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INTERIOR SHEEP STUDIES

By

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

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Project No.: W-22-1 Project Title: Big Game Investigations

Job No.: 6.9R Job Title: Dynamics of Selected Sheep Populations

Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

Comparative studies of high- and low-quality Dall sheep populations were continued to learn if differences in population quality manifest themselves as differences in population dynamics which should be considered in management planning. The Dry Creek sheep population was estimated at 1,450, a slight increase from last year. It included an estimated 646 ewes, 387 lambs, and 277 yearlings. The lamb:100 ewe ratio gathered at the mineral lick was 60 lambs:100 ewes; 43 yearlings/100 ewes were seen. In the Sheep Creek study area, lamb production was 52 lambs/100 ewes using conventional observations; among collared ewes of breeding age, it was at least 85 lambs/100 ewes. Survival of the 1981 lamb cohort in the Sheep Creek population appears to be better than at Dry Creek. Weather is likely the major cause of lamb mortality during the 1st year. Resightings of marked animals confirmed earlier findings of high fidelity to winter ranges and mineral licks at Sheep Creek.

Key words: population dynamics, sheep.

CONTENTS

BACKGROUND

Striking differences in Dall sheep (Ovis dalli) ram horn growth in the populations along the Alaska Range east of Mt. McKinley have been shown by previous Alaska Department of Fish and Game studies (Heimer and Smith 1975). The results of these studies were considered supportive of Geist's (1971) Quality Hypothesis. This theory states observable phenotypic differences exist among sheep populations and populations of high quality are composed of individuals with more rapid horn growth and larger horns at any given age than individuals from low-quality populations. The studies of Heimer and Smith (1975) also indicated Dall sheep population quality (as reflected by ram horn growth and size) was inversely correlated with population density.

Heimer and Smith (1975) divided the Alaska Range east of Mt. McKinley (ARE) into 3 areas to investigate "quality" based on ram horn growth characteristics. These areas, from Mt. McKinley to the east, are: ARE I, from the Nenana River eastward to the Delta River; ARE II, from the Delta River eastward to the Johnson River; and ARE III, from the Johnson River eastward to the Tok-Slana Road. In the quality ranking of Heimer and Smith

(1975), ARE I was of very low quality, ARE II was of average quality, and ARE III was of very high quality. For these reasons, it was decided to compare Dall sheep ecology in ARE I and ARE III to determine if different management approaches are necessary in areas of differing sheep quality.

Geist's (1979) dispersal theory predicts population dynamics will differ between high- and low-quality populations. His hypothesis specifically predicts that high-quality populations will show greater reproductive capability, better survival to yearling age, more rapid growth, and generally shorter life expectancy for individual animals than low-quality populations. Past observations have supported nearly all points of this hypothesis (Heimer 1980a, Heimer and Smith 1975). It is not known, however, if high-quality herds are increasing in numbers as a result of higher yearling recruitment or if the postulated higher adult mortality compensates for the greater number of sheep recruited. Population dynamics of the high-quality ARE III population are being compared with those of the low-quality (ARE I) population to answer this question.

OBJECTIVES

To determine initial lamb production, yearling recruitment, survival, and reproductive frequency in both the low-quality Dry Creek sheep population (ARE I) and the high-quality Sheep Creek population (ARE III).

PROCEDURES

Dry Creek

Estimated Population Size, Composition, and Trend:

Ewe sheep were trapped from 1-10 June 1981 using a rocket net (Heimer et al. 1980). Age and reproductive status were determined by standard techniques (Heimer et al. 1980), and blood was collected. All ewes were marked with individual visual neck collars and ear tags; lambs were ear-tagged.

The Dry Creek lick was observed from 5 June through 10 June and from 16 June through 1 July 1981. Daily observations started at 0430 and ended at 1200 hours. Initial lamb production and yearling survival were determined by classifying all sheep entering the lick as ewes, yearlings, lambs, or rams. Classifications were made using spotting scopes at distances of less than 200 m. The 5-day observation period in early June, during which the most intense use of the mineral lick occurred, was used in estimating the population instead of the last 5 days of the usual observation period (Heimer 1980a). This was done only in 1981 because the advent of spring and mineral lick use were earlier than usual this year.

Lamb Survival:

Survival of the 1981 lamb cohort through its 1st winter was monitored by fixed-wing aerial surveys in early December and April and a helicopter survey in March. The initial lamb:100 ewe ratio gathered at the mineral lick was adjusted for comparisons with aerial survey data by adding estimates of yearling and 2-year-old ram numbers to the number of ewes estimated at the lick. The lamb:100 "ewe" ratio was then recalculated to provide a starting point for comparisons with aerial survey data gathered during winter flights. Winter aerial surveys were flown using a Piper PA-18-150 Super Cub piloted by Bill Lentsch. These classifications were augmented by a helicopter survey flown in late March.

Sheep Creek

Estimated Population Size, Composition, and Trend:

The Sheep Creek mineral lick was observed from 25 May through 30 June 1981. Daily observation hours were from 0400 to 2000. All sheep entering the lick were classified into the same categories used at Dry Creek. The reproductive status of collared sheep was recorded.

Winter Studies:

A helicopter (Hughes 500-D piloted by Ron Warbelow) survey was flown on 15-16 April 1981 to locate collared ewes on their winter ranges. Survey time was 6 hours; 460 sheep were classified. Locations of collared sheep were plotted on 1:250,000 scale topographic maps.

FINDINGS

Dry Creek

During the 12-day adjusted observation period at the main mineral lick on Dry Creek, 1,466 sheep were classified. Sixty lambs and 43 yearlings were observed for each 100 ewes entering the mineral lick. These data are compared with historic productivity, survival, and estimated numbers of sheep influenced by the Dry Creek lick in Table 1. The ratios of lambs and yearlings/100 ewes, while accurate, are only relative numbers. It is assumed they are indicative of actual production and survival. Population dynamics are more meaningfully revealed by numbers of lambs produced and yearlings recruited. These can be calculated if the number of ewes in the study area is known. The number of ewes was calculated using the percentage of ewes observed among incoming sheep at the mineral lick and the total number of sheep in the study area. During the 12-day observation period, a mean of 122 sheep/day entered the lick. Using the nomogram in Fig. 1

Table 1. Productivity, survival, and estimated number of Dall sheep influenced by the Dry Creek mineral lick from 1970 through 1981.

Year	Lambs/ 100 ewes	Yearlings/ 100 ewes	% lambs surviving 1st winter	Estimated population
1968	63	13	--	--
1969	64	31	49	--
1970	55	31	48	1,500
1971	50	51	93	--
1972	15	16	32	1,473
1973	38	11	73	1,423
1974	28	25	66	1,280
1975	28	23	82	1,230
1976	36	16	57	1,310
1977	58	17	47	1,350
1978	41	25	43	1,390
1979	65	19	46	1,340
1980	67	36	55	1,425
1981	60	43	64	1,450

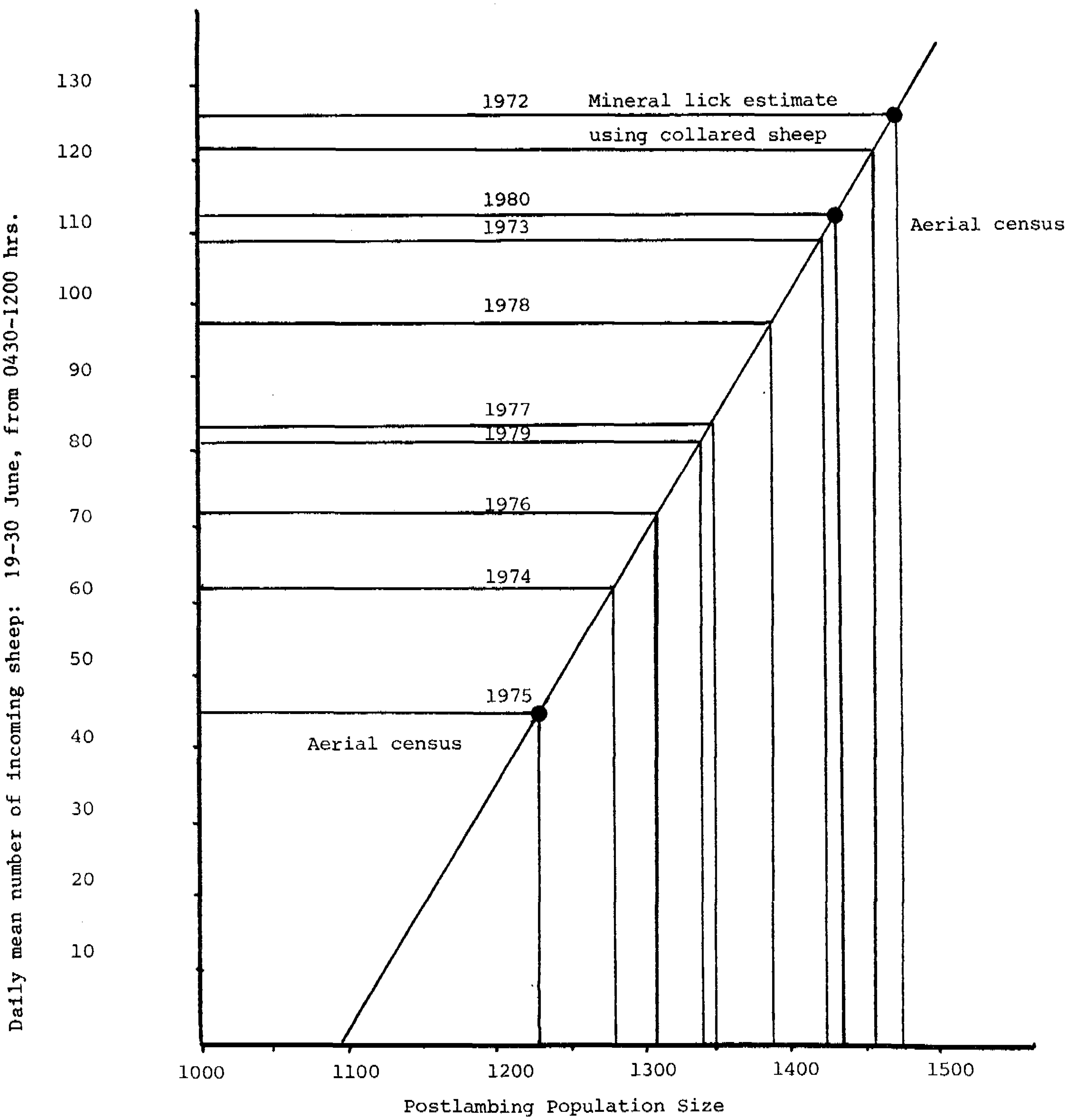

Fig. 1. Nomogram for estimating population size from daily mean number of incoming sheep to Dry Creek Lick during sample period in late June.

(from Heimer 1980a), the average number of incoming sheep predicts a population of 1,450 following lambing.

Ewes composed 46.6% of the incoming sheep during the observation period. Hence, 0.466 times the total population of 1,450 gives an estimated breeding population of 646 ewes. Lambs composed 27.8% of the population observed at the mineral lick, or an estimated 387. Similarly, the calculated number of yearlings produced was 277 (20.2% of the observed lick users). Comparable data for previous years are presented in Table 2.

A comparison of the survival rates presented in Table 1 and Table 2 reveals a difference between years in the percentage of lambs surviving to yearling age. Table 1 is based on relative ratios, while Table 2 is derived from estimates of absolute production and survival. The differences are caused by the changing number of ewes present in the populations. Table 2 shows that since 1976, when the overall population decline in the study area stopped and stability was apparently achieved, the mean variation in the number of breeding ewes has averaged about 32 ewes/year. The greatest change, a decrease of 109 breeding ewes, was between 1978 and 1979. This drop in ewe numbers may be due to the mortality of a large cohort of animals produced under favorable conditions in the late 1960's. Yearling recruitments in 1969, 1970, and 1971 were higher than any observed prior to 1981 (Table 1). Ewes produced in these years would have reached ages of high mortality by 1981; Heimer (1973) showed mortality rose drastically at age 9 in Dry Creek. This date coincides with the decline in breeding ewes between 1978 and 1979.

The number of yearlings produced has varied by as much as 160 since 1976 (Table 2). This translates into a variation in recruitment to the breeding population of as much as 80 ewes at the extremes. Actual variations from year to year would be less, not greatly different from mean difference observed (32/year). These figures indicate (although it may not be possible to account for every ewe recruited or lost) the trends can be explained and there is hope for understanding the population's responses.

Population trends in the Dry Creek study area were discussed in a paper submitted for publication (Appendix A).

Trapping and Marking:

Twenty-six ewes were trapped, marked, and released during the 1st half of June at Dry Creek. Four lambs were ear-tagged and released. Two trap mortalities occurred. Age, reproductive status, and collar numbers of sheep trapped during 1981 are presented in Table 3.

Three 2-year-old ewes were trapped on 9 and 11 June. None of these ewes were lactating when captured, but all 3 had swollen vulvae and enlarged, unpigmented udders. One died of internal

Table 2. Population and production estimates for the Dry Creek study population from 1972 through 1981.

Year	Estimated prelambing population	Estimated postlambing population	% breeding ewes	Number breeding ewes	Number lambs produced	Number yearlings produced	% survival
1972	1,300	1,473	55.9	823	123	132	--
1973	1,110	1,423	57.9	823	313	91	74
1974	1,070	1,280	58.6	750	210	187	60
1975	1,031	1,230	57.7	709	199	163	78
wolf control begun							
1976	1,050	1,310	55.2	723	260	116	58
1977	936	1,350	52.9	714	414	121	47
1978	1,094	1,390	51.9	721	296	180	43
1979	942	1,340	45.7	612	398	116	39
1980	1,003	1,425	44.2	630	422	227	57
1981	1,044	1,450	46.6	646	387	277	66

Table 3. Age, collar data, and reproductive status of ewes trapped and marked at the main mineral lick on Dry Creek, 1-10 June 1981.

Age in months	Collar number	Collar color	Reproductive status	Comments
12	7	Green with yellow	Inactive	
12	X	Green with yellow	Inactive	
12	11	Green with yellow	Inactive	
12	14	Green with yellow	Inactive	
12	-1	Red with yellow	Inactive	Has pink tongue
12	16	Red with yellow	Inactive	
12	22	Red with yellow	Inactive	
24	24	Yellow with black	Pregnant	
24	XX	Red with yellow	Pregnant	Bad lumpy jaw left maxilla
36	25	Red with yellow	Lactating	
36	27	Yellow with black	Not lactating	Bad lumpy jaw right maxilla
36	2-	Yellow with black	Not lactating	
36	23	Red with yellow	Lactating	
48	21	Red with yellow	Lactating	Old lumpy jaw
48	2424	Red with yellow	Not lactating	
48	21	Yellow with black	Lactating	
48	20	Yellow with black	Lactating	Bad lumpy jaw left maxilla
60	20	Red with yellow	Lactating	Vaginal discharge
60	27	Red with yellow	Lactating	
60	23	Yellow with black	Not lactating	
60	2X	Yellow with black	Lactating	Has pink tongue
72	2X	Red with yellow	Lactating	
84	0-	Red with yellow	Not lactating	Old lumpy jaw left maxilla
84	2626	Red with yellow	Not lactating (udder hard)	Old lumpy jaw left maxilla
120	22	Yellow with black	Not lactating	Old lumpy jaw right maxilla
120	2-	Red with yellow	Lactating	Old lumpy jaw right maxilla

hemorrhage resulting from capture. Field necropsy revealed she was pregnant. The fetus, probably at least 4 weeks from term, was covered with darkly pigmented hair and had yellow and cartilaginous hooves. One of the surviving 2-year-olds was seen with a very small lamb at the end of June. These findings support the conclusion that ewes in Dry Creek breed first at 18 months of age (Heimer 1980b). Heimer and Watson (1982) speculated that the early breeding age was a function of a ram age structure greatly altered by hunting. The abstract is presented in Appendix B.

Lamb Survival:

After mineral lick data were adjusted to allow comparison with data gathered on aerial surveys, the lamb:100 "ewe" ratio in June was 40 lambs:100 "ewes" (see Procedures). An aerial survey on 9 December indicated the lamb:100 "ewe" ratio had declined from its initial high to about 19 lambs:100 "ewes" (N = 215). A helicopter flight on 24 March (N = 232) and another Super Cub survey on 4 April (N = 96) also gave lamb:100 "ewe" ratios of 19 lambs:100 ewes. Survey efficiency and costs are discussed in Appendix C.

The changes in lamb:100 "ewe" ratios indicate a loss of approximately 50% of the lamb cohort between mid-June and 9 December 1981. This is in marked contrast to the data gathered in 1980 (Heimer 1982) when little mortality was observed in the lamb cohort throughout the winter. Differences in the snow conditions during winters 1980 and 1981 suggest weather is a major factor in winter lamb survival.

Sheep Creek

Estimated Population Size, Composition, and Trend:

Population size was not estimated during the past year. Population composition data were gathered at the Sheep Creek mineral lick and are presented in Table 4. It should be emphasized that the lamb:ewe ratio in Table 4 was computed from all incoming ewes at the Sheep Creek mineral lick. Since ewes are not reproductively active until age 3 in the Sheep Creek population, the ratio is deceptively low. In 1981, all of the 63 collared ewes were reproductively active (≥3 years of age) for the 1st time; the lamb:ewe ratio for marked ewes was at least 85 lambs:100 ewes. Table 5 contains data on resightings of marked sheep at the Sheep Creek lick and reproductive status of marked ewes.

Winter Studies:

During the helicopter survey of 15 and 16 April 1982, 460 sheep were observed. The lamb:100 "ewe" ratio was 43 lambs:100 "ewes." The lamb:100 ewe ratio observed at the Sheep Creek lick during June was 52 lambs:100 true ewes. The ratio at the lick is likely to be greater than that obtained by aircraft due to differences

Table 4. Productivity, survival, and sample size of Dall sheep classified at the Sheep Creek mineral lick from 1974 through 1981.

Year	Lambs/ 100 ewes	Yearlings/ 100 ewes	% lambs surviving 1st winter	Sample size
1974	56	21	--	116
1975	43	37	66	273
1976	35	26	60	257
1977	52	18	51	593
1978	57	35	67	757
1979	63	25	44	465
1980	69	29	46	821
1981	52	32	46	5,758

Table 5. Resightings of collared sheep at Sheep Creek mineral lick, 1977-1981. C=Capture date, X=Resighting.

Sex	Collar number	Collar color	Ear tag number	Ear tag color	1977	1978	1979	1980	1981	Yrs w/ lambs	Comments
M			07 Blk	Yel		C	X		X		
M			17 Blk	Yel		C			X		
M			27 Blk	Yel		C	X				
M			37 Blk	Yel		C		X			
M			47 Blk	Yel		C	X	X			
M			57 Blk	Yel		C					
M			67 Blk	Yel		C					
M			77 Blk	Yel		C					
M			-7 Blk	Yel		C					
M			X7 Blk	Yel		C		X			
M			L17 Blk	Yel		C	X	X			1980, lump jaw right side
M			L27 Blk	Yel		C					
M			L37 Blk	Yel		C					
M			L47 Blk	Yel		C	X				
M			07 Wht	Blu		C	X		X		
M			17 Wht	Blu		C			X		
M			27 Wht	Blu			C				
M			47 Wht	Blu			C	X			
M			57 Wht	Blu			C	X	X		
M			67 Wht	Blu			C	X	X		
M			77 Wht	Blu			C				
M			-7 Wht	Blu			C				
M			09 Wht	Grn			C				
M			19 Wht	Grn			C				
M			29 Wht	Grn			C				

Table 5. Continued.

Sex	Collar number	Collar color	Ear tag number	Ear tag color	1977	1978	1979	1980	1981	Yrs w/ lambs	Comments
M			39 Wht	Grn			C				
M			49 Wht	Grn			C	X			
M			59 Wht	Grn			C	X			
M			69 Wht	Grn			C	X			
M			79 Wht	Grn			C	X			1979, has golf ball size lump jaw both sides
M			-9 Wht	Grn			C	X			
M			X9 Wht	Grn			C				
M			29 Wht	Red			C	X	X		
F			L07 Wht	Red			C				
F			L17 Wht	Red			C				
F	0 Blk	Yel	0 Blk	Yel			C	X	X	81	
F	1 Blk	Yel	1 Blk	Yel			C	X	X	81	
F	2 Blk	Yel	2 Blk	Yel			C	X	X	81	
F	3 Blk	Yel	3 Blk	Yel			C	X	X	81	
F	4 Blk	Yel	4 Blk	Yel			C		X	81	
F	5 Blk	Yel	5 Blk	Yel			C	X	X	81	
F	6 Blk	Yel	6 Blk	Yel			C	X	X	80,81	
F	7 Blk	Yel	7 Blk	Yel			C				
F			L07 Blk	Yel		C					
F	0 Yel	Red	0 Wht	Red		C		X	X	81	
F	1 Yel	Red	1 Wht	Red		C			X	81	
F	2 Yel	Red	2 Wht	Red		C	X		X	81	
F	3 Yel	Red	3 Wht	Red		C	X	X	X	80	
F	4 Yel	Red	4 Wht	Red		C	X	X	X	80,81	1978, quite small left horn
F	5 Yel	Red	5 Wht	Red			C	X	X	81	

Table 5. Continued.

Sex	Collar number	Collar color	Ear tag number	Ear tag color	1977	1978	1979	1980	1981	Yrs w/ lambs	Comments
F	6 Yel	Red	6 Wht	Red			C	X	X	80,81	
F	7 Yel	Red	7 Wht	Red			C	X	X	80	
F	X Yel	Red	X Wht	Red		C	X	X	X	80,81	
F	- Yel	Red	- Wht	Red			C	X	X	80,81	
F	00 Yel	Red	00 Wht	Red			C				dead?
F	01 Yel	Red	01 Wht	Red			C				dead?
F	02 Yel	Red	02 Wht	Red			C		X	81	1979, right horn broken off
F	03 Yel	Red	03 Wht	Red			C	X	X	81	
F	04 Yel	Red	04 Wht	red			C	X	X	80,81	1979, right horn broken off
F	05 Yel	Red	05 Wht	Red			C		X		
F	06 Yel	Red	06 Wht	Red			C	X	X	80,81	
F	07 Yel	Red	07 Wht	Red			C		X	81	
F	0 Yel	Blu	0 Wht	Blu	C	X	X	X	X	77,78,79,80,81	
F	1 Yel	Blu	1 Wht	Blu		C	X		X	78,79	
F	2 Yel	Blu	2 Wht	Blu		C	X	X	X	78,79,81	
F	4 Yel	Blu	4 Wht	Blu	C	X	X	X	X	80	
F	5 Yel	Blu	5 Wht	Blu	C	X	X	X		78,80	Dead, hunter kill
F	6 Yel	Blu	6 Wht	Blu		C	X	X	X	80,81	
F	7 Yel	Blu	7 Wht	Blu	C					77	1977, hunter kill
F	- Yel	Blu	- Wht	Blu	C	X	X			77,78,79	
F	X Yel	Blu	X Yel	Blu	C	X	X	X	X	77,78,79,81	
F	20 Yel	Blu	20 Wht	Blu			C		X	81	
F	0 Yel	Grn	0 Wht	Grn			C				1979, hunter kill
F	1 Yel	Grn	1 Wht	Grn			C		X	81	
F	2 Yel	Grn	2 Wht	Grn			C	X	X	81	1980, had CE lesions on udder last year, no lambs

Table 5. Continued.

Sex	Collar number	Collar color	Ear tag number	Ear tag color	1977	1978	1979	1980	1981	Yrs w/ lambs	Comments
F	3 Yel	Grn	3 Wht	Grn			C	X	X	79,81	1980, large (50¢ size) black lesion on right maxilla
F	4 Yel	Grn	4 Wht	Grn			C		X	79,81	
F	5 Yel	Grn	5 Wht	Grn			C	X	X	79,80,81	1979, lump jaw both sides
F	6 Yel	Grn	6 Wht	Grn			C	X	X	80	1979, lump jaw left side
F	- Yel	Grn	- Wht	Grn		C		X	X	78,80,81	
F	00 Yel	Grn	00 Wht	Grn		C	X	X	X	78,79,80,81	
F	01 Yel	Grn	01 Wht	Grn		C	X	X	X	80,81	
F	02 Yel	Grn	02 Wht	Grn			C	X		79	1979, small udder and mucoid discharge
F	03 Yel	Grn	03 Wht	Grn			C	X	X	79,80,81	
F	05 Yel	Grn	05 Wht	Grn			C	X	X	79,81	
F	06 Yel	Grn	06 Wht	Grn			C	X	X	79,80,81	
F	07 Yel	Grn	07 Wht	Grn			C		X	79,80,81	
F	0 Blk	Red	0 Blk	Red		C				78	1978, lump jaw
F	1 Blk	Red	1 Blk	Red			C	X	X	79,80,81	
F	2 Blk	Red	2 Blk	Red			C	X	X	79,80,81	
F	3 Blk	Red	3 Blk	Red			C	X	X	79,81	
F	4 Blk	Red	4 Blk	Red			C	X	X	79,81	
F	5 Blk	Red	5 Blk	Red			C	X	X	79,81	
F	6 Blk	Red	6 Blk	Red			C	X	X	79,81	1979, small udder with discolored milk; lamb may have died and milk drying up
F	00 Blk	Red	00 Blk	Red		C	X			78,79	
F	01 Blk	Red	01 Blk	Red		C	X		X	81	1978, lump jaw both sides, left side severe

Table 5. Continued.

Sex	Collar number	Collar color	Ear tag number	Ear tag color	1977	1978	1979	1980	1981	Yrs w/ lambs	Comments
F	02 Blk	Red	02 Blk	Red		C	X	X	X	78,79,80,81	
F	03 Blk	Red	03 Blk	Red			C			79,81	
F	04 Blk	Red	04 Blk	Red			C			79,81	
F	05 Blk	Red	05 Blk	Red			C	X	X	79,80,81	
F	07 Blk	Red	07 Blk	Red			C	X	X	79,81	
F	30 Blk	Red	30 Blk	Red			C	X	X	79,80,81	
F	40 Blk	Red	40 Blk	Red		C	X		X	78,79,81	
F	41 Blk	Red	41 Blk	Red		C	X	X	X	78,79,80,81	
F	42 Blk	Red	42 Blk	Red			C	X	X	79,80,81	
F	43 Blk	Red	43 Blk	Red			C		X		
F	44 Blk	Red	44 Blk	Red			C				1979, lump on left jaw
F	45 Blk	Red	45 Blk	Red			C	X	X	80,81	
F	4- Blk	Red	4- Blk	Red			C		X	81	

in ability to classify more accurately at the lick. This consideration leads to the conclusion that lamb survival at Sheep Creek during winter 1981-82 was not greatly different than at Dry Creek.

Twenty-four marked ewes were identified during the helicopter survey in 1982; 9 of these were also located and identified on the same dates during 1981 (Heimer 1982). Locations of collared ewes identified on the flights during 1982 are shown in Fig. 2. For the 9 ewes identified in both 1981 and 1982, the mean distance from the previous year's locations was 3.7 km (2.3 mi) (Heimer 1982). These sheep have displayed typical loyalty to their winter range (Heimer 1973). These observations support last year's tentative conclusion that at least 2 separate ewe populations exist in the Sheep Creek study area. The proportion of collared ewes sighted in these distinct populations suggests a disproportionate number of marked individuals inhabit the study area west of Sheep Creek. Nine percent of the ewes observed east of Sheep Creek had collars; 24% of those observed west of Sheep Creek had collars.

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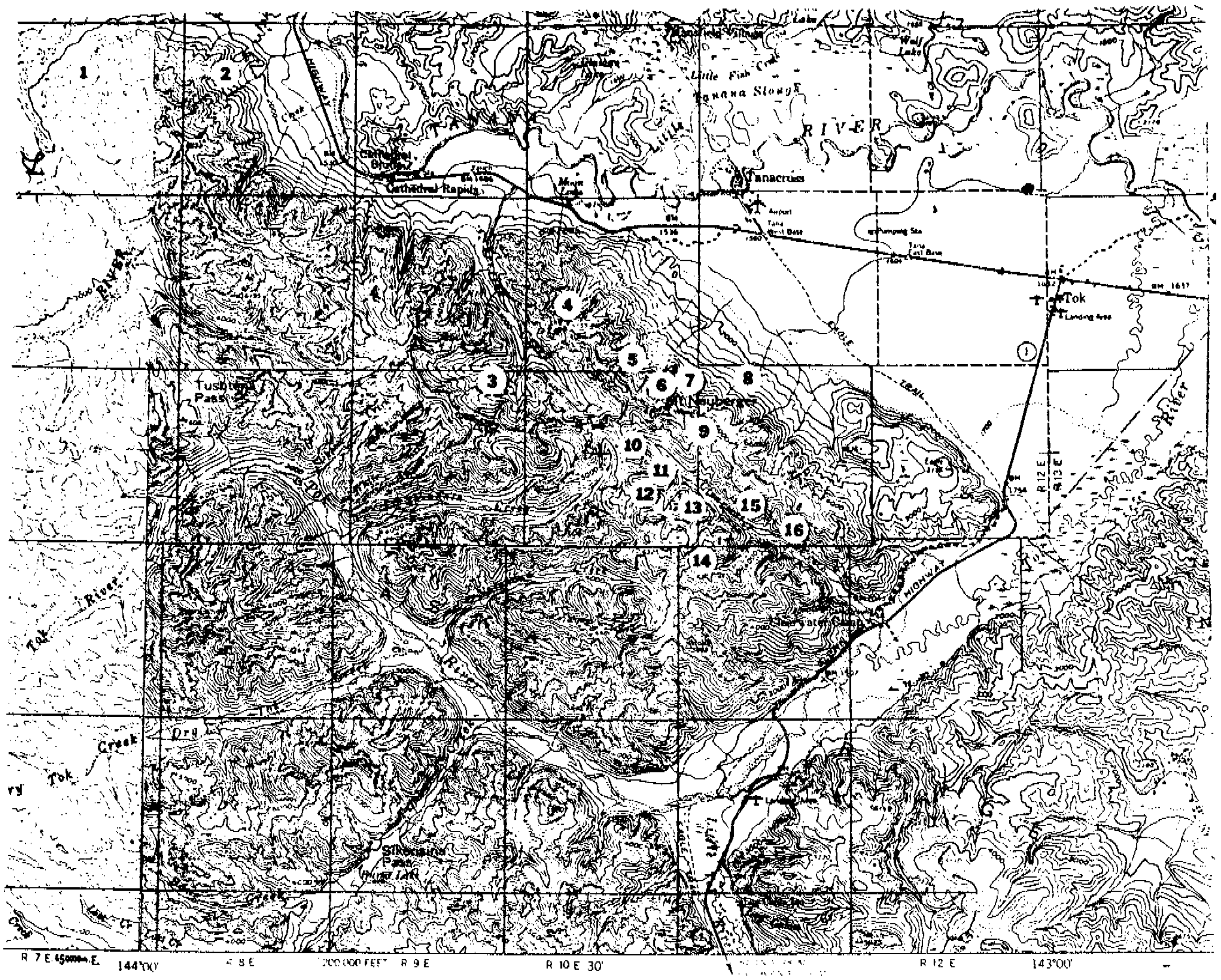

Collars sighted are indicated above and in tabulation below. Asterisk denotes those collared ewes sighted during aerial surveys in March and April 1981.

ID no.	Collar color	Collar no.	ID no.	Collar color	Collar no.	ID no.	Collar color	Collar no.	ID no.	Collar color	Collar no.
1	Red Yel	1	4	Red Blk	5	8	Blue Yel	2*	11	Blue Yel	1
	Red Yel	06	5	Yellow Blk	1	9	Green Yel	01	12	Red Yel	--
2	Red Yel	6*	6	Yellow Blk	3		Green Yel	03*	13	Red Yel	X
	Green Yel	06		Red Blk	4*		Green Yel	05	14	Red Blk	05
	Red Yel	5*	7	Blue Yel	0*				15	Green Yel	07*
3	Blue Yel	4		Green Yel	00	10	Yellow Blk	5	16	Red Blk	30*

Fig. 2. Location of collared ewes sighted 15-16 April 1982 during aerial surveys of Sheep Creek study area.

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APPENDIX A

RESPONSES OF DALL SHEEP POPULATIONS TO WOLF CONTROL IN INTERIOR ALASKA

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INTRODUCTION

Severe winters in the mid-1960's and the early 1970's initiated a moose (*Alces alces*) decline in the Tanana Flats south of Fairbanks. Excessive sport hunting and wolf (*Canis lupus*) predation sustained the moose population decline. Other ungulate species, particularly caribou (*Rangifer tarandus*), were also declining. The gravity of moose and caribou population declines prompted the Alaska Department of Fish and Game to initiate a wolf control program to reduce mortalities on the ungulate species involved. This program had immediate beneficial effects on moose and caribou numbers which have increased to levels that can safely support reasonable levels of both human harvest and predation. Wolf numbers are also increasing again (Gasaway et al., submitted 1982).

Sheep numbers also responded to reduced wolf numbers but to a smaller degree than moose or caribou populations. The purpose of this paper is to describe changes in the sheep population prior to and following wolf control and to discuss, in general, the effects wolves may have on Dall sheep abundance in Interior Alaska.

METHODS

Wolves

The abundance and distribution of wolves in the study area were determined primarily by extensive aerial surveys (Stephenson 1978). Population estimates for the 17,060-km^2 area were made annually between 1972 and 1979 with the most accurate estimate resulting from 324 hours of fixed-wing flying prior to and during initial wolf control efforts in winter 1975-76. Wolves were removed by shooting from a helicopter after tracking and locating wolf packs with fixed-wing aircraft. A mandatory sealing program provided accurate harvest data on wolves taken by the public. The carcasses of 162 wolves killed in the study area from 1976 through 1979 were necropsied in the laboratory. Data on sex and age, nutritional and reproductive condition, and food habits were collected.

Sheep Population Size

Lamb production and yearling recruitment were determined from composition counts at the major mineral lick in the study area. Sheep were classified using spotting scopes at distances of less than 200 m. The mineral lick was observed daily from 19 June through 30 June from 1972 through 1981 from 0430 to 1200 hours.

Population estimates were made from collared sheep resighting data, aerial surveys, and intensity of mineral lick use during the observation period. An estimate for 1970 was based on a partial aerial survey, although total numbers in 1970 were not estimated until Heimer (1976) surveyed the entire study area in 1975. A 1970 postlambing population of 1,500 sheep was estimated by assuming that sheep distribution in 1970 was similar to that observed during the complete survey in 1975 (see Heimer 1973). In 1972, the mineral lick was observed 24 hours/day for 6 weeks. The return frequency for 200 collared sheep was then used to estimate the total sheep population. This technique yielded a population estimate of 1,473 in 1972. After 1972, various sampling methods were used to estimate annual population size based on data gathered in a particular year. Heimer's 1975 aerial census enumerated 1,232 sheep. Since 1975, population estimates have been made from a nomogram constructed by plotting the mean daily number of sheep using the mineral lick as a function of population size and a sample period from 0430 to 1200 hours beginning 19 June and ending 30 June. An additional known data point, in which a mineral lick estimate was confirmed by aerial census, was obtained in 1980. During all aerial surveys, data were divided into census units which correspond to the home ranges of ewes determined from movement studies (Heimer 1973). A map detailing census blocks is shown in Fig. 1. Estimates of population size made from this nomogram were an average of 3.2% higher than those derived by other sampling methods. The standard deviation of estimates from the mean was 4.7%.

Sheep Population Trend

Data for population size were divided into time periods before and after wolf control in the vicinity of the study area. Prelambing population size was plotted as a function of time, and the method of least squares was used to determine the equation describing the best straight line through the data.

RESULTS

Wolves

The Tanana Flats wolf population was estimated at 239 prior to the initiation of control efforts in winter 1975-76. Less extensive surveys indicated at least 200 wolves were present during early winter from 1972 through 1974. The 1975 population included 23 packs with an average size of 9.3 wolves, distributed

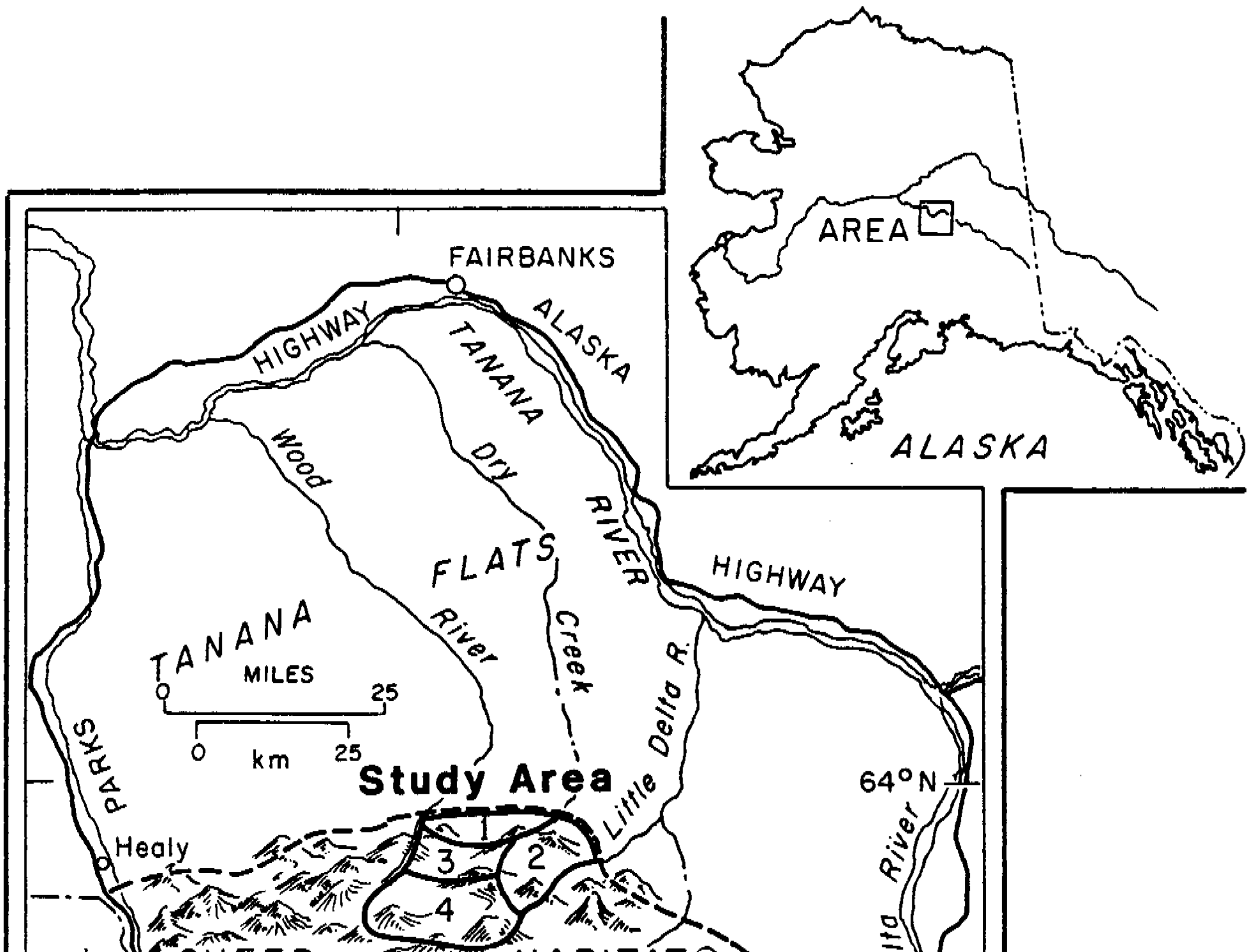

Fig. 1. Map of the Tanana Flats and the sheep habitat lying along the southern edge. The count blocks in the Dry Creek study area are numbered 1-4.

fairly uniformly on the Tanana Flats. This population was reduced by about 60% during winter 1975-76 when 145 wolves were taken. Wolf numbers were maintained near this level through 1979. This program was primarily designed to benefit moose and caribou populations, and control efforts were emphasized in areas used by these species. Moose and caribou habitat overlapped considerably with sheep between 1976 and 1979.

Data reflecting winter food habits were obtained from the stomachs of 156 wolves killed between 1976 and 1979. Fifty-five percent of the stomachs contained moose remains, 12% contained caribou, 2% sheep, 3% snowshoe hares, and 26% were empty. Of the 99 wolves killed near sheep habitat, only 3% had sheep remains in their stomachs. Although both successful and unsuccessful attempts by wolves to prey on sheep have been observed during summer and winter fieldwork, neither of these observations nor the occurrence of food remains in stomachs suggests that wolves preyed on sheep as regularly as on moose and caribou.

Sheep Population Size and Trend

Sheep populations adjacent to the wolf control area showed immediate trend reversals. Those that were in decline began increasing when wolves were removed from their home ranges. Where wolves were not removed, sheep populations continued to decline at the same rate observed before wolf control. Fig. 1 shows the sheep study area divided into count blocks corresponding to discrete ewe subpopulations (Heimer 1973). These subpopulations were used for comparative analyses of the aerial censuses in 1970, 1975, and 1980. Table 1 gives flight times and total sheep seen during the census flights in these years. Since lamb production is variable from year to year, it is best to use the number of adults for year-to-year comparisons. We have gone further, using only adult "ewes" from censuses of 1975 and 1980, those years immediately prior to and following sustained wolf control (Table 2).

Postlambing sheep population size estimates and sex and age compositions for the entire study area before and after wolf control are given in Table 3. The 4 estimates of prelambing population size prior to initiation of wolf control show a downward trend. This trend is described by the equation $y = 1,254 - 85X$. After wolf control, the population trend is described by the equation $y = 1,010 + 0.5X$. It should be noted that these slope coefficients have units of "sheep lost or gained" per year in the prelambing population. Before wolf control, the overall population trend was downward at a rate of 85 sheep/year. Following wolf control, the population trend changed, indicating a gain of about 1 sheep annually. That is, the number of sheep lost/year was reduced by 86 sheep/year following wolf control. However, during the pre-wolf control period, research-associated mortalities (Heimer 1982) accounted for an average of 6 sheep/year. These mortalities were not wolf

Table 1. Total Dall sheep counts from 1970, 1975, and 1980 for Dry Creek, Alaska Range.

Area surveyed	1970		1975		1980	
	Count	Time	Count	Time	Count	Time
1	315	*	250	3.0hrs	407	3.5hrs
2	485	*	347	2.4hrs	454	4.0hrs
3	332	*	341	3.0hrs	327	4.0hrs
4			294	5.9hrs	220	7.8hrs

* Specific time not available by area; total time 11 hrs.

Table 2. "Ewe"[1] numbers for survey areas within the Dry Creek vicinity in 1975 and 1980.

Area surveyed	1975	1980	Direction and magnitude of change
1	183	197	+8%
2	240[2]	294	+23%
3	186[2]	166	-11%
4	152[2]	116	-24%

[1] Definition of "ewe": sheep not identifiable as lambs or rams during aerial surveys. This class includes yearlings and young rams which cannot be reliably distinguished from adult ewes in July.

[2] Number of lambs not classified in these areas for 1975. The number of ewes is back-calculated using aerial counts, mineral lick data for 1975 for lambs and yearlings, and lick data from 1974 to give a number of 2-year-old rams likely to be present with ewes and classified as such from the air.

related and should be subtracted. Hence, differences in population trend indicate about 80 sheep/year were not lost to the prelambing population of sheep following wolf reduction. The total overall prelambing population size has stabilized near the 1975 level with count blocks 1 and 2 15.5% higher and blocks 3 and 4 17.5% lower than 1975 levels.

DISCUSSION

Impact of Wolf Reduction on Dry Creek Study Population

It is clear that sheep numbers and population trend in blocks 1 and 2 changed noticeably at the time wolf control began. Shepherd, Lentsch, and Haggland (pers. commun.), continuous participants in wolf reductions since 1975, report wolves continue to frequent count blocks 3 and 4 but are virtually absent from blocks 1 and 2. This suggests that wolves were, in large measure, responsible for the decline in sheep numbers seen in the 1st half of the 1970's. These findings tend to corroborate Murie's (1944) conclusion that wolf predation was the primary force controlling sheep numbers in Mt. McKinley National Park, adjacent to the Tanana Flats. Data given in Tables 2 and 3 suggest the various sheep subpopulations in the study area did not respond uniformly to wolf control. Populations in areas 1 and 2 increased to 1970 levels after declining by about 20% by 1975, while populations in areas 3 and 4 have apparently continued to decline from 1975 levels. These differences could be due to survey irregularities but may indicate that subpopulations closest to the focus of wolf removal (the Tanana Flats) showed the greatest response in terms of population trajectory. However, the low frequency of sheep hair in wolf stomachs during late winter suggests sheep were not a major food source for wolves during this time. This raises the question of how wolves could have depressed sheep numbers.

Changes in lamb production, survival, and yearling recruitment in the Dry Creek study area are strikingly similar to those in Denali National Park, about 70 km to the west, where no wolf control occurred and where moose and caribou populations are still low or declining. Therefore, the pattern of lamb survival does not appear to be related to wolf density. That is, wolves do not appear to exert their primary influence on Dall sheep populations through selective predation on lambs and yearlings. Because wolves did not appear to take large numbers of sheep in the study area during winter when caribou and moose are most vulnerable, 1 remaining hypothesis is that most wolf predation selects the various sex and age classes of sheep in the same proportions in which they occur in the populations during summer. It is also possible that no packs specializing in sheep hunting were collected during the wolf control effort on the alpine fringe of the Tanana Flats, and that some wolves relied more on sheep during winter than our food habits data indicate.

Impact of Wolf Reduction on the Entire GMU 20A Sheep Population

During an aerial survey in July 1970, 4,142 sheep were observed in GMU 20A; 25% were lambs. Assuming a sightability factor of 0.8 (Heimer 1982), the total population would have included 5,178. Subtracting the estimated number of lambs results in an adult population estimate of 3,882. Prior to wolf control, the prelambing population (Table 3) in the Dry Creek study area averaged 1,150 sheep and was declining by about 80 sheep/year. Use of data from Dry Creek to estimate prewolf control losses for the entire sheep population influenced by wolf control indicates the total population declined by about 280 sheep annually. This decline ceased following wolf control, suggesting the annual loss of sheep to wolves had exceeded recruitment by about 280.

During winter 1975-76, 39 wolves were taken in or near sheep habitat. During the 3 subsequent winters, an additional 11, 39, and 10 wolves, respectively, were taken. Because sheep numbers responded immediately following the reduction in wolf numbers in 1975-76 and because subsequent removal of wolves probably maintained the population near the level initially reached, it appears the removal of about 39 wolves resulted in 280 additional sheep surviving annually. Although this does not tell us the total number of sheep killed by wolves annually, it does indicate the amount by which the loss of sheep to net wolves removed exceeded recruitment.

These figures appear to be reasonable when the following calculations are considered. The composition of the sheep population averaged 22% lambs and yearlings with a mean weight of 16 kg, 58% ewes with a mean weight of 50 kg, and 20% rams with a mean weight of 77 kg. Assuming the average weight for sheep in this area is 48 kg (Heimer 1973) and that wolves preyed on the various sex and age classes of sheep in the proportion at which they occur in the population, the total weight of sheep taken annually by wolves (above recruitment) would have been 13,440 kg. Since wolves consume about 80% of a sheep carcass, the total weight of sheep actually consumed was nearly 11,000 kg. Based on a study of radiocesium concentrations in wolves and their prey in the Tanana Flats, Holleman and Stephenson (1981) calculated that wolves preying primarily on moose consumed at least 2.8 kg/day/wolf. This estimate compares favorably with estimates of the amount of prey consumed in various field studies of free-ranging wolves (Mech and Frenzel 1971, Kolenosky 1972, Mech 1977, Peterson 1977, Fuller and Keith 1980) which range from 1.7 to 10 kg/day/wolf. If wolves occupying sheep habitat also consumed 2.8 kg daily, 11,000 kg of sheep would support about 11 wolves for 1 year.

These conservative calculations suggest the equivalent of 11 wolves relying on sheep for all of their diet would be sufficient to make the difference between stability and the observed decline in sheep numbers prior to wolf control. If wolves maintained a higher consumption rate, the number of wolves required to cause a decline of the magnitude observed would be even less.

Table 3. Population and production estimates for the Dry Creek study population from 1972 through 1981.

Year	Estimated prelambing population	Estimated postlambing population	% breeding ewes	Number breeding ewes	Number lambs produced	Number yearlings produced	% survival
1972	1,300	1,473	55.9	823	123	132	--
1973	1,110	1,423	57.9	823	313	91	74
1974	1,070	1,280	58.6	750	210	187	60
1975	1,031	1,230	57.7	709	199	163	78
wolf control begun							
1976	1,050	1,310	55.2	723	260	116	58
1977	936	1,350	52.9	714	414	121	47
1978	1,094	1,390	51.9	721	296	180	43
1979	942	1,340	45.7	612	398	116	39
1980	1,003	1,425	44.2	630	422	227	57
1981	1,044	1,450	46.6	646	387	277	66

Other Factors

Lamb production and/or survival in the study area were variable between 1969 and 1981. The decline in Dall sheep numbers from 1970 to 1975 coincided with low lamb production and yearling recruitment (Table 3). This was during a period of what are considered "normal" winters in interior Alaska except for the winter of 1971-72 which was particularly severe for sheep. Only 123 lambs were produced the following spring, and only 91 survived to yearling age. Generally higher lamb production after wolf control probably resulted from milder winter weather after 1975. Winters have been noticeably mild since the mid-1970's. It is possible that overall increased lamb production and subsequent recruitment could be a result of decreased numbers of breeding ewes mediated by a density-dependent mechanism. However, Table 1 shows that in 1975, 709 ewes produced 199 lambs. In 1977, 714 ewes produced 414 lambs. This number of lambs in 1977 more than doubled the number produced by nearly the same number of ewes 2 years earlier. We think the increases in lamb production are more likely related to mild winters than to decreased density. It is interesting to note that survival to yearling age decreased following wolf control.

In summary, it appears reduced wolf numbers in the Tanana Flats had a noticeable effect on the area's sheep population, resulting in a general increase or stabilization in sheep numbers. Our calculations of wolf numbers and the amount of wolf predation necessary to account for the observed response are approximate. However, they do show how relatively small increases or decreases in wolf predation could influence sheep population dynamics.

In recent years, the varying effects of predation on moose and caribou populations in Alaska have been brought into perspective (Gasaway et al., submitted 1982). The data from our study indicate that in areas where large predators exist at normal levels of abundance in the presence of moose and caribou, predation may have a significant controlling effect on sheep. However, there is little evidence suggesting that over large areas wolves rely on Dall sheep to the extent they do on moose or caribou since the decline we observed in sheep numbers during the early 1970's was less precipitous. Nevertheless, our data showing changes in sheep population trends where wolves are absent and continuing sheep declines where wolves are present suggest wolves may have depressed sheep numbers and were probably a major cause of mortality. The occurrence of wolves and other predators and other general ecological conditions in this area are to a large degree representative of most Dall sheep habitat in Interior Alaska. These specific considerations suggest that increases in the human harvest of sheep must be approached cautiously in areas, such as Alaska, where large predators are still abundant. Furthermore, areas with less stable weather patterns should receive an even more cautious appraisal when increased human harvest is considered.

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APPENDIX B

DIFFERING REPRODUCTIVE PATTERNS IN DALL SHEEP:

POPULATION STRATEGY OR MANAGEMENT ARTIFACT?

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ABSTRACT

Observed lamb:ewe ratios, collection programs, and studies of marked ewes indicate differing reproductive patterns between ewes of high and low quality populations in interior Alaska. The low quality population has a high incidence of lambing at age 2, and subsequent alternate-year production of lambs has been documented there. In the high quality population, ewes have their 1st lambs a year later, at age 3, and then produce lambs annually. Nutrition and body composition data suggest no differences in energy availability on the 2 ranges. The major difference between the 2 groups is age composition of the breeding rams. In the low quality population, maximal harvest at 3/4 curl has been practiced for more than a decade, and young rams take part in the rut. The high quality group has been managed for trophy production since 1974 and has an essentially undisturbed ram age structure. We think the behaviorial differences due to the removal of dominant males before the rut may result in the breeding of 18-month-old ewes in the low quality group. Early breeding in these populations is not a direct result of density-mediated nutritional conditions.

APPENDIX C

COST COMPARISON OF SHEEP CENSUS USING FIXED-WING OR ROTARY AIRCRAFT

We found the Super Cub, a fixed-wing aircraft, to be a more cost-effective survey tool than the Bell 206-L helicopter. Three surveys were flown in the Dry Creek study area, 2 in the Super Cub, and 1 in the helicopter. The 1st Super Cub flight was flown with an experienced observer (Heimer) under favorable counting conditions; 102 sheep/hour were seen. The 2nd Super Cub flight was flown with the same pilot (Lentsch) and an inexperienced observer (Watson) under turbulent conditions; 64 sheep/hour were seen. The mean unit cost for the Super Cub surveys was $1.37/ sheep seen. The helicopter survey was flown with both observers under ideal counting conditions. The number of sheep seen per hour was 84 at a cost of $3.91/sheep observed. For comparison, the helicopter survey in the Sheep Creek study area was flown in a Hughes 500D with both observers and under ideal counting conditions. In 6.0 hours of helicopter survey time, 77 sheep were seen/hour at a cost of $5.09/sheep. All costs were derived without consideration of ferry time to the survey area.

We recommend Super Cub aircraft for population surveys based on these results and similar past experiences. The helicopter survey even with 2 observers and under ideal counting conditions was not as cost-effective as the Super Cub survey. We suspect that helicopter noise creates sufficient disturbance that sheep take evasive action before they can be spotted by the observers. However, the helicopter is preferred when attempting to read visual collars.