WOLF ECOLOGY IN THE KLUANE REGION, YUKON TERRITORY

By

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A THESIS

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WOLF

ECOLOGY

IN THE

KLUANE REGION, YUKON TERRITORY

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This thesis "Wolf ecology in the Kluane Region, Yukon Territory" is hereby approved in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN FORESTRY.

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ABSTRACT

During late winters of 1985 and 1986, 16 gray wolves (*Canis lupus*) in 8 packs were captured and radio-collared in a 9,800 km^2 area of west-central Yukon.

Primary prey of wolves was Dall sheep (*Ovis dalli dalli*) (density 1.05/km^2 of habitable sheep range), yet this species was least preferred where other ungulate prey such as caribou (*Rangifer tarandus granti*) and moose (*Alces alces andersoni*) were available.

Wolf packs or lone wolves were observed on 24 kills; 14 were sheep kills. Kills of young sheep ($<$ 3 years old) did not occur. Middle age rams and old age sheep were prominent among wolf-kills.

Wolf density was approximately 6.7/1000 km^2. Mean territory size was 754 km^2. Mean pack size was 4.0 wolves. Predation rates ranged from 1 kill/5 days/pack to 1 kill/12.5 days/pack. On an individual basis kill rates of sheep were higher for lone wolves than for individual pack members. Consumption rates were lowest for wolves which ate sheep. All but one pack which did not eat sheep, had food intakes considered marginal for successful reproduction.

Wolf use of habitat reflected primary prey hunted. Wolves which had sheep as primary prey preferred alpine habitats and avoided non-alpine habitats. Wolves did not

exhibit a clear tendency to sleep more when on a reduced food base as noted elsewhere.

Biomass:wolf and prey:wolf ratio were low and within a range where wolves can limit prey in wolf-single-prey systems.

Sheep appear to be difficult ungulate prey to capture frequently enough to support wolves over long periods. Low wolf density, large territories, small pack size, low predation and consumption rates, and dispersal of alpha males were noted for wolf packs reliant on sheep. Known wolf mortality was human caused.

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During the four years spanning the initiation and completion of this study, many individuals have willingly assisted and supported this research.

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Bob Hayes offered me this research opportunity in the southern Yukon. However, following some unfortunate circumstances the study had to be terminated and begun anew in Kluane. Despite the setback Bob was certain the study had merit and we pressed ahead. Bob was steadfast in his support when others threatened to divert my funding and I am certain without Bob's backroom support I would have been another disgruntled graduate student. Bob's assistance in the field, his recommended reading of certain literature, and pragmatic advice usually got me over the impending hurdle. I hope that I have provided some insight into wolf-Dall sheep relationships. He is a friend.

I am thankful that my numerous outdoor experiences spent with my family have motivated me to this end.

My wife Inge, tolerated our unsettled life, and regular commutes between university and Yukon. She has assisted with some of the graphics within and her constructive criticism has improved my writing. Most importantly, Inge has been my best friend and confidant throughout the highs and lows of my graduate experience. Without Inge's support my graduate experience would have been less positive or non-existent.

Finally, to those who ask,"What good is a wolf?" I

only wish ten million of you could have sat in the Supercub with me and shared what I have seen.

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CHAPTER I:

Introduction

Except for a few published accounts of wolves (*Canis lupus*) killing Dall sheep (*Ovis dalli dalli*) (Child *et al.* 1978, Hoefs *et al.* 1986, Murie 1944), ecological relationships between wolves and this prey species are poorly known. The most recent study of wolves and sheep is 43 years old. The advent of radio-collars, combined with modern radio telemetry techniques offered a chance to gain new insight into wolf-Dall sheep relationships.

Murie (1944), in his classic study of wolves in Alaska, has suggested sheep are important prey to wolves. Murie felt wolves had a beneficial long-term effect on sheep populations by removing old and sick individuals. In addition, Murie noted very high lamb mortality rates, and he inferred wolf predation on lambs to be the critical factor limiting sheep population growth. Murie believed predation on sheep would have been even more significant had not barren-ground caribou (*Rangifer tarandus granti*) acted as a "buffer", or alternate prey species. Dall sheep increased in an area of interior Alaska where wolves were reduced, but continued to decline in areas where wolves were not removed (Heimer and Stephenson 1982).

While a broad objective of this study was to gather general information on wolf ecology, more focused objectives were to:

1) determine the extent to which wolves might rely upon Dall sheep in winter; and

2) measure predation rate of wolves feeding on sheep and other ungulates; and

3) assess the population status of wolves where they relied primarily on Dall sheep.

CHAPTER II:

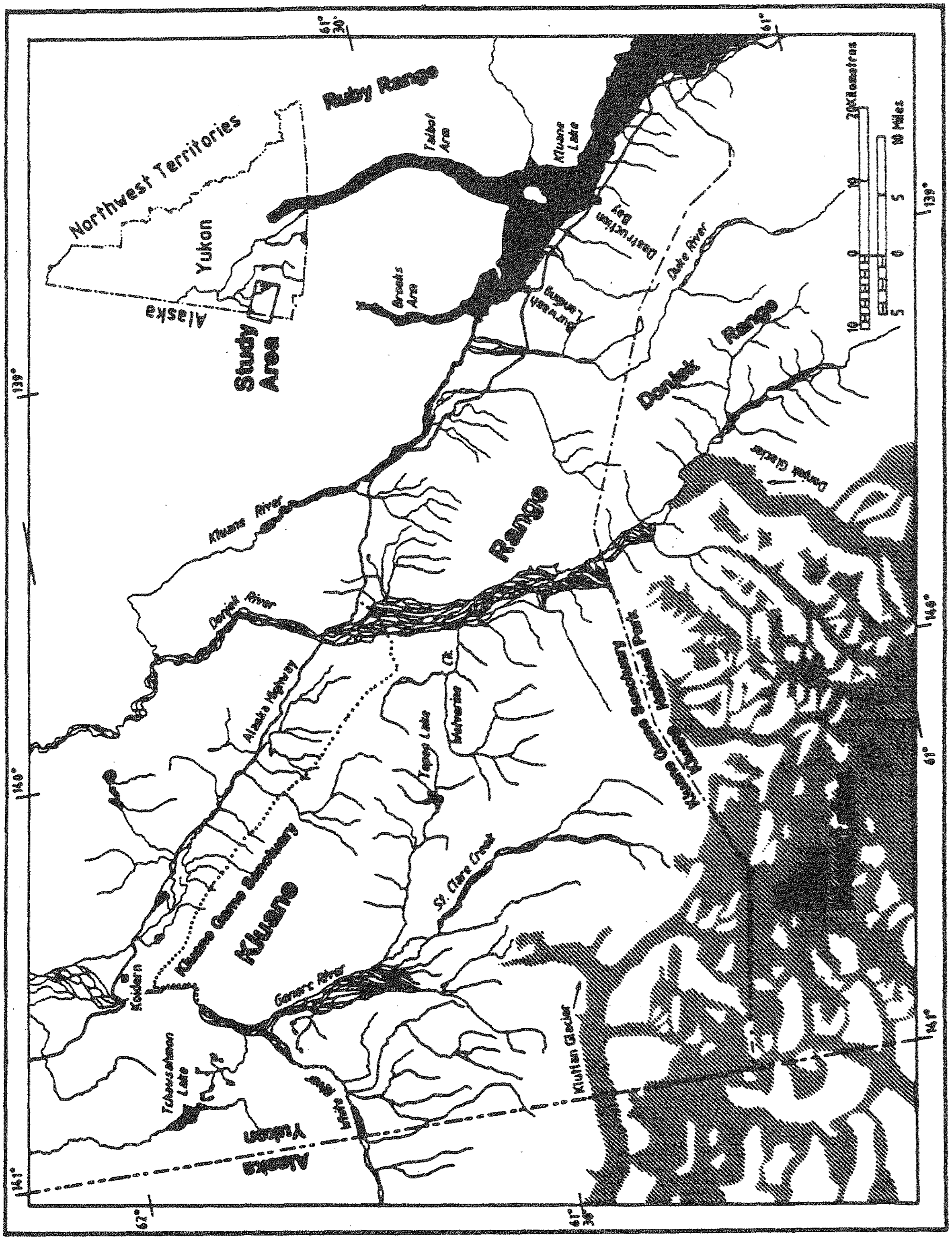
Study Area

A study area was chosen where there was little human exploitation of wolves and where sheep densities were relatively high. The Kluane study area (KSA) met both criteria; in most of the KSA, Dall sheep constitute the most common ungulate and, more importantly, the greatest available prey biomass for wolves.

Before beginning this research some wolf-prey relationships in the Kluane area had been documented. Immediately south of the study area Hoefs *et al.* (1986) observed wolf predation on Dall sheep, although in the southwest portion of the KSA, Gauthier (1984) found wolves preying heavily on caribou.

The KSA of 9,770 km^2 is located in west central Yukon and east central Alaska (Fig. 1). The study area included portions of Kluane National Park (1,875 km^2), and Kluane Game Sanctuary (4,675 km^2) where wolves were legally protected throughout the year (Smith 1983). In the remainder of the Yukon portion (2590 km^2) of the KSA, wolves could be hunted between August 1 and June 15. Trapping season for wolves, which includes the use of snares or leg-hold traps, extended from November 1 to March 31. In Alaska (630 km^2) wolves could be hunted

Figure 1. Map of the Kluane study area (KSA).


Northwest Territories
Yukon
Alaska
Study Area
Ruby Range
Talbot Arm
Kluane Lake
Destruction Bay
Burwash Landing
Brooks Arm
Duke River
Donjek Range
Donjek Glacier
Kluane River
Range
Donjek River
Alaska Highway
Tepee Lake
Wolverine Ck.
Kluane Game Sanctuary
Kluane National Park
Kluane
St. Clare Creek
Generc River
Koidern
Klutlan Glacier
White River
Alaska
Yukon
20 Kilometres
10 Miles
139°
140°
141°
61°
62°
61° 30'

between August 10 and April 30. Wolves in Alaska could also be harvested by snare or by aircraft "land and shoot" methods between October 1 and April 30; leghold traps could be set from November 1 to April 30.

Two Yukon communities, Destruction Bay, and Burwash, lie within the study area. A third community, Beaver Creek, lies 30 km north of the study area. All are located along the Alaska Highway and constitute a total population of less than 1000 people. Apart from travel along the Alaska highway, little human activity occurred within the study area during winter.

The study area is comprised of portions of the St. Elias Mountains Ecoregion and the Ruby Range Ecoregion (Oswald and Senyk 1977). Within the study area, the St. Elias Mountains Ecoregion is characterized by rugged metamorphic and volcanic peaks and numerous icefields. Many peaks rise well above 1,500 m and peaks over 2,500 m are common. In this ecoregion the St. Elias Mountains, and Kluane Range constitute major physiographic subunits. Within the study area the Ruby Range Ecoregion consists of less rugged yet rolling terrain composed of metamorphic, intrusive, and volcanic rock. Physiographic subunits include the Kluane and Ruby Ranges.

The study area is drained by the White, Generc, Donjek, Duke, and Kluane rivers all of which drain into the Yukon River. Kluane Lake (396 km^2) is the only major lake within the study area.

The high peaks in the western part of the study area exhibit continuous permafrost, while the remainder lies in an area of discontinuous permafrost. Treeline generally occurs at 1,050-1,200 m. White spruce (*Picea glauca*) dominates well drained soils, while stunted black spruce (*Picea mariana*) is common on poorly drained sites. Paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*) are found in warm, lowland areas. Lodgepole pine (*Pinus contorta*) is rare. Willow (*Salix* spp.), dwarf birch (*Betula* spp.), soapberry (*Shepherdia canadensis*), and ericaceous shrubs dominate understory, riparian, and subalpine regions. Sedge-tussock fields are common in poorly drained sites and gentle slopes. Steeper slopes give way to alpine forbs, ericaceous shrubs, grasses and lichens, (Oosenbrug and Theberge 1980).

The study area lies within the St. Elias Mountains rainshadow and is classified as a dry, cold, continental climate, receiving an average of 32.4 cm (water equivalent) of annual precipitation. Annual snowfall averages approximately 115 cm in Burwash and 132 cm at Beaver Creek. Annual snowfall was slightly below average in 1985 (104 cm Burwash and 128 cm Beaver Creek). Annual snowfall in 1986 was also below average (109 cm in Burwash and 118 cm in Beaver Creek). Deepest snows were in the St. Elias Mountains to the west. Snow in alpine areas was wind-modified and hard-packed. In addition many ridges and slopes were blown clear of snow.

Mean annual temperature is -4.4° C at Burwash and -6.6° C at Beaver Creek. Temperatures were similar during both winters of the study, ranging from -46.1° C to 4.5° C, and averaging -17.8° C (Atmospheric Environment Service).

Prey Populations

Major ungulate species within the study area include Dall sheep, mountain caribou (*Rangifer tarandus caribou*), and moose (*Alces alces andersoni*). Approximately 150 horses (*Equus equus*) winter on open range within the study area and fewer than 40 mountain goats (*Oreamnos americanus*) inhabit the KSA. Approximately 70 horses have wintered along the Donjek river for many years, yet no horses had been preyed upon by wolves in the previous 12 years (D. Dickson pers. comm.). Horses and goats were believed to be unimportant prey for wolves in the KSA.

Snowshoe hares (*Lepus americanus*) were at the low of their cycle (B. Slough pers. comm.) and are probably unimportant to wolves at such low densities.

CHAPTER III:

Methods

Wolf predation rates, wolf density, pack size, spatial relationships, and other facets of wolf ecology were determined by monitoring radio-collared wolves. The principal goal of field work was to radio-collar and monitor as many wolves from different packs as possible.

Wolf Capture

Wolf packs, pairs or individuals were initially located by following wolf tracks in snow using a Supercub (PA-18) aircraft. A darting crew in a helicopter (Bell 206B or Hughes 500D) pursued uncollared wolves and delivered 3-cc darts at close range from a Cap-Chur gun (Palmer Chemical and Equipment Co., Douglasville, GA). Wolves were injected with fixed drug doses of Ketamine Hydrochloride (Parke-Davis, Brockville, ON) and Xylazine (Rompun, Miles Laboratories, Rexdale, ON) in a 7:1 ratio. Depending on their weight, wolves received drug concentrations between 11 mg/kg and 14 mg/kg.

Thompson wolf snares (Raymond Thompson Co., Lynwood, WA) modified to stop closing at 34-38 cm proved effective for capturing wolves. Snared wolves were hand-injected with drugs.

Wolves captured in 1985 were fitted with Telonics

(Mesa, AZ) or reinforced Austec (Edmonton, AB) radio-collars. Wolves captured in 1986 were fitted with Lotek (Toronto, ON) radio-collars.

When possible, immobilized wolves were weighed and measured. From canine eruption and tooth wear (Ballard *et al.* 1981, R. Hayes pers. comm.) each wolf was classified as pup ($\leq$12 months old), yearling (13-23 months old), or adult ($\geq$24 months old).

Wolf Telemetry

In late winter we attempted to locate wolves daily from aircraft (PA-18 Supercub and occasionally Cessna 185) equipped with Telonics (Mesa, AZ) TR-2 receiver, TS-1 scanner and wing mounted H-style antennae. Telemetry methods followed those of Mech (1974).

Wolf frequency, location, activity, number of wolves, habitat type, elevation, aspect and presence or absence of kills were recorded at each radio-fix. More intensive searches for kills were conducted when wolves were located in the same place for two or more days, or trails suggested a kill was attempted.

Wolf Density

Wolf density estimates were derived from the known area occupied by instrumented wolves and pack associates within the study area. Wolf population estimates for the study area were derived by multiplying the density estimate by the total size of the study area and then adding 10% to the product to compensate for estimated lone wolves (Peterson 1977).

Analysis of Prey Remains

All wolf-kill sites were examined from the air, and all but 5 sheep carcasses were examined from the ground after wolves had abandoned the carcass. Sex of sheep was determined by sheep horn morphology, while horn annuli indicated age (Geist 1966). Several biologists experienced in sheep age determination were enlisted to age ewe horns, as Hoefs (1984) documented a tendency to underestimate age of ewes when using horn annuli. Ewe ages presented should be considered conservative.

Moose incisors were collected and moose age was determined by counting cementum annuli in thin sections of incisors using transmitted light (Sergeant and Pimlott 1959). Sex of moose was determined from presence or absence of antler pedicels. Bone marrow fat content was determined for a leg bone by the method of Neiland (1970).

Caribou were classified as calves or adults from carcass size and antler characteristics. Size and morphology of antlers indicated caribou sex.

Territory Size

Excluding some snare capture locations where wolves may have been drawn to baits beyond their usual territory bounds, pack territories were defined as the minimum convex polygon which included all locations (Mohr 1947). Territory size was calculated using MCPAAL, a menu-driven software program (Stüwe and Blohowiak 1985).

Habitat Use

Wolf use of non-alpine and alpine habitats were determined to investigate the relationship between preferred prey of wolf packs and habitat use by those packs. Analysis of wolf habitat use and availability follow methods by Neu *et al.* (1974) and Byers and Steinhorst (1984). A chi-square goodness-of-fit test determined whether there was a significant difference between expected use of habitat and observed frequency of use of that habitat. If a statistically significant chi-square value results, Bonferroni confidence intervals can indicate which habitat types are being preferred. Wolf use of alpine ($\geq$ 1370 m) and non alpine (< 1370 m) habitat was compared to availability. These 2 habitats were chosen since moose and caribou were often observed below 1370 m, while sheep predominated above 1370 m. This elevation does not define an absolute separation of these species, or habitats, but it represents a subjective altitudinal boundary based on observations of ungulates and habitat ecotones.

The majority of the Burwash caribou herd were located at elevations above 1370 m in winter (Gauthier 1984). However, wolf habitat analysis did not include the range of this herd. During winter, the Chisana caribou herd at the north end of the KSA appeared to occupy nonalpine habitat almost exclusively (Gauthier and Theberge 1983 unpubl. report).

During mid-winter moose surveys, in 1981 and 1982, Gauthier (1984) observed moose at a mean elevation of 20-85 m higher than the 1370 m dividing point chosen for my use-availability analysis. However, in late winter as snow depth increases and moose nutritional status declines, moose are known to migrate to lower elevations and seek forested habitat (Coady 1974, LeResche 1974, Peek 1976). In addition moose are likely to be observed less in low elevation forests than in open, subalpine habitats, producing an overestimate of the mean elevation. Since a moose sightability correction factor was not obtained, (D. A. Gauthier pers. comm.) suspected that he had over estimated the mean elevation at which moose wintered. No other late winter moose survey results from Yukon are available for comparison to Gauthier's findings.

Predation and Consumption Rates

Except where noted, consumption and predation rates are calculated over the longest monitoring period during which no more than 1 day was missed between radio locations. The entire consecutive monitoring period was divided by number of kills and the value produced was the estimated kill rate. Accurate determination of predation rates over the entire study was compromised when foul weather interrupted scheduled daily flights.

Ungulate Abundance and Biomass Estimates

Body weight of prey were taken from the literature for Dall sheep (Bunnell and Olsen 1976) and moose (Franzmann *et al.* 1978). Female and calf caribou weights were taken from Skoog (1968) while caribou weights for males were taken from Gauthier and Farnell (1986). Estimates of edible biomass of carcasses available to wolves include the amount removed by avian scavengers such as the common raven (*Corvus corax*), black-billed magpie (*Pica pica*), and the gray jay (*Perisoreus canadensis*), plus mammalian scavengers.

Moose represent 75% consumable biomass for wolves (Peterson 1977, Fuller and Keith 1980, Peterson *et al.* 1984). Schaller (1977) stated that edible biomass of rams was reduced 10-11% because of their horns. Therefore, rams were estimated to provide 85% consumable biomass for wolves while ewes were estimated to have 95% edible biomass (Hayes and Baer 1986). For caribou 85% of bull, 87% of cow and 95% of calf caribou biomass were assumed to be consumed by wolves. Bull caribou are estimated to have a lower percentage of edible biomass than cow caribou because some bulls retained heavier antlers. Appendix I contains a summary of prey weights and edible biomass weights used in consumption calculations.

A moose population survey was conducted during the midwinters of 1981 and 1982 for the southwest KSA (Gauthier 1984). Moose density was assumed to have remained stable since then, and Gauthier's estimates and composition counts were used to calculate a moose population estimate for the KSA, as well as for individual wolf pack territories.

Burwash caribou herd estimates were assumed to be similar to those determined during 3 consecutive late winter surveys during 1980, 1981 and 1982. The caribou population was considered stable, ranging from 330 to 402 animals and averaged 376 caribou (Gauthier and Theberge 1985).

Estimates for the number of caribou occupying the KSA from the Chisana caribou herd were determined from incidental observations, by Kelleyhouse (Alaska Department of Fish and Game (A.D.F.& G.) unpubl. report), and Gauthier and Theberge (unpubl. report).

During 1985, the author conducted aerial surveys of sheep over small mountain blocks within the Yukon portion of the KSA. Lamb/ewe and yearling/ewe ratio were determined on the basis of ground observations of nursery sheep herds. Sheep composition and sheep density were assumed to be similar for suitable sheep range within the entire KSA, excluding the portion of the KSA north of the White River. Sheep densities and population estimates for the KSA north of the White River were derived from sheep surveys conducted in summer, 1984 (A.D.F.& G. unpubl. report). The two density estimates were multiplied by their respective areas of sheep habitat, to yield a sheep population estimate for the entire KSA.

Age distribution data for sheep in the KSA were obtained by assigning ages to rams that were classified and counted during a July 1985 helicopter survey. Photographs (Yukon Govt.) of harvested rams from adjacent sheep populations (Ruby Range and Coast Mountains) which are thought to have horn growth similar to KSA sheep, allowed determination of horn curl-age relationships. A "side view" photograph of "unbroomed" ram skulls allowed us to determine age at which rams attained each horn curl class (half curl, three quarter curl and full curl). Paired observations of horn curl and age produced a frequency distribution of ages at which rams attain each horn curl class. The frequency distribution was applied to rams observed during sheep surveys to estimate an age distribution assuming that a representative sample of rams were observed. The age distribution data was compared to ages of wolf-killed sheep to determine if wolves selected certain age groups.

Using population estimates for moose, caribou, and sheep, wolf/ungulate ratio and wolf/biomass ratio were calculated for the entire study area and for individual pack territories.

CHAPTER IV:

Results

Taxonomic Status and Physical Characteristics of Wolves

According to Goldman (1944) wolves found in the KSA are classified as the Interior wolf (*Canis lupus pambasileus*). Pelage color varied from white to light gray to completely black. Black wolves appeared chocolate brown when examined at close range. Light gray wolves were similar to those described by Peterson *et al.* (1984). During the study 44 (59%) gray, 30 (40%) black wolves and 1 (1%) white wolf were observed (Table 1).

Excluding average neck circumference, male wolves had larger mean morphometric measurements than female wolves (Table 2). The small sample of wolves captured precluded statistical comparisons of male and female wolf morphometry. One female with a large neck influenced the small sample of females enough to produce a greater mean neck circumference than males. Mean weights of Kluane wolves fall below those documented by Peterson *et al.* (1984) but are between those presented by Hayes *et al.* (1985) for southern Yukon wolves, and Hayes and Farnell (1985) for east-central Yukon.

Wolf Capture

During 1985, ten wolves were captured a total of 11

Table 1. Coat color proportions among Kluane wolves.

Pack Name	1985 Gray:Black:White	1986 Gray:Black:White
Brooks Arm Pack (BAP)	2:1:0	—
Cement Creek Pair (CCPR)	0:2:0	—
Tepee Lake Pack (TLP)	1:5:0	—
Generc River Pack (GRP)	8:0:0	1:0:0
Steele Creek Loner (SCL)	1:0:0	—
Arch Creek Loner (ACL)	0:1:0	—
Kluane River Loner (KRL)	—	1:0:0
Donjek River Pack (DRP)	—	3:2:0
No Home Pair (NHPR)	—	2:0:0
Miles Ridge Pack (MRP)	—	1:2:0
St. Clare Pair (SCPR)	—	1:1:0
Uncollared #1	—	2:5:0
Uncollared #2	2:3:1	—
Uncollared #3	—	1:1:0
Uncollared #4	—	2:3:0
Uncollared #5	0:1:0	—
Harvested	8:2:0[a]	8:1:0[a]
Total	22:15:1	22:15:0

[a] Hunters and trappers are not required to report harvested wolves; therefore, this represents minimum harvest obtained from reliable reports. Excludes members of collared packs included elsewhere.

Table 2. Morphometry of captured Kluane wolves.

Male Measurements	*n*	$\bar{x}$	SE	Range
Weight (kg)	7	40.6[a]	2.05	33-51
Contour Length (mm)	6	1260.8[b]	25.31	1160-1330
Chest Circ. (mm)	6	739.3	26.46	686-840
Neck Circ. (mm)	6	406.0	5.53	380-420
Canine Len./Wid. (mm)	6	30/15	0.3/0.5	29/14-31/17
Female Measurements	***n***	$\bar{x}$	**SE**	**Range**
Weight (kg)	6	33.8[a]	1.96	27-39
Contour Length (mm)	4	1130.8[b]	51.24	1050-1280
Chest Circ. (mm)	5	707.8	41.18	625-864
Neck Circ. (mm)	4	417.8	38.51	333-508
Canine Len./Wid. (mm)	3	29/16	2.1/0.0	25/16-32/16

[a] Some weights estimated not measured (Appendix II).
[b] Excludes tail length.

times (1 recapture), while in 1986, six wolves were captured a total of 7 times (1 recapture). Eight males and 8 females were captured and recaptures included 1 wolf of either sex. Seven wolves were captured in snares and 2 were recaptured in snares. In addition, 1 wolf was captured in a box trap intended for live wolverine capture. All 8 wolves captured from helicopter darting suffered minor wounds at the injection site, but appeared normal within 24 hours, including 1 wolf which was accidently hit by the helicopter skid during pursuit. Effective drug dose for snared wolves was approximately half that administered for aerially captured wolves. One wolf died during handling at a snare site. An additional recaptured wolf was euthanized since the lower 20 cm of the right rear leg had been missing for some unknown time, and general condition of the animal had diminished since its initial capture, 48 days earlier when all 4 legs were healthy. Another snared wolf was shot by a local resident before personnel had checked the snare site. Wolf capture summaries are presented in Appendix II and pack summaries are presented in Appendix III.

Wolf Telemetry

Wolves were sighted in 158 (78%) of the 203 radio-collar locations. Only 1 of 9 radio-collars placed on wolves in 1985 was functioning on a live wolf during the

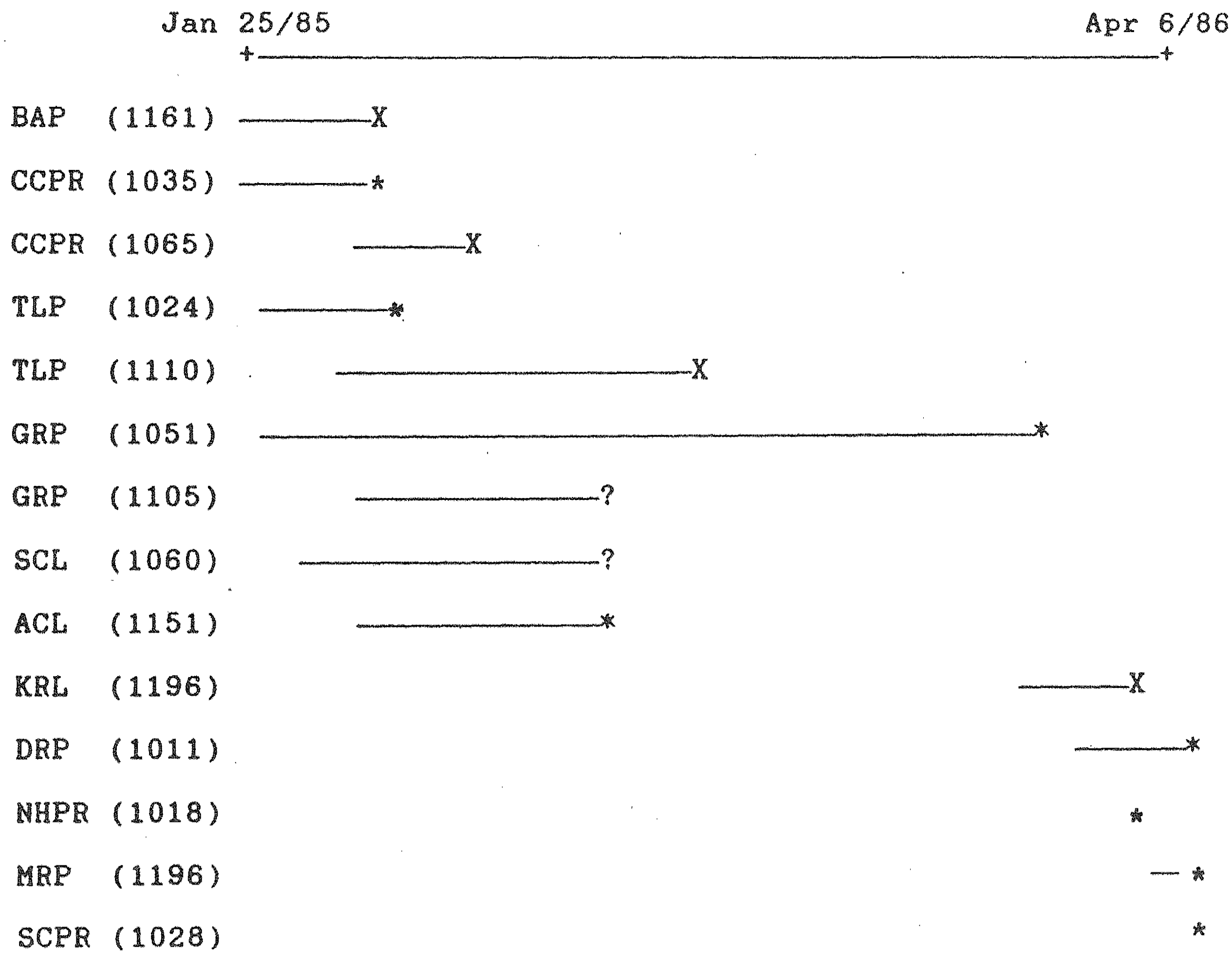
1986 field season. Only 3 of 5 radio-collars placed on wolves during 1986 functioned properly. Radio-collar malfunctions, wolf mortalities and wolf dispersals contributed to a significant amount of data loss. Transmitter life ranged from 1 day to at least 13 months (Fig. 2).

Age and Sex of Wolf-Killed Sheep

Wolf-utilized carcasses of 14 sheep, 5 caribou, 4 moose, and 1 horse were located during the study. In addition wolves were observed scavenging at garbage dumps and on spawned salmon (*Onchorynchus* spp.). All ungulate carcasses found, excluding the horse, resulted from wolf predation.

Attempts were made to visit all wolf-killed sheep, but 5 sheep kill sites could not be reached by foot or helicopter. In addition no horns were recovered during a ground check of 1 wolf-killed ewe. The failure to recover 6 of 14 sheep horns could bias the age distribution of kills. Of the 6 unrecovered horns 4 were ewes and 2 were of unknown sex. Therefore 6 ewes and 6 rams are known to have been killed by wolves. No lambs were detected among sheep killed by wolves. Six ram skulls were recovered. Only 1 ram was older than 11 years while the other 5 were middle aged, approaching or having just attained full curl status. Both ewes with recovered horns were mature (Table

Figure 2. Wolves radio-collared in the KSA. Solid line indicates mobile, active transmitter. An asterisk (*) indicates active, mobile transmitter when last observed, where subsequent fate of the wolf is unknown. A question mark (?) denotes an active, immobile transmitter where the fate of the radio-collared wolf is unknown. Wolf mortalities are designated with an X.


Jan 25/85
Apr 6/86
BAP (1161)
X
CCPR (1035)
*
CCPR (1065)
X
TLP (1024)
*
TLP (1110)
X
GRP (1051)
*
GRP (1105)
?
SCL (1060)
?
ACL (1151)
*
KRL (1196)
X
DRP (1011)
*
NHPR (1018)
*
MRP (1196)
*
SCPR (1028)
*

3).

Data collected from aerial surveys of sheep suggested that the Kluane sheep population was not stable during the study period. Assuming the aerial survey included a representative sample (n=205 rams, ≈7%) of the ram population, age distribution data derived from the survey differed from that of a stable sheep population (Hoefs and Cowan 1979). Age distribution data indicate a cohort flux among 4-7 year old sheep or a lack of representation in young age classes, or a combination of both (Fig. 3). Sample sizes were too small for statistical analyses of age and sex selection patterns. However, general comparisons between the estimated age distribution of the sheep population and ages of sheep killed by wolves indicate middle-aged rams may have been preyed upon most because they represent the largest age class in the sheep population.

Sex and age of other wolf-killed ungulates are documented in Appendix IV.

Condition of Prey

Long bones were entirely consumed at all sheep kills. Femurs from 2 moose, 1 caribou, and 1 horse were recovered. Fat content of femur marrow is useful for determining whether prey are starving. However, it is not a useful indicator of whether animals are in good health.

Table 3. Age and sex of wolf-killed sheep in Kluane.

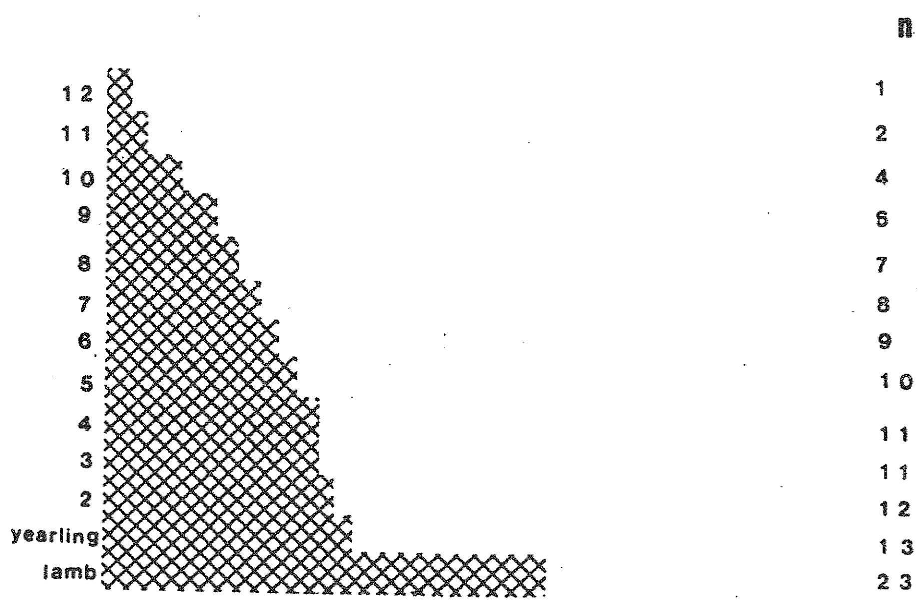
Age	Sex	Date Killed dd/mm/yy	Pack Responsible
4.8	M	18/02/85	Generc River pack (GRP)
11.8	M	21/02/85	Cement Creek pair (CCPR)
9.8	F	24/02/85	Tepee Lake pack (TLP)
Ad.	F	08/03/85	Cement Creek pair (CCPR)
5.8	M	13/03/85	Tepee Lake pack (TLP)
Ad.	-	13/03/85	Steele Creek loner (SCL)
5.8	M	28/03/85	Steele Creek loner (SCL)
4.8	M	28/03/85	Tepee Lake pack (TLP)
Ad.	F	31/03/85	Tepee Lake pack (TLP)
Ad.	-	24/02/86	Donjek River pack (DRP)
Ad.	F	20/03/86	Donjek River pack (DRP)
12.8	F	30/03/86	Donjek River pack (DRP)
Ad.	F	31/03/86	Donjek River pack (DRP)
7.8	M	03/04/86	St. Clare pair (SCPR)

Figure 3. Comparison of sheep age distribution data derived from an unstable sheep population observed in the KSA (A), and sheep life table data (B) taken from Hoefs and Cowan (1979) showing a stable sheep population.

A


AGE IN YEARS
n
11
10
9
8
7
6
5
4
3
2
6
13
25
36
40
36
26
21

B


n
12
11
10
9
8
7
6
5
4
3
2
yearling
lamb
1
2
4
6
7
8
9
10
11
11
12
13
23

Both moose had high marrow fat content values (89%) while the horse (11%) and caribou (29%) exhibited extremely depleted fat reserves.

Territory Characteristics, Pack Size and Wolf Density

Average territory size for packs ≥ 2, (n=5) was 754 km^2 (SE=231). The (DRP) occupied a much larger territory than other packs (Table 4, Fig. 4).

Mean pack size (packs ≥ 2, n=9) during late winter was 4.0 (SE=0.73, range=2-8), (Table 4). This calculation includes 1 uncollared pack. Other uncollared wolf packs containing 2, 5 and 7 wolves respectively were not included in this calculation since their pack sizes were known only in early winter.

The loss of 8 radio-collared wolves between the 1985 and 1986 field season reduced the potential sample of wolf pack territories and may have obscured an accurate estimate of wolf density in the KSA. Density estimates (both weighted (11.2 wolves/1000 km^2) and unweighted (8.9 wolves/1000 km^2) by pack size are believed to be liberal (Table 4). In contrast, if the study area (9770 km^2) is divided by mean territory size (754 km^2), there were 12.9 territories in the KSA holding a mean of 4.0 wolves/territory. On this basis wolf density in the KSA was conservatively estimated at 5.3 wolves/1000 km^2. Summing the area of KSA wolf pack territories and dividing

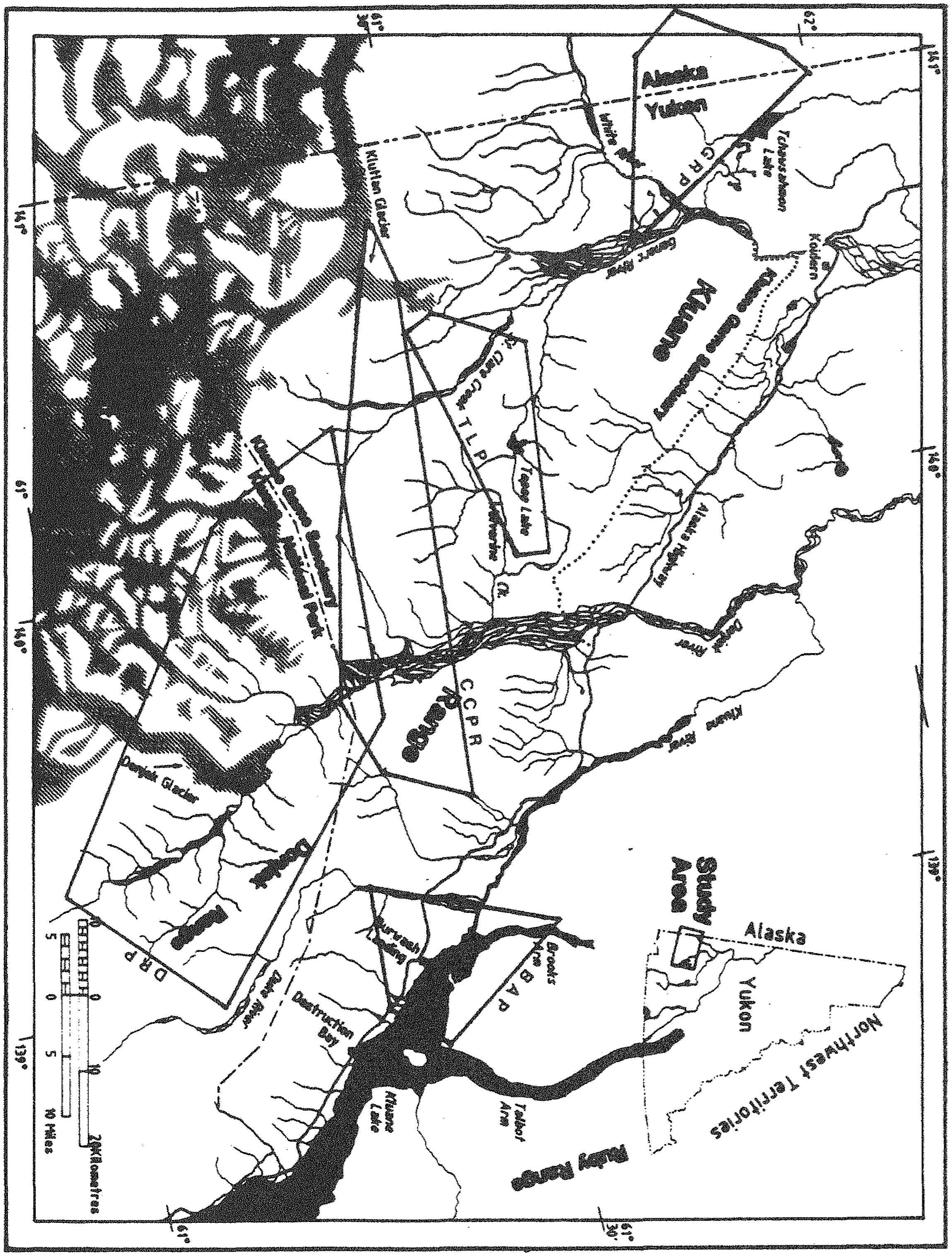
Table 4. Wolf pack size, territory size, and density in the KSA, determined from late winter observations.

Pack Name	Pack Size	# Radio Fixes	Year	Territory Size (km^2)	Wolves/ 1000 km^2	km^2/ Wolf
GRP	8	19	1985	540	14.8	67.5
TLP	6	39	1985	350	17.1	58.3
DRP	4	29	1986	1757	2.3	439.2
BAP	3	35	1985	412	7.3	137.3
MRP[a]	3	10	1986	179	16.6	60.2
CCPR	2	29	1985	711	2.8	355.5
SCL[b]	1	27	1985	1172	0.8	1172.0
Unweighted Average				754	8.9	175.5
Weighted Average				699	11.2	145.6

[a] Excluded from most calculations because territory size probably larger than the data indicate.

[b] Excluded from most calculations since this is a lone wolf.

Figure 4. Location of territories of radio-collared KSA wolf packs. Excluding the DRP (1986), all other pack territories are from observations during 1985.


Alaska
Yukon
G R P
Tchawsahmon Lake
Koidern
Kluane
Kluane Game Sanctuary
Alaska Highway
White River
Donjek River
Kluane River
Northwest Territories
Yukon
Alaska
Study Area
Ruby Range
Tepee Lake
St. Clare Creek
T L P
Wolverine Ck.
C C P R
Range
Brooks Arm
B A P
Talbot Arm
Kluane Lake
Burwash Landing
Destruction Bay
Duke River
Kluane Game Sanctuary
Kluane National Park
Kluttan Glacier
Donjek Glacier
Donjek Range
D R P
Kilometres
10 Miles
141°
140°
139°
62°
61° 30'
61°

by the number of wolves occupying those territories yields a realistic estimate of 6.1 wolves/1000 km^2. If lone wolves are considered to represent 10% of the wolf population then the wolf density for the KSA is 6.7 wolves/1000 km^2.

Characteristics at Sites where Sheep were Killed

Sheep kills occurred between 1220 m and 1980 m at a mean elevation of 1515 m (SD=167 m), (Table 5). Twelve sheep were killed in alpine habitat and 2 were killed on the ecotone between subalpine and alpine habitat. Two sheep were killed on open slopes in low willows interspersed with aspen 5 m in height. Four sheep were caught in shallow ravines which vertically bisected large open slopes, a result of either successful open slope pursuit, or surprise from wolves approaching to the lip of the shallow ravine. Three sheep were killed on creek or river ice. Two sheep were captured before they reached the safety of the cliffs or wolves forced sheep to fall from steep cliffs, typical escape terrain, to the ice below in a manner similar to descriptions by Hayes and Baer (1986). However, the ice was not slippery since it was level and snow-covered. The third kill on creek ice appeared to result from a downhill, open slope pursuit which ended on the ice at the bottom of a deep ravine. Two sheep kills occurred in canyons, and one of these was open to

Table 5. Characteristics of sheep kill-sites.

Kill	Elevation (m)	Area Habitat	Local Habitat	Distance to Escape Terrain (m)
1	1370	SA/Alp.	Decid./Shrub	200
2	1525	Alpine	Shallow Ravine	500
3	1220	SA/Alp.	Decid./Shrub	300
4	1615	Alpine	Creek Ice	600
5	1430	Alpine	Canyon	200
6[a]	1525	Alpine	Talus Slope	___
7	1525	Alpine	Shallow Ravine	300
8	1370	Alpine	River Ice	10
9	1525	Alpine	Cliff	5
10	1525	Alpine	___[b]	300
11	1525	Alpine	Shallow Ravine	60
12	1555	Alpine	Canyon	30
13	1980	Alpine	Shallow Ravine	50
14	1525	Alpine	Creek Ice	10

[a] Kill assumed based from strong evidence although kill-site not located.

[b] Wolves observed eating sheep but main kill site never located.

interpretation from tracks in the snow. Wolves had chased the sheep from a canyon wall to the canyon bottom where the sheep was killed. Tracks indicated the sheep had broken through crusted snow intermittently while wolves remained on the snow surface. One sheep was killed on a very steep slope within one downward jump of a steep cliff. The capture had to occur from above.

At most kill sites it was difficult to determine if sheep had been alone or in groups prior to being killed. In the two cases where group size could be determined, 1 ram was solitary and the other ram had been a member of a herd of 14 rams which included juvenile to mature rams.

In all cases when signs of a chase were observed in the snow, wolves had pursued sheep from above. Snow conditions at kills varied from absent to 2 m deep and was variably loose or heavily crusted.

Kill distance from escape terrain also varied greatly. Escape terrain for sheep is defined here as any terrain (usually cliffs) where sheep can reside and remain invulnerable to wolf predation. It was sometimes evident that victims were either forced out of escape terrain by wolves or pursued for some distance away from escape terrain. Descriptions of wolf-sheep encounters are detailed in Appendix V.

Predation and Consumption Rates

Accurate determination of predation rates was sometimes compromised because foul weather interrupted scheduled daily flights. Yet 4 packs, 1 pair, and 1 loner were monitored almost daily for 20 days or more, providing direct estimates of predation and consumption rates for these groups (Table 6, Fig. 5).

Predation rates for packs eating sheep were between 7.7-9.0 days/sheep kill or 1 sheep/31-54 days/wolf (Table 6). The 33 days/kill documented for the CCPR female is likely inflated. On the day prior to a 3 day period where foul weather prohibited flying, a sheep kill occurred. If the first kill is considered in combination with the 36 day period following, the predation rate increases to 18.5 days/kill. Therefore, predation rates for lone wolves were between 16.5 and 18.5 days/kill.

Pack size and kill rate were correlated (r^2=0.64, $P < 0.02$),(Fig. 6). Ballard *et al.* (1987) also found a significant relationship between kill rate and pack size. However, where prey are highly vulnerable, kill rate may be unrelated to pack size (R. Peterson *pers. comm.*).

Consumption rates were generally low, ranging from 0.028 kg/kg wolf/day to 0.145 kg/kg wolf/day. Mean daily consumption rate for KSA wolves was 0.078 kg/kg wolf/day (Table 6).

Table 6. Predation and consumption rates of Kluane wolves.

Pack Name	Pack Size	Dates dd/mm/yy	Locations (N)/ Period (days)	Species Killed During Period	Days/ Kill	Consumption Rate (kg/kg wolf/day)
BAP	3	19/02/85-15/03/85	21/25	1 caribou/1 horse	12.5[a]	0.145[a]
BAP	1	19/02/85-30/03/85	31/36	2 caribou/1 horse	12.0[b]	0.148[b]
CCPR	1	25/02/85-30/03/85	29/33	1 sheep	33.0[c]	0.041[c]
CCPR	1	21/02/85-30/03/85	30/37	2 sheep	18.5[d]	0.062[d]
TLP	6	25/02/85-14/03/85	15/18	2 sheep	9.0	0.028
TLP	1	25/02/85-01/04/85	30/36	3 sheep	12.0[e]	0.062[e]
GRP	8	11/03/85-30/03/85	16/20	2 caribou/1 moose/1 un.	5.0	0.091-0.11[f]
SCL	1	25/02/85-29/03/85	24/33	2 sheep	16.5[g]	0.090[g]
DRP	4	13/03/86-06/04/86	23/25	3 sheep	7.7	0.037
MRP	3	28/03/86-05/04/86	10/10	0 ungulates	>9.0[h]	0.000[h]
Ave.					14.0	0.078

[a] Calculation includes horse which had died of malnutrition and was consumed by the BAP. Consumption calculations do not include scavenging at dump.

[b] Calculation includes horse which had died of malnutrition and was consumed by the BAP. Calculation for wolf 1160 over a longer period which includes separation from the other 2 BAP members. Calculations do not include scavenging at dump.

[c] Calculation for female 1035 only i.e. excludes male partner 1065.

[d] Calculation for 1035 only. Includes 3 consecutive days where wolf was not located.

[e] Calculation for wolf 1024 of TLP only.

[f] Variation in consumption rate includes possibility that unknown species killed is a wolf or a caribou.

[g] Calculation includes a suspected adult, ewe kill based on strong evidence. Includes 2 periods where 2 consecutive days of locations were missed.

[h] Monitored the last 10 days of the study during which time they made no kill.

Figure 5. Periods for which predation rates are calculated, showing days missed.

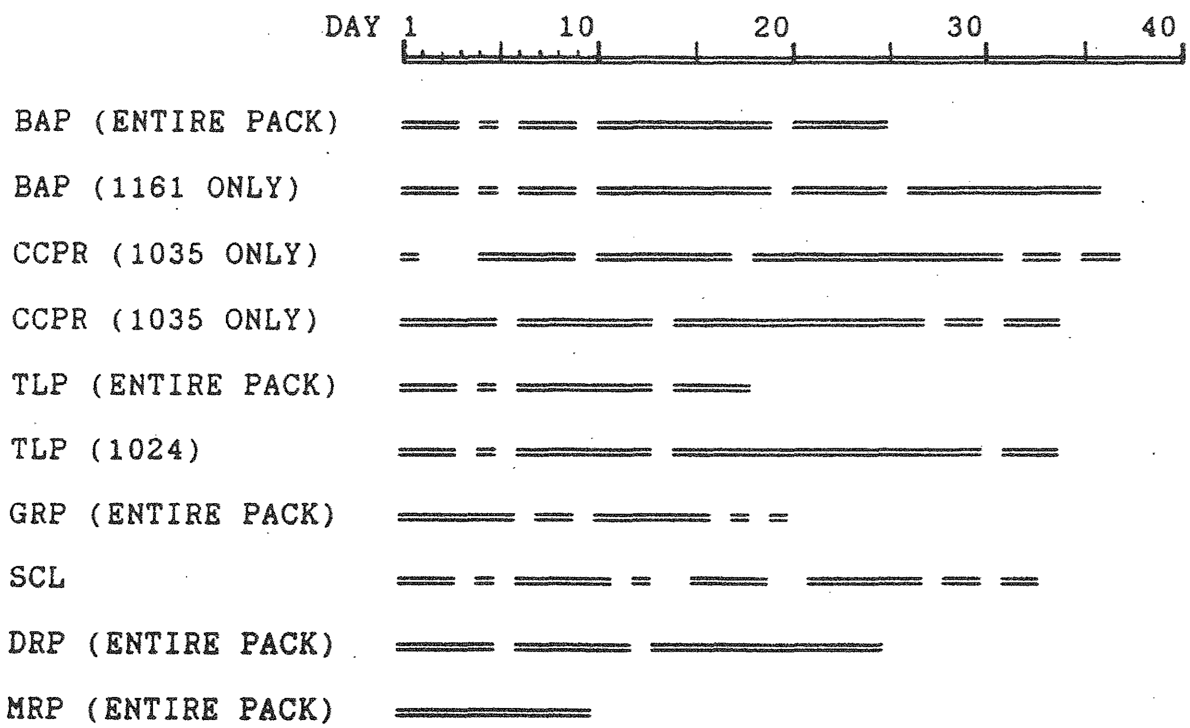
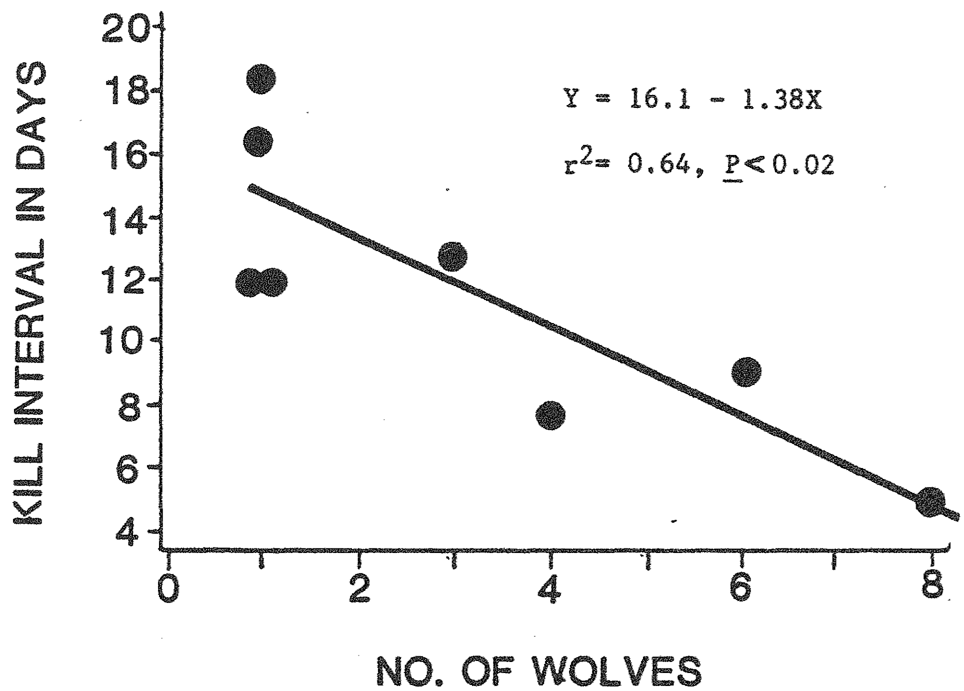

DAY 1
10
20
30
40
BAP (ENTIRE PACK)
BAP (1161 ONLY)
CCPR (1035 ONLY)
CCPR (1035 ONLY)
TLP (ENTIRE PACK)
TLP (1024)
GRP (ENTIRE PACK)
SCL
DRP (ENTIRE PACK)
MRP (ENTIRE PACK)

Figure 6. Relationship between wolf number and kill rate.


Y = 16.1 - 1.38X
r2= 0.64, P<0.02
KILL INTERVAL IN DAYS
20
18
16
14
12
10
8
6
4
0
2
4
6
8
NO. OF WOLVES

Sheep killed by lone wolves were consumed in an average 3.0 (n=4) days while those killed by packs were consumed in an average 1.4 (n=4) days. Only 1 sheep killed by a pack was consumed in 1 day. Therefore when foul weather prohibited telemetry flights for 1 day the possibility of missing a sheep kill was relatively low. If more than 1 consecutive day of monitoring was missed the possibility of missing kills was high for packs but low for lone wolves.

Wolf Activity

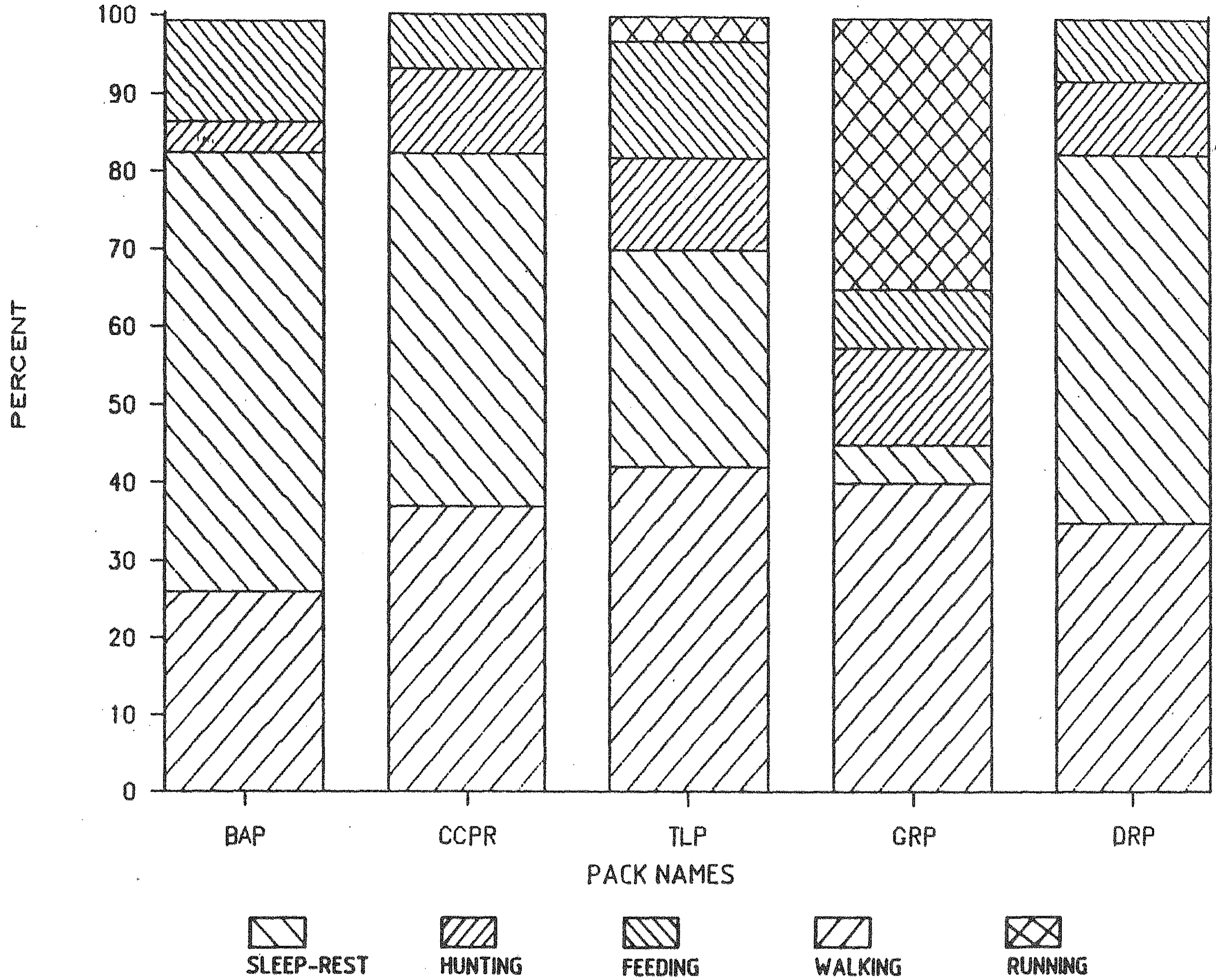
Sleeping or resting was the most common behavior observed among Kluane wolves. This activity, combined with walking accounted for 57% of activities of Kluane wolves.

Excluding the GRP, KSA wolf packs appeared to spend similar amounts of time in different activities (Table 7, Fig. 7). The GRP was the only pack that did not tolerate daily locations from aircraft thus GRP members were walking or running during the majority of locations. In addition the pack was often observed dispersed over distances up to 8 km. Rarely were they observed together and only once were they observed resting. The GRP frequently ran when research aircraft approached indicating that these wolves may have been hunted from aircraft in the past. During the study, "land and shoot" hunting was permitted in the area occupied by the GRP. All

Table 7. Activities of Kluane wolves.

	Activity					
Pack Name	Walking	Sleep/Rest	Hunting	Feeding	Running	Unknown
BAP	6	13	1	3	0	8
CCPR	10	12	3	2	0	3
TLP	11	7	3	4	1	3
GRP (1985)	7	1	2	1	6	2
SCL	2	6	2	1	1	14
ACL	0	1	0	0	0	3
KRL	1	0	0	1	0	0
GRP (1986)	1	0	0	0	4	0
DRP	9	12	2	2	0	5
NHPR	1	0	0	0	0	0
MRP	2	3	1	0	1	2
SCPR	0	2	0	0	0	0
Total	50(27%)	57(30%)	14(7%)	14(7%)	13(7%)	40(21%)

Figure 7. Activities of Kluane wolf packs.


PERCENT
100
90
80
70
60
50
40
30
20
10
0
BAP
CCPR
TLP
GRP
DRP
PACK NAMES
SLEEP-REST
HUNTING
FEEDING
WALKING
RUNNING

other packs studied were in areas where "land and shoot" hunting was not prohibited.

Wolf Habitat Use Versus Habitat Availability

Wolf habitat use reflected the prey species they hunted (Table 8). The GRP and TLP hunted all 3 major prey species, and although the TLP was unsuccessful at killing moose and caribou, the use-availability results indicated that these 2 packs did not prefer nor did they avoid alpine or non-alpine habitat. The BAP did not meet the requirements of this statistical technique since they had virtually no alpine habitat within their territory.

In contrast, 3 other groups of wolves (SCL, CCPR, DRP) that hunted sheep only showed clear preference for alpine habitat and avoidance of non-alpine habitat even though 2 groups were observed scavenging moose killed by other wolves in non-alpine habitat.

Wolf Dispersal, Mortality, Extraterritorial Forays and Colonization

Wolf dispersal (departure from original pack), mortality and extraterritorial movements were complicated by their interrelationship, season of occurrence and radio-collar failure. Since 8 of 9 radio-collars placed on wolves in 1985 were inactive in 1986 it was difficult to determine dispersal, mortality and extraterritorial movements. Three wolf dispersals are believed to have

Table 8. Comparison of wolf habitat use to available habitat in respective wolf pack territories.

Pack Name	Chi-Square	Bonferroni Intervals Non-alpine	Bonferroni Intervals Alpine
(CCPR)	3.70[a]	$0.014 \le P_i \le 0.319$[b]	$0.680 \le P_i \le 0.986$[c]
(TLP)	2.33	$0.192 \le P_i \le 0.642$	$0.357 \le P_i \le 0.808$
(GRP)	0.01	$0.217 \le P_i \le 0.730$	$0.269 \le P_i \le 0.783$
(SCL)	7.24[d]	$0.000 \le P_i \le 0.234$[e]	$0.740 \le P_i \le 1.103$[f]
(DRP)	5.87[g]	$0.000 \le P_i \le 0.150$[e]	$0.850 \le P_i \le 1.124$[f]

[a] Significant at α= 0.075

[b] Significantly underused at α= 0.05

[c] Significantly overused at α= 0.05

[d] Significant at α= 0.01

[e] Significantly underused at α=0.001

[f] Significantly overused at α=0.001

[g] Significant at α=0.025

occurred during the study.

Wolf 1065 was found dead, a victim of illegal poison 40 km east of any previous radio-location in April, 1985. Since he was killed it is unknown if this was an extraterritorial foray, a dispersal, or a reflection of changes in distribution made by Kluane wolves during spring. Female 1035 the intermittent partner of 1065 was not found where 1065 died yet 2 other wolves were. The relationship of 1065 to these wolves is unknown.

Wolf 1110 was alone when shot by an Alaskan trapper, 80 km north of any previous radio-location. Based from observations of wolf 1110 during telemetry locations wolf 1110 was thought to be the alpha male of the TLP, numbering 6 wolves. During 1986, apparently no wolf pack occupied the territory of the 1985 TLP. Given the low consumption rate of TLP members, I suspect 1110 had dispersed after most packmates shifted activities away from the 1985 area, dispersed, or died of malnutrition.

Wolf 1051 of the GRP occupied a territory which was highly exploited by Alaskan trappers. There is a high probability that most of 1051's pack mates were trapped. During 1986, 1051 was located 80 km south of her territory and after several scattered locations she dispersed out of the KSA and was never located again.

It was difficult to determine the frequency of territorial trespassing because of radio-collar failure, wolf mortality and dispersal. In addition some radio-collared packs were not adjacent to each other and the extent of overlap with other packs could not be determined. The most relevant data concerning extraterritorial movements were obtained from baits at snare sites. Apparently, the DRP and CCPR had travelled at least 5 km beyond their territory boundaries to reach the bait where they were initially radio-collared. In addition, although temporally separated, wolf 1051, the NHPR, and the DRP were observed at the same snare site.

In addition, 2 other snare sites were visited by 2 different groups of wolves. The SCL and wolf 1035 of the CCPR scavenged from a moose that was killed by an uncollared pack.

On one occasion, the SCL, the CCPR, and the TLP were located within an 8 km^2 area at the edge of the TLP and CCPR territories.

Wolves that ate large ungulates other than sheep appeared to have relatively stable traditional territories whereas wolves that hunted sheep may have had less traditional or long term occupancy. The BAP, GRP, and uncollared KRP were wolf packs known to inhabit the same respective areas since at least 1983; all occupied territories where sheep do not exist or do not represent their primary prey. All three packs lived in areas where human hunting and trapping is allowed and all packs suffered heavy mortality as a result. Despite human caused mortality these packs frequented the same area annually. In contrast, I have no knowledge regarding the traditional occupancy of the DRP, TLP, or CCPR territories. Since these packs lived well within the Kluane Game Sanctuary, human caused mortality was probably light and only occurred when members dispersed from the Sanctuary. Excluding a small quantity of moose scavenged by the CCPR female, both the CCPR and TLP ate only sheep and most members are believed to have shifted away from the area or based from consumption rates died from malnutrition. In 1986, 2 pairs (SCPR and NHPR) of wolves were radio-collared just southwest and southeast of the 1985 TLP territory and within the homerange of the 1985 CCPR. Although radio-collars on both pairs failed within 24 hours, one pair is known to have continually used the area. Both pairs were likely new colonizers attempting to survive by hunting sheep, the only significant ungulate prey in the area. Only wolf packs that were preying primarily on sheep exhibited such extensive turnover. In 1986, the entire GRP may have been removed through trapping and dispersal therefore under this extreme exploitation, a complete turnover of wolves likely occurred.

Moose density, Population Size and Biomass

A moose population survey was conducted during the midwinters of 1981 and 1982 for the southwest KSA (Gauthier 1984). Gauthier estimated a moose density of 0.12 moose/km^2 with moose calves comprising 8% of the moose population and adults comprising 92% of the population. This represents one of the lowest density estimates recorded for a Yukon moose population although an identical density estimate was obtained by Larsen (1982) for a moose population directly east and almost adjacent to the KSA. Incidental observations suggested moose may have declined since Gauthier's surveys. However, because my observations were non-systematic, moose density was assumed to be similar during 1985-1986. However, considerable annual variability has been recorded in the proportion of moose calves in several populations in the southern Yukon (Gauthier 1984).

Because of human hunting outside the Park and Game Sanctuary, moose composition and density outside the park and sanctuary may be lower than what exists within the protected areas.

Based on Gauthier's (1984) estimated moose density, from surveys conducted in 1981 and 1982, 606 moose were included within the KSA, or a moose biomass of 213,554 kg, assuming a composition of 92% adults and 8% calves.

Caribou Population Size and Biomass

Gauthier and Theberge (1985) stated that the Burwash caribou herd was stable, and averaged 376 caribou during the three mid-winter inventories conducted in 1980-1982. Members of the Burwash caribou herd traditionally winter on the Brooks Arm Plateau or the Burwash Uplands. However, during the three winters that the caribou population was monitored, varying percentages (1980-36%, 1981-47%, and 1982-78%) of the caribou herd wintered on the Brooks Arm Plateau, a plateau which is outside the boundaries of this study area. The other wintering area for Burwash caribou lies inside the KSA on the Burwash Uplands. During the study, I assumed most (75%) of the Burwash caribou herd wintered on the Brooks Arm Plateau since very few caribou were sighted near the Burwash Uplands.

Burwash caribou population size and composition were assumed to be similar to those determined by Gauthier and Theberge (1985). Bull caribou represented 38% of the population. Cows represented 44% of the population, while calves comprised the remaining 18%. Therefore, 94 members of the Burwash caribou herd are believed to have wintered in the KSA which represented an estimated 11,972 kg of available prey biomass to wolves.

The Chisana caribou herd is comprised of approximately 1100 caribou (Kelleyhouse unpubl. rep., Valkenburg pers. comm.), of which an estimated 350 winter within the KSA (Gauthier and Theberge unpubl. rep.). Assuming a composition (10% calves, 26 bulls, and 64% cows) similar to that determined by Kelleyhouse (unpubl. report), the Chisana herd contributes an estimated caribou biomass of 42,850 kg to the KSA.

Sheep Density, Population Size and Biomass

Substantial declines in sheep populations near the KSA have been associated with winters of deep snow. During the severe winter of 1981-1982 a 25% decline in a sheep population occurred immediately south of the KSA (Burles and Hoefs 1984), and there is no evidence to suggest declines did not occur throughout the KSA. A decline of 18% occurred at the same time in the northern KSA (A.D.F.& G. unpubl. report). Similar declines are assumed to have occurred across the entire KSA since a decline in sheep abundance occurred in all other areas of the Yukon where sheep were surveyed (Burles and Hoefs 1984). Age distribution data reflect the 1981-82 sheep decline.

During 1985, aerial surveys of sheep were conducted over 9% (424 km^2) of available sheep habitat within the KSA. Sheep composition (43% rams, 51% ewes and 6% lambs) and sheep density (1.05 sheep/km^2) are assumed to be similar for the entire KSA, excluding the area north of the White River. A 1984 A.D.F.& G. unpublished report estimated there were 1181 sheep within the Alaskan portion of the KSA. Sheep density was approximately 4.9 sheep/km^2. Composition included 39% rams, 44% ewes, and 17% lambs. Within the Yukon portion of the KSA and north of the White River, sheep densities and composition are assumed similar to Alaskan values rather than values determined from surveys in the south KSA..

The density estimates for sheep are multiplied by area of sheep habitat in the Yukon portion of the KSA to obtain a sheep population estimate. The estimated Yukon sheep population (5474 sheep) is added to the sheep population estimate for the Alaskan portion (1181 sheep) of the KSA to yield a total KSA sheep population estimate. The estimated 6,655 sheep within the KSA yields a total of 345,500 kg of sheep biomass annually.

An estimated total of 613,876 kg of wolf-prey biomass is within the Kluane study area (Table 9). Given that wolf density in the KSA was 6.7 wolves/1000 km^2 there was approximately 9370 kg of prey annually available per wolf.

Table 9. Prey:wolf and biomass:wolf ratio within respective pack territories.

Pack name	Territory size	Prey:wolf Sheep	Moose	Caribou	Ungulates	Biomass (kg):wolf Sheep	Moose	Caribou	Ungulate
BAP	412 km^2	0	16	31	85	0	5638	3932	9570
TLP	350 km^2	61	4	5	70	3560	1409	623	5592
CCPR	711 km^2	250	14	1	265	14602	4934	122	19658
GRP	540 km^2	180	3	32	227	9211	1057	2985	13253
DRP	1757 km^2	359	12	1	372	20968	4228	122	25318

CHAPTER V:

Discussion

Wolf predation is often concentrated on very old or young individuals (Mech 1970, Peterson 1977, Carbyn 1983, Peterson *et al.* 1984). In addition, Murie (1944), stated that wolves preyed primarily on old and young sheep. Since few ewe skulls were recovered during this study it was impossible to determine age distribution for ewes killed by wolves. Although sample size of wolf-killed sheep was small, wolves did not show preference for either sex of sheep and, in contrast to Murie's (1944) findings there was no data indicating that wolves preyed on lambs or yearlings.

Five of the 6 rams killed by wolves were middle aged (range 4.8-7.8). Because the data base is small, I considered it was insufficient to consider predation in relation to condition. However, Peterson (1982 and unpubl. data) documented slow growth and higher vulnerability among moose born following harsh winters. Four middle-aged rams would have been yearlings (2 rams) or 2 years old (2 rams) during the severe winter of 1981-82. The winter of 1981-82 included heavy snowfalls which covered forage on traditional sheep winter ranges and caused significant declines in many Yukon sheep populations (Burles and Hoefs

1984). Apparently these 4 middle-aged rams survived the severe winter but such harsh conditions during this critical developmental stage may have predisposed them to predation.

An alternative argument would be that wolf predation was non-selective with respect to age. Wolves preyed most on middle age rams which were also the most abundant cohorts in the KSA.

Interpretations of wolf hunting behavior from snow tracking and observations were consistent with reports by Murie (1944), Child *et al.* (1978), and Hoefs *et al.* (1986). Although sheep were killed in many different terrain types, some common features of wolf kills and wolf hunting strategies were evident. Wolves frequently attacked sheep from above and only severe escape terrain deterred wolves. Consistent with Hayes and Baer (1986), wolves frequently pushed sheep from steep cliffs to the ground below or caught them at the base of cliffs.

Excluding the DRP and considering packs of similar sizes, Kluane wolves occupied territories of similar size to those of southern Yukon wolves, interior Alaska wolves and Kenai Peninsula wolves (Gasaway *et al.* 1983, Peterson *et al.* 1984, Hayes *et al.* 1985, Hayes and Baer 1986). Consistent with Peterson *et al.* (1984), the 2-member CCPR occupied a territory similar in size to larger packs thus supporting the idea that wolf pairs occupy territories large enough for 1-2 years of pack growth. However, this pair frequently separated, and during the separation many of the most extensive movements occurred.

Mean pack size in late winter ($\bar{x}$=4.0) for wolves occupying the KSA was considerably lower than the mean early winter pack size documented by Gasaway *et al.* (1983) for interior Alaska, ($\bar{x}$=9.3) and Peterson *et al.* (1984) for the Kenai Peninsula, ($\bar{x}$=11.2). Early winter pack sizes are consistently higher than late winter pack sizes because of overwinter wolf mortality and dispersal has not occurred. Yet mean pack size in late winter was also lower than late winter mean pack size of southern Yukon wolves ($\bar{x}$=6.8) and northeastern Alberta wolves ($\bar{x}$=6.8), (Fuller and Keith 1980, Hayes *et al.* 1985). Mean late winter pack size in the KSA is similar to the low prey density (LP) area ($\bar{x}$=3.7 wolves) observed by Messier (1985).

Pack sizes (collared and uncollared) of KSA wolves generally were greater in the north and east ($\bar{x}$=5.0, n=4) portions of the KSA where moose or caribou were more abundant even with greater human caused wolf mortality. Wolves occupying the south and west were largely dependent on sheep as the sole ungulate prey. Wolf mean pack size in the southwest KSA was 3.2 wolves (n=5). Based on subjective observation, moose habitat improves dramatically northeast of the rugged St. Elias range. In addition, caribou occupied traditional ranges in the north and east KSA.

Mech (1970) summarized variable wolf densities from 83 wolves/1000 km^2 to 1.9/1000 km^2 for various regions of North America. Recent studies in Alaska and the southern Yukon document wolf densities ranging from 20 wolves/1000 km^2 to 11.8 wolves/1000 km^2 (Haber 1977, Gasaway *et al.* 1983, Peterson *et al* 1984, Hayes *et al.* 1985, Hayes and Baer 1986). Wolf density in the KSA (6.7 wolves/1000 km^2) is slightly less than the "moderate" wolf density (8.2 wolves/1000 km^2) described by Messier and Crete (1985). All of these other wolf populations have moose or caribou as principal prey although Dall sheep were important to certain packs in the southwest Yukon and interior Alaska (Haber 1977, Hayes and Baer 1986, Hayes and Baer in prep). Ungulate abundance is low within the KSA further indicating that ungulate abundance determines wolf density on a coarse scale (cf. Fuller and Keith 1980). Variation in wolf density in the KSA was related to wolves having differing species and proportions of available prey.

The effect of a diet of sheep on wolf densities is apparent when wolves of the Tetlin flats are considered. Tetlin flats is largely a non-mountainous area directly northwest and adjacent to the KSA. Preliminary data suggests Tetlin wolves feed almost exclusively on moose and caribou, and wolves presently exist at approximately 9.0 wolves/1000 km^2/wolf. Mean pack size of Tetlin wolves is 9.3 wolves (Kelleyhouse and Stearns pers. comm. 1987).

In the case of Kluane wolves species diversity of available ungulate prey may also be an important determinant of wolf population size and status. For example the second largest Kluane pack (TLP) had abundant sheep available and likely ate mainly sheep. This pack disappeared from the study area in 1986. It is unknown whether the pack dispersed, died of natural causes or were illegally taken. The collared alpha male was shot while alone, 80 km north of any previous location in autumn 1985, and during 1986 this pack was absent from the study area. Such evidence might suggest that packs are unlikely to flourish on a diet of sheep.

Predation and consumption rates from this study represent some of the lowest figures documented. Excluding the GRP, predation rates (1 kill/pack/7.7-12.5 days) for Kluane wolves are among the lowest documented in the literature. Wolf kill rates between 1 kill/pack/2.7 days to 1 kill/pack/4.7 days are common for ungulates such as moose or elk (*Cervus elaphus*), (Mech 1966a, Shelton 1966, Fuller and Keith 1980, Carbyn 1983, Peterson *et al.* 1984).

Predation rates for deer-eating wolves are more comparable since deer are approximately of equivalent size

(54 kg) to sheep. Predation rates on deer have been 1 deer/3.4-37.8 days/wolf (Mech and Frenzel 1971, Kolenosky 1972, Mech 1977, Holleman and Stephenson 1981). In the KSA predation rate increased with pack size. However, lone wolves in Kluane made kills every 18.5 days while kill rates per wolf for wolves in packs were 1 kill/31-54 days/wolf.

Mech (1977) calculated that wolves require 1.7 kg/wolf/day or approximately 0.06 kg/kg wolf/day to survive in the wild. Wolves require 3.2 kg/wolf/day or 0.13 kg/kg wolf/day to reproduce successfully (Mech 1977, Messier 1985).

Only members of the BAP (non-sheep consumers), had food intakes above 0.13 kg/kg wolf/day. The next highest consumption rate was by the GRP, which had available alternate prey and appeared to prefer these alternate prey over sheep. Predation rates suggest that the lone wolf's strategy may be favorable when sheep are hunted, even at the expense of lost reproduction.

Despite more than 200 hours of flying during this study fewer than 50 live moose were sighted. Yet 4 wolf-killed moose were located. Despite much greater numbers of sheep available to most KSA wolves, a preference for moose was evident. Moose apparently represent a greater energetic reward when compared to sheep.

Holleman and Stephenson (1981) indicated that generally caribou are preferred by wolves over most northern ungulate prey. However, they qualified their remark by indicating prey availability and prey preference ultimately determine prey selection. Hayes and Baer (1986) found caribou were not selected by wolves where moose and sheep predominated in the southwest Yukon.

For many of the KSA wolves, sheep were the only prey available in reasonable abundance during winter. Excluding the SCL, consumption rates documented indicate all other wolves which preyed primarily on sheep were nutritionally stressed.

Although some weights for wolves were estimated most wolves (10 of 14) captured were heavy and appeared in healthy condition. However, 5 and possibly 6 of the 10 wolves rated as healthy were alpha wolves. Alpha wolves would be expected to be the most healthy pack members since they dominate at feeding sessions. However, 1 alpha female was rated the most unhealthy of all wolves captured. Three of the remaining 4 wolves that were not alpha animals had or were members of packs that had the 3 highest consumption rates.

Mech (1977) observed a wolf pack over a 7 year period during which time daily food intake for the wolf pack declined to marginal levels. Concurrently, he observed an increase in frequency of wolves sleeping, and a decrease in wolf travel and rest. Mech believed the wolves were not energetically stressed but rather, being familiar with their territory, they had detected the low levels of available prey and spent less time hunting. The majority of Kluane wolves were apparently living at or below marginal survival levels yet they did not exhibit similar percentages of activity to those observed by Mech (1977). In contrast, Fuller and Keith (1980) observed wolves which were obtaining adequate quantities of food yet they had similar percentages of activity to the wolf pack observed by Mech (1977).

I do not intend to discount Mech's findings since he was examining one pack which held, and was familiar with the same general territory for 7 years. I have little knowledge of the historic occupancy of wolf territories in the KSA. However, I observed the disappearance of one pack (TLP) in 1985 and the arrival of 2 new pairs (NHPR and SCPR) into adjacent areas during 1986. Because the only gray member of the TLP was killed in 1985 and 3 wolves in the 2 colonizing pairs were gray, only 1 wolf could possibly have been a former member of the 1985 TLP and at least 3 of the 4 wolves were new occupants. Therefore, given frequent pack turnover KSA wolves may have been much less familiar with their territories thus behaved differently than the Harris Lake Pack described by Mech (1977).

Excluding the behavior of the GRP, activities of Kluane wolves indicate some variability but are relatively consistent considering the varying pack sizes, preferred prey and consumption rates.

Analysis of use-availability data indicate that if mere non-visual, general habitat locations had been recorded during winter wolf locations, accurate inferences could have been made about prey hunted in this multi-prey system. Significant use of alpine habitats by wolves indicated packs mainly hunted sheep while packs showing no selection for non-alpine or alpine habitats were hunting all three large prey species.

Mech (1977) noted increased mortality among adult wolves, including an alpha male, which were killed by humans after travelling outside familiar territories in search of food. Similarly, two alpha males (1065 and 1110) known to have low consumption rates dispersed and were killed.

Current findings suggest that when moose are the primary prey of wolves, wolves can cause a moose population decline at ratios less than 20 moose/wolf. At moose-wolf ratio between 20 and 30 moose/wolf, wolves could limit moose population growth in the presence of other negative factors. Finally, at ratio >30 moose/wolf, wolf predation could be significant but may not cause a moose population decline (Gasaway *et al.* 1983). Moose wolf ratios should be examined with caution since they do not consider prey vulnerability. For example, Isle Royale moose were being limited by wolves at ratio of 40 moose/wolf, however several years later, healthy, less vulnerable moose were not being limited by wolves when the ratios were still 40 moose/wolf. Critical wolf-moose ratios presented by Gasaway *et al.* (1983) convert to wolf/moose biomass ratio of 1 wolf/7,500-11,000 kg moose. In addition Messier (1985) stated that when no alternate ungulate exists wolves cannot subsist when moose densities are below 0.2 moose/km^2. Messier's threshold density figure converts to biomass density of approximately 75 kg/km^2.

Much of the data on thresholds at which wolves limit prey is derived from wolf-single-prey systems and wolves inhabiting the KSA are in a more complex wolf-multi-prey system. However, it is important to note that there is on average, less than 11,000 kg ungulate biomass/wolf, on average less than 10 moose/wolf, and less than 75 kg of available ungulate biomass/km^2 in the KSA. All these values suggest that wolves could limit prey in a wolf-single-prey system.

However, sheep are known to have well developed eyesight, hearing and sense of smell. Well developed senses combined with horns for defense and the ability to traverse and reside in very precipitous topography appears to be too much for wolves to overcome with regularity. Since sheep proved so difficult to kill I speculate that wolves would try to prey on moose or caribou at every opportunity. In essence, the difficulty of preying on sheep forces wolves to seek other large prey.

Within the KSA most wolves occupying alpine areas were dependent on sheep yet consumption rate data indicates wolves led a marginal existence. In essence wolves were being limited by available prey. Yet sheep were maintaining wolves sufficiently so that if given the opportunity wolves would consume moose. Moose were very scarce in the KSA and only a few wolf kills annually would be necessary to prohibit moose population growth. Moose habitat within the KSA is very poor. Many lowland regions are devoid of willow and covered in stunted black spruce. Moose appeared restricted to small corridors of riparian and upland willow along creeks and rivers. In such focused yet open terrain moose are likely easily located by wolves, thereby increasing probability of encounter with opportunistic wolves.

CHAPTER VI:

Conclusions

While a broad objective of this study was to gather general information on wolf ecology, more focused objectives were to:

1) determine the extent to which wolves might rely upon Dall sheep in winter; and

2) measure predation rates of wolves feeding on sheep and other ungulates; and

3) assess the population status of wolves in a primarily Dall sheep-prey system.

Wolves totally reliant on Dall sheep appear to be marginally supported. Although the study did not provide definitive evidence that wolves were nutritionally stressed, the preponderance of the evidence indicates:

1) the wolves of the KSA rely heavily on sheep in winter, however, predation rates on sheep are so low that wolves cannot readily obtain necessary food requirements; and

2) the populations of sheep eating wolves are characterized by: low density, small pack size, large territories and frequent abandonment and recolonization of territories.

This research is the first to specifically address the role of Dall sheep in wolf ecology. The study represents a brief 120 day view into the operating window of wolf-Dall sheep ecology and was completed largely without the benefit of comparable data. However, comparisons with contemporary wolf research in other wolf/ungulate systems were relevent.

The following traits were characteristic of wolves and wolf-Dall sheep interaction in the KSA:

1) wolves often killed middle and old-aged sheep;

2) mean pack size in late winter was among the lowest documented;

3) wolf densities were among the lowest documented for boreal wolves;

4) predation and consumption rates were low enough to suggest a marginal food base for wolves relying on sheep, probably not sufficient for consistent recruitment.

5) wolf/prey ratio and wolf/biomass ratio indicate wolves could limit prey in a wolf-single-prey system;

6) dispersers or wolves living outside the protected Park or Sanctuary were frequently killed by humans;

7) all known wolf mortality was human-caused;

8) baits or large ungulate kills were frequently visited by different wolf groups suggesting territory instability and food shortages for some wolves;

9) territories were large, regularly abandoned and re-colonized in areas where only sheep were the only

available prey. All dispersing wolves (N=3) were adults, 2 being alpha males; taken together, the above evidence points to a wolf population strongly limited by available prey.

Sheep were the most common ungulate prey and represented the greatest available biomass to most Kluane wolves. Although wolves proved surprisingly adept in precipitous terrain, sheep clearly have an advantage, and in 4 of the 6 hunts observed, escape terrain proved to be the deciding factor that prevented predation by wolves.

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APPENDIX I. Live weights of moose, sheep, caribou and horse and estimated average amount consumed by wolves.

Moose	Mean weight (kg)	Source	Mean Amount Consumed (kg)
Ad. Bull	375	Franzmann *et al.* 1978	281
Ad. Cow	365	Franzmann *et al.* 1978	274
Calf	150	Franzmann *et al.* 1978	113
Dall Sheep			
Ram	75	Bunnell and Olsen 1976	64
Ewe	49	Bunnell and Olsen 1976	46
Lamb	28	Bunnell and Olsen 1976	27
Caribou			
Ad. bull	176	Gauthier and Farnell 1986	150
Ad. cow	115	Skoog 1968	100
Calf	52	Skoog 1968	48
Horse			
Ad.	400		300

APPENDIX II. Summary of wolf capture data in the KSA, 1985-1986.

Wolf number	Capture date dd/mm/yy	Sex	Wt (kg)	Color	Age	Original pack affiliation	Pack size	Collar type	Length of tracking period (days)	Radio locations (N)	Cause of Tracking Termination	Ultimate fate
1161	25/01/85	F	30	Gray	Yrlg	BAP	3	Telonics	66	35	Signal lost	Suspected shot
1035	28/01/85	F	27	Gray	Ad	CCPR	2	Austec	62	31	Signal lost	Unknown
1024	01/02/85	M	38[b]	Black	Yrlg	TLP	6	Austec	58	38	Killed	Unknown
1051	03/02/85	F	38[b]	Gray	Yrlg	GRP	8	Telonics	403	25	Dispersed	Unknown
0000	07/02/85	F	____	Black	Pup	KRP	4-7	______	0	0	Killed	Shot in snare
1060	20/02/85	M	33	Gray	Ad	SCL	1	Telonics	149	28	[c]	Unknown
1161[a]	21/03/85	F		Gray	Yrlg	BAP	3	Telonics	66	35	Killed	Suspected shot
1151	27/03/85	F	32	Black	Ad	ACL	1	Telonics	4	3	Unknown	Unknown
1105	28/03/85	M	51[b]	Gray	Ad	GRP	8	Austec	113	4	[c]	Unknown
1065	28/03/85	M	42[b]	Black	Ad	CCPR	2	Austec	30	3	Killed	Poisoned
1110	01/04/85	M	40[b]	Gray	Ad	TLP	7	Telonics	184	3	Killed	Shot
1196	23/01/86	M	40[b]	Gray	Yrlg	KRL	1	Lotek	48	4	Euthanized	Death
1011	17/02/86	F	36	Gray	Ad	DRP	5	Lotek	49	31	Study end	Unknown
0000	18/02/86	M	45	Black	Ad	DRP	5	______	0	0	______	Capture death
1018	05/03/86	M	40	Gray	Yrlg	NHPR	2	Lotek	1	1	Trans. fail.	Unknown
1196	12/03/86	M	35	Gray	Yrlg	KRL	1	Lotek	48	4	Euthanized	Death
1196[a]	27/03/86	F	33[b]	Black	Ad.	MRP	3	Lotek	10	10	Study end	Unknown
1028	05/04/86	F	39	Black	Ad	SCPR	2	Lotek	0	0	Trans. fail.	Unknown

[a] Recaptures.
[b] Estimated weights.
[c] Radiocollar transmitting but immobile.

APPENDIX III. Individual pack summaries.

Brooks Arm Pack (BAP)

Gauthier (1984) reported that between 1978 and 1981, 5-9 wolves occupied a territory similar to that occupied by the BAP. A yearling female wolf, 1160 was captured by snare at the Burwash dump on January 25, 1985. She was radio-collared and released. One member of the four member pack of unknown age, sex and color was shot on Kluane Lake just prior to intensive telemetry monitoring on Feb. 12, 1985. Pack members included one black and two gray wolves. All three wolves were monitored regularly until March 17, 1985, when the collared female was snared again at the Burwash dump. All snares were believed to have been removed from the dump earlier in the study so it was not until four days after the snaring that suspicions warranted a ground investigation, and the unintended capture discovered. The female was immobilized and transported 12 kilometers by vehicle to a safer release site. After the second capture the female was never observed associating with the other two BAP members. Wolf 1160 was monitored until April 1, 1985 when field work ended for the 1985 season. Her signal was never received again. Reliable sources indicate that this female was shot on the ice later that month. The wolf and the collar were never recovered to verify her death. In addition, two wolves matching the description of the other two BAP members were collected in May at the site of an illegal poisoning in the heart of the BAP territory. Therefore it is possible all members suffered human caused deaths. However, the 2 uncollared BAP members may have survived since a black and a gray wolf were observed together, during 1986 within the 1985 BAP territory.

Deaths to wolves in this area were common since wolves travelling on Kluane Lake (396km^2) were often pursued on snowmobile and shot after being observed from the lakeshore communities of Burwash Landing and Destruction Bay. At least half of this pack's territory lay outside the Park and Sanctuary. This pack was frequently at risk when sleeping within one kilometer of residences, frequenting the Burwash dump and crossing Kluane Lake.

As a trio this pack killed and ate a horse and a cow caribou. In addition female 1160 killed and ate a calf caribou on her own.

<u>Cement Creek Pair (CCPR)</u>

A very emaciated black, adult, female wolf (1035) was captured on Jan. 28, 1985 in a box trap intended for capturing live wolverine. She was radio-collared and released. During the next several days she returned to feed on a horse carcass near her capture site. It is rare for wolves to return to capture sites and I believe her poor physical condition motivated her to return for food. On Feb. 5, 1985 a black wolf was spotted walking within 0.5 km of 1035. Judging from tracks this black wolf was suspected to be associated with 1035. Foul weather prevented radio-tracking until Feb. 21 when the pair was spotted feeding on a Dall ram. On Feb. 27, 1035 was located alone and she remained alone until Mar. 14 when she reunited with the black wolf. During the period 1035 was alone she scavenged from a moose carcass killed by an adjacent uncollared pack, (see summary Steele Creek Loner) and killed and ate a Dall ewe. This pair was observed hunting sheep on 3 occasions, (see Appendix III) but failed to kill again before their last location on Mar. 30. Except for scavenging from a moose kill, the pair hunted and ate only sheep. At the end of the 1985 season, 1035 appeared tired and emaciated, having not fed during the preceding 22 days. After Mar. 30, female 1035 was never located again.

The partner of 1035 was darted, radio-collared and released on Mar.28. He was a male adult (1065) in good physical condition considering he also had not eaten large prey during at least the previous 16 days.

On May 14, 1985, 1065 was found dead at the previously mentioned illegal poisoning site (see BAP summary). He died 40 km east of any previous location.

Tepee Lake Pack (TLP)

A black yearling male (1024) was darted on Feb. 1, 1985. This pack consisted of 5 black wolves and a gray wolf. Monitoring began Feb. 5 and continued until Apr. 1, 1985. Although this pack visited the site of an old caribou kill, hunted caribou once and was observed worrying one moose, they preyed on sheep only. Up through Mar. 14, the pack had killed a ewe and a ram. On Mar. 15, 1024 was observed alone and appeared to have a leg injury. I believe the injury resulted from a successful sheep hunt on Mar. 13. Excepting brief forays of less than 300 m, 1024 shared a small bluff with a Dall ram, and lay in virtually the same bed for 17 days. After two weeks, 1024 killed and consumed the ram which had also occupied the bluff. On Apr. 1, 1024 left the sheep carcass and rejoined the TLP, which had not been observed since Mar. 14. The TLP had just consumed a sheep of unknown sex and age. In addition, a gray, adult, male (1110), from the TLP was darted and radio-collared on Apr. 1. The frequency of 1024 was never heard again, while 1110 was generally located in June within the core of the TLP homerange. When I returned to the study in Feb. 1986 I located 1110's signal coming from a trapper's cabin in Alaska. Wolf 1110 had been shot by the trapper during fall 1985. This location was 72 km north of any previous TLP location.

Members of the TLP ate at least 4 sheep while being monitored.

Generc River Pack (GRP)

D. Kelleyhouse (pers. comm.) stated that, as early as 1982 that 7-8 wolves had an established territory within the area occupied by the 1985 GRP.

A yearling, gray, female (1051) was darted near a moose carcass on the Generc River on Feb. 3, 1985. Monitoring began on Feb. 18, 1985, when the GRP was observed feeding on a ram. A combination of funding constraints and foul weather negated daily monitoring until Mar. 11. Between Mar. 11 and Mar. 30, the last day of monitoring, these wolves killed and ate a cow caribou, a bull caribou, a cow moose and an animal of unknown species.

Initially the unidentified carcass was thought to be a sheep or caribou; however, only a blood spoor was visible. A flight over the killsite 2 days later revealed an intact dead wolverine and a live red fox nearby. The wolverine carcass had not been there when the kill was first discovered. We landed the aircraft and attempted to hike to the kill but were forced to turn back when daylight waned. I travelled to the site by helicopter 2 weeks later and found a hard snowdrift had blown over much of the remains. This visit revealed no sign of an ungulate or wolverine carcass. Instead an extensive amount of wolf hair was discovered. Time constraints, low helicopter fuel and the lack of a shovel to dig out the snowdrift all contributed to an inadequate investigation of this kill. Several explanations, including illegal poisoning are possible. Failing to solve the mystery at this site hinders accurate calculations of consumption rates. The GRP are known to have eaten 2 moose, 2 caribou, 1 sheep and an animal of unknown species.

On Mar. 28 an adult, male wolf (1105) from the GRP was darted and radio-collared. Although bumped with the helicopter skid during pursuit he appeared in excellent condition. On July 19, 1985, 1105's collar was located from aircraft in very open terrain. Since there was no sign of a wolf it must have died and decomposed or the collar was shed. The frequency was never heard again.

Wolf 1051 was observed alone, in sheep habitat on July 19. Of the 9 wolves radio-collared in 1985, wolf 1051 was the only living wolf with an active signal when I returned in 1986. She was alone within the 1985 GRP homerange when first located on Feb. 17, 1986. She was difficult to locate on subsequent flights until she was located 70 km southeast of any previous location, on the Donjek River. After 4 locations she was lost from monitoring and I believe she dispersed. At least 8 wolves were harvested from within and adjacent to the GRP homerange in both study years and I suspect the majority of the GRP were harvested.

Kluane River Pack (KRP)

This pack, consisting of 5-8 wolves was well established prior to 1985 (T. Hoggins and D. Makkonen pers. comm.). During Dec., 1985, 2 black and 5 gray wolves were observed along the Kluane river by the same persons.

A black, female (0000) was snared at the 1118 mile dump in early February, 1985. She was shot in the snare by a local resident before study personnel had completed a daily check of the snare site. This pup was probably a member of the 7 member Kluane River pack which occupied the area.

Steele Creek Loner (SCL)

During a flight over a snare site on Feb. 19, 1985 we observed a black wolf feeding on bait. The black wolf was not captured but a gray, adult, male wolf (1060) was snared during that night. We concluded that 1060 was probably a member of a pack. On Feb. 26 a black canid (either wolf or fox) was seen in the vicinity of 1060. On Mar. 1, 1060 was observed resting among 6 other wolves atop a ridge; several hundred meters below was a moose kill. This is the same moose kill fed upon by 1035 of the CCPR.

Wolf 1060 was never observed with these wolves again and the relationship 1060 had with these other wolves remains a mystery.

Although 1060 occupied a large homerange, the majority of his activity was in the Steele Creek drainage. Earlier in the study a lone wolf of similar color was observed in Steele Creek. This was likely 1060 prior to capture. The SCL made a confirmed kill of a ram and a suspected kill of an ewe. On Mar. 12 the SCL was observed within meters of pulling down an ewe. The chase and suspected kill occurred on an expansive, snow free mountainside. Wolf 1060 remained at this location for another 3 days. Despite many passes with aircraft we never sighted 1060 in the cryptic, brown shale. The SCL displayed no sign of injury after leaving the area, therefore I conclude that his immobility was a result of feeding on a kill. Referring to the suspected kill, the evidence is so strong that a kill was made that I have included it in consumption and predation rate calculations. On July 19, 1985 the SCL was located 50 kilometers north of any previous location. Many caribou tracks in the surrounding sand suggested he was hunting caribou. July 19 was the last time 1060 was seen alive.

When I resumed the study in 1986 I located a stationary signal, that of 1060 at the head of Steele

Creek. Although he may have shed his collar I suspect he died there.

Arch Creek Loner (ACL)

This black, adult, female (1151) in poor to fair condition was snared on Mar. 27, 1985; four days before terminating the 1985 field season. Tracks at the snare site and 3 subsequent locations indicate she was a lone wolf. She was snared anterior to the rear legs rather than the intended neck and incurred an 8 cm cut to the dorsal region. The cut was not believed serious; however, Bicillin was administered as a precaution. She was located 4 more times and she was observed only once after capture.

During a rare summer telemetry flight (July 18, 1985) her signal was heard 10 km south of the capture site but the wolf was not observed. The following day a more maneuverable aircraft was enlisted in hopes of obtaining a visual observation. The signal was not received in the vicinity of the previous days location indicating she was probably alive. Her signal was never received again. During the brief period under observation this wolf was not observed feeding.

Kluane River Loner (KRL)

A gray, male, yearling wolf (1196) was snared on Jan. 23, 1986. Subsequent locations indicated this male was a loner rather than a member of the 4-7 member Kluane River pack which occupied the area. Due to funding constraints and the desire to focus on sheep eating wolves I discontinued radio telemetry monitoring of this wolf after fewer than 5 locations. While under observation, 1196 regularly scavenged spawned salmon frozen in the river ice.

Wolf 1196 was recaptured 20 km west of any previous location on Mar. 12. He was snared at a 6 week old moose kill made by an uncollared wolf pack. Unfortunately 20 cm of the right, rear leg was missing. The injury was not a result of snaring. I euthanized 1196, since he appeared to have lost 10 kg body weight and I believed he would soon die.

Note this radio-collar was later placed on a member of the Miles Ridge Pack (1196) hence the same identification number.

Donjek River Pack (DRP)

A gray, adult, female (1011) was snared, radio-collared, and released on the Donjek River on Feb. 17, 1986. The following day a mature, black, male was snared from the same pack. Unfortunately this male died while being handled.

When I approached the captive male he was actively trying to free himself. I administered the drug and began removing the remaining snares. Intermittent glances indicated he was going under in the usual manner. However I failed to notice that his throat was resting on a portion of the snare stretched taut between 2 trees. Not until I heard the wolf gurgle did I note the problem. Lengthy CPR failed to resuscitate him. A similar incident occurred in a southern Yukon wolf study (B. Hayes pers. comm.). Future investigators using this capture technique should be aware of this type of capture problem.

It is possible the male that died was an alpha male. However, the remaining 4 members remained together until the study ended on April 6, 1986. During the period under study the DRP killed and ate 4 sheep, all believed to be ewes. The DRP was not observed hunting any other prey species.

No Home Pair (NHPR)

On Mar. 5, 1986 a pair of gray wolves were observed feeding on bait at a previous snare site (see Donjek River pack summary). Since snares had been removed from this site, a male, yearling wolf (1018) was darted from a helicopter. The following day, wolf 1018 was located alone, several hundred meters from its capture point. The collar signal was never received again and I believe the radio-collar failed. It is unlikely there were more than 2 wolves since they were captured on a wide, open river plain.

Miles Ridge Pack (MRP)

A black female (1196) was captured on March 27, 1986. She was associated with a gray and a black wolf. These wolves were only monitored 9 days and during that time they ate no large prey. The MRP traveled in alpine as well as lowland habitats suggesting they may have had similar diets to the GRP i. e. eating moose, caribou, and sheep.

St. Clare River Pair (SCPR)

On April 4, 1986 a gray and a black wolf were tracked to a resting point 2 km from a freshly killed ram. Since a helicopter was unavailable the pair were tracked and located near the carcass the following day. A black, adult, female (1028) was darted on Apr. 5. Tracks from this pair are believed to have been seen and followed unsuccessfully several times during the 1986 field season. The study terminated 2 days later but I believe the radio-collar malfunctioned since extensive telemetry flights those last days failed to receive a signal.

Female 1028 had a distinctive silver pelage similar to a wolf belonging to the 1985 TLP. Activities of this pair were within or immediately south of the 1985 TLP homerange suggesting she may have been a member of the 1985 TLP. However, female 1028's gray companion could not have been a former TLP member since the only gray member was killed in late 1985.

On Sept. 11, 1986 a unidentified collared, black wolf, a gray wolf and 3 other black wolves were observed feeding on a bull caribou, along the St. Clare river. Possibly this was 1028, her gray mate, and 3 pups. It is also possible that the collared wolf was 1024, of the 1985 TLP. The location of the sighting supports either possibility. During 1986, a snare site supplied with ample bait was set in a core activity area of the 1985 TLP. No wolves visited this snare site.

There is a remote possibility that the collared wolf observed in September may have been 1035 of the CCPR or 1151, the ACL, since they are the only other black, radio-collared wolves possibly alive in the study area.

APPENDIX IV. Sex and age of other wolf-killed ungulates in Kluane, excluding Dall sheep.

Species	Age	Sex	Date Killed dd/mm/yy	Pack Responsible
Caribou	Ad.	F	19/02/85	BAP
Horse[a]	Ad.	_	25/02/85	BAP
Moose	Ad.	_	28/02/85	UNK.
Unknown	__	_	12/03/85	GRP
Caribou	Ad.	F	14/03/85	GRP
Caribou	Ad.	M	17/03/85	GRP
Caribou	Ad.	F	26/03/85	UNK.
Moose	11.8	F	26/03/85	GRP
Caribou	0.8	F	31/03/85	BAP
Moose	1.8	M	05/02/86	UNK.

[a] Died of malnutrition and was consumed by wolves.

APPENDIX V. Observations of Wolves Hunting Sheep.

Although wolves were frequently observed in close proximity to sheep, only 5 sheep hunts were observed. Sheep are known to fear aircraft and sheep often flee even when aircraft are a considerable distance away (pers. obs.). Therefore, during some hunts we left the area before the hunts were complete to avoid having our aircraft affect the outcome of the hunt.

Hunt #1

On 21 February 1985, 4 members of the TLP were observed traversing the upper elevations of a mountain. All 4 animals were separate from one another. Tracks on the south slope indicated there had been much wolf activity. One wolf suddenly left the ridge and bounded down the south aspect. The running wolf generated a small avalanche of snow just ahead, similar to a boats bow wave. Any sheep in the path of the avalanche would have been knocked down. Whether this wolf was taking advantage of the snow conditions to improve hunting success or whether sliding snow occurred incidentally to this animals downhill charge is unknown. The wolf ran almost to the mountain base, passing many small, rock outcrops. Clearly this wolf was hoping to surprise and overtake a sheep among the outcrops. Approximately 5 minutes later another pack member ran down the north aspect in similar fashion. However, snow conditions were variable and at some points a very hard crust would cause the wolf to lose balance and traction.

The other 2 wolves, although separate from each other, were pursuing a band of 10 nursery sheep on the ridge. The tightly bunched herd stopped occasionally to observe the trotting wolves 200 m behind. The sheep left the main ridge and ran to the end of a perpendicular ridge. The ridge ended with a sheer cliff at least 200 m high. The sheep remained standing, tightly packed at the cliffs edge. Both wolves approached to within 100 m of the sheep, but one descended the mountain soon after. The other stood assessing the situation but also descended soon afterward. Although any attack on the sheep in their position would have been extremely dangerous, an approach to within 5 m was very feasible and I was surprised that the wolves did not approach in hopes that a sheep would panic and flee the cliff edge. Shortly after the wolves had descended, the sheep returned to the main ridge. Two wolves were not seen during this hunt but they were probably on the mountain. The TLP hunted the same band of sheep on this small, rugged mountain many times during 1985 but failed to make a kill.

<u>Hunt #2</u>

On March 14 1985, while locating the CCPR, 3 mature rams were observed traversing a 30 m high cliff, above a tributary of Cement Creek. Female 1035 was paralleling the sheeps' course from the cliff top. The 2 leading sheep were slightly ahead and they soon outdistanced the wolf. However, the third sheep stopped abruptly and faced uphill toward the wolf. As it faced uphill snow and rock fell away from beneath its hind feet and for a brief moment it appeared that the sheep would fall to the creek ice below. The ram recovered, adjusted his footing and watched 1035, while she looked down from above.

The female wolf started down the cliff toward the sheep but retreated to the cliff top when she could not reach the ram and footing became unsafe.

We left the scene once this standoff had continued for several minutes. During the encounter, the male wolf (later known as 1065) was 20 m upstream, also at the cliff edge, lying amongst a willow bush. During the entire hunt he never moved from the willows and it was difficult to say whether he was sleeping or hiding.

Wolf 1035 was located the following day, limping on the creek ice below the site of the previous days hunt. The male was not observed.

<u>Hunt #3</u>

On March 19 1985, the CCPR were observed resting on a mountainside 500 meters above the valley floor. As we approached, 1035 arose and walked west on the same contour. Four hundred meters above was a lone, half curl ram. The ram was looking at the wolf, and the wolf would occasionally look up at the sheep. When 1035 reached the same ridge that the sheep was on, the wolf started uphill toward the ram. As 1035 approached, the sheep began to walk uphill, directly away from the wolf. When the ram reached the mountaintop it walked westward. Once 1035 reached the mountaintop it trotted after the ram and only when the ram travelled out of sight, behind a rolling knoll and below 1035 did 1035 pursue aggressively. The wolf approached the ram at high speed, but when 10 meters away the running ram gained ground. The ram started down the mountain and then contoured eastward just below the crest of the mountain. The wolf, easily outdistanced, gave up the chase.

Meanwhile, the male wolf, oblivious to the activity above, stood up and walked directly uphill on a course intersecting that of the fleeing ram. The ram passed just 10 m above the wolf, and the seemingly disinterested wolf did not pursue the sheep. I believe the ram and the male wolf knew nothing of each others proximity until the sheep passed by. The wolves reunited and did not continue the hunt.

Hunt #4

The CCPR were observed hunting again on March 25

1985. This hunt was very similar to the hunt #2 in Cement Creek. Female 1035 was at the top of a 300 m tall, clay cliff overlooking the Klutlan Glacier. Again she was paralleling a three-quarter curl ram which was traversing the cliff 20 m below. The ram stopped and turned uphill, almost losing balance in the process. For a few moments they stared at one another and then 1035 walked down to within a half metre of the ram. The ram tried to butt the wolf and contact was very close. Wolf 1035 turned and returned to the cliff top. We left the area after what appeared to be a standoff.

During the entire period the male wolf (1065) lay at the cliff edge. It was difficult to tell whether he was resting or laying in wait.

When we returned the following morning, the ram was standing in the same location. The wolves were sleeping 400 m from the cliff edge. The ram walked up to the cliff top, peered over briefly and dashed to the closest mountainside. The wolves continued sleeping.

The almost exact similarity between the first and third hunts by the CCPR is likely not a coincidence. The inactivity of the male in all three hunts could reflect a differing tactical hunting style or role. The differing behavior by each wolf may have reflected their differing nutritional status. Female 1035 was in very poor condition while 1065 was in excellent physical condition.

It appeared on all occasions that a unified approach with a more active cooperative role played by the male would have enhanced hunting success. However, I may be overlooking a very logical reason for their strategy. Stephenson (1978) related many of the shortcomings of the western scientists' mental framework and perhaps I am a victim of that framework in these observations.

Hunt #5

On March 19 1985, 3 members of the GRP were observed harassing a band of 20 nursery sheep on a rolling talus ridge. The wolves has surrounded the sheep an rather than gradually tighten the circle, the wolves preferred to pursue the sheep individually. There was no escape terrain nearby and a kill appeared imminent. One wolf was above the herd and 2 were below. Each wolf took turns pursuing the herd. At one point one of the lower wolves managed to split the herd but both sheep herds remained tightly packed. One of the herds climbed a rock outcrop while the other stood on the open talus waiting for the wolves to actively pursue again. The sheep on the outcrop seemed especially vulnerable and I expected the wolves to surround the outcrop and attack. Instead the wolves discontinued the hunt and walked away. I felt as though the wolves could easily have made a kill, especially if all 8 members had been present. The hunt lasted less than 5 minutes.

Hunt #6

Only one hunt was observed in 1986. On March 23, the Donjek pack were descending a long, rolling ridge. The wolves were fanned out across the ridge when suddenly they all sprinted downhill for 1000 m. Although many sheep were on adjacent ridges no sheep were on this particular ridge. The strategy appeared similar to the TLP where they hoped to surprise and overtake a sheep amongst the outcrops and undulating terrain. One could argue that the wolves were merely running but their behavior before the run indicated they were searching for prey.

Although none of the hunts observed were successful, hunting strategies employed by wolves and defense strategies employed by sheep are similar to other observations (Murie 1944, Child *et al.* 1978, Hoefs *et al.* 1986). Wolves prefer to hunt from above and little teamwork is evident among pack members when hunting. One wolf is capable of capturing and killing sheep. Wolves are very agile in difficult terrain.

Sheep seek escape terrain when pursued by wolves and if necessary will defend themselves with their horns.