THE DALL SHEEP POPULATION OF SHEEP MOUNTAIN/KLUANE NATIONAL PARK

REVIEW OF NATURAL HISTORY, ASSESSMENT OF POPULATION DYNAMICS, AND RECOMMENDATIONS FOR MANAGEMENT

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INTRODUCTION AND STUDY OBJECTIVES

"Sheep Mountain" on Kluane Lake, Yukon, and its surroundings have been of special interest for a variety of reasons for many years. We know very little about the importance of this area and its Dall sheep to the native people of the Yukon prior to the arrival of White man, but around the turn of the century the general area was already an important goldmining district. Silver City, at the south end of Kluane Lake, now a ghost town, serviced some 200 miners during the first decade of the century. Many of them worked Sheep Creek and Bullion Creek, water courses within the study area reported on here. There is general agreement, that the miners hunted the local sheep population very heavily, since game was their only source of fresh meat. Hunting by commercial meat hunters was also legal at the time, and parties from as far away as Dawson were observed in the area (Hoefs, 1975). While no data are available to assess the degree to which the sheep population had become depleted, indirect evidence points to the fact that the Slims River valley had become useless to trophy hunters (Martindale, 1913 ; Auer, 1917; McGuire, 1921). Mining activity declined after going strong for 15 years and in 1914 Silver City was closed down as an official R.C.M.P. station, Post Office and trading centre. Subsequently the sheep population recovered, and - based on eye witness reports - had by the late 1930's reached a size of 150 to 200. At that time this Mountain was already known to Yukoners as an exceptional good sheep range.

The population received its second severe blow as a consequence of the construction of the Alaska Highway in 1941. As had been the case

during the gold rush days, Sheep Mountain was again in a very vulnerable location. This time it was the route of this new military highway. While no official records are available, interviews with oldtimers revealed that army personnel responsible for the building and maintenance of this highway engaged in intensive hunting activity. Reference to the depletion of game along this road is found in a report by Clark (1945), who was commissioned to do the first biological reconnaissance of the area, which had by then been declared a "park reserve" with hunting being prohibited.

In 1950 a forest ranger was stationed at Kluane Lake, and since then some records and publications are available about the sheep population. A number of zoologists worked in the area for short time intervals until 1969, when our detailed study was initiated (Cameron, 1952; Banfield, 1953, 1960; Geist, 1971). A more thorough historical review of the human activity in the area and the fate of the sheep population is given in Hoefs (1975). From 1969 to 1972 the writer carried out an ecological study in the area, which addressed botanical (Hoefs et al 1975) as well as zoological questions (Hoefs & Cowan, 1979). During this study period the adult number of Dall sheep, established in late winter prior to the lambing period, remained relatively stable at around 200.

In 1972 the establishment of a national park was announced for the area, and the perimeter of the range of this sheep population was in part used as park boundary. In consultation with the National Parks Service and the Yukon Wildlife Branch it was then decided to continue the surveillance and monitoring of this sheep population. The reasons or

study objectives can be summarized as follows:

1. The investigation had concluded that this winter range is filled to capacity with around 200 adult sheep and no population build-up should be expected, now that National Park status allowed for stricter enforcement of game laws and complete protection of the population. It should be pointed out, that prior to Park establishment a significant proportion of the annual "mortality" was man-induced (live capture of sheep for game farm and zoos, poaching, accidental deaths during trapping operations - Hoefs, 1975).

2. Concern was expressed about the presence of feral horses on the winter range, and a population decline was predicted, should this competition be allowed to continue (Hoefs and Brink, 1978).

3. The designation of the area as National Park and the concomitant advertising of that fact, was expected to attract tourists to the area. It was of interest to find out how the sheep population would react to this increasing disturbance by visitors.

4. Botanical investigations (Hoefs et al 1975; Douglas, 1974) had revealed, that this area is not only of importance as sheep range, but that it contains rare plant associations and unique species, of significance on a continental scale. The proposed Park management plan, therefore, gave this Mountain the designation of "special preservation area", which is given to certain unique places that require special precaution in their management.

The continued surveillance of the sheep population provides one of the baseline requirements upon which a management itinerary can be drawn up.

5. Long term studies of ungulate populations are rare. More and more of the research activities of government, industry and universities is centered around short-term investigations, so-called "fire-fighting" jobs. And yet it is long-term investigations which are needed to properly assess the dynamics of a population to be able to establish parameters upon which management plans can be based.
In this investigation, the first 5 years of intensive study had provided us with many facts, such as range of the population, migration times and patterns, and appropriate survey procedures. The follow up of annual monitoring could therefore be carried out at relatively little expense.

This report addresses zoological aspects only. The accompanying report, entitled "Sheep Mountain, Kluane National Park - an assessment of its importance as a Dall sheep winter range and recommendations for its management", deals with botanical matters.

This report, firstly, reviews natural history parameters of this population, which are relevant for management. Secondly, the population dynamics of this herd are described for this 12-year assessment period. Finally, recommendations are made for the conservation of this unique sheep population.

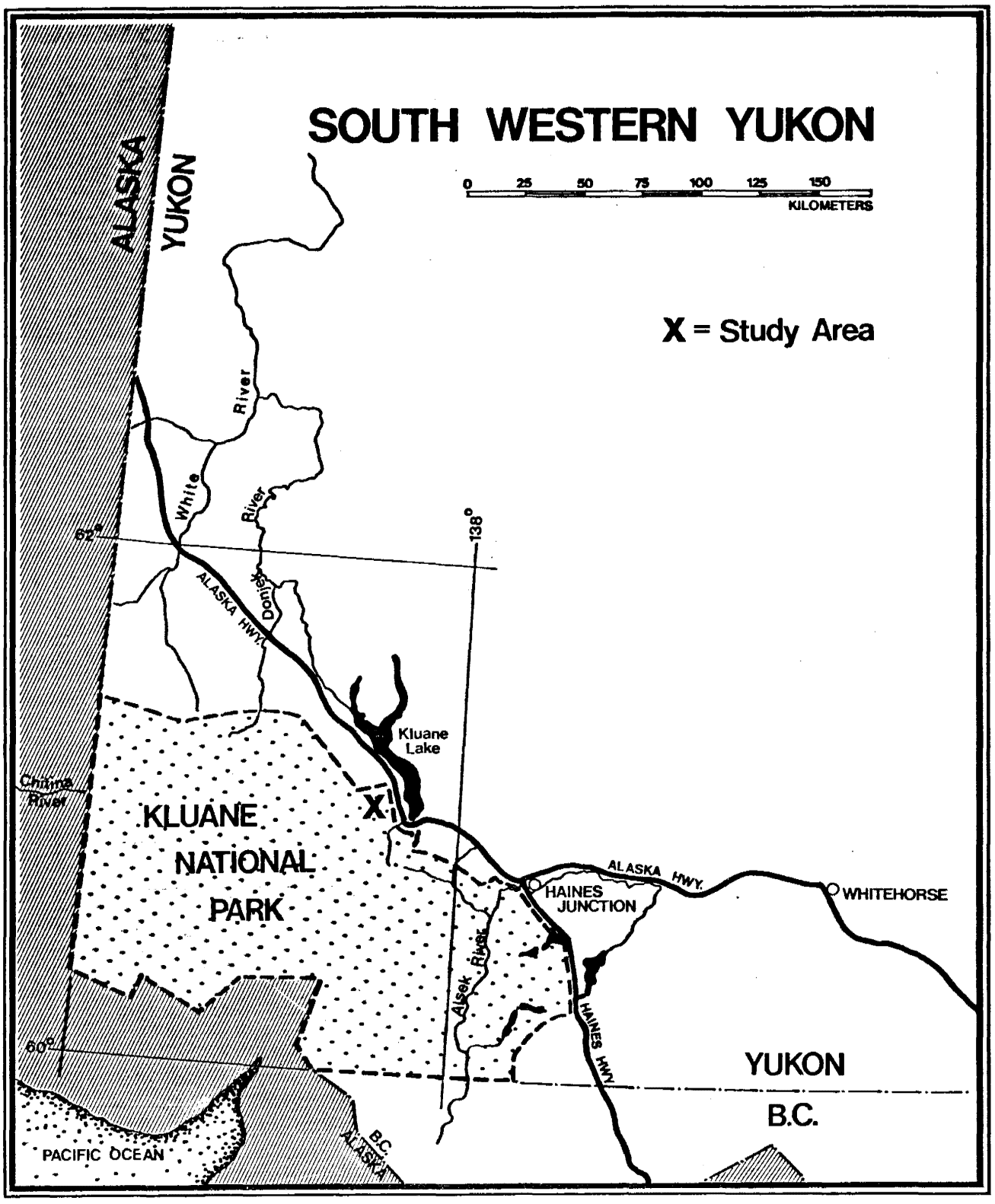
CHARACTERISTICS OF THE ECOSYSTEM

The study area "Sheep Mountain" is located at Kluane Lake, southwest Yukon Territory, in the centre of the newly established Kluane National Park (Fig. 1). The geographic coordinates of the entire range of the sheep population, of which Sheep Mountain comprises the wintering area, are 61° 00' to 61° 10' N and 138° 30' to 138° 50' W. This entire area is about 165 km^2 in size, 113 km^2 of which are actually utilized by sheep. The elevation of the Shakwak Trench, in which Kluane Lake is located, is about 775 metres above sea level, the highest peaks of Sheep Mountain rise to 1950 metres.

The boreal vegetation zone extends to an elevation of about 1200 metres and consists mostly of white spruce (Picea glauca) forests. The subalpine shrub zone, composed mainly of dwarf birch (Betula glandulosa) and several willow species (Salix spp.) may reach an elevation of 1550 metres on favourable sites. Dry, south-facing slopes in the forested as well as in the subalpine zones are usually occupied by grassland vegetation. It is these grasslands, that make up the winter range of the local sheep population. Frequent species in them are: Artemisia frigida, Carex filifolia, Calamagrostis purpurascens, Agropyron yukonense, Arctostaphylos ura-ursi, Oxytropis viscida and Erigeron caespitosus. The alpine zone in the most extensive vegetation type in the area. Dryas integrifolia, Festuca altaica and Cassiope tetragona are dominant plants here. The altitudinal limit of vascular vegetation is reached at an elevation of 2150 to 2300 metres. Permanent snow is encountered above the 2500 metres level.

The bedrock in the area consists mainly of metamorphic and sedimentary

FIGURE 1.


SOUTH WESTERN YUKON
0 25 50 75 100 125 150
KILOMETERS
X = Study Area
ALASKA
YUKON
White River
White River
62°
138°
ALASKA HWY.
Donjek
Kluane Lake
Chitina River
KLUANE NATIONAL PARK
X
ALASKA HWY.
HAINES JUNCTION
WHITEHORSE
Alsek River
HAINES HWY.
60°
YUKON
B.C.
PACIFIC OCEAN
B.C.
ALASKA

deposits of Triassic, Permian and Cretaceous ages. Three glacial periods modified the physiography and left a thick layer of glacial till around the base of Sheep Mountain. The soils are juvenile and azonal. They are characterized, particularly at lower elevations, by recent loess deposits. The deposition of loess continues to this date, whenever strong down-glacier winds stir up the silt deposits of the Slims River floodplain at times of low water. Most soils are characterized by high alkalinity. Detailed description of the vegetation of the area and its substrate are found in Hoefs et al (1975).

The Kluane area lies in the rainshadow of the St. Elias Mountains and the climate is semi-arid and continental. Annual precipitation is usually less than 250 mm. Summer temperatures hardly reach 25°C and winter temperatures of -40°C to -50°C are not unusual. Local modifications of the regional climate are brought about by the proximity of Kluane Lake and the funnelling effect of the Slims River valley on down-glacier winds. The former results in a moficiation of the local temperature when the water is not frozen, the latter adds to the dryness of the region and is responsible for creating snow-free areas in winter, which are heavily grazed by sheep. Detailed description of the local climate and weather patterns are found in Taylor-Barge (1969).

The sheep population is characterized by a high density, short life expectancy, and a great incidence rate of various mandibular diseases, collectively referred to as "lumpy jaw". While the sheep is the only abundant large mammal in the area, competition for forage is provided by a large groundsquirrel population and by the occasional presence on parts

of the winter range by feral horses. The area has many coyotes, which appear to be the main predator of sheep. On the other hand, perhaps because of the proximity of the Alaska Highway, wolves are not observed very often. Considering the latitude, the avifauna of the area is rich and includes members of several major Canadian biomes (Therberge, 1978; Hoefs, 1973).

METHODS AND MATERIAL

The writer worked in the study area during the following time intervals: May 16, 1969 to September 14, 1969; April 10, 1970 to November 14, 1971, and from May 4, 1972 to September 14, 1972. Subsequently he took up a position with the Yukon Wildlife Branch at Whitehorse, but the gathering of population data was continued at specific times during short stays in the area throughout 1980. The dates at which surveys were carried out subsequent to 1973 are listed in Table 1. At least three surveys were carried out annually, usually more: One survey in late winter/early spring (March/April) to assess winter mortality, particularly first year mortality of lambs, one survey after completion of the lambing period in June or July to assess lamb production as well as total population size. This census always included a surveillance of the entire range of this population by helicopter, with 3 or 4 observers. Additional surveys from the ground were made, whenever the opportunity presented itself. Helicopter surveys served the purpose to establish the total population size, the number of lambs present after the lambing period, as well as a broad separation of the population into bands of older rams and nursery groups. Ground counts allowed a separation of nursery groups into adult ewes, yearlings and young rams.

The population data presented here, differ somewhat from those collected by the National Parks staff during the last few years. These differences are explained by the use of different survey boundaries. The writer has always used Congdon Creek as the northern boundary of this populations' range, but has included "Bullion Plateau", which is used by Sheep Mountain

rams in winter and spring, surveys by National Parks staff have included both sides of Congdon Creek, but have omitted "Bullion Plateau".

REVIEW OF ANNUAL ACTIVITY CYCLE ON SHEEP MOUNTAIN

The population occupies its winter range on Sheep Mountain and along Williscroft Creek till early June. During the winter months rams are usually found at lower elevations than ewes, the mean value for January being 980m for ram bands and 1100m for nursery bands (Fig. 2). Snow distribution, temperature, and windchill influence the distribution during winter. It was observed that sheep of both sexes moved downhill when it became colder and avoided windchills with an index of V (Hoefs, 1975). Sheep preferred to feed on sites with no snow or very little snow. Over 50 percent of all feeding took place on exposed, wind-swept ridges with no snow cover, and no feeding was observed in snow depth exceeding 30 cm. During the winter months the average band size was six to eight with 20 to 50 percent of the bands observed, consisting of "mixed groups" (Fig. 3). This mixing was a result of the very high density of sheep on the winter range, it was not a phenomenon of social behaviour. Densities on preferred sites of the winter range reached 17.7 sheep 1 km^2 for several months. As spring approaches there is a gradual uphill movement of sheep and a slow separation of sexes. During May some rams follow the retreating snow line uphill, but return again to feed on new, green vegetation at low elevations. The average band size in May is the lowest for any month with 4.5 sheep/band, because pregnant ewes isolated themselves from nursery groups to give birth and remain by themselves with their young lambs before rejoining the nursery bands. Most lambs are born in the cliffs above the large, southeast-facing slope of Sheep Mountain at altitudes exceeding 1700m. During the second half of May and early June heavy use is made of the mineral licks above the abandoned cabin at Mile 1054 and along several cuts

Fig. 2

Vertical migration of sheep population

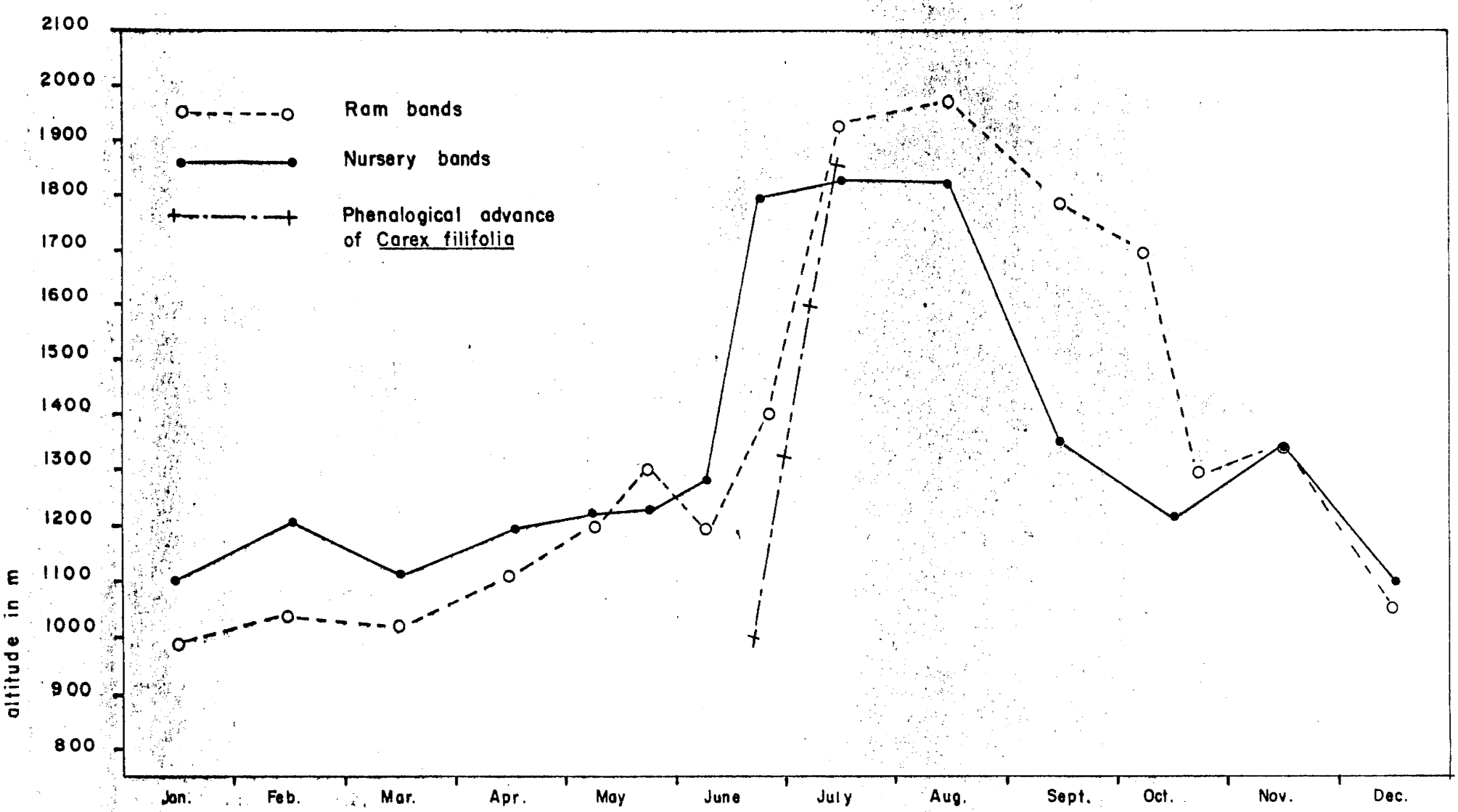
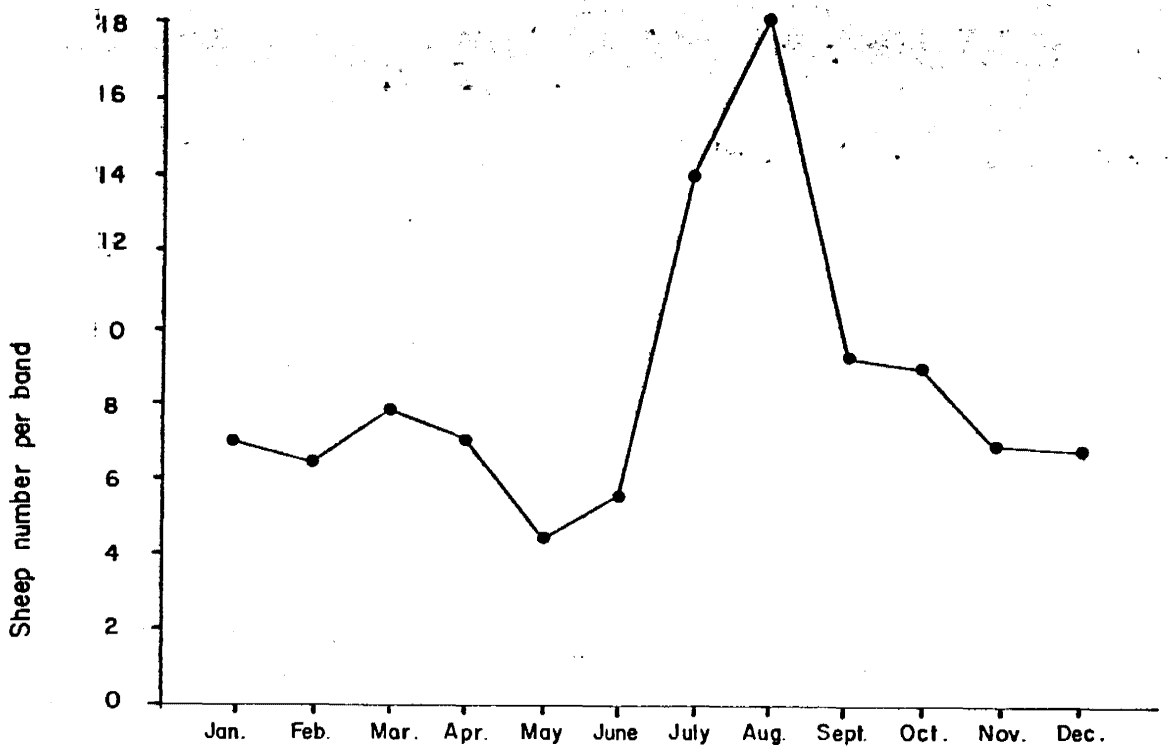
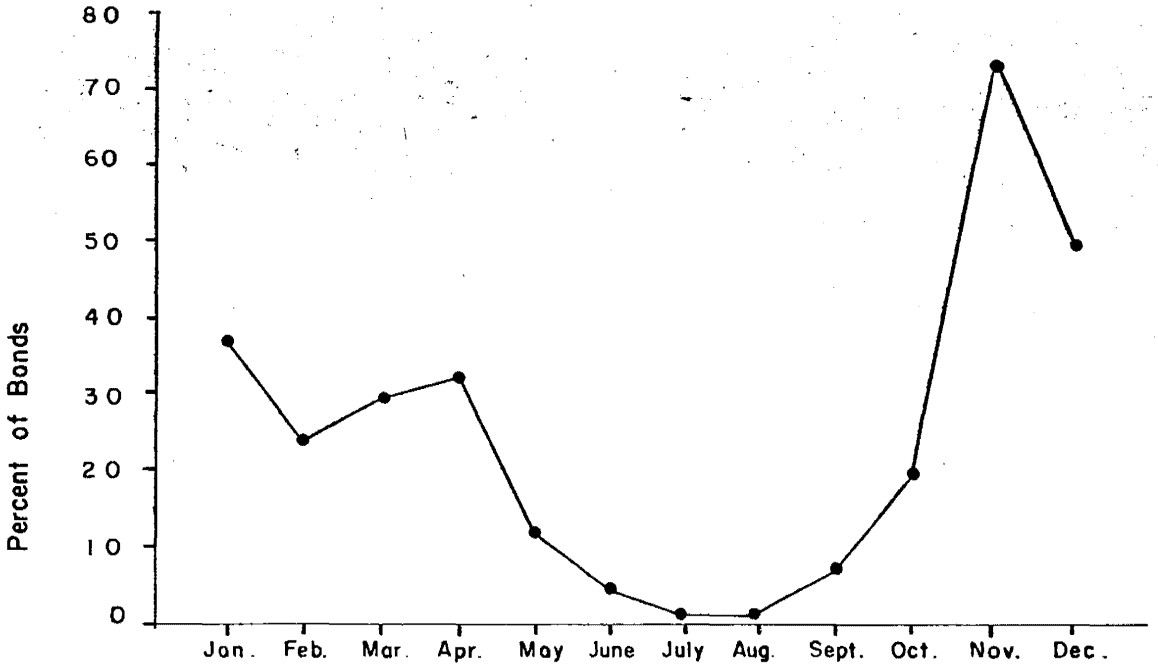


Fig.3 Average band size in Dall sheep population over the annual cycle.



Percentage of mixed band over the annual cycle



made to accommodate the pipeline. During the latter part of May and early June both sexes begin their vertical migration to alpine summer range (Fig. 2). Several years of observations indicate that most lambs are born during the third week of May, and that the lambing period is essentially completed by June 1. By mid June some sheep, particularly rams, have reached the boundary of the annual range and may mix with members of adjacent populations. This is particularly the case along Congdon Creek, and it can impose a bias on population estimates, if aerial surveys are done too late. It is therefore recommended to carry out the annual population surveys as soon after June 1 as possible. By June 7, in an average year, some rams may have reached Congdon Creek, but usually no nursery bands yet. It is also known, that some rams cross Sheep Creek at this time and migrate toward Bullion Creek. The Plateau between these two creeks should therefore be included in the annual aerial surveys. During the summer months (July, August), the sheep form often large bands, particularly the nursery groups (Fig. 3). Average band sizes for July and August are 14.2 and 18.2, with nursery groups of up to 96 being observed. Ram bands are usually smaller. July and August are the months when the sheep are found in the highest elevations during the annual migratory cycle and at the greatest distance from their winter range. Mean elevations for rams in August are 1970 m and for nursery bands 1830 m (Fig. 2). While the average distance from winter range of all sheep is only 5 km from Sheep Mountain, some rams may move as far as the headwaters of Duke River, 14 km from Sheep Mountain. Generally speaking, however, it was found from observations of marked sheep that Congdon Creek is a good northern boundary of this population's range, and the Plateau between

Sheep and Bullion Creek a good western one. The number of sheep crossing these boundaries is small, and it is compensated for by sheep from other populations moving in during these summer months. The most heavily used summer range for this population is the north-facing slope of Sheep Mountain and the adjacent west-facing slope of Mt. Wallace. More than 75 percent of the population spend the summer months in this area. Bullion Plateau and adjacent area to the north to the headwaters of Congdon Creek and Duke River are primarily used by ram bands. In most years nursery bands begin to move back to Sheep Mountain in August, and some may be observed on the large southeast slope already during the middle of that month. However, they remain at high elevations. By the middle of September most nursery bands have returned to Sheep Mountain and Williscroft Creek and may descend to an elevation of 1400 m. At this time they make extensive use of the willows in the sub-alpine shrub zone, which still have green leaves, while most of the ground vegetation has already dried up. Most rams remain at alpine elevations till the latter part of October (Fig. 2). During November, the rutting period, the sexes are mixed, and the average band size is small (6.9), because of many isolated rams or small groups of rams moving about in search of estrous ewes. Subsequent to the rutting period, both sexes move farther downhill, and the usual winter distribution comes into being, with rams usually found at lower elevations and forming smaller bands.

Staff at the information booth at the base of Sheep Mountain report that in recent years nursery sheep have been observed high on Sheep Mountain's south face even during July, which was not the case during our intensive study period ten years ago.

POPULATION SIZE AND COMPOSITION

Result of the population survey data for this 12-year assessment period are given in Table 1. Rams listed for the period 1974 to 1980 do not include 2-year old rams, which are still with nursery bands, correspondingly the ewes listed for this period include those 2-year old rams. The numbers of lambs listed are those established during June surveys, after the lambing season is completed. The data therefore do not include those lambs that have died during the first few weeks of life. A graphical presentation of the population trend is shown in Fig. 4.

An attempt has also been made to estimate the population structure consisting of the following components: Lambs and yearlings of both sexes, 2-year old females and female 3 years old and older, and rams 2 years old and those 3 years old and older (Table 2). A knowledge of the population structure is important to estimate the adult sex ratio and to determine productivity, since in this population females only give birth after they have reached their third birthday. The 2-year old ewes in the female cohort would introduce a bias, for instance, in the estimation of reproductive potential of the population (Hoefs, 1975). Their number has to be deducted from the total numbers of females. As far as the males are concerned, most of the 2-year olds are still in nursery bands and will introduce a bias in the calculation of population dynamics parameters, such as sex ratio or lamb to ewe ratio, if they are not accounted for. Two-year olds can only be recognized at very close range. It was not possible to approach each band in the population close enough for proper identification of 2-year olds during one counting procedure. Their numbers were therefore calculated under

TABLE 1 CLASSIFIED COUNTS OF THE SHEEP MOUNTAIN POPULATION

YEAR		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	$\bar{x}$
Survey dates				Hoefs, 1975			Apr 12 May 4 Jul 24	Mar 20 May 6 Jun 5 Jun 24	Mar 12 Apr 17/18 May 28/30 Jul 2	May 9,22 Jun 8 Jul 9	Mar 25 Apr 21 Jun 10	Apr 15/16 May 25/27 Jun 5	Apr 20 May 17/19 Jun 11	
Rams	(1)	65	81	85	82	77	75	77	79	59	66	62	64	72.7
Ewes	(2)	69	90	89	86	84	112	113	107	91	100	104	103	95.7
Yearlings	(3)	30	24	32	36	36	28	14	6	15	8	35	24	24.0
Lambs	(4)	33	37	50	40	29	17	9	15	19	43	43	29	30.3
TOTALS		197	232	256	244	226	232	213	207	184	217	244	220	222.7

(1) Rams from 1974 to 1980 do not include 2-year old rams, which are still with the nursery bands.

(2) Ewes from 1974 to 1980 include 2-year old rams.

(3) The numbers of lambs listed are those established in early July and therefore do not consider early mortality.

Fig.4 Graphical presentation of population composition and trend

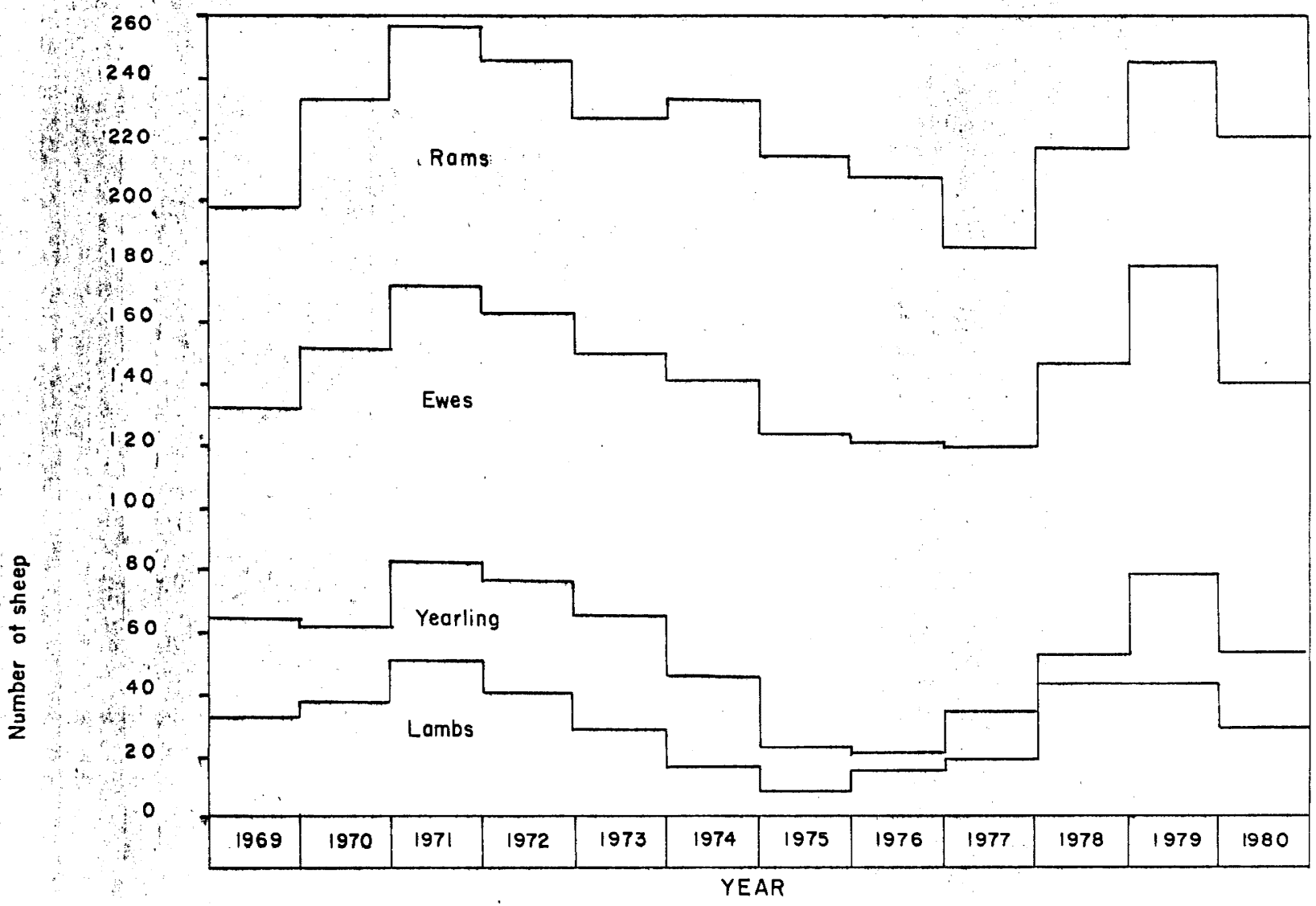


TABLE 2 CALCULATED COMPOSITION OF THE SHEEP MOUNTAIN POPULATION

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	$\bar{x}$
Male ⩾3y.	?	68	74	67	61	75	77	79	59	66	62	64	68.4
Male 2y.	?	13	11	15	16	16	13	7	5	4	4	16	10.9
Male total	65*	81	85	82	77	91	90	86	64	70	66	80	78.1
Female ⩾3y.	?	77	78	71	68	79	87	94	85	86	96	71	81.1
Female 2y.	?	13	11	15	16	17	13	6	1	10	4	16	11.1
Female total	69*	90	89	86	84	96	100	100	86	96	100	87	90.3
Yearling	30	24	32	36	36	28	14	6	15	8	35	24	24.0
Lambs	33	37	50	40	29	17	9	15	19	43	43	29	30.3
SUM	197	232	256	244	226	232	213	207	184	217	244	220	222.7

* count incomplete

the following assumptions: a) an equal sex ratio exists among the yearlings on the average, even though variations can be observed in a given year or population, particularly when the sample size is small; b) the mortality during the second year of life is less than 10 percent. Evidence, that these assumptions are realistic, is found in Geist (1971), Hoefs (1975), and Simmons et al (1982). A third assumption made was, that immigration or emigration of sheep is not significant, and therefore the number of adult seen in any one year should first of all be explained by natural mortality and by recruitment of previous year's 2-year olds into the cohort. Support for this assumption comes from Geist (1971) and Hoefs (1975). Unequal sex ratios among the yearlings had to be assumed only in 1976 and 1977 and consequently in the 2-year olds of 1977 and 1978 to explain the number of adults observed.

The average composition of this population for the 12-year observation period was therefore as follows: 68.4 male ($\geq$ 3 years old), 10.9 male (2 years old), 81.1 female ($\geq$ 3 years old), 11.1 female (2 years old), 24.0 yearlings and 30.3 lambs for a total average population size of 222.7 in June/July.

The population fluctuated around this mean value by up to 17 percent. Adult ewes were the most stable population component, varying by only 10 percent about their mean number. Yearlings and lambs, with $\leq$ 75 percent and $\leq$ 70 percent respectively, varied most. The number of adult rams fluctuated by up to 16 percent.

There is some indication, that the population fluctuations observed, which were based primarily on variations in the numbers of lambs and yearlings, were not random events, but proceeded in a distinct downward trend from 1971 to 1976/77, followed by an increase to 1979. In this phase of decline and build-up the lamb and yearlings set the pace and the total population size lagged behind by one year. This trend is obvious from the graphical presentation of population size and composition in Fig. 4.

a) Productivity

The number of lambs observed in June/July, after the lambing period is completed, averaged 30.3 for the 12-year observation period, with peaks being reached in 1971 (50) and 1978,79 (43,43). Very few lambs were observed in 1975 and 1976 with 9 and 15 respectively. It must be emphasized that these observations in June/July do not account for very early mortality, which will be referred to later. Expressed as percentage of the total population, lambs comprised on the average 13.6%, the range being 19.5% (1971) to 4.2% (1975). Natality presented as ratio of lambs to ewes or lambs to "nursery sheep" is given in Table 3. The lamb to ewe ratio, where ewe is referred to as female in reproductive age ($\geq$3 years old), was on the average 41:100; it reached a high of 64:100 in 1971 and a low of 10:100 in 1975. The ratio of lamb to "nursery sheep" is not a very realistic indicator of productivity, since "nursery sheep", includes yearlings and 2-year olds of both sex. However, this ratio is often given in the sheep literature, because of the difficulty of separating the nursery bands into individual components during aerial surveys. This ratio averaged 24:100, the range

TABLE 3

RATIOS BETWEEN POPULATION SEGMENTS

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	$\bar{x}$
Male / 100 Female	0.94	0.90	0.96	0.95	0.92	0.95	0.90	0.86	0.74	0.73	0.66	0.92	0.86
Male (≥ 3y) / 100 N.S.	N/A	0.48	0.56	0.49	0.45	0.54	0.61	0.70	0.56	0.61	0.45	0.50	0.50
Lambs / 100 ♀ (≥ 3y)	N/A	0.48	0.64	0.56	0.42	0.22	0.10	0.16	0.22	0.50	0.45	0.41	0.41
Lambs / 100 N.S.	N/A	0.29	0.38	0.29	0.21	0.12	0.07	0.13	0.18	0.40	0.31	0.23	0.24
Yearlings / 100 ♀ + 2y-olds	N/A	0.21	0.32	0.36	0.36	0.25	0.12	0.06	0.16	0.08	0.34	0.23	0.24
Yearlings / 100 ♀ (≤ 3y)	N/A	0.31	0.41	0.51	0.53	0.35	0.16	0.06	0.18	0.09	0.36	0.34	0.32

being 40:100 (1978) to 7:100 (1975).

A review of the literature on the productivity of other northern sheep population had revealed a range of 74:100 (Luckhurst, 1973) to 14:100 (Nichols and Heimer, 1972). The mean value of 41:100 for the Sheep Mountain population must therefore be considered as average performance, particularly in light of the fact that it did not take into consideration lamb mortality during the first few weeks of life. It is not known, whether ewes gave birth in alternate years only, as was recently described for a poor quality population in Alaska (Heimer, 1978). In a recent investigation Simmons et al (1982) reported a mid summer lamb to ewe ratio of 62:100, a value significantly higher than that of the Sheep Mountain population. Both population maintained relative stablility. The Sheep Mountain ewes had fewer lambs, but these had a good winter survival rate (76.9%). The MacKenzie Mountains ewes had more lambs, but their winter survival rate was only 54.3% (Simmons et al 1982).

b) Mortality during the first year of life

The mortality of lambs from June/July, when they are about one month old, to May following, when they are one year old, can be calculated from the numbers of lambs observed and the number of yearlings seen next spring (Table 2). The results are summarized in Table 4 and expressed as percent survival. This survival rate averaged 76.9%; it was as low as 42% from 1977 to 1978, and as high as 100% from 1976 to 1977. In the calculation the assumption had to be made, that there was no exchange of yearlings with neighbouring populations.

TABLE 4 SURVIVAL RATES OF POPULATION SEGMENTS

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	$\bar{x}$
Male	N/A	N/A	91.4%	78.8%	74.3%	97.4%	84.6%	87.8%	68.6%	100%*	88.6%	96.9%	85.3%
Female	N/A	N/A	86.7%	79.8%	79.1%	94.0%	90.1%	94.0%	85.0%	100%	100%	71.0%	88.0%
Lambs	N/A	72.7%	86.5%	72.0%	90.0%	96.6%	82.4%	66.7%	100%	42.0%	81.4%	55.8%	76.9%

* In the calculation of the mean value the year 1978 was not considered, since immigration is known to have occurred.

Mortality during the first month of life could only be documented for the years 1971, 1972 and 1976, when it amounted to 15%, 20% and 22% respectively. It is not unreasonable to predict that this early mortality happens every year, and we have therefore for the life table construction, estimated a total first year mortality rate of 42%, consisting of 19% during early life ($\bar{x}$) and 23% during the remaining 11 months, primarily the first winter.

Mortality during the first few weeks of life is difficult to document; (Heimer, 1978) estimating it to be between 0 and 60%, depending on weather conditions. Simmons et al (1982) calculated an early mortality of 21% based on a known pregnancy rate of 94 ewes and a summer lamb to ewe ratio of 62%. Here the assumption was made that all pregnant ewes carry to term.

A comparison of the survival rates of Sheep Mountain lambs with that of other populations, must be restricted to that of the 11-month period from June/July to May following; with few exceptions, only this is reported in the literature. With a rate of 77% these lambs have an exceptional good survival, one of the best reported (Hoefs, 1975).

The total first year survival rate of 58%, can only be compared with that of the MacKenzie lambs with 34.7% (Simmons et al, 1982). This distinct good characteristic of the Sheep Mountain population is obvious.

c) Mortality of adults

Mortality during the second year of life is difficult to document

without marked animals. However, if one assumes an equal sex ratio among yearlings and establishes the number of 2-year old males in the population around their second birthday, when they can be distinquished from females and older males by their horns (Hoefs, 1975), it is possible to caluclate that this mortality is betwwen 5% and 10%. For life table construction we have used 7.1%, which was the average value observed (n = 5 years).

Mortality in the older classes can be calculated from the number of adult animals in a given year, and the number of adults plus yearlings in the previous year (Table 2). The mortality rate for rams averaged 14.7% and for females 12% (Table 4). The 1978 value for rams (100%) was not considered in the calculation of this mean rate, since immigration of a few young rams was observed. The mortality rates for rams varied between 31.4% in 1976/77 and 26% in 1973/74, for ewes the range was 0% in 1978/79 and 29% in 1979/80.

The mortality rate of adult males based on 130 skulls was calculated from the life table (Table 5) to be 14.23%. This value is remarkably close to the 14.7% actually observed (Table 4) and gives some support to the use of life tables in predicting population dynamics parameters, a use, whose reliability is sometimes being questioned (Geist, 1971; Simmons et al, 1981).

d) Sex ratios

An equal sex ratio at birth was estimated from a sample size of 81, based on observations during the early phase of this study and reports

from the literature (Hoefs, 1975). To this it can be added observation by Simmons et al (1982) of sixty-eight fetuses with a sex ratio of 33 male:35 female.

While an equal sex ratio at birth can be assumed on the average, considerable discrepancies have been documented, particularly if the sample sizes are small. Of six lambs born in the Yukon Game Farm, Whitehorse in 1969, two were males and four were females. In a live capture operation on Sheep Mountain in 1971, of eight lambs were caught six were males and two were females. We have no evidence of the claim, that in years of poor lamb production, females dominate, while in years of good productivity the reverse is true.

The adult sex ratios observed are listed in Table 3. The 12-year average was 86 male:100 female. It was closest to equality in 1971 with 96 male:100 female. The greatest discrepancy was documented for 1979 with 66 male:100 female.

The ratio of adult rams to 100 nursery sheep is of practical value, for instance to assess to impact of hunting from aerial surveys. Adult rams (> 3 years old) are usually separated from other sheep during summer, while nursery bands include ewes, yearlings and 2-year old males. The ratio was on the average 50 male:100 "nursery sheep", and varied between 70:100 in 1976 and 45:100 in 1973 and 1979.

Despite reports to the contrary (Murie, 1944; Buechner, 1960) it is my

disposition based on this 12-year investigation and on many unpublished survey reports on file with the Yukon Wildlife Branch, that an equal sex ratio in Dall sheep population (unhunted) is the exception rather than the rule.

e) Life table

Life tables can be used to determine such ecological parameters as age composition of a population, mean mortality rate, age-specific mortality rate, rate of replacement, and such "practical" questions as percentage of rams becoming "legal" in a given year, if life table data are combined with those of age-specific horn growth rates (Hoefs, 1982).

Based on skulls collected by Murie (1944) in Alaska, life tables have been constructed by Deevey (1947), Kurten (1953), Taber and Dasman (1957), Buechner (1960), Caughley (1966) and Bradley and Baker (1967). Deevey's (1947) tables have become classics and have been widely reproduced. Murie's (1944) data have often been criticized, most recently by Bradley and Baker (1967), and a re-evaluation of them has shown that the younger age classes were under represented, and the sex ratio of the population was unequal, favouring females (Murphy, 1974; Murphy and Whitten, 1976). Bradley and Baker (1967) modified the original life table for the Mt. McKinley Dall sheep, by combining data based on skull collections with those on mortality in the juvenile age classes obtained from surveys in the field. The combination of these two sets of data requires, that the population has been stable.

TABLE 5

LIFE TABLE FOR RAMS OF THE SHEEP MOUNTAIN POPULATION

X	fX	FX	dX	1x	100qx	100px
0 - 1	101	241	420	1000	42.0	58.0
1 - 2	10	140	41	580	7.1	92.9
2 - 3	4	130	16	539	3.0	97.0
3 - 4	5	126	21	523	4.0	96.0
4 - 5	7	121	29	502	5.8	94.2
5 - 6	5	114	21	473	4.4	95.6
6 - 7	11	109	46	452	10.2	89.8
7 - 8	14	98	58	406	14.3	85.7
8 - 9	19	84	79	348	22.7	77.3
9 - 10	22	65	91	269	33.8	66.2
10 - 11	23	43	95	178	53.4	46.6
11 - 12	14	20	58	83	70.0	30.0
12 - 13	6	6	25	25	100.0	0.0

X = Age in years

fX = Frequency in sample

FX = Cumulative frequency

dX = Numbers dying in age interval out of 1000 born

1x = Numbers surviving at beginning of age interval out of 1000 born

100qx = Mortality rate per 100 alive at beginning of age interval

100px = Survival rate per 100 alive at beginning of age interval

Fig. 5 Comparison of mortolity rates of rams

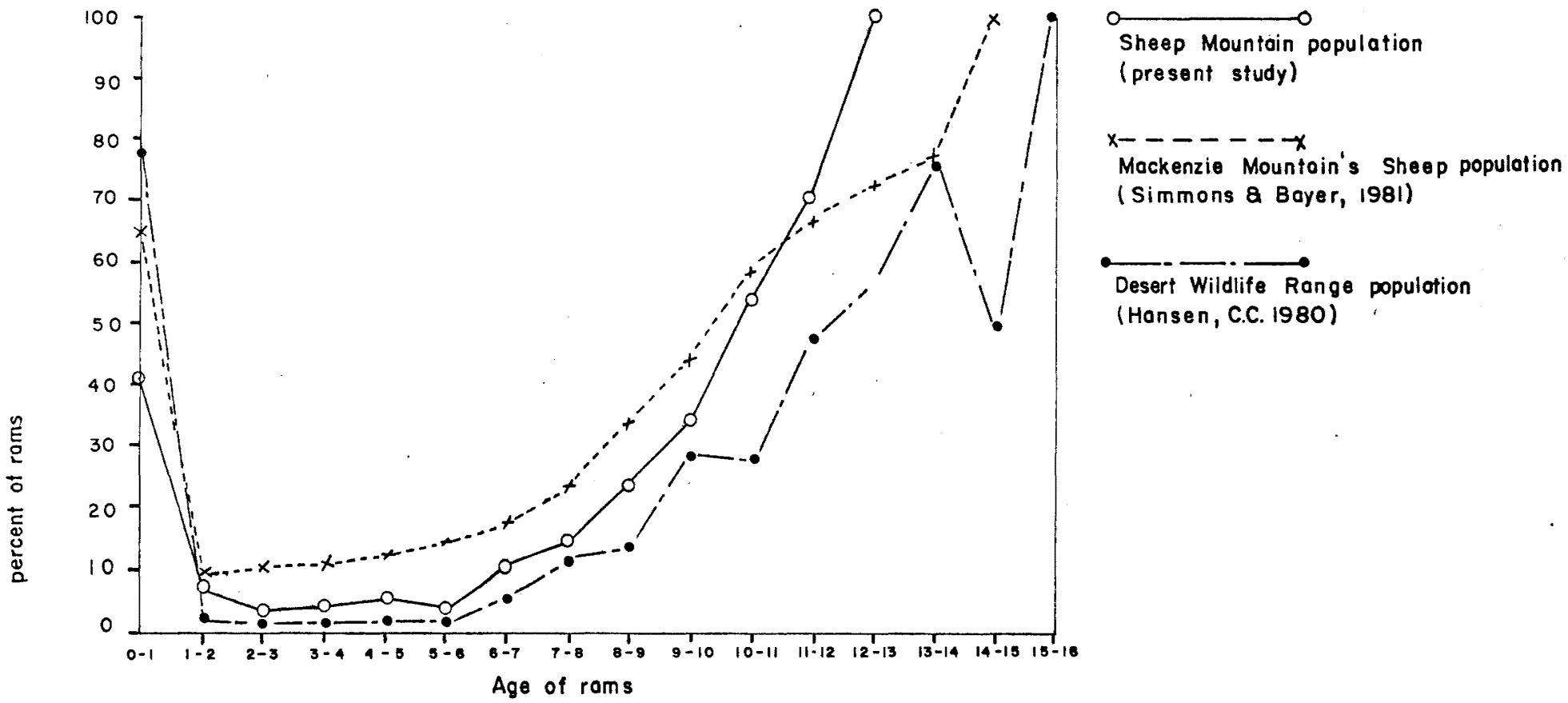


Table 5 is based on 130 skulls of rams that died of natural mortality within the range of this population. The ages were determined by the horn ring method (Geist, 1966; Hemming, 1969). Mortality during the first and second year was based on direct observations, being the mean value for this 12-year investigation period. As pointed out earlier, 42% was estimated for the first year of life, 7.1% for the second. The remaining mortality of 50.9% was calculated from the ages of 130 skulls collected during the period.

Table 5 varies somewhat from the life table presented earlier (Hoefs, 1975), since that table was based on the 1969 to 1973 period, in which the average lamb production was higher. The present, updated, table shows a higher mortality during first year, somewhat lower mortalities from the second to the 7th year, and similar mortalities in the old age cohorts. The maximum life expectancy of 12 to 13 years remained.

Fig. 5 shows a comparison of the mortality rates based on Table 5 with those for Dall rams in the MacKenzie Mountains (Simmons, 1982). The Sheep Mountain rams are characterized by considerably lower mortality during the first year of life. They have also lower mortality rates than the MacKenzie Mt. rams in the middle age classes, but not as low as the rates of Desert Bighorns. In the old age classes the mortality increases greatly and exceeds that of the other two populations in the 11 - 12 and 12 - 13 year cohorts. The maximum life expectancy for the Sheep Mountain rams is 2 years less than that of the MacKenzie Mt. rams and 3 years less than that of the Desert Bighorns. A survey of the literature revealed, that the

maximum life expectancy may be the shortest of any North American sheep population, whose dynamics have been subject to study (Hoefs, 1975). It has been hypothesized that the reasons are unusual rapid tooth wear because of wind-deposited silt on the forage, as well as a very high incidence rate of various jaw diseases, collectively referred to as "lumpy jaw". These diseases result in displaced and missing molariform teeth, and thereby may contribute to a lowering of the life expectancy (Hoefs, 1975). Supportive information for this hypothesis comes from the Russian literature on the wild sheep of the Pamir (Egorov, 1967).

No life table could be constructed for the ewes of the Sheep Mountain population. Based on 12 skulls found in the field and on observations of marked animals, it appears that their maximum life expectancy is similar to that of rams. Mortality in the young age classes appears to be comparable also. The unbalanced sex ratio seems to come into being by heavier mortality of rams in the middle and old age cohorts.

DISCUSSION

The Sheep Mountain population is characterized by a very high density. If the total potential range of 165 km^2 is considered, then a maximum July population of 250 sheep translates into a year-round density of 1.5 sheep/1 km^2. However, it is known, that 75% of the population only uses Sheep Mountain and the adjacent Mt. Wallace. This year-round density works out to be 7.5 sheep/1 km^2, which is the highest reported for any northern sheep population. Higher yet is of course the density on the winter range, which nursery bands may use up to 9 months of the year. Preferred sites on the winter range have densities as high as 17.7 sheep/1 km^2 (Hoefs, 1975).

To explain this high carrying capacity was one of our initial study objectives. That investigation as well as a concurrent assessment of range productivity (Hoefs and Brink, 1978) led to the assumption, that the winter range is filled to capacity and that no population increases should be expected. On the contrary, it was predicted, that the continued presence of feral horses in the area, the disturbance of sheep by an increasing number of tourists as well as more frequent aircraft travel in the area, or a series of dry summers would result in a population decline.

While monitoring of population dynamics parameters was carried out for a 12-year period, simultaneous assessment of potentially influencing factors (weather, forage production, disturbance, competitive by horses, predator pressure, etc.) could not be done, or only sporadically. It is therefore only possible to speculate about the reasons for the population fluctuations observed.

Sheep populations in general are characterized by stability (Geist, 1971; Simmons et al, 1982). Exceptions are observed in areas, where severe winter conditions cause great mortality in certain years (Murie, 1944; Nichols and Smith, 1971; Palmer, 1941), or in populations that are subject to periodic decimations by parasites or diseases, often introduced by domestic livestock (Stelfox, 1971).

The Yukon Wildlife Branch monitors the performance of a number of Dall sheep populations, which for various reasons (great hunting pressure, disturbance by industry, presence of diseases) are of importance. These data also reveal some variation in population size from one year to the next, depending on winter mortality and size of the lamb crop. However, these fluctuations are more randomly distributed about some mean value, nor do they show the amplitude of variation observed on Sheep Mountain. The distinct downward and upward trend observed requires an explanation. The trend documented is primarily brought about by variation in the number of lambs, and survivial of lambs to yearling age. The numbers of adult sheep have fluctuated very little.

In general it can be said, that years of population peaks (1971, 1977) are characterized by high lamb crops, high survival rates of previous years' lambs to yearling age and above average winter survival rates of adults (Tables 2, 4). Population lows (1975, 1976) are characterized primarily by exceptionally low lamb crops. There is some indication that during the recovery phase of the population (1976 to 1979) the female component builds up faster than the rams segment of the population, which

led to a considerable discrepancy in the sex ratio (Table 3).

Interesting is the fact that the population peak reached in 1979 is similar to that of 1971/72. This supports our earlier assumption, that the winter range is filled to capacity at that population level (Hoefs, 1975; Hoefs and Brink, 1978).

Range production studies on the wintering areas, carried out in 1969 to 1971 and 1979, had shown a significant correlation between forage produced and the number of lambs born the following spring, as well as winter survival of previous years' lambs (Hoefs and Brink, 1978; Hoefs, 1981).

In the early 1970's up to six feral horses were occasionally observed on portions of the Sheep Mountain winter range. Their number build up to 11 by the mid 1970's. Several letters were written to the Administration of Kluane National Park predicting adverse effects for the sheep by this artificially introduced competition, and requesting that the horses be removed. While their presence in the area was never quantified, it is known that they have not used Sheep Mountain as much in recent years. The creation of Kluane National Park is 1972 brought with it two by-products with a potential of influencing the dynamics of the Sheep Mountain population. Firstly, the removal of sheep through live capture for zoos, game farms, or scientific purposes was disallowed. These annual live captures and related man-caused accidents had previously been a significant "mortality" factor (Hoefs, 1975). Secondly, the advertising of this new

National Park in the north subsequent to 1972 attracted an increasing number of tourists to the area, primarily to Sheep Mountain, being the only easily accessible sheep range in the park. While these sheep had some experience with people, they had not been faced with large numbers of them invading their winter range, particularly at lambing time, when they are still at relatively low elevations and visible from the Alaska Highway. Several letters were written to the administration of Kluane National Park, pointing out the potential danger this type of disturbance could have for the lambing success of this sheep herd. There can be no doubt that this factor had some negative influence on the lamb production for a number of years, until the sheep had become accustomed to this new situation and access to the area was more strictly regulated by the national parks staff.

The nearest weather stations that record weather data in winter are in Burwash and in Haines Junction, a distance of 40 and 50 miles from the study area. An inspection of their data did not reveal a paralleling trend to the population trend in either temperature or snow parameters. We also have no evidence of an increase in predators in the mid 1970's. Possibly because of the closeness of the Alaska Highway, wolves are not seen very often in the area.

Our tentative explanation for the population trend observed, is therefore as follows: The upper population level is determined by the forage production of the winter range. This production can vary, depending on rainfall during the growing season, by as much as $\pm$ 10% about the

mean value, and can explain variation in population size, through variation in lamb production and lamb survival rates, for the years 1970 and 1974 and 1978 to 1980. Declines below this level, as observed in 1975 to 1977 will have been caused by additional, complicating factors. It is suggested that the impact of feral horses on the winter range and the disturbance created by an increasing number of tourists during the lambing period, paralleled by more frequent aircraft and particularly helicopter flights, were these complicating factors. Severe winters, which can cause increased mortality have not been reported for these years of low population level.

In spite of the fluctuations observed the data presented support the general concept of stability in sheep populations. They are a continuation of the historical trend observed (Hoefs, 1975). They argue against the hypothesis presented by Stelfox (1971), that sheep cannot "regulate" their number, and build up to levels that exceed the carrying capacity of their range and are therefore subject to periodic die-offs of perhaps 25- to 30-year intervals.

IMPACT OF DISTURBANCE AND ITS PREVENTION

Having hypothesized that increased use of the area by people and horses may have been responsible for the decline of the population below a level that could be explained by variation in winter range productivity, it is appropriate to analyze the impact of disturbance in more details and to suggest mitigative measures.

The disturbances this sheep population is or could be exposed to can be either direct or indirect. Direct disturbance consists of physical displacement of sheep by direct contact with people or horses, by low-flying aircraft, or dogs running loose. Other examples are the preventing of sheep from carrying out their normal daily activity rhythum, by being excluded from using certain parts of their range, mineral licks, or lambing area, because people may be close to such areas. The negative impact of direct disturbance is usually not directly apparent, and sometimes difficult to document.

There is general agreement that sheep are more sensitive to disturbance than other large mammals based on work done in relation to proposed pipelines (Foothills, 1976; McCourt et al, 1974; Interdisciplinary Systems, 1977). Experimental work was done on the effects of noise disturbance on Dall sheep in the Mt. Goodenough area in the northern Richardson Mountains by McCourt et al, 1974. The investigators set up a sound simulator which imitated the noise of a gas compressor station. They found that the sheep changed their regular bedding and feeding periods, that they changed their range within one mile of the sound

simulator. McCourt et al, 1974, conclude their findings as follows: "Reactions to helicopter and sound simulator noise disturbance can probably be extrapolated to potential disturbance by construction equipment. Therefore, besides the need for caution in the selection of compressor station sites, the location of borrow pit sites and the timing of construction in the vicinity of a Dall sheep range will have to be carefully planned". From this experiment it is reasonable to conclude that sheep will adversely react to construction activity with a noise level comparable to that of a gas compressor station at least one mile on either side of the pipeline right-of-way, and that this "corridor of negative response" will be considerably wider than two miles with noise levels of a greater magnitude, for instance, those accompanying rock blasting.

Of equal, if not greater concern to the wildlife manager, however, are the disturbances created in the back-country far beyond a narrow construction corridor. Disturbance of the sheep in the back-country could be created by large numbers of people invading it on foot or by the use of all-terrain vehicles and snowmobiles, but most importantly by the use of aircraft, particularly that of helicopter. Sheep appear to be particularly sensitive to noise disturbance. Geist (1975) speculates that loud noises frighten sheep as well as other mountain ungulates because they can resemble sounds made by descending avalanches and rock slides.

Aircraft disturbance of wildlife is generally recognized as a major concern accompanying development activities in remote areas (Foothills,

1976; Geist, 1971(b); Klein, 1973). This problem is particularly severe with social animals like sheep and caribou (Foothills, 1976; Calef and Lortie, 1973; McCourt and Horstman, 1974; Surrendi and DeBock, 1976; Calef and Lortie, 1976). It is also generally agreed upon that helicopters frighten animals more than fixed-wing aircraft (Klein, 1973; McCourt et al, 1974).

"The direct effect of harassment is usually flight by the animals which may result in excessive expenditure of energy, possible injury or accidental death, fragmentation of social structures (including separation of mothers and offspring), withdrawal from critical habitat and decreased reproductive performance" (Foothills, 1976). Disturbance during winter can be particularly harmful. Because the nutritional status of pregnant ewes influence the conditions of lambs at birth and their survival, harassment and displacement from winter ranges can severely depress birth rates and increase mortality (Geist, 1971(b), 1971(c)). Disturbances on lambing areas can have similar results (Interdisciplinary Studies, 1977).

Considerable experimental work has been done on the effects of aircraft on caribou (McCourt et al, 1974); Surrendi and DeBock, 1976; Calef, DeBock and Lortie, 1976). There appears to be general agreement that aircraft overflights in excess of 1000 feet do not disturb caribou. Sheep are known to be much more sensitive than caribou, even though no experimental work has been done to enable us to recommend safe overflight altitudes. What little is known on this subject has been summarized by Interdisciplinary Studies (1977) as follows: "The anticipated increase in

irregular aircraft overflights, especially of helicopters, is expected to cause moderate disturbance in alpine and sub-alpine areas in both summer and winter. This will be a problem especially if efforts are made to observe sheep closely from aircraft. Lenarz (1974) found 85% of sheep reacted to a nearby FH-1100 helicopter. McCourt et al, (1974) found helicopter operating near sheep caused temporary range evacuation, displacement of bedding activities and change in the regularity and distribution of activities. A greater use of talus slopes by sheep was also observed during the period of helicopter disturbance. Similarly, Price (1974) found sheep reacted to helicopters up to 1 km away. A helicopter flight over a band of sheep caused visible disturbance and agitation for nearly half an hour. The most serious effect was observed when a helicopter at low altitude circled a band of sheep (Price, 1972). Irregular aircraft traffic produces much greater disruption than regular, frequent flights (Geist, 1975)". It is for these reasons, that aerial census work of this population be restricted to one flight per year.

However, it should also be pointed out that sheep can habituate to strange, but frequent and harmless, stimuli (Geist, 1975). From national parks like Banff and Jasper we know that sheep as well as other big game species have got accustomed to large numbers of people, to roads and the heavy traffic. There are reports from Alaska of Dall sheep living in active strip mines (Geist, 1975). The secret behind these observations is that sheep have learnt that people are harmless in these areas. This process of habituation, however, is a very slow and gradual one.

Indirect disturbance can consist of destruction of critical areas such as mineral licks, lambing sites, important migration trails and winter ranges, at times when sheep are not in the area. The existence and quality of such critical areas determines how many sheep the range can support. This is particularly applicable to the Sheep Mountain situation, where hunting is not allowed and predator pressure is low, allowing the population to exist at the carrying capacity level of its winter range. Reduction of available forage is not only brought about by the grazing of horses, but more importantly by the trampling of horses and people. In an analysis of the impact of horses in Tongquin Valley, Jasper National Park, Scotter (1975) made the following comments: "Although production estimates were obtained during that summer to determine the carrying capacity, it was apparent that the real problem was not related to forage used by horses but primarily to the impact of their trampling".

"The most serious effects of horse grazing are the destruction of plants by trampling and compaction and puddling of soils rather than the consumption of plants". "Forage require a rest from grazing pressure and are particularly vulnerable to damage from grazing, gouging, and soil compaction when growth commences in the spring. Late spring and early summer is the period when horse-use has the most detrimental influence".

In a detailed analysis of forage production of the Sheep Mountain winter ranges and the utilization rates of sheep and horses in the early 1970's Hoefs and Brink (1978) calculated that in 1971/72 sheep and horses together removed 58.4% of the vegetation. This is beyond the level of safe

range use practice, and concerns were expressed that the continued presence of horses in the area may lead to a decline of the sheep population. At that time six horses were using the east side of Sheep Mountain up to six months of the year, particularly in late winter and spring.

In his work in Jasper Park, Scotter (1975) made the assumptions that a horse requires 25 lbs. of forage (air-dried) per day and that only 20% of the current year's growth should be used. This very conservative value of 20% is a reflection of the short growing season in alpine and arctic areas, problems with distribution of horses and the fact that only certain portions of the forage in each community are taken.

If we accept similar standards for Sheep Mountain, then the combined forage removal of sheep plus horses already exceeded a safe range use practice in the years 1969 to 1972. While no continued surveillance of horse use in the area was possible after 1972, periodic visits revealed that the number of horses build up and reached 11 in the spring of 1976. Several letter expressing concerns about the negative impact of free-ranging horses on this critical sheep winter range were addressed to Parks Canada; that written on April 21, 1976 is attached as an appendix to this report. The use by horses of the east side of Sheep Mountain declined after 1972, but some use is continuing to this date. At present (winter 1981/82) between 3 and 5 horses have been grazing at low elevations in the vicinity of the rock slide area. They have in recent years not been observed as far as the cabin, which was the case in the mid 1970's, nor do they appear to move higher up on the mountain, where competition with sheep would be more important.

TABLE 6

TREND IN VISITOR USE OF THE KLUANE AREA

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Haines Junction Information Centre	12155[1)]	13427	14115	16144	19468	21227	16255	17144	23310	14063	26411	38864
Sheep Mountain Information Centre								28.1[2)]	38.9	39.9	65.3	98.3

1) These are the number of tourists registering at the Tourist Information Centre at Haines Junction from late May to mid September.

2) These are the average numbers of visitors per day registering at the Sheep Mountain Information stand.

Besides this increase in numbers of horses using Sheep Mountain, to the mid 1970's there was an increase in the numbers of visitors. Table 6 shows the trend in visitor use of the Kluane area. A 10-year period is shown for the Haines Junction Tourist Information Centre, which was initially managed by the Government of Yukon, but has in recent years been jointly maintained by Yukon Government and Parks Canada.

Prior to the announcement of the Kluane area as one of three new National Parks in Canada's north in 1972, there was an average increase of tourists travelling the area of 5 to 7% per year. Since the announcement, from 1973 to 1981, the mean rate of increase of tourists registering at the Centre has been 18% per year.

An even greater increase has been documented for the Sheep Mountain Information Centre, which was established in 1976, and has been run for a 3.5 months period since 1977. The average number of visitors per day has grown from 28.1 in 1977 to 98.3 in 1981, at a mean rate of 63% per year.

There is no doubt in our mind that the impact of horses to the mid 1970's and this increasing number of tourists on the mountain were two of the factors responsible for the decline of the population. The recent recovery can be explained by a decreased use of the area by horses and the sheep becoming habituated to people.

Free roaming horses in the area will not only have a negative impact on sheep and winter range, but their presence is contrary to national parks policy. Large numbers of people will have a similar impact through direct disturbance and the trampling of the winter range vegetation. People should not be allowed on the mountain during critical periods, and

at other times their number should be strictly regulated to assure firstly, no negative impact is brought about on sheep and vegetation, and secondly, to assure a truly satisfying wilderness experience to hikers.

Considerable work has been done on this concept of "carrying capacity" of a wilderness area for back-country hikers in the national parks of the United States. The following excerpts are taken from the "Back-country Management plan of Mt. McKinley".

"Acceptable damage" (by hikers) is defined as "Loss of vegetation cover, or damage to roots or aerial portions of trees or shrubs, due to trail or campsite formation or other human recreational activities that can be regenerated by natural processes by the following year". "Carrying capacity" is defined as that level and character of use in a given area, over a given time, at a given level of development, which does not cause unacceptable levels of impact on the natural resources or to appropriate user experience of the area (Lime and Stankey, 1971). In one major study conducted in three Rocky Mountain wilderness areas, about 70% of over 400 people sampled indicates that encountering more than two other parties per day on their trip would adversely affect their satisfaction (Stankey, 1973). Mt. McKinley National Park is divided up into 23 units for the purpose of regulating back-country hiking. The average size of these units is comparable to the total range of the Sheep Mountain population. Results of research related to negative impact on terrain and vegetation by hikers in Mt. McKinley Park revealed, that curtailing impact to "acceptable damage" would allow 5 to 6 people per unit per day. This "carrying capacity"

in relation to impact on range, is very similar to the "carrying capacity" referred to above, in relation to user satisfaction. In McKinley Park it is therefore recommended to allow two parties or six people per day to hike in each unit. A similar regulation would be appropriate to Sheep Mountain and Mt. Wallace - the range of this sheep population.

SUMMARY AND RECOMMENDATIONS

The Sheep Mountain ecosystem, of which the Dall sheep population is an important component, is one of the special features of Kluane National Park, which has led to its designation as "Special Preservation Area". This designation does not only pay tribute to the very high sheep density this mountain supports, but is also a reflection of other unique features of the area, such as plant communities and rare plant species, which have not been documented anywhere else in the Yukon. The sheep population exhibits a number of characteristics, which are interesting not only from the point of view of fauna preservation and National Park Management but also from the scientific point of view since some of these characteristics are contraversial in nature and at this time difficult to explain. A few of these features should be mentioned.

The population appears to maintain itself at a level which does not exceed the carrying capacity of its range, in spite of lack of hunting and low present (1980) predator pressure. The population did not exceed the carrying capacity of its range and did not crash in years of heavy predator control in the 1950's. These observations indicate that some kind of population regulation mechanism is in operation. Ungulate in general are denied the capacity to regulate their numbers, and populations are in general maintained at a level below which food becomes limiting by predators, hunters, severe winters and parasites and diseases. The hypthesis proposed from the observations made of this sheep population and its range which point to the regulation being brought about by forage production of the winter range influencing winter survival of lambs and natality rate the

following spring, is an important and unique one, which is worthwhile pursuing further.

The density observed on this range, considering Sheep Mountain and the Mt. Wallace area, where 75% of the sheep spend the entire year, is the highest documented so far for any northern sheep population. In general high density, relatively low productivity, and a high incidence rate of various mandibular diseases, collectively referred to as "lumpy jaw", would justify a designation of this population as one of "low quality". On the other hand, the exceptionally good horn growth characteristics, a short life expectancy and higher than average body weight, are symptomatic of "good quality" populations - a paradox that calls for an explanation.

The continued monitoring of this sheep herd and its range is therefore not only a requirement to accomplish the goals and objectives of the Kluane Park Management Plan and to establish baseline requirements for this special preservation area, but is also a scientific exercise to reject or verify a number of hypotheses on population regulation and population quality. The data collected over the past 12 years reveal the importance of long term studies. The demographic observations made during the latter 7 years vary significantly from those documented in the first 5; even though in the opinion of most, a 5-year study is already referred to as "long term". Continued monitoring is also important to assess the effectivness of management strategies and to evaluate the impact of increasing disturbance. The fact cannot be ignored that Sheep Mountain is located

along the Alaska Highway. Traffic was increasing at an average rate of 7% per year prior to park establishment; and at a higher rate subsequently (Table 6). A natural gas pipeline is planned for the area. There can be no doubt that disturbance will increase, particularly when sheep are at low elevations on their winter range close to the Alaska Highway.

Some of the recommendation made are incorporated already in the National Park Policy, but are difficult to enforce because of the location of Sheep Mountain, the restricted number of enforcement personnel available, and traditional use of the area prior to Park establishment. Nevertheless, a sincere attempt must be made to change this unfortunate situation and to bring the management of Kluane in line with that of other national parks.

To provide baseline data for the management of this Special Preservation area, to follow up with goals and objectives of the Kluane Park Management Plan, to adhere to National Park Policy, and lastly, to address scientific inquiries the following recommendations are made:

1. The monitoring of the Dall sheep population and its range must continue, and is to be carried out by the following methods:

    a) One aerial survey by helicopter to classify and count the entire population, immediately after the lambing period is completed and before the sheep have dispersed too far onto their summer range.

    The period from June 3 to June 10 is the most

appropriate. Sheep encountered north of Congdon Creek must not be included in the total estimate for the Sheep Mountain population. "Bullion Plateau", the area between Sheep Creek and Bullion Creek must be included into this survey, since Sheep Mountain rams are known to use this area at that time. No other aerial survey should be carried out, to avoid unnecessary disturbance. Supplementary to this, several counts from the ground should be undertaken, particularly in late winter to assess winter survival of the previous years' lambs, and adult winter mortality.

b) The collection of skulls and jaws of winter-killed sheep by Parks personnel should continue. While this is contrary to Parks Policy, the proximity of Sheep Mountain to the Alaska Highway assures, that these skulls are picked up by tourists otherwise, and would be lost to scientific investigations on the performance and health of this sheep herd.

c) The vegetation enclosures still in existence should be maintained and surrounded by "chicken wire:, and periodically, at 3- to 5-year intervals, range productivity assessments should be carried out.

d) To test the hypothesis that rainfall during the

growing season influences forage production, which in turn influences lamb production and lamb survival, rain gauges should be established on Sheep Mountain from April 1 to August 30 and rainfall should be registered by the staff of the information booth.

e) The sightings of predators in the area should be recorded. These include wolves, coyotes, grizzly, black bear, lynx, wolverine and cougar as well as occupied by golden eagle eyeries. While such documentations will not reveal the total numbers of predators using the area, repeated observations over a number of years may be indicative of a trend.

2. For the preservation of this sheep population and its range, the following steps are to be taken:

a) The entire range of this population, in the west to Bullion Creek and in the north to Congdon Creek, must be included in this Special Preservation Area. The importance of protecting the entire range of this herd was recognized, when the boundaries for Kluane National Parks were decided on, it should not be ignored now.

b) During late winter and during the lambing

period, for a total time period from January 1 to May 31, the area should be closed to hikers. This is not a unique regulation proposal, but one which is already exercised to protect the fauna and flora in certain areas of Mt. McKinley Park during critical periods.

c) During other times of the year, hikers on the range of this sheep population should be limited to two parties or six people per day. This number appears to be a good compromise between the two types of "carrying capacity" in wilderness area. One is determined by "acceptable damage" by hikers to terrain plus vegetation, the other by the perceiving of crowding by wilderness travellers, and its adverse impact on their satisfaction.

d) To monitor these provisions, to record sheep and predator observations, and to collect rainfall (weather) data, the information booth established at the base of Sheep Mountain must be continued, but it should start the monitoring process already on April 1.

e) Coloured information brochures about Sheep Mountain and its Dall sheep population, as well as the necessity of the imposed restrictions, should be printed by Parks Canada and distributed

in this information booth.

f) Horses and dogs must not be allowed to roam freely in the area and if they are observed, their numbers and the locations of their activities should be recorded.

g) Aircraft flight in the area should be restricted to Slims River valley, at least 1000 m away from Sheep Mountain during those time intervals when sheep are present.

h) A sincere attempt should be made to maintain the present range use pattern of this sheep population by not attracting them to certain areas or displacing them from others. Feeding of sheep, the putting out of salt blocks, or other attempts to tame them or attract them should be strictly disallowed. No seeding of the highway right-of-way should be contemplated.

The recommendations made support the following park management objectives as outlined in the Kluane National Park Management Plan:

1. To preserve the wilderness characters of Kluane National Park.
2. To recognize and preserve the wide variety of unique and significant resources of Kluane including representative ecosystems of the northern coast mountain region, rare plant species and communities, characteristic wildlife

populations, and landforms characteristic of this glacier dominated region.

3. To allow natural processes to continue without interference except to offset man's influence, or to protect unique resources or man-made facilities.
4. To control public access into Kluane for the benefit of preserving its wilderness character and natural features.
5. To develop an interpretive program which will emphasize appreciation of Kluane's wilderness character and importance of preserving it.

As far as the implementation of the Kluane National Park management plan is concerned, the information provided in this document and the recommendations made address the following management strategies and assist in their accomplishments:

1. Preparation of a resource description and evaluation that will identify and document the limitations and capabilities for preservation, development, use and operation of the park.
2. Preparation of a park conservation plan comprising of detailed priorized list of resource management objectives based on the park management plan and resource description and evaluation.
3. Preparation of Resource Management Strategies appropriate to Kluane's protection objectives.
4. Continuation of the monitoring and documenting the natural evolution of the park ecosystem; the evaluation of the

results of resource management actions, and the assessments of the effects of human activities.

EXPLANATORY NOTE ON POPULATION CENSUS AND RANGE ASSESSMENT

The aerial reconnaisance of the population is recommended for early June, because of the migration pattern and lambing time of this population. The great majority of lambs (>95%) have been born by June 1. If surveys are carried out around June 5 to 10; the current lamb crop can be expected to be complete. This sheep population has two winter ranges and lambing areas: the largest and most important one is Sheep Mountain itself, a smaller and less important one is the Williscroft Creek drainage. We know from continuous field work in the early 1970's and from over 80 marked animals, that Williscroft is used for lambing and wintering, while Congdon Creek and Bullion Creek are not. In late May and early June sheep disperse from these winter ranges in a northerly and westerly direction. Congdon Creek and Bullion Creek have their own year-round sheep populations, which are separated from the Sheep Mountain herd in winter and during the lambing time. However, as the sheep disperse in early June, they may move as far north as Congdon Creek and as far west as Bullion Creek, which we established from observations of marked animals. Only rams have been observed to move in early June across the Bullion Plateau, while rams as well as nursery sheep move toward Congdon Creek. When they reach Congdon Creek, a mixing with the local population takes place. This mixing reaches the highest degree in July and August. The later the survey is carried out, the greater the number of sheep that have reached Congdon Creek and mixed with the local population. The winter ranges along Congdon Creek are almost all located

on its north side, while Sheep Mountains animals approach this creek from the south. If surveys are carried out early in June, one can use this creek as a boundary, and arbitrarily consider sheep found south of it as members of the Sheep Mountain population. If surveys are conducted later than mid June, the interpretation of survey data from the Congdon Creek area becomes much more difficult.

It is for this reason that surveys should be carried out as early in June as possible. Even if a few late-born lambs may be missed, this would introduce a much smaller error, than the one we are confronted with through the mixing of these two populations at a later survey.

As far as the collection of precipitation data are concerned, it is recommended to have four rain gaugues set up around Sheep Mountain at its base, since observation during 1969-71 indicate that rainfall varies considerably between the east and west side of Sheep Mountain. These suggested locations would be Bayshore Inn, the Information booths near the Old Cabin, the new Parks cabin and the mouth of Sheep Creek. Standard rain gauges should be used, which need to be protected by a low fence to prevent them from being knocked over. These locations can be reached from the road in a short time. On the average, there is rain only once a week, and therefore, little time is necessary to collect these data.

Periodic range productivity assessment should be done in the same manner as was done in 1970, 71 and 79. This could be done by small contract jobs, since no more than 2 to 3 weeks time are required for clipping, drying, weighing, and report writing.

Only exclosures #3, 5 and 7 are still in existence. They can be maintained by surrounding them by a 3 to 4 feet high chicken wire fence to prevent lambs and yearlings from crawling under the barb wire.

The relative severe restriction recommended in this report for the use of Sheep Mountain by tourists and the other restrictions recommended must be seen in light of its biological value. We have no evidence of another area within a Kluane Park combining such a high sheep density with other unique features, such as rare vegetation types and individual species.

If biological reconnaissance reveals that equally good areas are located within the park in other less accessible areas (ie, the Donjek River drainage), much of the concerns regarding biological values and Park obligation in regards to Sheep Mountain could be shifted to such other sites. However, the location of such sites requires some detailed work; it cannot be established on the basis of a aerial survey only that may have documented a large number of sheep on a given day.

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