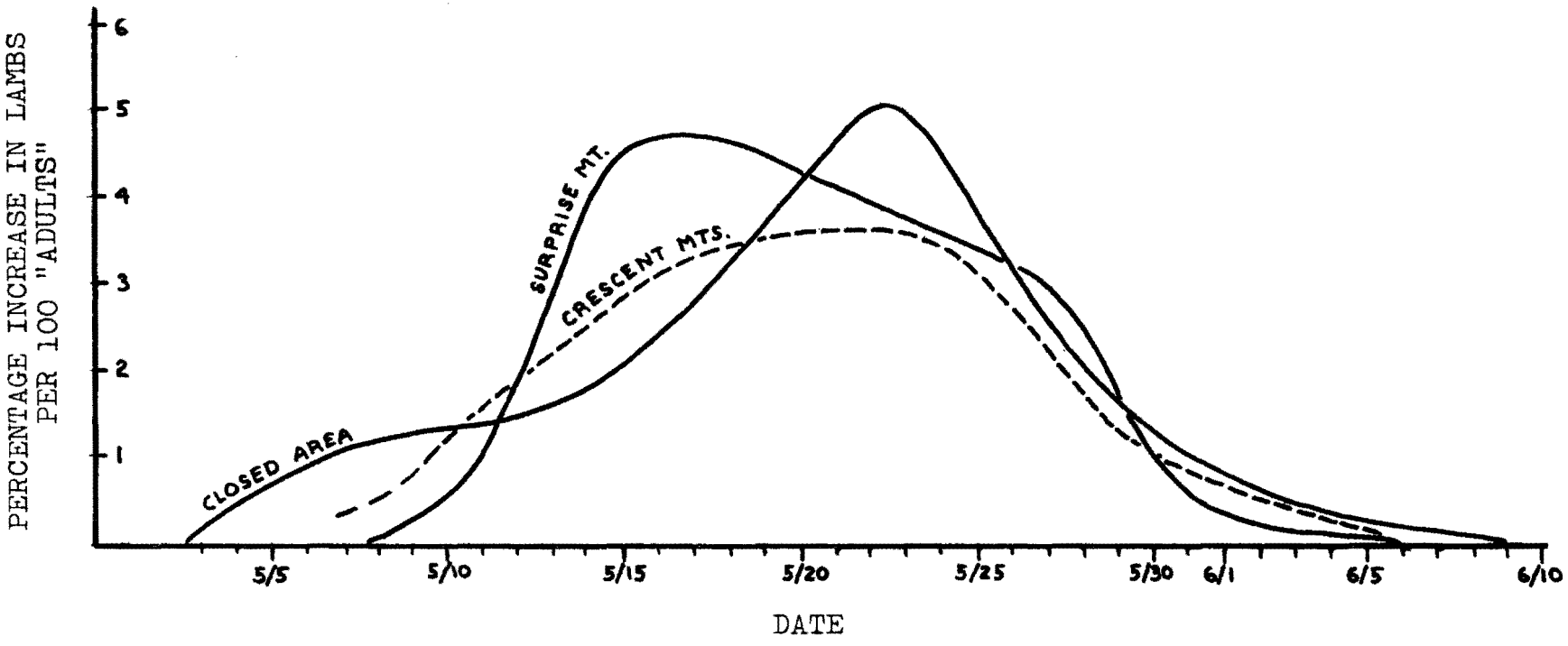
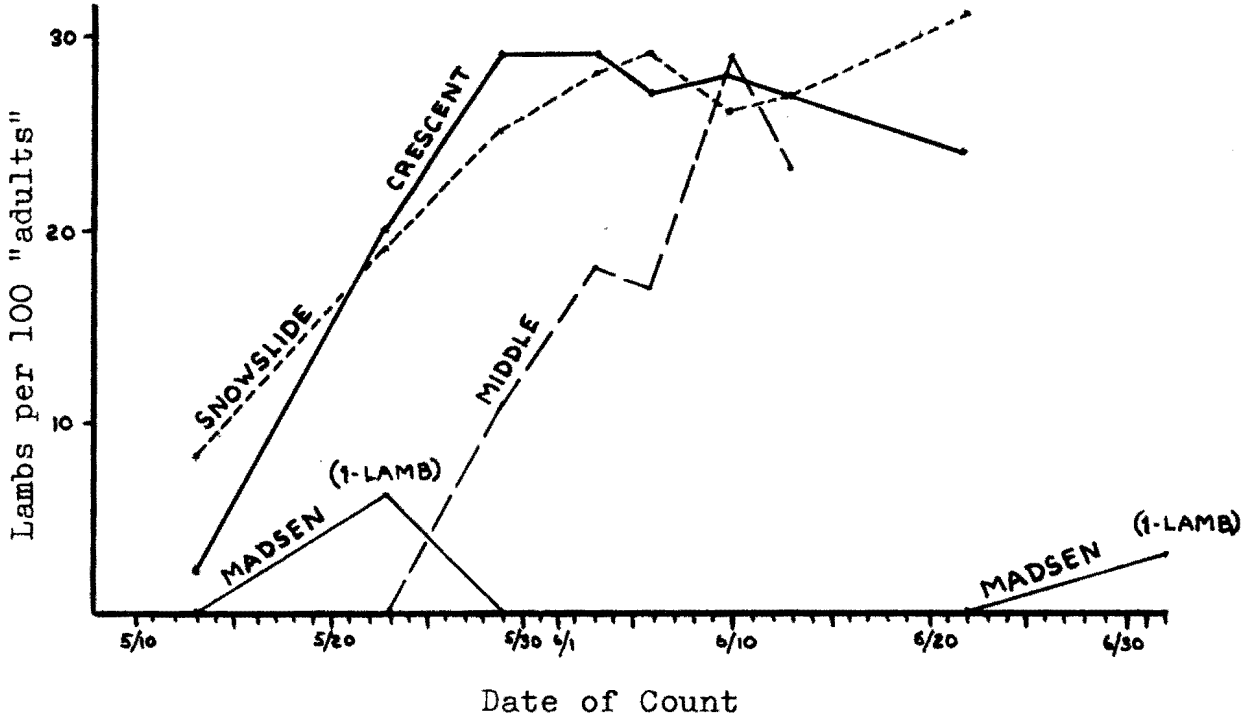


Fig. 6 . Lambing progression by observed lambs per 100 "adults" and date, 1973, Crescent Mountain Complex, only.



of the four mountains. It is the closest to the coast and is affected more by the maritime climate of Prince William Sound. Probably as a result of harsher winter conditions, lambing in this herd of some 36 sheep was very poor. Only one lamb was born early in the season, but it apparently died as it was not seen again. The only other to be seen was born after June 20. The difference in lambing success within this relatively small mountain complex illustrates the important differences in winter climate that may occur between adjacent areas within this southern edge of Dall sheep habitat, and which may allow sheep to inhabit one mountain but not survive on one nearby.

Population Trends

Listed in Table 5 are the dates and results of the main aerial surveys conducted during 1973 and early 1974. Population models, constructed from the data obtained in the several counts on each area, are presented in Table 6. These models represent the best estimates for the status of each herd in the summer of 1973.

When compared with similar models constructed for each herd in 1972 (Nichols 1973) the 1973 models show that the herd on Crescent Mountain increased by 17 percent from 229 to 268, that on Surprise Mountain increased by 6 percent from 201 to 213, and that on Cooper Landing Closed Area increased by 11 percent from 282 to 312. Lamb production on Crescent Mountain increased by 29 percent from 1972 to 1973 (34:100 ff to 44:100 ff), on Surprise Mountain by only 3 percent (from 38 to 39:100 ff), and in the closed area by 11 percent (45 to 50:100 ff).

Table 7 lists the computed number of lambs, yearlings, nonlambs and herd totals in each herd from 1971 to 1973, and shows the estimated mortalities between years. It can be seen that lamb mortality (loss of lambs over their first winter) was about the same between 1971 and 1972 on both Crescent and Surprise Mountains, and quite a bit higher in the closed area. However, between 1972 and 1973, lamb mortality decreased by 24 percent in the Crescent Mountain herd, increased by 11 percent in the Surprise Mountain herd, and decreased by only 6 percent in the closed area herd. During the 1972-73 winter lamb mortality was far lower in the Crescent Mountain herd than in either of the others.

Overall herd mortality (overwinter losses from summer one year to spring the next year, before lambing) was not too different between herds from 1971 to 1972, but decreased sharply from 1972 to 1973 in the Crescent Mountain herd. Mortality increased during the same period in the Surprise Mountain herd, while decreasing only half as much in the closed area herd.

In summary, between 1972 and 1973 the Crescent Mountain herd size increased at a greater rate than that of either of the other two herds, its lamb production increased more, and overwinter lamb and herd mortality were lower. At this time, it can only be speculated that this was in response to initial herd reduction, lowered competition for winter forage, and consequently increased ability for the herd to withstand winter hardships.

Table 5. Results of Aerial sheep classification surveys, 1973-74.

Area	Date	Young Rams	Legal Rams	All Rams	Ewes Plus Yearlings1/	Ewes	Yrlgs.2/	Lambs3/	Total
Crescent Mt.	1/15-23/73	43	18	61	124	95	29	--	185
	5/13/73	--	--	67	130	102	28	--	197
	6/13/73	--	--	--	--	--	--	50	268
	12/30-31/73	29	34	63	81	81	36	--	180
Surprise Mt.	3/16/73	11	12	23	140	115	25	--	163
	6/13/73	--	--	--	--	--	--	46	213
	1/24/74	8	6	14	58	47	11	--	72
	2/28/74	13	8	21	110	85	25	--	131
Cooper Landing Closed Area	3/4/73	31	21	52	146	119	27	--	198
	5/12/73	--	--	55	161	135	26	--	216
	6/13/73	--	--	--	--	--	--	67	312
	2/20-26/74	23	14	37	144	107	37	--	181

1/ This category may include a few young rams mis-identified as "ewes" and is the main source of error in aerial classification.

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 6. Computed population models and ratios, 1973.

Area	Date	Rams	Ewes	Yearlings	Lambs	Non-Lambs	Total
Crescent Mt.	6/73	74 (65:100 ff)	113	31 (27:100 ff)	50 (44:100 ff)	218	268
Surprise Mt.	6/73	24 (20:100 ff)	118	25 (21:100 ff)	46 (39:100 ff)	167	213
Cooper Landing Closed Area	6/73	86 (64:100 ff)	134	25 (19:100 ff)	67 (50:100 ff)	245	312

Table 7. Mortality estimates from 1971 to 1973 based on computed population models.

Area	Date	Yearlings	Lamb Mortality	Lambs	Yearlings	Herd Mortality	Lambs
Crescent Mt.	6/71	--		20	208		228
			35%			15%	
	6/72	13		35	194		229
			11%			5%	
	6/73	31		50	218		268
Surprise Mt.	8/71	9		21	156		177
			33%			12%	
	6/72	14		45	156		201
			44%			17%	
	6/73	25		46	167		213
Cooper Landing Closed Area	6/71	17		50	238		288
			56%			19%	
	6/72	22		50	232		282
			50%			13%	
	6/73	25		67	245		312

Winter Range and Climate

Specimens of those plant species found to be most important in the diet of Dall sheep were collected from winter feeding sites on each of the three study areas both in summer, at the peak of their growing season, and in late winter when the sheep would presumably be most dependent upon them. Analyses of these specimens were undertaken to learn what changes in nutritive quality took place from summer to winter as indicated by changes in nitrogen (N), crude protein (CP = N x 6.25), total available carbohydrate (TAC) and gross energy (GE). Results of the analyses of summer-collected specimens were presented in the previous progress report (Nichols 1973). Table 8 lists results of the analyses of winter-collected specimens from sites similar to those from which the summer-collected plants were taken.

Table 9 shows the results of statistical comparisons between the forage component values found in summer-collected specimens and those from winter-collected specimens. In all cases there were significant differences between summer and winter values, with the winter values being much lower. Values from winter-collected plants were compared statistically between areas but no differences could be found; the analyses are not presented here. Since not enough specimens of each plant species could be analyzed to enable summer vs. winter, or area vs. area comparisons by species, the comparisons were made by lumping data for all species and then comparing seasons and areas.

These data show that on the areas under study forage quality decreases sharply within forage plants from summer to winter. Plants on the winter feeding sites may furnish sheep with adequate nutrition during the summer growing season (however, most feeding is done on different sites during the summer), but probably do not furnish even the minimum requirements in late winter when feeding is restricted to these sites. Thus, it may be hypothesized that once sheep are forced by snow conditions to feed only on the wind-blown, exposed ridges, the available forage probably will not sustain them and they become largely dependent upon stored body reserves for survival.

Climatological data were obtained from the automatic recording weather stations previously established in each area. Average monthly temperature and wind data are presented in Figs. 7 and 8, and seasonal wind and temperature data are shown in Figs. 9 and 10. Breaks in the wind and temperature lines, as illustrated, resulted from periods when the weather stations were inoperative.

It can be seen that Crescent Mountain (actually Snowslide Mountain within the Crescent Mountain complex) was both colder and much windier than Surprise Mountain, which, in turn, was colder and windier than Slaughter Mountain in the Cooper Landing Closed Area. An exception was the average winter temperature on Surprise Mountain, which was slightly lower than that of the other two areas. On Crescent Mountain, both winter and summer winds blew predominately from the east from the direction of Prince William Sound. On Surprise Mountain, summer winds blew mostly from the southeast (from the direction of Harding Ice Field) while

Table 8. The percentages of nitrogen (N) and crude protein (CP); mg/g of total available carbohydrates (TAC); and kcal/g of gross energy (GE) in forage samples collected in late winter (April, 1973) from winter feeding sites of three Dall sheep herds.

Species	Surprise Mt.				Slaughter Mt.				Crescent Mt.			
	N	CP	TAC	GE	N	CP	TAC	GE	N	CP	TAC	GE
Hial	.64	4.0	66	4143	.59	3.7	50	3722	.66	4.1	57	3734
Care	.56	3.5	53	3326	.69	4.3	57	3724	.50	3.1	43	3835
Feru	.93	5.8	64	3941	--	--	--	--	--	--	--	--
Feal	.54	3.4	42	3911	.53	3.3	52	3683	.77	4.8	50	3962
Trsp	--	--	--	--	.48	3.0	41	3955	.45	2.8	35	3719
Poas	.85	5.3	44	4350	.44	2.8	41	4151	.54	3.4	50	4151
Dryas	.94	5.9	50	3980	1.10	6.9	44	4856	1.05	6.6	39	4316
Emni	.88	5.5	124	4858	.99	6.2	132	4915	1.05	6.6	163	5225
Salix	1.00	6.3	120	4161	.98	6.1	95	4173	1.40	8.8	87	4210
Vavi	1.00	6.3	195	4201	1.20	7.5	213	4358	.76	4.8	163	4217
Vaul	1.07	6.7	102	5141	1.07	6.7	114	4955	1.43	8.9	152	4271
Moss	.75	4.7	29	2736	.96	6.0	37	3925	.45	2.8	39	4053
Clad	.62	3.9	25	3710	--	--	--	--	.46	2.9	38	3479

Hial= *Hierochole alpina*
Care= *Carex* spp.
Feru= *Festuca rubra*
Feal= *Festuca altaica*
Trsp= *Trisetum spicatum*
Poas= *Poa* spp.
Dryas= *Dryas* spp.
Emni= *Empetrum nigrum*
Salix= *Salix* spp.
Vavi= *Vaccinium vitus-idaea*
Vaul= *Vaccinium uliginosum*
Moss= Moss
Clad= *Cladonia* spp.

Table 9. Comparison of forage components between summer-collected and winter-collected specimens from winter feeding sites.

N (Nitrogen in percent)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
X(summer) = 1.823	X(summer) = 1.699	X(summer) = 1.823
X(winter) = 0.821	X(winter) = 0.793	X(winter) = 0.821
t = 5.3448	t = 4.7031	t = 5.3448

All: highly significant difference at p = .01.

TAC (Total available carbohydrates in mg/g)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
X(summer) = 156.7	X(summer) = 163.1	X(summer) = 147.4
X(winter) = 76.2	X(winter) = 76.3	X(winter) = 79.6
t = 3.7870	t = 4.4221	t = 3.1677

All: highly significant difference at p = .01.

GE (Gross energy in kcal/g)

Surprise Mt.	Crescent Mt.	Slaughter Mt.
X(summer) = 5293.0	X(summer) = 4905.0	X(summer) = 5188.8
X(winter) = 4038.2	X(winter) = 4097.7	X(winter) = 4219.7
t = 5.2550	t = 3.6872	t = 4.9739

All: highly significant difference at p = 0.1.

Fig. 7. Average, Maximum and Minimum Monthly Temperatures by Area.

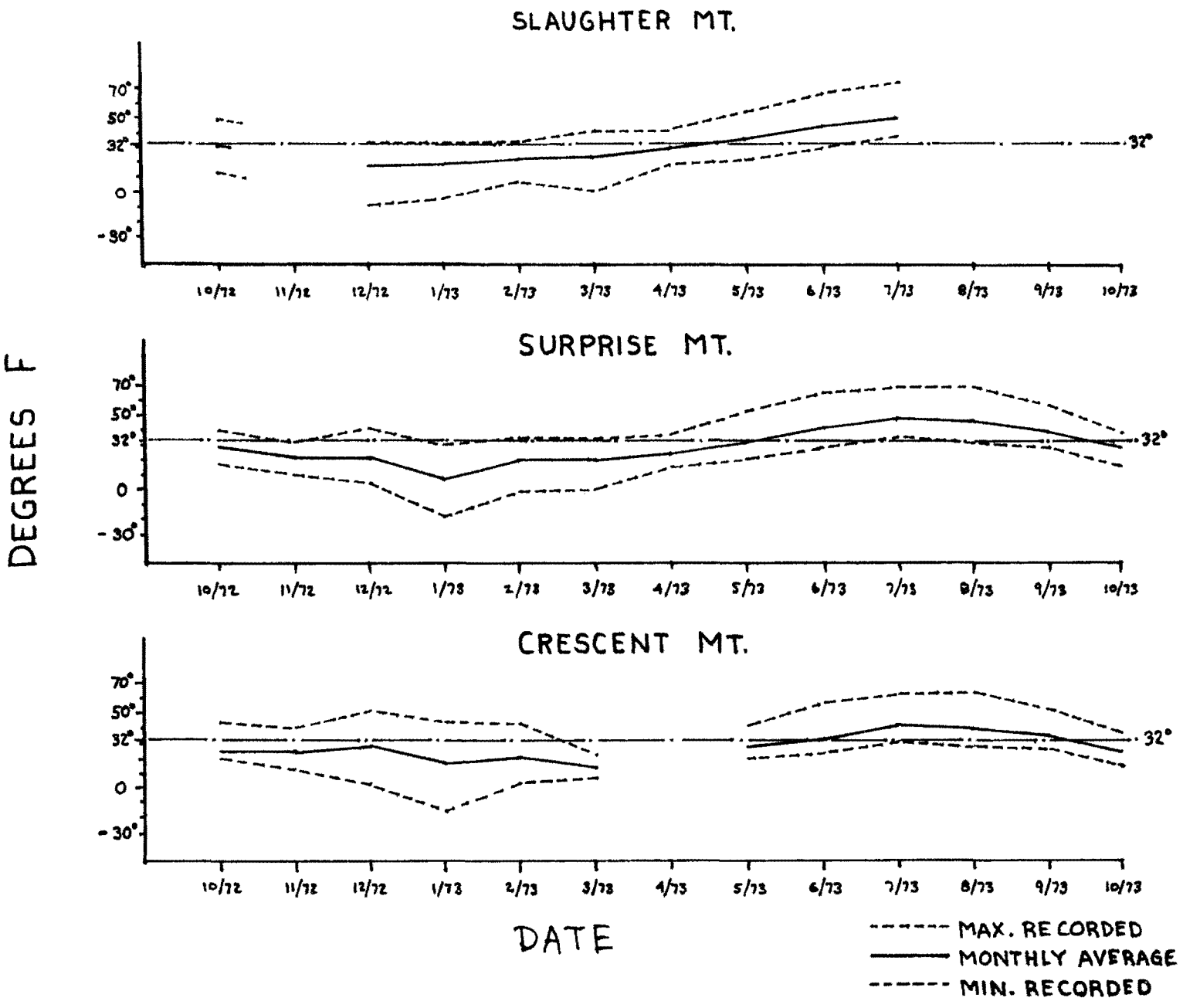


Fig. 8. Average and Maximum Monthly Winds by Area.

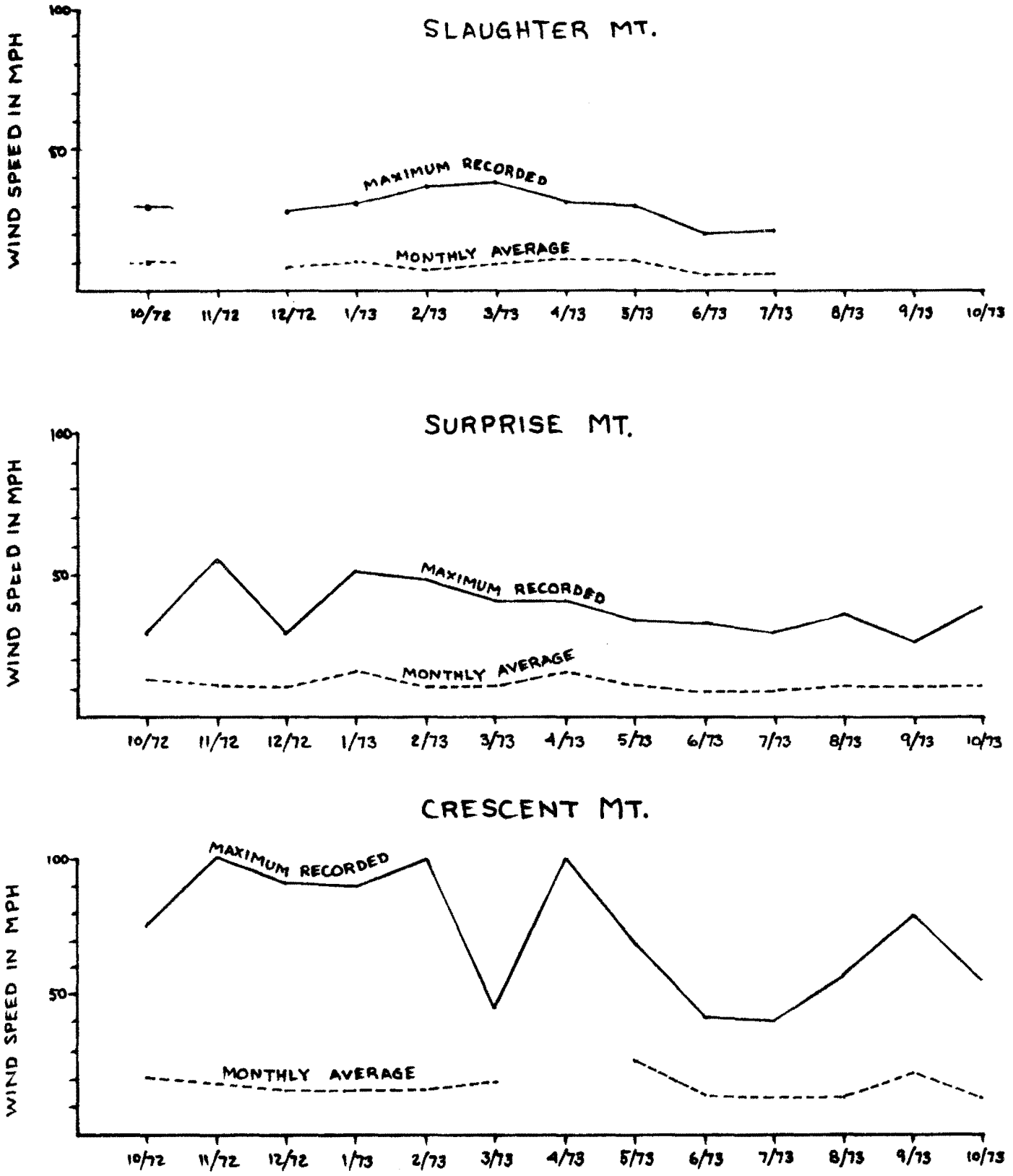
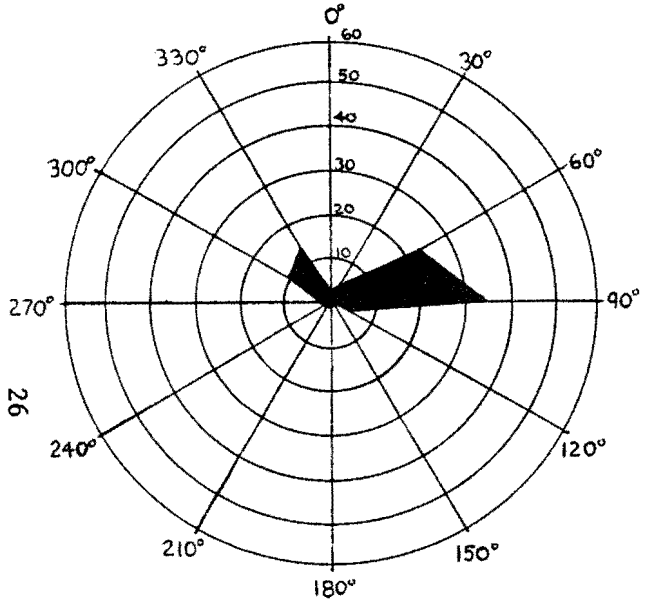


Fig. 9. Summary of wind and temperature data during the winter (October through April) period, 1972-73.

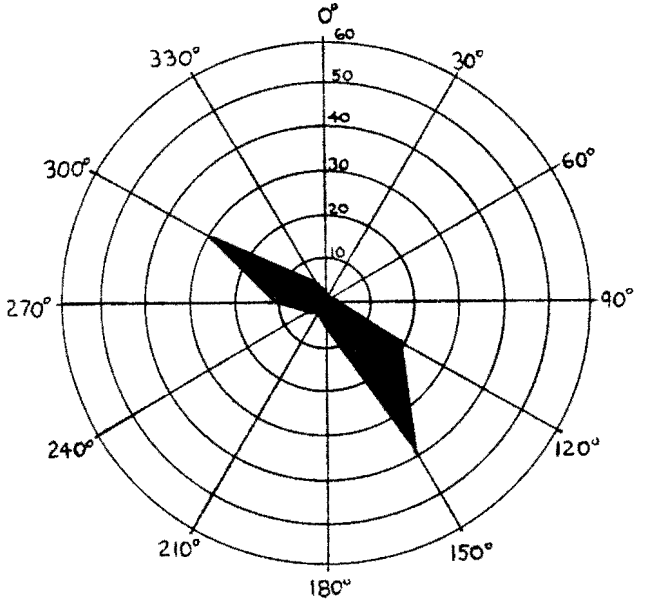
Average wind direction by degrees magnetic from which it blows and by percent of time.

CRESCENT MT.



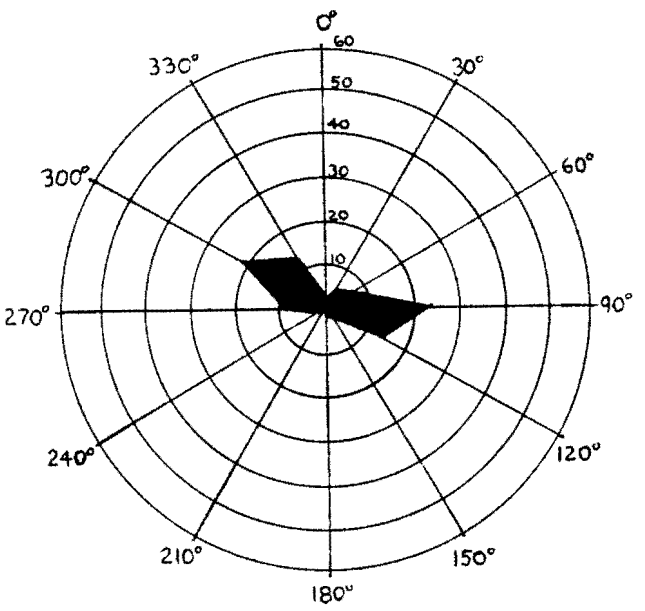
WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
100+	52°
Aver. seasonal	Min. recorded
17.6	-17°
	Aver. seasonal
	21.6°

SURPRISE MT.



WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
55	41°
Aver. seasonal	Min. recorded
12.8	-18°
	Aver. seasonal
	20.3°

SLAUGHTER MT.

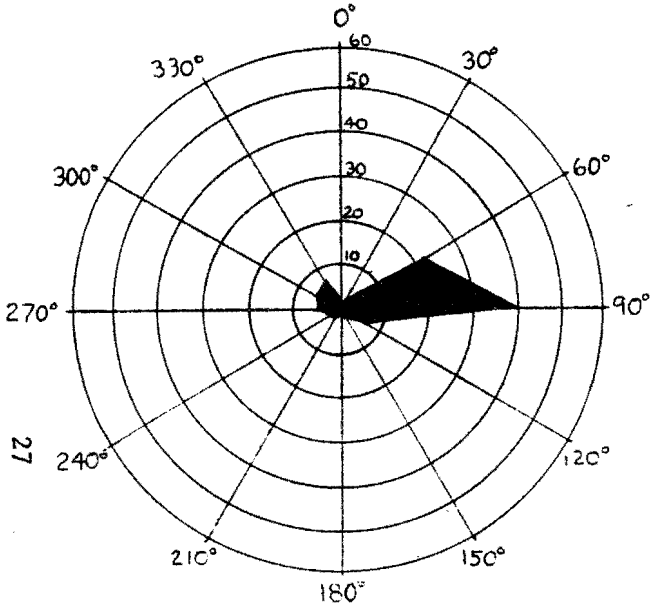


WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
38	48°
Aver. seasonal	Min. recorded
9.4	-9°
	Aver. seasonal
	23.0°

Fig. 10. Summary of wind and temterature data during the summer (May through September) period, 1973.

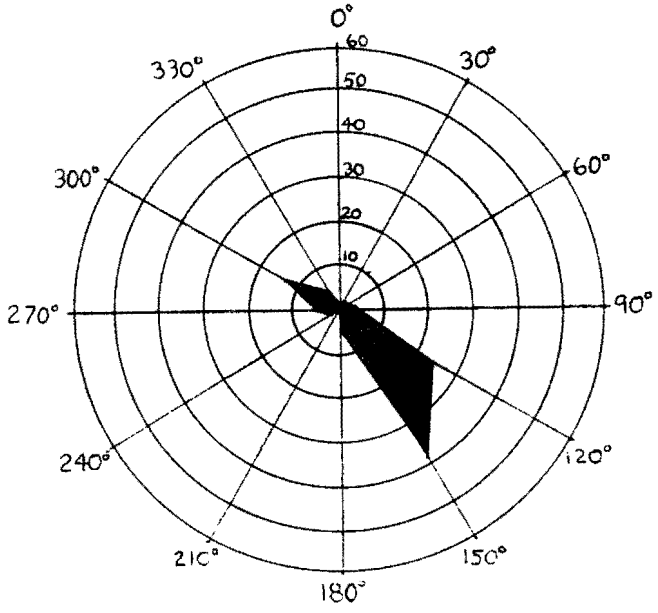
Average wind direction by degrees magnetic from which it blows and by percent of time.

CRESCENT MT.



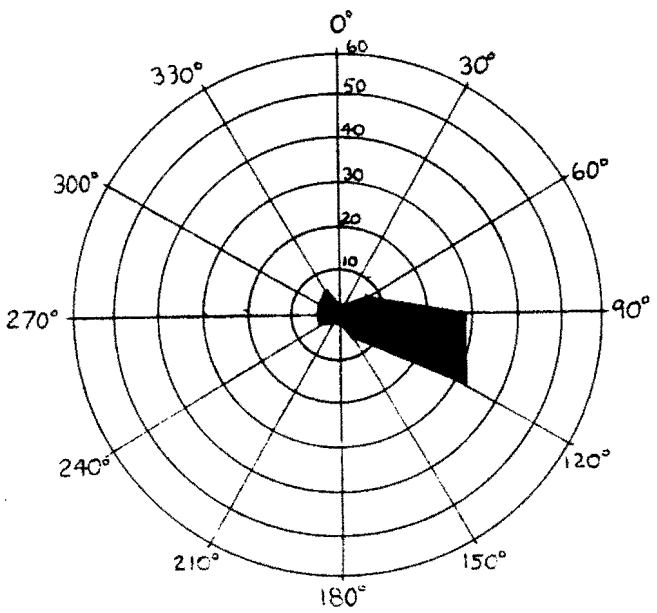
WIND (MPH)	TEMP.(DEG.F)
Max. recorded 79	Max. recorded 63°
Aver. seasonal 18.0	Min. recorded 20°
	Aver. seasonal 35.3°

SURPRISE MT.



WIND (MPH)	TEMP.(DEG.F)
Max. recorded 37	Max. recorded 68°
Aver. seasonal 10.4	Min. recorded 21°
	Aver. seasonal 41.0°

SLAUGHTER MT.



WIND (MPH)	TEMP.(DEG.F)
Max. recorded 30	Max. recorded 74°
Aver. seasonal 8.0	Min. recorded 22°
	Aver. seasonal 42.6°

winter winds come almost equally from the northwest. Summer winds blew generally from the east and southeast on Slaughter Mountain, which also is probably influenced by the presence of Prince William Sound. In winter, northwesterly winds are more prevalent.

Snow transects were read on Crescent Mountain (Jan. 29), Surprise Mountain (Jan. 31) and Slaughter Mountain (Jan. 28) in 1974. Depth and hardness data were analyzed statistically and compared by area; results are summarized in Table 10. Snow was significantly shallower on Crescent Mountain than it was on the other two areas. There was no detectable difference in depth between snow on Surprise and Slaughter Mountains. The snow was significantly harder on Surprise Mountain than on Crescent Mountain, and significantly harder on Crescent Mountain than on Slaughter Mountain. During the winter of 1973 the snow was harder on Crescent Mountain than on Surprise Mountain, while that on Slaughter Mountain was significantly softer than either of the other mountains during both winters.

Snow data obtained in the winter of 1973 are compared with those from 1974 in Table 11. No significant differences were found between winters in snow depth, although it was suggestively deeper in 1974 on Surprise Mountain. Snow was significantly softer in 1974 than in 1973 on Crescent Mountain, with an average hardness approximately half as much as in 1973. On the other hand, it was significantly harder on Surprise Mountain in 1974 than in 1973, with the average being almost half again as hard.

A summary of annual weather, snow, lamb production and mortality data is presented in Fig. 11. Weather data include those for the winter of 1972-73 and the summer of 1973. The snow data are from the winter of 1972-73, and lamb production is from the spring of 1973. Gross climate, as indicated by average wind, temperature and snow measurements, was harsher on Crescent Mountain than on Surprise, and harsher on Surprise than on Slaughter Mountain. However, lamb production was higher on Crescent than on Surprise Mountain, though not as high as on Slaughter Mountain in the closed area. Overwinter mortality, including both lamb and overall herd mortality, was significantly lower on Crescent Mountain than on either of the other two areas.

RECOMMENDATIONS

Due to the variability of climatic and biological factors influencing the sheep populations under study, it is recommended that the Crescent Mountain herd be maintained at a level of approximately 200 sheep by public hunting for a period of at least three more years, with concurrent monitoring of populations, reproduction, mortality and climate so that trends may be assessed over a sufficiently long period for accurate judgements on the effects of either-sex hunting to be made.

I recommend that another range survey of sheep winter range be done in the summer of 1976, utilizing the initial transects and methods, to determine any changes in forage production which may be attributable to the Crescent Mountain herd reduction.

Table 10. Comparison of snow depth (in inches) and hardness (in pounds per cm^2) between areas in the winter of 1974.

Snow Condition	Comparison		t	DF	Difference
	Crescent vs. Surprise				
Depth	($\bar{x}D$ = 6.3)	($\bar{x}D$ = 17.2)	3.4632	98	Highly significant at p = .01
Hardness	($\bar{x}H$ = 17.7)	($\bar{x}H$ = 23.0)	3.1594	334	Highly significant at p = .01
	Surprise vs. Slaughter				
Depth	($\bar{x}D$ = 17.2)	($\bar{x}D$ = 16.0)	0.3863	98	No significant difference
Hardness	($\bar{x}H$ = 23.0)	($\bar{x}H$ = 6.8)	11.855	378	Highly significant at p = .01
	Crescent vs. Slaughter				
Depth	($\bar{x}D$ = 6.3)	($\bar{x}D$ = 16.0)	4.2890	98	Highly significant at p = .01
Hardness	($\bar{x}H$ = 16.7)	($\bar{x}H$ = 6.8)	7.5566	330	Highly significant at p = .01

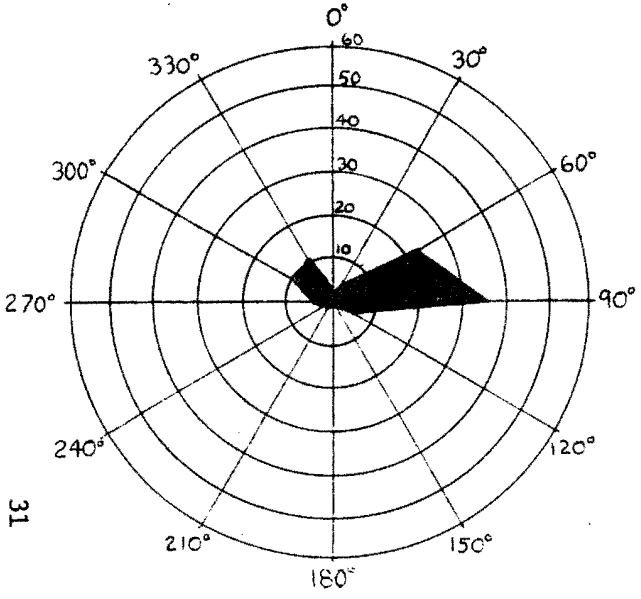
Table 11. Comparison of snow depth (in inches) and hardness (in pounds per cm^2) between the winters of 1973 and 1974 by areas.

Area	Snow Condition	Comparison		t	DF	Difference
Crescent		1973 vs. 1974				
	Depth	($\bar{x}D = 4.7$)	($\bar{x}D = 6.3$)	0.8037	98	No significant difference
	Hardness	($\bar{x}H = 32.2$)	($\bar{x}H = 16.7$)	5.7160	266	Highly significant at p = .01
Surprise		1973 vs. 1974				
	Depth	($\bar{x}D = 11.4$)	($\bar{x}D = 17.2$)	1.6676	98	Suggestive difference at p=.1
	Hardness	($\bar{x}H = 16.0$)	($\bar{x}H = 23.0$)	4.2048	378	Highly significant at p = .01
Slaughter		1973 vs. 1974				
	Depth	($\bar{x}D = 17.2$)	($\bar{x}D = 16.0$)	0.4699	98	No significant difference
	Hardness	($\bar{x}H = 5.9$)	($\bar{x}H = 6.8$)	1.7154	366	Suggestive difference at p=.1

Fig. 11. Summary of annual weather, snow, lamb production and mortality data by area.

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

CRESCENT MT.



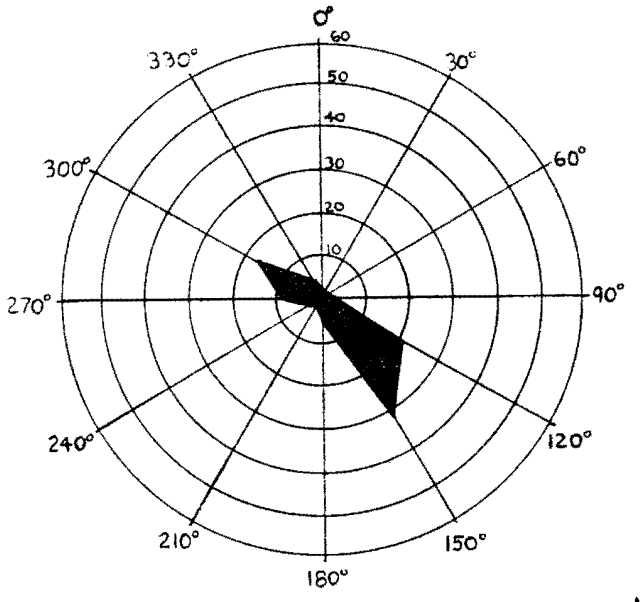
WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
100+	63°
Aver. annual	Min. recorded
17.8	-17°
	Aver. annual
	27.8°

Aver. snow depth: 4.7 in.
Aver. snow hardness: 32.2 lb/cm²

Lamb production: 44:100♀

Mortality (1972 to 1973):
Lambs: 11%
Overall: 5%

SURPRISE MT.



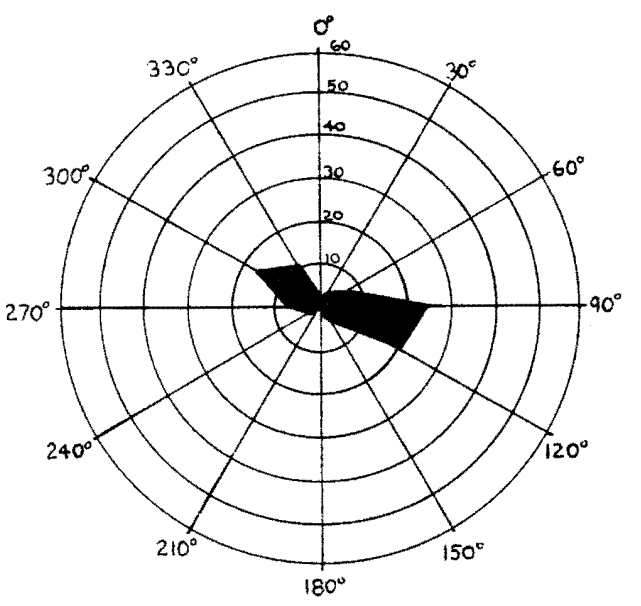
WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
55	68°
Aver. annual	Min. recorded
11.8	-18°
	Aver. annual
	28.9°

Aver. snow depth: 11.4 in.
Aver. snow hardness: 16.0 lb/cm²

Lamb production: 39:100♀

Mortality (1972 to 1973):
Lambs: 44%
Overall: 17%

SLAUGHTER MT.



WIND (MPH)	TEMP.(DEG.F)
Max. recorded	Max. recorded
38	74°
Aver. annual	Min. recorded
8.9	-9°
	Aver. annual
	29.5°

Aver. snow depth: 17.2 in.
Aver. snow hardness: 5.9 lb/cm²

Lamb production: 50:100♀

Mortality (1972 to 1973):
Lambs: 50%
Overall: 13%

Further analyses of forage plants are needed to compare changes in quality from summer to winter in those which are normally covered by snow but are still available to sheep digging in winter as compared to those which are available without digging on open, windblown ridges.

Further study is needed to determine the daily intake of forage by Dall sheep, both in summer and winter, and to relate this to forage availability and winter range carrying capacity.

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

In relation to the harvesting of female sheep, we need to learn something of the survival of lambs orphaned at different times during the hunting season.

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