SPRING AND FALL MOVEMENTS OF NELCHINA CARIBOU IN RELATION TO THE TRANS-ALASKA PIPELINE

Renewable Resources Consulting Services Ltd.

SPRING AND FALL MOVEMENTS OF NELCHINA CARIBOU IN RELATION TO THE TRANS-ALASKA PIPELINE

Renewable Resources
Consulting Services Ltd.

SPRING AND FALL MOVEMENTS OF NELCHINA CARIBOU IN RELATION TO THE TRANS-ALASKA PIPELINE

Prepared for

Alyeska Pipeline Service Company

by

D.R. Carruthers, R.D. Jakimchuk and C. Linkswiler

Renewable Resources Consulting Services Ltd.

March 1984

SUMMARY

The majority (>80%) of the Nelchina caribou herd crossed TAPS each fall and spring 1981-1983, moving east to traditional winter range in fall and west to traditional calving areas and summer range in spring. Major wintering areas included the Gulkana and Chistochina River drainages and northern foothills of the Wrangell Mountains east of TAPS, and the Ewan-Crosswind Lakes area west of TAPS.

The timing of migrations was similar to that recorded prior to construction of TAPS. Spring migration across TAPS peaked in April except in 1983 when most caribou crossed in February because of below normal snow depths. Fall migration across TAPS peaked in November with pre-migration movements occurring near TAPS in September and October.

Major crossing locations were unchanged from the period prior to pipeline construction. Lowlands of the Spring Creek drainage and between Hogan Hill and the Gulkana River were major spring crossing zones. Fall crossing zones were in upland habitats from Hogan Hill to Spring Creek. Crossing sites are traditional and appear to be related to ease of movement. Spring routes are located where snow depth is least and large open areas (lakes and meadows) are abundant. Fall

routes are more dispersed and follow upland areas when lakes are not yet frozen.

Special crossing structures such as designated big game crossings, sag bends and special burials were used by 29 percent of caribou crossing TAPS. Special burial sections south of Hogan Hill were used most (27%) because they were placed in a major spring crossing zone. All other structures were used very little (<2%) since most (89%) were outside of major caribou crossing zones. All structures were used less in fall than in spring.

Caribou showed no preference overall for crossing at buried or above-ground pipe. Above-ground pipe was crossed as it was encountered, with no apparent preference for particular BOP-TOPs. Most above-ground pipe (>90%) was over 1.8 m (6 ft) high (median = 7.6 ft) and caribou crossed at a mean pipe height of 2.4 m (8 ft). Pipe heights were relatively uniform over long distances with little option for "choice" by caribou. Caribou crossed at heights ranging from 1 m (3.5 ft) to 5.3 m (17.5) ft.

Crossing success was high (99%) and no evidence of caribou being "deflected" by TAPS was observed. Caribou used old cutlines as travel routes in the vicinity of TAPS and sometimes encountered the right-of-way while travelling on these cutlines.

Caribou groups, upon entering the right-of-way, were usually led by an adult female. The group characteristically stopped briefly on the right-of-way (7.6 minutes) and spent most of the time standing and feeding before crossing and leaving the ROW. Alarm responses were infrequent with alert behavior occurring 1.1 percent of the time. Small groups spent less time on the right-of-way than larger groups; otherwise there were no differences in behavior related to group size or composition. Feeding activity was concentrated at the edges of the right-of-way where forage species were more abundant than elsewhere on the right-of-way. Small sample size precluded tests for differences between pipe modes and group composition.

The use of TAPS by wolves corresponded to the seasonal location of caribou migration routes. No evidence of caribou being killed on or immediately adjacent to TAPS by predators was observed.

The Nelchina caribou herd continues to cross TAPS as it did prior to construction. The herd has increased from a low of 8,000 animals at the time of construction to 25,000 in 1983. Movements and distribution are similar to those reported over the past 25 years and reflect the influence of environmental features such as snow and terrain rather than TAPS.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Alyeska Pipeline Service Company. We wish to acknowledge the support and assistance of Ben Hilliker and Dennis Prendeville of Alyeska in Anchorage.

The logistic support provided by Alyeska staff in Anchorage, Fairbanks and Pump Stations 10 and 11 was greatly appreciated. Pump station personnel were unfailingly helpful in providing assistance throughout the study, and a special thanks goes to Security staff who kept a "caribou watch" for us. Stan and Wanda Brown of Paxson Lodge and Bud and Patty Lauesen of Sourdough Roadhouse kept us warm and well-fed during field work.

Alaska Department of Fish and Game personnel, particularly Ken Pitcher in Anchorage and Jim Lieb in Glenn-allen, greatly assisted our work by sharing their data on locations of radio-collared caribou.

Data could not have been collected without the assistance of Peter Bente, Darleen Masiak, Don Vernam, Dave Volsen, Jack Winters, John Rose, Nick Cassara, Mary Maurer and Charlie Edwards.

We acknowledge the critical review and comments on the study design and final report provided by L. Sopuck and S. Ferguson.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

1.0 INTRODUCTION

The influence of petroleum development on wildlife populations in Arctic and Subarctic regions has been an issue for many years (Weeden 1971). A major concern prior to construction of the Trans-Alaska Pipeline System (TAPS) was whether it would constitute an impediment to the free movement of wildlife (Weeden and Klein 1971, Luick et al. 1975). Efforts were made to address this concern during planning and construction (Child 1973, Van Ballenberghe 1978) but few studies have been conducted since completion of the project (Cameron and Whitten 1980). Consequently, Alyeska Pipeline Service Company in 1981 contracted Renewable Resources Consulting Services Ltd. for a three-year study to determine the status of four mammal populations and their interactions with TAPS. These populations include the Central Arctic and Nelchina caribou herds (Rangifer tarandus granti), Dall's sheep (Ovis dalli dalli) in the Central Brooks Range and moose (Alces alces gigas) in the Interior.

This report presents results of a study of the Nelchina caribou herd conducted along the TAPS corridor between Paxson and Glennallen, Alaska (Figure 1) from April 1981 to November 1983.

The Nelchina caribou herd is well suited for study because the herd has moved through and wintered in the area now

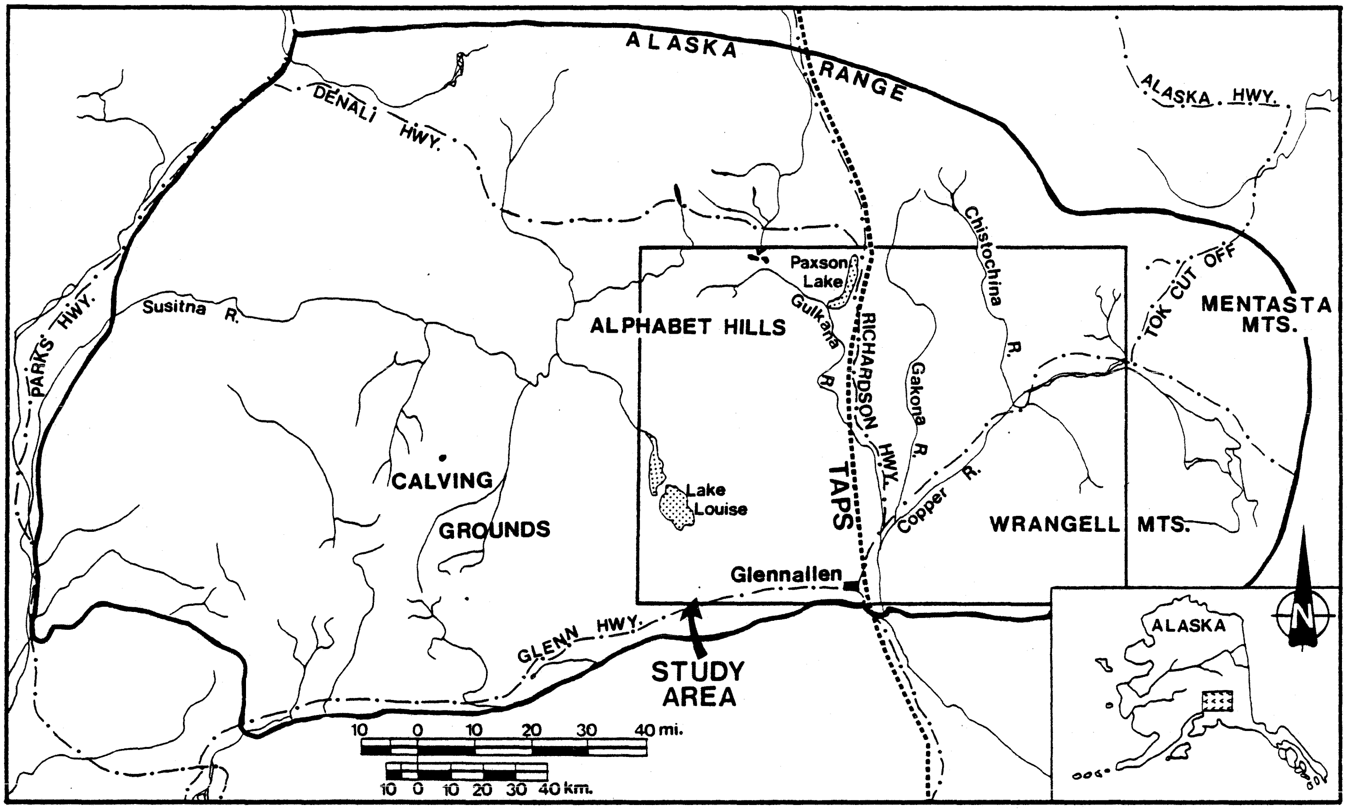


Figure 1. The range of the Nelchina caribou herd and the location of the study area.

crossed by TAPS during much of its documented history (see Section 2.0 Historical Background). Movements during fall and spring provide an excellent opportunity to examine caribou interactions with the pipeline. In addition, the Nelchina herd has been intensively studied for longer than any other caribou herd in Alaska (Doerr 1980) and, hence, more information is available for comparison of pre- and post- pipeline construction on movements and distribution.

Since the turn of the century a highway has bisected the range of the Nelchina herd and in 1973 the Trans-Alaska Pipeline was constructed next to this highway. The herd was large during the 1960s but declined to less than 10,000 animals in the early 1970s through a combination of overhunting and predation (Bos 1975, Bergerud 1980, Doerr 1980). Since then the herd has increased to about 25,000 caribou (Pitcher, pers. comm.).

Skoog (1968) and Hemming (1971) have documented the distribution and movements of the Nelchina herd over a 15 year period. Pitcher (1982, 1983), using radio telemetry, has provided more detailed documentation of distribution and movements in recent years which is similar to those reported by Skoog and Hemming. Emphasis in this study was on the spring and fall periods when caribou have maximum interaction with TAPS.

1.1 OBJECTIVES

The overall objectives of the study were to document crossing of TAPS by Nelchina caribou, determine characteristics of crossing areas, and describe behavior of caribou when they encounter the pipeline.

Specific objectives were:

1) To document crossing of the TAPS corridor by the Nelchina caribou herd during spring and fall migration,
2) To determine and describe the physical characteristics of TAPS crossing sites used by caribou,
3) To assess the use of special crossing structures by caribou,
4) To quantify the crossing success and behavior of caribou encountering TAPS,
5) To document caribou group characteristics (e.g., size, composition) which may influence crossing success,
6) To document habitat use by caribou adjacent to the TAPS corridor.

2.0 HISTORICAL BACKGROUND

The Nelchina caribou herd has traditionally occupied an area of 82,000 km^2 (20,000 mi^2) in southcentral Alaska (Hemming 1971), a region that is now crossed by the Trans-Alaska Oil Pipeline (Figure 1).

Population levels and distribution of the Nelchina caribou herd have fluctuated widely in the previous 100 years. Although documentation is lacking prior to the late 1940s, the herd seems to have reached a peak population level of approximately 70,000 animals in the mid-1800s (Skoog 1968). The number of caribou in the herd declined to a low of possibly 10,000 animals in the late 1930s-early 1940s (Watson and Scott 1956). As the number of caribou declined, so did the proportion of range they used. In the mid-1800s the entire range was used, but only the southwestern third was used in the early 1800s when the herd was much smaller. This southwestern portion of the range has been defined as the "center of habitation" by Skoog (1968) because it has been used perennially, regardless of fluctuations in herd size.

Since 1948, population fluctuations and changes in distribution of the Nelchina caribou herd have been more closely monitored. The herd rapidly expanded in size to its former level of approximately 70,000 animals in the early 1960s (Skoog 1968) and then, in the following decade, declined sharply to fewer than 10,000 animals in the early 1970s (Hemming 1975, Bos 1975, Doerr 1980). Since then, population numbers have slowly increased to the current estimate of almost 25,000 animals (Figure 2) (Pitcher, pers. comm.).

Population fluctuations in the past 35 years have been accompanied by changes in the distribution of the herd. The calving area and summer range (Figure 1) have remained at the center of habitation described by Skoog (1968), but winter ranges have varied greatly. As the herd grew in the early

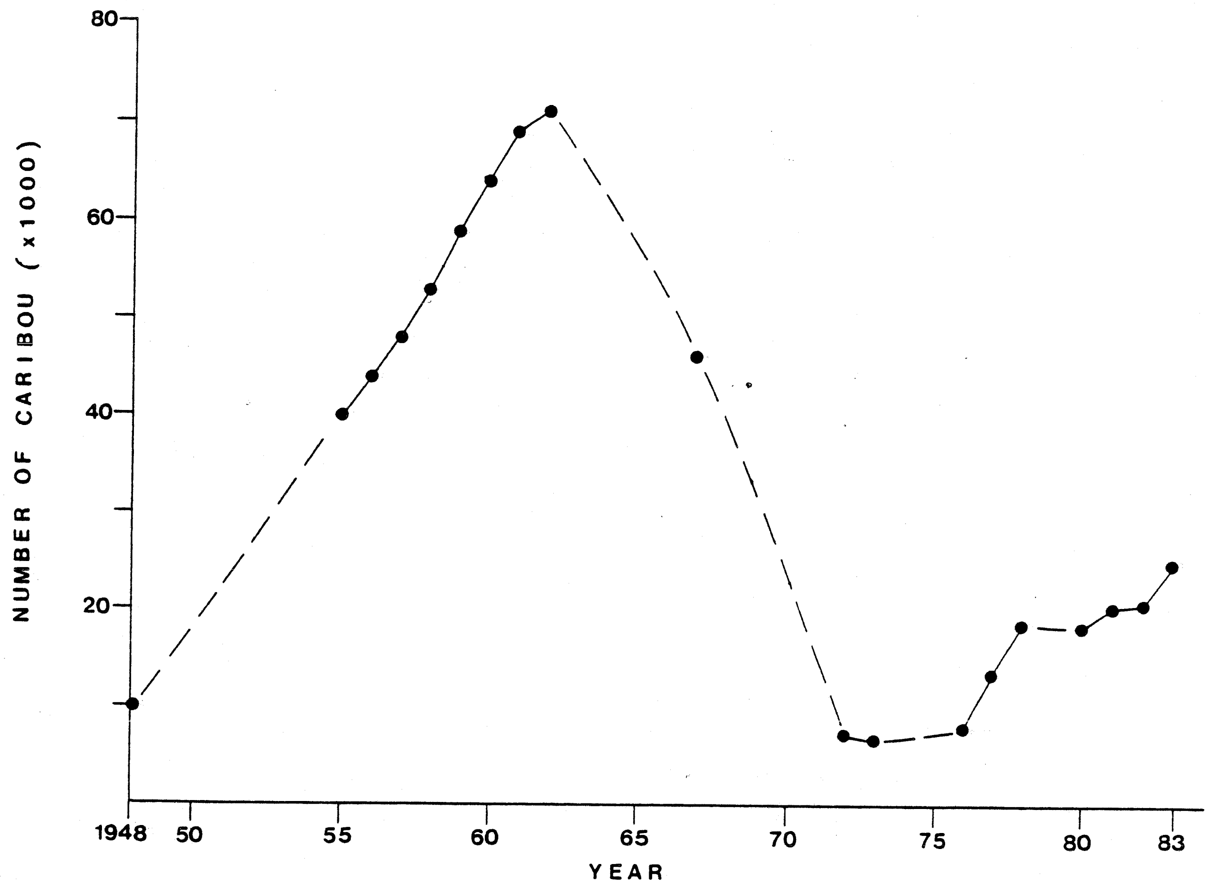


Figure 2. Population estimates of the Nelchina caribou herd, 1948-1983 (Watson and Scott 1956, Skoog 1968, Siniff and Skoog 1964, Hemming and Glenn 1969, Eide 1980, Pitcher 1982, 1983, pers. comm.).

1950s, it used winter range west of the Richardson Highway Figure 3a). In the late 1950s, winter ranges were used, also generally west of the Richardson Highway but overlapping the Highway near Sourdough (Figure 3b). Several thousand caribou commonly wintered between Paxson and Isabel Pass. Erratic long distance movements also began during this period, a phenomenon

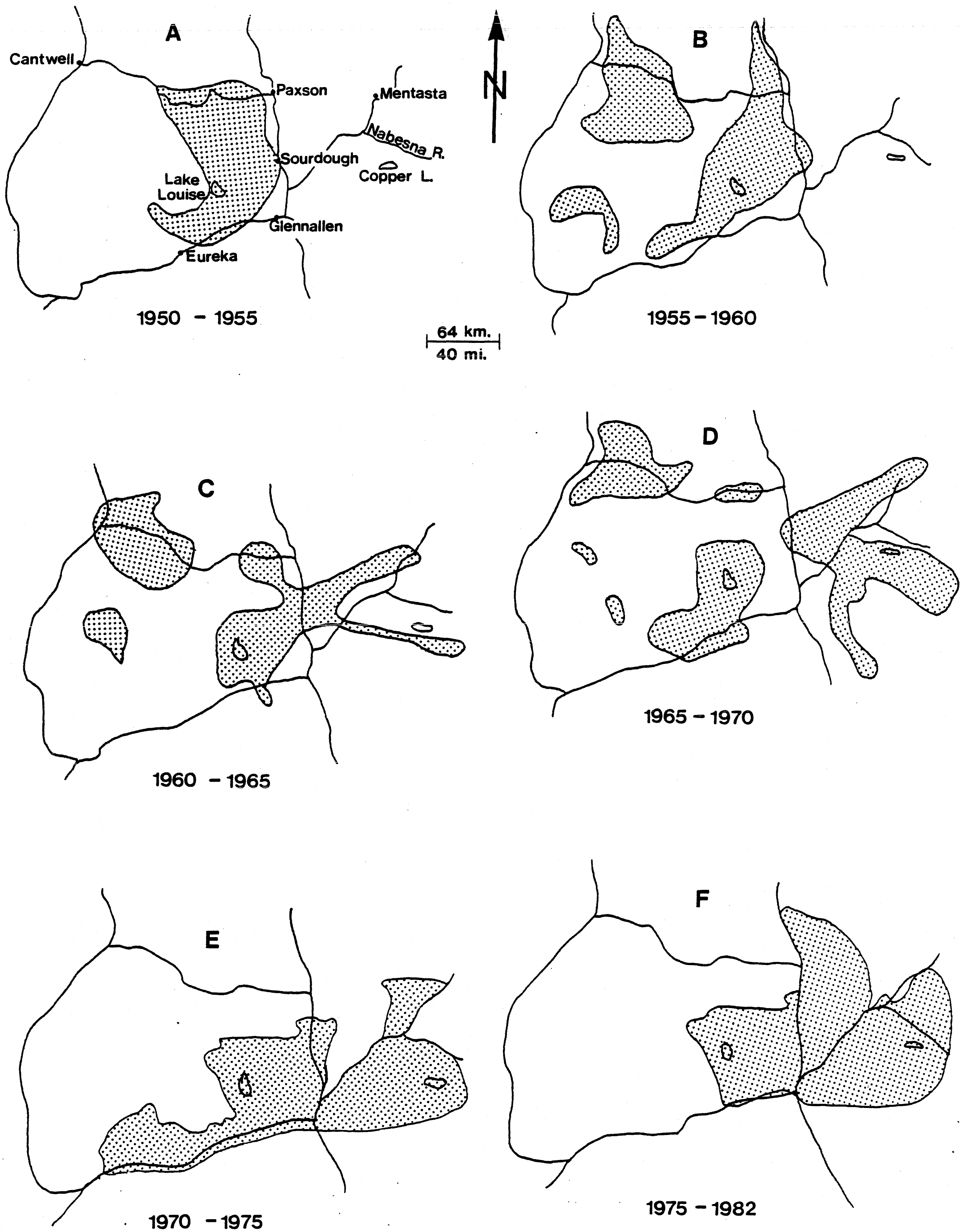


Figure 3. Winter range use by the Nelchina caribou herd, 1950-1982 (a-d Hemming 1971; e-f Pitcher 1982, 1983).

that has been associated with increasing herd size (Skoog 1968). Similar erratic movements have been observed in recent years (Pitcher 1983).

Between 1960 and 1965, as population levels reached a maximum, caribou began using winter ranges to the east of the Richardson Highway (Figure 3c). Specifically, the Chistochina River drainage, drainages of the Mentasta Mountains, and the low north slopes of the Wrangell Mountains became important wintering areas (Hemming 1971). For the rest of the 1960s, these were primary winter ranges of Nelchina caribou (Figure 3c) (Skoog 1960, 1961, 1962, 1963, Lentfer 1965, McGowan 1966, Glenn 1967, Hemming and Glenn 1969, Johnson 1971).

During the decade of very low population levels in the 1970s, caribou use of winter range was continuous east and west of the Richardson Highway (Figure 3e), although use of the Mentasta Mountains declined in the early 1970s. In the late 1970s, the north slopes of the Wrangells were a major wintering area (Figure 3f) (McIlroy 1972, 1975, 1976, Bos 1973, 1974). In the past three years, winter range use has been continuous east and west across the Richardson Highway.

Routes followed by Nelchina caribou to and from winter ranges and timing of movements are consistent over the years, despite variability in relation to population size.

Caribou encounter TAPS in the spring and from the fall to early winter (Skoog 1968). The total length of the annual migration increased from 600 km (370 mi) in 1955 to 1,580 km (980 mi) in 1964, as herd size increased (Skoog 1968).

In spring, movement from winter range east of TAPS towards the calving area to the west typically begins in April. Caribou in the Mentasta Mountains move south and those in the Wrangells move north to the Copper River (Figure 4). They travel west down the Copper River valley and most cross the river near Chistochina. From there, they generally move directly west towards Fish Lake. The major zone where most animals cross the Richardson Highway/TAPS is within a few kilometers on either side of Sourdough (Figure 4) (Skoog 1968).

In the fall, Nelchina caribou commonly move east along the Alphabet Hills from summer ranges with some crossing the Richardson Highway/TAPS in early October (Skoog 1968, Pitcher 1983). From there, they make a clockwise swing south and west to the flats around Lake Louise (Figure 4). Dispersal from the flats to winter range occurs after the rut and continues through November and December. Caribou that winter east of the Richardson Highway typically cross the Highway and TAPS in early November. The major crossing area extends from Paxson Lake to Sourdough; the Spring Creek drainage south of Meiers Lake has traditionally been a location of intensive use by fall

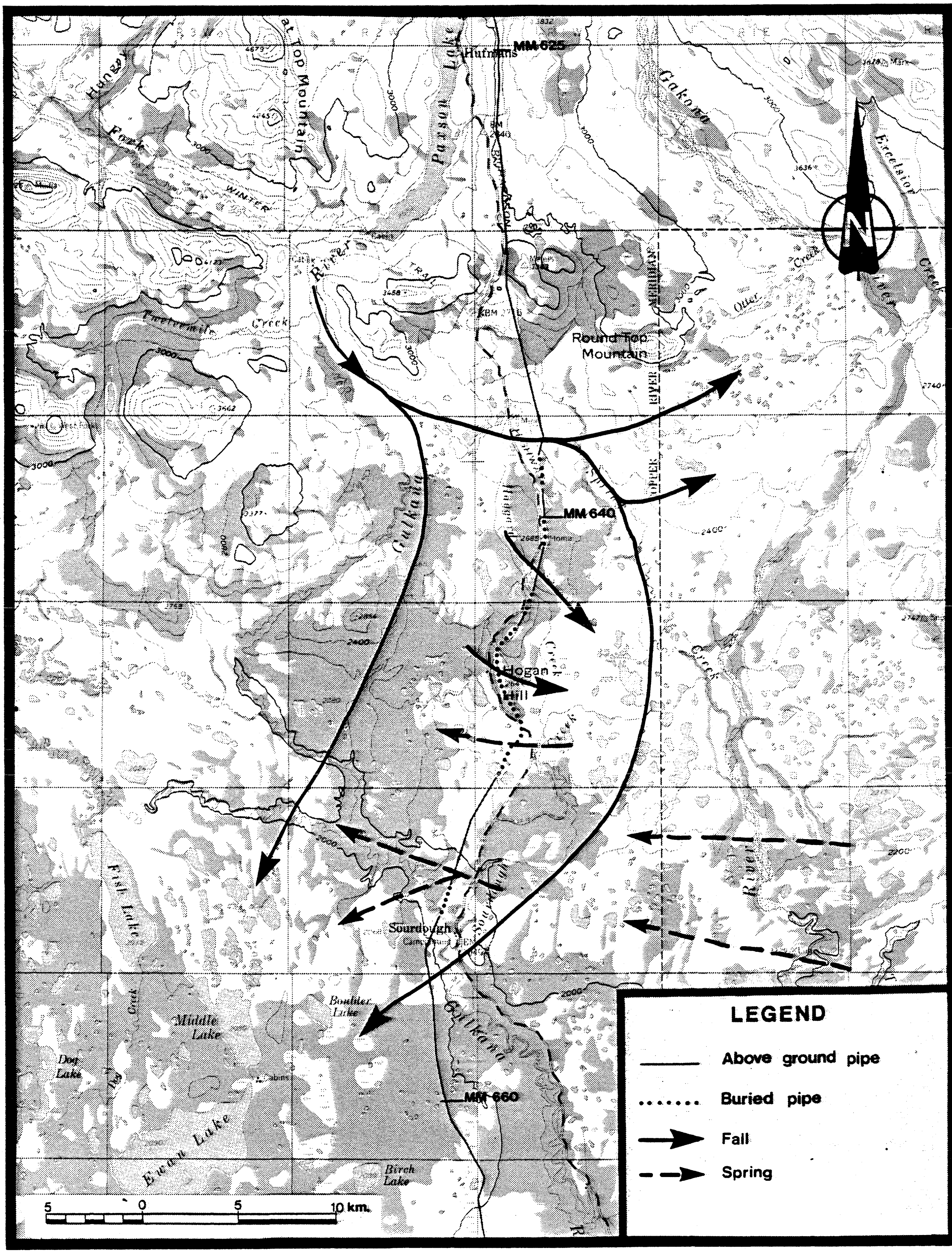


Figure 4. Seasonal movements of the Nelchina caribou herd (Skoog 1968, Hemming 1971).

migrating caribou (Skoog 1968, Hemming, pers. comm.). In recent years the Nelchina caribou herd has generally continued this pattern of movement (Pitcher 1982, 1983).

3.0 STUDY AREA

The study area lies in southcentral Alaska (63°00'N, 145°00'W) within a region referred to as the Nelchina Basin (Figure 1). The Trans-Alaska Oil Pipeline was constructed in 1974-76 in the eastern portion of the area from TAPS Mile Marker (MM) 618 at Paxson to MM 683 at Glennallen (105 km, 65 mi). This study is based on the section of TAPS between MM 620 to MM 660 (64 km, 40 mi).

The Richardson Highway which generally parallels TAPS was first a wagon road constructed at the turn of this century. It was upgraded to automobile standards in the 1920s and paved in 1957. Until 1971, the Richardson Highway was the only road between Fairbanks and Anchorage. In 1972 average traffic volume was 500 vehicles per day.

Elevations average 550 m (1,800 ft) in the south and gradually increase to 1,600 m (5,450 ft) in the north. Lakes and ponds are numerous, particularly in the southern half of the area. Major rivers are oriented generally north-south.

Skoog (1968) provides a detailed description of the topography of the area.

The climate is classified as continental with a maritime influence (Selkregg 1974). Temperatures range from -51°C (-60°F) to near 32°C (90°F); mean monthly temperatures in the last decade have ranged from a minimum of -26.7°C) -16.1°F) in January to 20.1°C (68.2°F) in July (Apppendix 1). Precipitation averages 28 cm (11 in) annually, including 118 cm (47 in) of snow at Gulkana. Ten-year averages of precipitation, temperature and maximum snow depth at Gulkana are presented in Appendix 1. To the north, montane influence is strong, and precipitation is over 43 cm (17 in) annually, including 277 cm (109 in) of snow at Paxson. The frequency of years when total snowfall is likely to exceed a 68 year mean maximum (156 cm, 61 in, Fairbanks) is presented in Appendix 1. Data for local stations were insufficient, so Fairbanks was used as an index.

A variety of vegetation types are present, ranging from lowland coniferous forest to alpine tundra. The dominant tree species are black spruce (*Picea mariana*) and white spruce (*P. glauca*). Birch (*Betula papyrifera*), aspen (*Populus tremuloides*) and cottonwood (*P. balsamifera*) are present on warmer, drier sites.

Common shrubs are willow (*Salix* spp.), alder (*Alnus crispa*) and dwarf birch (*B. glandulosa* and *B. nana*); the latter occur over large areas at elevations of 915-1,220 m (3,000-4,000 ft). Mat and cushion tundra is present above 1,200 m (4,000 ft). Extensive areas of herbaceous cover, largely sedges (*Carex* spp.), are associated with the many lakes and ponds. Pegau and Hemming (1972) provide a detailed description of vegetation in the study area.

Intensive studies were conducted between TAPS MMs 620 and 660 (Figure 4). In the north TAPS crosses gently-rolling hills with the exception of the rather steep drainages of Haggard Creek (TAPS MM 642.7) and an unnamed creek on the north side of Hogan Hill (TAPS MM 644.8). All of this area is above 700 m in elevation. South of Hogan Hill (TAPS MM 647-660) terrain is generally flat, and elevation decreases gradually from 700 m to 550 m. Most of the area is overlain by glacial or alluvial deposits with extensive permafrost, especially south of Hogan Hill (USDI 1972). Vegetation along TAPS is typical of the study area, consisting mostly of spruce forest frequently mixed with shrubs. Spruce forest is more common at lower elevations in the southern part of the area whereas shrub communities are more common to the north. Because TAPS was constructed across uplands as much as possible, fewer wetlands occur along TAPS than in the study area overall. Wetlands are most common south of Hogan Hill. Aspen and birch are found most frequently on well-drained south-facing uplands.

The TAPS right-of-way (ROW) within the study area includes the pipeline, a driveable workpad and adjacent cleared area. The ROW averages 30 m (100 ft) in width and includes a gravelled pad elevated a meter or less above the surrounding terrain. The pad averages seven meters (28 ft) wide. ROW width at above-ground pipe (27 m, 90 ft) was less than at buried pipe (37.5 m, 124 ft) (Appendix 2). Vegetation is generally sparse on the ROW and consists mostly of introduced grasses; at the lower edges of the ROW, however, grasses and sedges are often abundant.

The 122 cm (48 in) diameter pipeline was constructed above ground over 61 percent of the study area (38.9 km, 24.2 mi) and is supported by vertical support members (VSM) at 18 m (60 ft) intervals. The average height of the pipe (BOP-TOP) is 2.4 m (7.9 ft) above ground with 92.6 percent of its length greater than 1.8 m (6.0 ft) in height. Above ground pipe occurs most frequently (80.3%) from immediately north of Haggard Creek (MMs 640-620) to Paxson Lake and south of Sourdough (MMs 655-660) (Figure 4).

Buried pipe occurs between MM 638 and MM 654 near Sourdough and comprises 39 percent of TAPS in the study area

(Figure 4). Two buried sections (each 2.9 km, 1.8 mi) separated by 6.4 km (4 mi) of above ground pipe and located between Hogan Hill and Sourdough are specially refrigerated burials installed as special crossing sites for caribou (Figure 4). The remaining four sections of buried pipe (18.6 km, 11.6 mi) were installed for geotechnical reasons and coincide with well- drained uplands including Hogan Hill and the high ground south of Spring Creek. These sections range in length from 2.4-3.2 km (1.5-2.0 mi).

Special wildlife crossing sites include 30 elevated designated big game crossings (DBGC) characterized by BOP-TOPs >3.3 m (10 ft) over at least 18 m (60 ft), and six short (<18 m, 60 ft) sections of buried pipe called sag bends. All DBGCs occur north of MM 635, as do all but one sag bend.

TAPS lies approximately parallel to the Richardson Highway through the study area, crossing to the west at the base of Hogan Hill. The pipeline is less than 2 km (1 mi) from the Highway over 88 percent of its length in the study area and, in the vicinity of Hogan Hill and north of Haggard and Spring Creeks, it is less than 400 m (0.25 mi) from the highway over 25 percent of its length in the area. Fourteen gated access roads at irregular intervals connect the highway to TAPS. Access to the TAPS ROW is restricted to authorized personnel and helicopter surveillance flights (<50 m above ground) occur about twice a day.

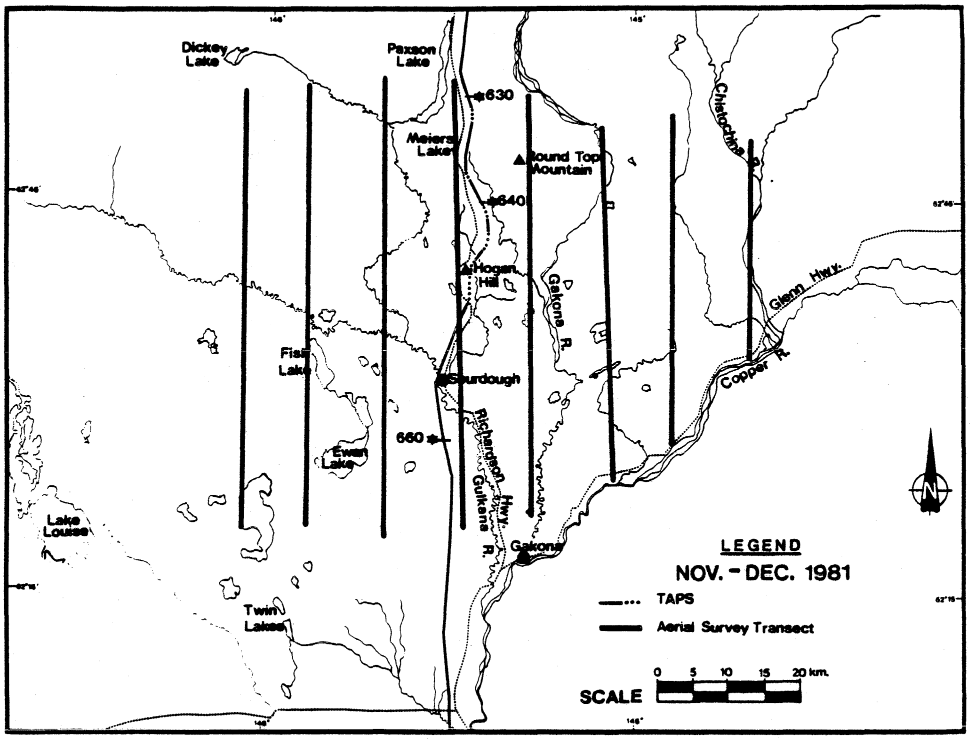
4.0 METHODS

The interaction of the Nelchina caribou herd with the pipeline was measured using five techniques: aerial surveys, corridor surveys, forward- and back-tracking of caribou trails, control trail surveys, and behavioral observations. Field work coincided with usual periods of migration of the Nelchina caribou herd to and from winter range adjacent to and east of TAPS (Appendix 3).

4.1 AERIAL SURVEYS

Aerial surveys were conducted to assess caribou distribution and monitor movement of caribou in relation to TAPS. Surveys were conducted only in the first year of the study to verify distribution and movement patterns reported in the past. Data on distribution in subsequent years were obtained from reports by K. Pitcher (1982, 1983).

Aerial survey sampling consisted of parallel strip transects perpendicular to caribou movements (Figure 5)



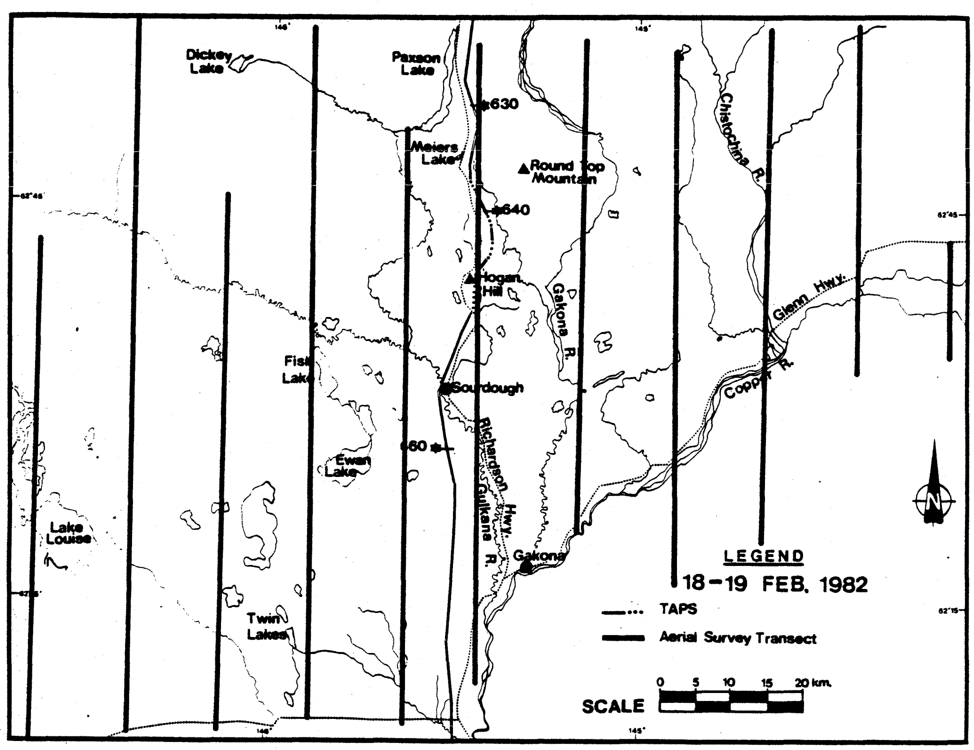


Figure 5. Aerial survey transects, 1981-1982.

(Eberhardt 1981)). The area was sampled systematically (without replacement). This method is "...by far the most efficient means of mapping the distribution of animals..." (Caughley 1977:611). The precision of this sampling technique is as good or better than random sampling (Cochrane 1963) and precision was most important for this portion of the study.

Helio Courier and Cessna 185 fixed-wing aircraft were flown at 120 m (400 ft) above ground at an airspeed of 160 kmph (100 mph). The survey team included two observers in the rear seats and a navigator and pilot in the front. Transect width was controlled through markings on the aircraft wing struts and windows or a wire strung from eye bolts under the wing of the Helio Courier (Miller et al. 1977). These markings were checked against a known distance on the ground while flying at 120 m (400 ft) above ground.

Five aerial surveys were flown in 1981-1982 (Table 1). Transects flown during 1981 were 1.0 km (0.6 mi) wide and spaced 10 km (6 mi) apart. Transect spacing in February 1982 was 12.5 km (7.25 mi), which reduced the sample from 10 to 8 percent of the study area. The location of each caribou group observed was plotted on 1:250,000 scale topographic maps. Observers recorded the number and composition of caribou in the group, the vegetation in which they were located, and their direction of travel. Also noted were orientation and intensity

Table 1. Timing and sampling intensity of aerial surveys of Nelchina caribou, 1981-1982.

DATE	CARIBOU LIFE CYCLE PHASE	TRANSECT AREA SAMPLED km^2 (mi^2)	PERCENT SURVEY COVERAGE	TOTAL AREA SAMPLED km^2 (mi^2)
1981				
22 Apr.	Spring migration	380 (148)	10	3800 (1485)
30 Apr.	Spring migration	238 (93)	10	2380 (930)
11 Nov.	Fall migration	446 (173)	10	4460 (1734)
2 Dec.	Fall migration	442 (173)	10	4420 (1734)
4 Dec.	Fall migration	452 (177)	60	753 (294)
1982				
18-19 Feb.	Mid-winter	793 (306)	8	9916 (3062)

of use of caribou trails, the presence of feeding craters and observations of other wildlife species.

One intensive aerial survey was conducted in December 1981 to determine caribou distribution in an approximately 15 km (9.3 mi) wide area centered on TAPS/Richardson Highway between TAPS MMs 627.6 and 653.4 (Figure 6). Those transects were oriented approximately east-west, perpendicular to the pipeline and extended 5 km (3 mi) east or west of either the pipeline or the highway. Transects were 600 m (0.5 mi) wide and 1 km apart, providing a 60 percent sample of this area (Table 1, Figure 4c). Observations were recorded as on the aerial reconnaissance surveys, except that locations of caribou were plotted on 1:63,000 topographic maps.

For the analysis of spring and fall aerial surveys a line estimating the orientation of caribou movements was calculated. An east/west (x axis) - south/north (y axis) grid overlain on distribution maps of caribou group locations was used to regress a line. The slope and intercept of this line described objectively the alignment of caribou groups with respect to the TAPS corridor during migration.

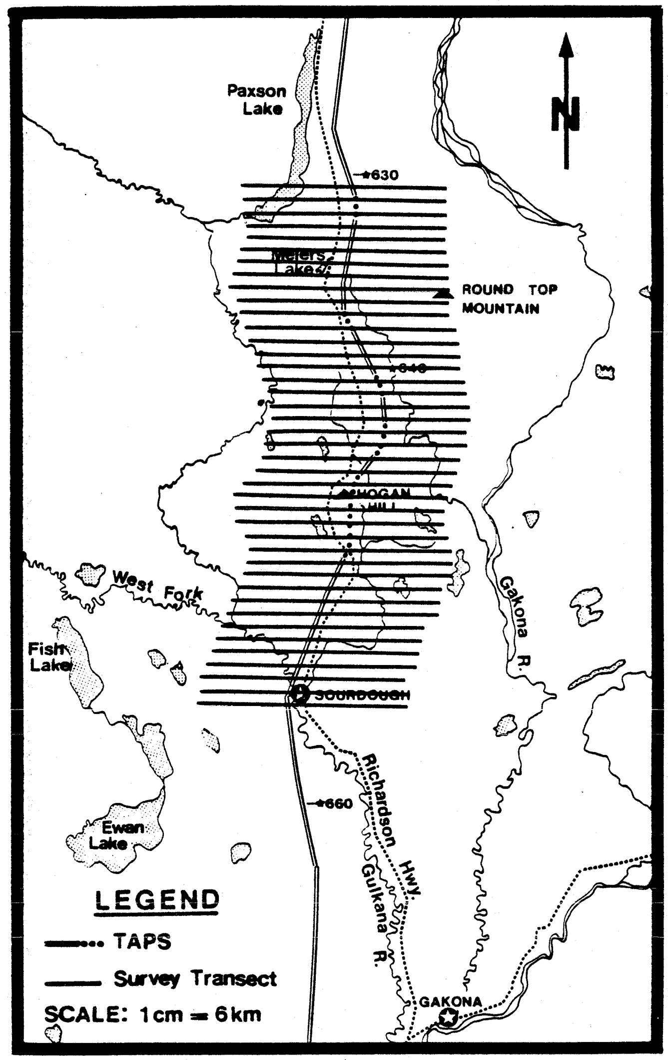


Figure 6. Aerial survey transects within a 15 km corridor centered on TAPS/Richardson Highway, 4 December 1981.

4.2 CORRIDOR SURVEYS

Corridor surveys were conducted to locate and describe caribou crossings of TAPS. Surveys by snow machine or truck were conducted several times during 1981-1983 to document crossing of the pipeline by caribou (Appendix 3). Sections of the TAPS ROW were driven daily (Table 2) and trails that could be followed across the ROW were measured.

4.2.1 Initial Reconnaissance

During initial ground reconnaissance in each survey period, emphasis was on determining where caribou were crossing TAPS. The following information was recorded for each trail:

1) Location in relation to a vertical support member (VSM) or mile marker (MM),
2) Pipe mode (above-ground, buried, special crossing) at the point of encountering the ROW,
3) Estimated number of caribou,
4) Direction of travel,
5) Crossing success (successful or unsuccessful, and distance of any lateral movements along ROW, see Glossary, Appendix 4),
6) Vegetation type (one of 15 categories, Table 3),
7) Topography, slope and aspect.

Table 2. Corridor survey dates, location and distance, 1981-1983.

SURVEY DATE	SAMPLE AREA TAPS Mileage Marker	SAMPLE DISTANCE km	(mi)
<u>1981</u>			
24 April - 2 May	639.2 - 653.0	22.1	(13.8)
22 October	627.6 - 653.4	41.3	(25.8)
5-6 November	633.0 - 642.0	14.4	(9.0)
5-6 November	644.8 - 653.4	13.8	(8.6)
28 November	636.6 - 653.4	26.9	(16.8)
<u>1982</u>			
6-9 April	623.5 - 661.0	60.0	(37.5)
17-19 November	623.5 - 660.0	58.4	(36.5)
<u>1983</u>			
30 March	623.5 - 660.0	58.4	(36.5)
3 October	623.5 - 660.0	58.4	(36.5)
22 October	632.5 - 660.0	44.0	(27.5)
7 November	623.5 - 660.0	58.4	(36.5)

During several surveys, large numbers of trails in some areas made counts difficult because individual trails were obscured. In these instances, one count was made on each side of the ROW where individual trails were more easily discerned and the mean of these values was used in analyses. Where this was impossible, an estimate was made of the number of caribou crossing the pipe between VSMs.

Table 3. Vegetation classification categories used in Nelchina study area.

DETAILED CATEGORIES*	COMBINED CATEGORIES
Open conifer Closed conifer Conifer woodland	Conifer
Open deciduous Closed deciduous Deciduous woodland Open mixed conifer/deciduous Closed mixed conifer/deciduous	Deciduous/mixed
Open tall shrub Closed tall shrub Open low shrub Closed low shrub	Shrub
Lake Wet meadow	Wet meadow/lake
Disturbed	Disturbed

*Viereck and Dyrness 1980.

The number of caribou using a trail was visually estimated from the various trail characteristics. Sometimes a trail branched on the ROW and we could then count how many animals had used it. More often our estimate was based on the width of the trail and the extent to which separate hoofprints remained with snow ridges in between. In our opinion these estimates represent a minimum number of caribou that used a trail.

4.2.2 Trail Configurations

Subsequent to the reconnaissance survey, a subsample of trails was measured to describe their configuration within 20 m of the TAPS ROW. We made these measurements to quantify the degree to which caribou were or were not "deflected" by TAPS upon approach. This has been a concern expressed for over a decade (Klein 1971, 1980, Geist 1975, Berger 1977), yet quantitative measurements have not been made.

In fall 1981, a systematic subsample of every third trail was used. In fall 1982 and spring 1983, most individual trails were obscured; our subsample then consisted of <u>all</u> trails whose configuration we could determine[1]. The following following information was recorded for these trails:

1) Pipeline bearing (degrees true),
2) Trail bearings (degrees true) for approach and departure (Figure 7), from pipeline centerline to a point on the trail 20 m (66 ft) distant from the ROW edge (20 m to center, #1 and #2)[2],

---

1. We do not believe the trail sampling scheme in 1982 and 1983 biased the data as trail orientations did not differ: Mean 1981 = 65.0°, S.E. = 1.9, n = 115; 1982 = 68.6°, S.E. = 4.0, n =22; 1983 = 64.7°, S.E. = 2.9, n = 67.

2. In order to ensure against potential bias related to caribou encountering the open ROW, we analyzed changes in orientation of caribou trails upon encountering the ROW edge ($\bar{x}$ = 24.1°, S.E. = 2.1, n = 111) and concluded that this change did not differ from changes elsewhere on the trail on or off the ROW ($t = 1.72$, $df = 252$, $p>0.05$).

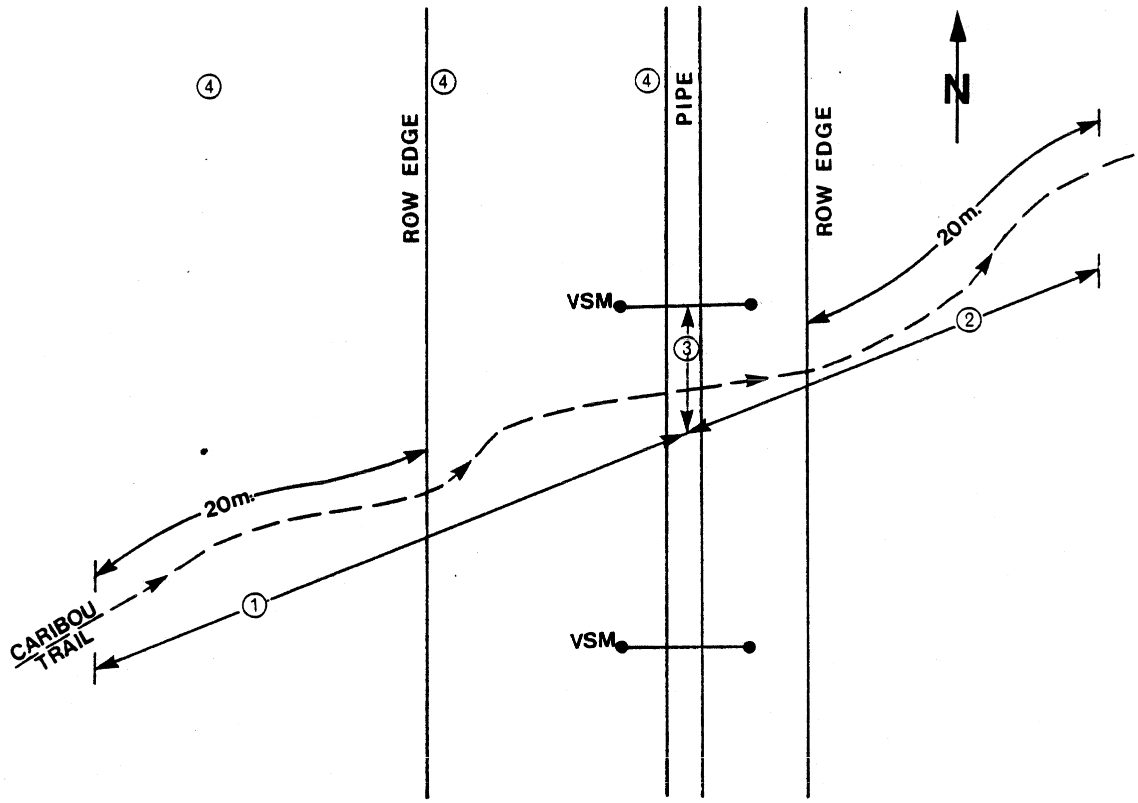


Figure 7. Schematic of measurements taken where caribou trails encountered the TAPS right-of-way (ROW).

3) Distance of the trail at the point of crossing the pipe from the nearest VSM if above-ground pipe (#3, Figure 7),

4) Bottom of pipe to top of pad (BOP-TOP) height at the trail crossing (above-ground pipe),

5) Snow depth at the ROW center line, the ROW edge and at a point on the trail 10 m (33 ft) distant from the ROW edge (#4, Figure 7).

Mean bearings (degrees true) for approach and departure segments of caribou trails were calculated (Zar 1974). To determine the mean overall change in direction of trails, we calculated the difference between departure and approach bearings. Values fall between 0° - 180°. If an animal completely reversed direction the change would be 180°. These differences were then compared between pipe modes, and to other difference values measured on caribou trails that were back-tracked from the ROW (see below).

The configuration of trails up to 200 m (660 ft) from TAPS was measured in 1981. A systematic subsample of every third trail was forward- and back-tracked in November 1981 to compare angular changes within 20 m (66 ft) of TAPS to changes measured beyond 50 m from TAPS. Beyond 50 m the pipeline and ROW are partially obscured from view due to vegetation and topography which may provide a different stimulus to an approaching caribou. These trails were followed forward and backward to a point 200 m along the trail from the ROW edge (Figure 8). Each trail was divided into 50 m segments; at each 50 m station the bearing to the previous station and vegetation type over a 50 x 50 m area were recorded. The mean change in bearing between 50 m stations was compared to the mean differences of trails measured within 20 m and crossing the ROW.

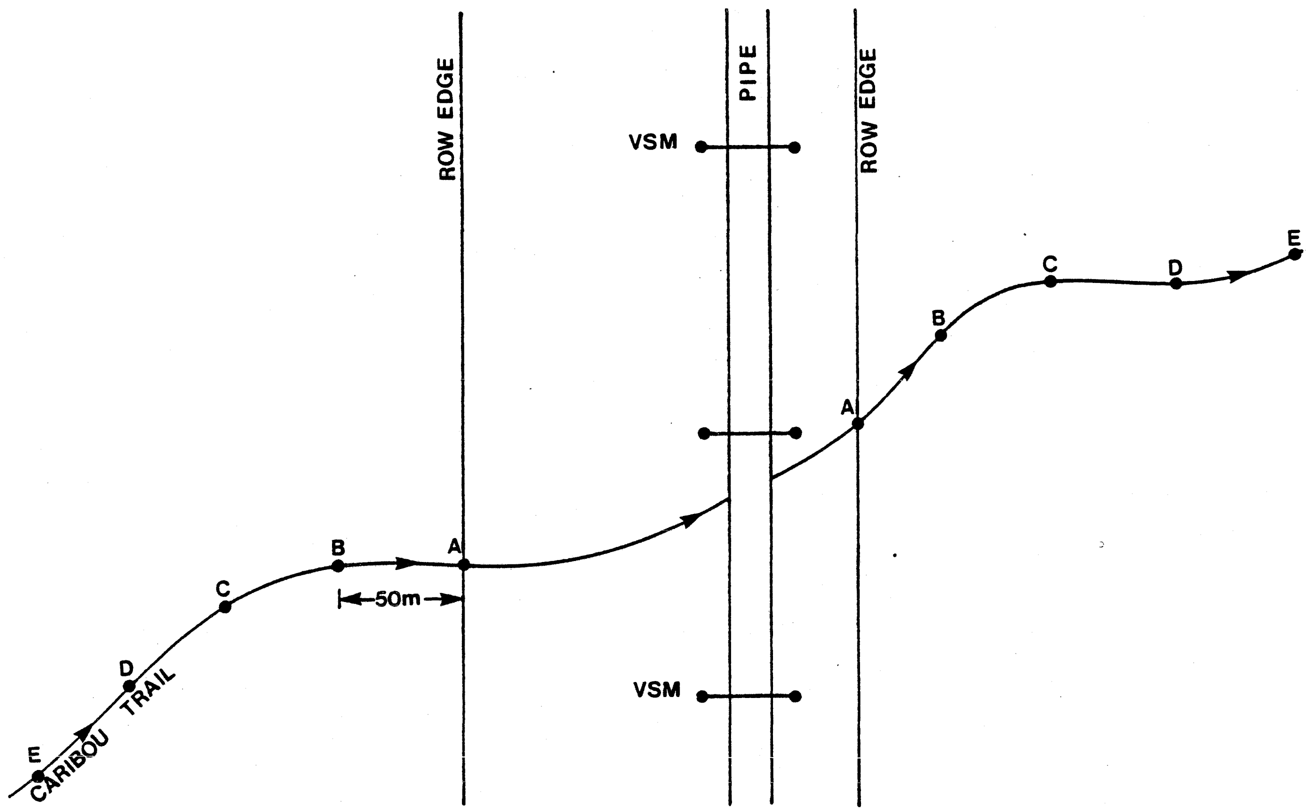


Figure 8. Schematic of measurements taken on fore- and back-tracked caribou trails.

Since we could not determine group size from trail records in most instances, we examined potential bias related to group size based on observations of 124 caribou groups crossing TAPS. None of these crossings suggested that differences in trail configuration relative to group size would be significant as most animals crossed directly. In addition, group size remained relatively constant during the study (aerial survey and observations on the ROW) with means never exceeding 9 animals (n = 493).

Bias in determining crossing success was possible in 1982 and 1983 because of trail mixing. When a trail entered and followed the ROW it commonly intersected other trails and its destination could not always be determined. These trails were not measured; only trails that could be followed onto and off the ROW (whether it crossed or not) were selected. Therefore, our sampling may have been biased to direct crossings (successful) of the ROW. We do not believe this bias was significant since differences in crossing success between unbiased trail measurements in 1981 and measurements in 1982 and 1983 combined were not evident (Success: 1981 = 100%, n = 134; 1982 = 96.4%, n = 28; 1983 = 100%, n = 68).

4.2.3 Pipe Mode and Height

Heights of above-ground pipe (BOP-TOP) beneath which caribou crossed (based on trail measurements) were compared with the BOP-TOP heights available between TAPS MMs 623 and 660. Availability of BOP-TOPs was determined by consulting Alyeska Pipeline "As-Built" design sheets. These values did not include the 0.25 ft of insulation surrounding the pipe; this value was subtracted from the "As-Built" data. Based on a sample of BOP-TOPs measured in the study area (n = 536), 13 cm (5 in) was then added to the "As-Built" data as a correction factor; this difference was probably a consequence of settling and erosion of the pad.

4.2.4 Vegetation

Vegetation in the study area was classified according to Level III categories of Viereck and Dyrness (1980). Several categories were combined to facilitate analysis.

The proportion of each vegetation type in the study area was determined from aerial surveys. Points were randomly selected (n = 209) along survey transects (December 4, 1981) within 7.5 km of TAPS, after Skoog (1968) and Marcum and Loftsgaarden (1980).

The proportion of each vegetation type along the ROW was determined from a ground survey conducted 26-27 August 1983. The percent cover of vegetation types present within 50 m of the ROW was estimated continuously between TAPS MMs 623 and 660.

In major crossing areas used by caribou, feeding had commonly occurred on and at the edge of the ROW. We therefore sampled vegetation in these areas to determine percent cover of plants (usually revegetation grasses) and species present. Three 60 m line transects were established in each area: over/ under the pipe, between the pipe and the ROW edge, and at the edge of the ROW. The transect at the ROW edge was divided into two 30 m segments, one on either edge of the ROW. Twenty 0.5 m^2 plots at 3 m intervals were sampled along each 60 m transect. Percent cover of each species present was estimated in each, and could range from 0 to >100 percent in plots with dense cover by several species (Daubenmire 1959). Species with flowering parts present were collected and later identified using a botanical key (Hulten 1968).

4.2.5 Snow Depth

Snow depths were measured every 0.8 km (0.5 mi) during corridor surveys. Three measurements were taken at the ROW center and 10 m off the ROW. The average of each group of three measures was used to describe snow depth.

4.3 CONTROL SURVEYS

Six control trail surveys were conducted at both above-ground and buried pipeline to determine caribou trail orientation at various distances from the TAPS corridor (Figure 9). These surveys were made in areas of high caribou use, as determined from a ground reconnaissance survey along the ROW. Each survey consisted of walking:

1) a transect parallel to the ROW and 500 m distant from it on the approach side of TAPS (east side in spring, west side in fall; c, c^1, Figure 10),
2) a series of 250 m transects perpendicular to the pipe on both approach and departure sides (E-H, Figure 10).

All transects were established with a compass, measured with hip chain or paced, and travelled on foot.

At each trail encountered, trail bearings over 10 m were measured with a compass, and the extent to which the pipeline (ROW) was visible (percent) was estimated within the field of view of the observer. When trails were encountered on transects perpendicular to TAPS, distance from the ROW edge was also recorded.

A mean of trail bearings relative to the pipeline (angle) was calculated. If a caribou walked parallel to the ROW, the angle would be 0°; if a caribou walked perpendicular to the ROW (the most direct route), the angle would be 90° Individual angles were then regressed on distance to determine any relationship.

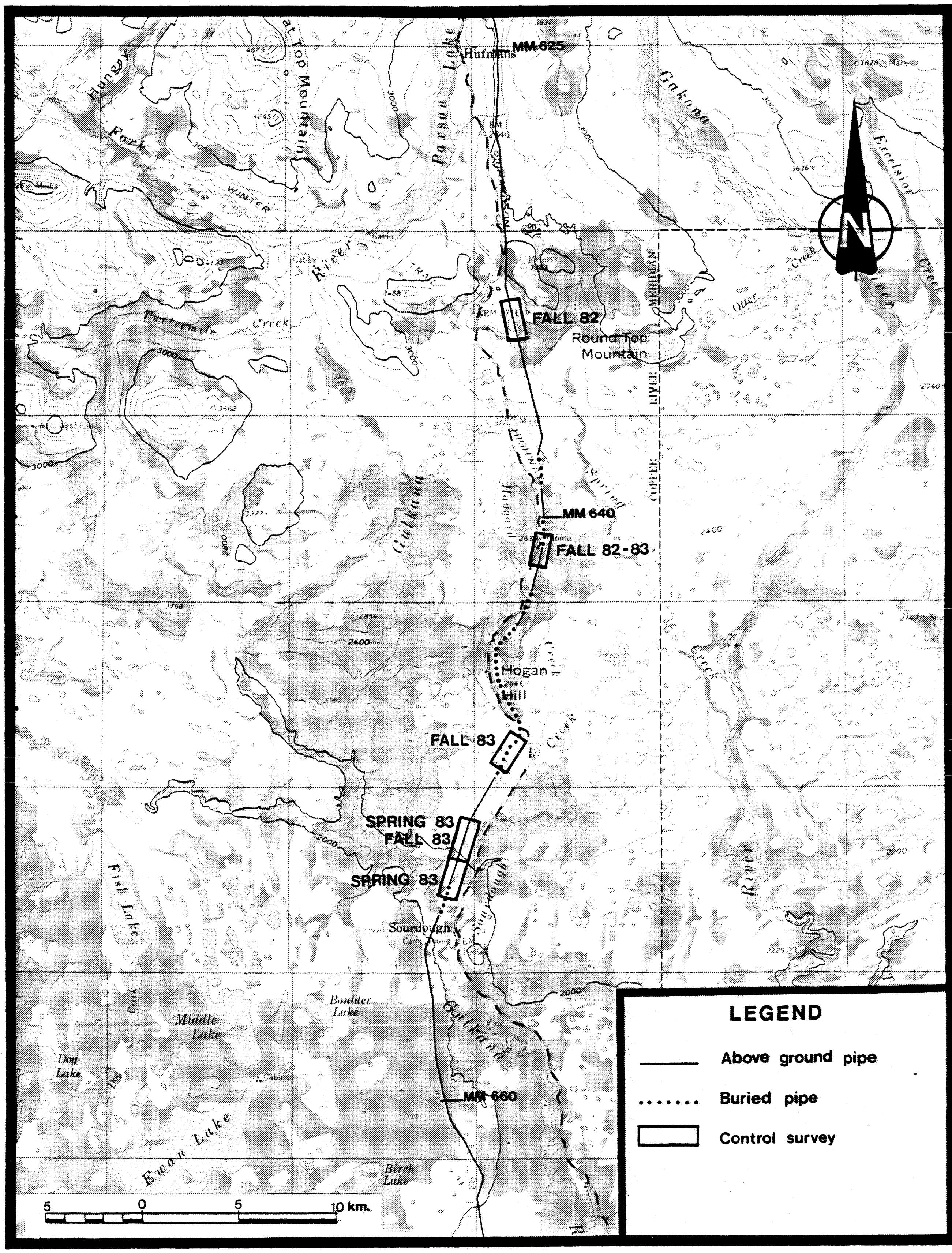


Figure 9. Locations of control surveys.

4.4 BEHAVIOR

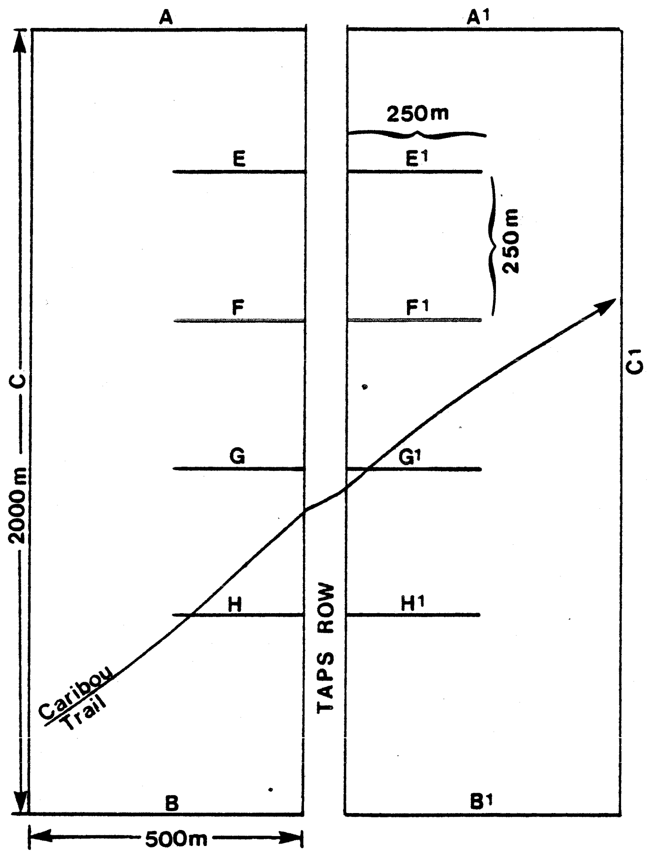


Figure 10. Schematic of control surveys to sample caribou trails adjacent to the ROW.

Direct observations of caribou behavior within the ROW were made in fall 1981 (213 hours). Observation sites were selected on the basis of previously observed frequency of use by caribou and were located between TAPS MM 638.7, north of Haggard Creek, and TAPS MM 648.9, south of Hogan Hill. Sixty percent (128 hr) of the observation effort was at buried pipe and 40 percent at above-ground pipe. One hundred twenty-two caribou groups were observed crossing the ROW, 105 (86%) at buried pipeline and 17 (14%) at above-ground pipeline.

Behavior was measured during daylight hours using the instantaneous scan method (Altmann 1974). Observers were positioned at the edge of the ROW, generally on a hill-top affording the greatest possible view of the ROW. Observation began for each caribou group when the first member of the group entered the ROW and was terminated when the last animal in the group departed the ROW. Information recorded on each group included sex-age composition, group leadership (sex-age of the first animal in the group to enter the ROW) and the length of time spent within the ROW. Activity scans were made at one-minute intervals and the number of animals feeding, standing, walking, lying, running, alert or exhibiting alarm behavior, within each group, was recorded. The distance of each group from the observer, direction of travel, pipe mode, location and weather conditions were also recorded. All observations where caribou were visibly disturbed by the observer were discarded.

Mean time on the ROW and mean group size were calculated and compared in relation to pipe mode and sex-age classification. Activity budgets (frequency of activity) were calculated for different group sex structures and comparisons were made between pipe modes. These data were statistically analyzed with non-parametric tests (median test - Zar, 1974) due to serial correlation between activity scans and small sample size.

5.0 RESULTS

5.1 SEASONAL MOVEMENTS - TIMING

During spring and fall 1981 and mid-winter 1982, caribou were consistently located east and west of TAPS with the distribution oriented along a northeast-southwest axis (Figure 11). They were in small groups ($\bar{x}$ = 5.6, S.E. = 1.2, n = 121, range = 1-15) with 44 percent (n = 48) of groups observed on lakes, 22 percent in meadow (n = 24) and 34 percent (n = 37) in spruce forest (Table 4). Use of lakes was higher

Table 4. Caribou group size and habitat use, aerial surveys April, November, December 1981 and February 1982 (numbers in parentheses = percent).

SURVEY DATE	Meadow	HABITAT Lake	Spruce	GROUP SIZE Mean	± S.E.	(n)
1981						
22 April	5 (71)	2 (29)	0 (0)	7.0	2.1	7
30 April	6 (46)	3 (23)	4 (31)	4.2	0.7	17
11 Nov.	4 (16)	16 (64)	5 (20)	5.9	1.1	26
2 Dec.	5 (15)	18 (54)	10 (30)	6.4	1.2	34
4 Dec.	1 (9)	3 (27)	7 (64)	7.7	2.1	12
1982						
18-19 Feb.	3 (15)	6 (30)	11 (55)	4.6	0.5	37
TOTAL	24 (22)	48 (44)	37 (34)	5.6	2.3	121

Comparison of use of lakes during fall and spring migration
Chi-squared test: $X^2 = 6.31$, df = 1, p = 0.025, n = 89.

Comparison of use of meadow during fall and spring migration
Chi-squared test: $X^2 = 11.96$, df = 1, p = 0.001, n = 89.

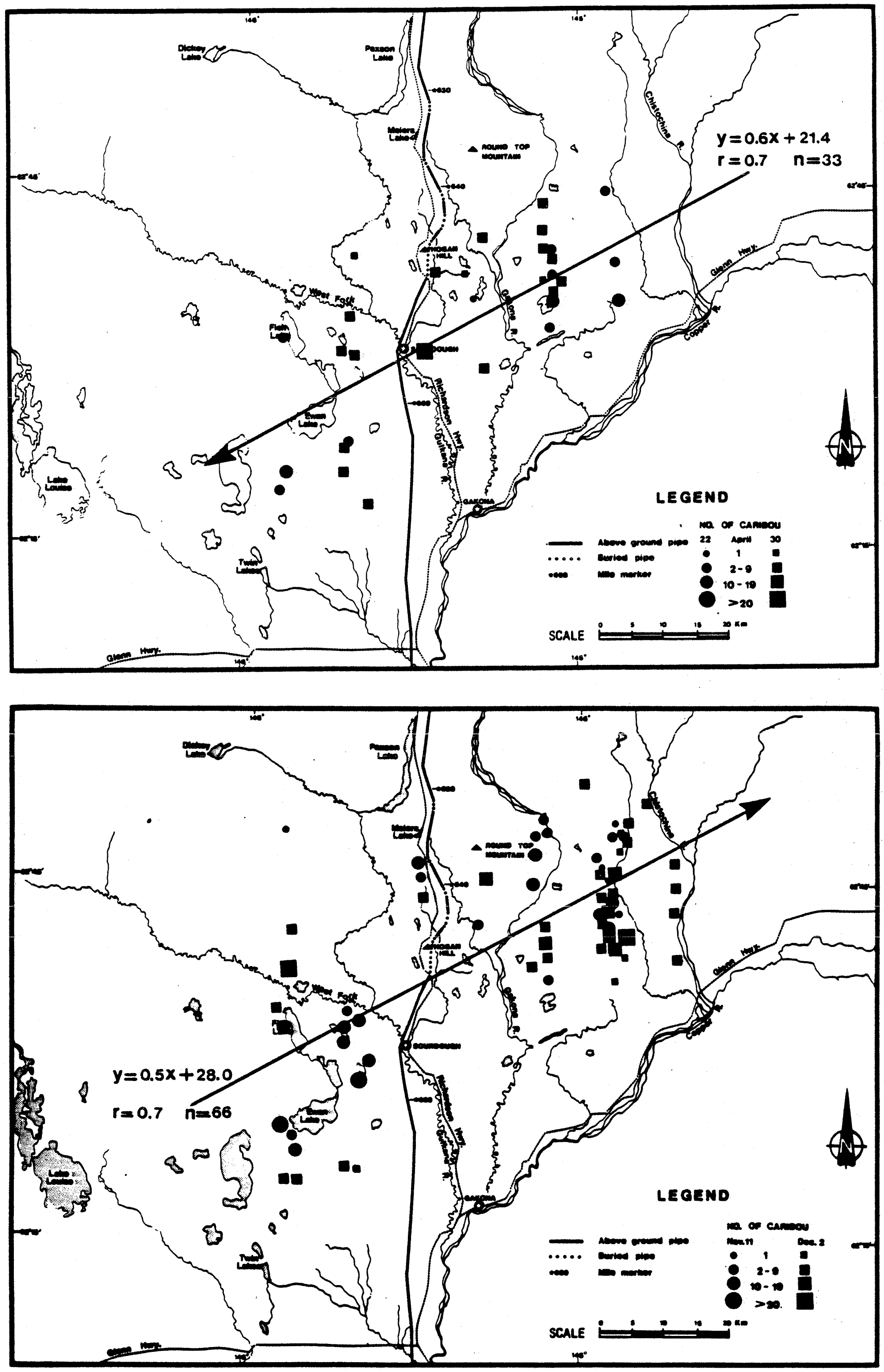
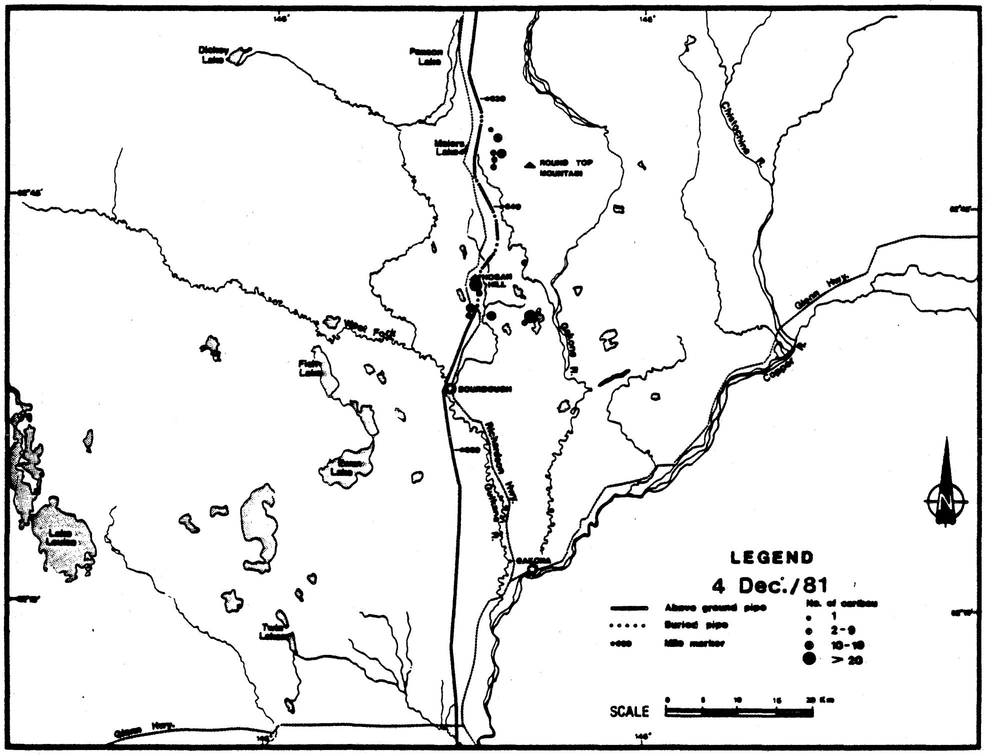


Figure 11. Caribou distribution from aerial surveys conducted in spring and fall 1981 and February 1982.



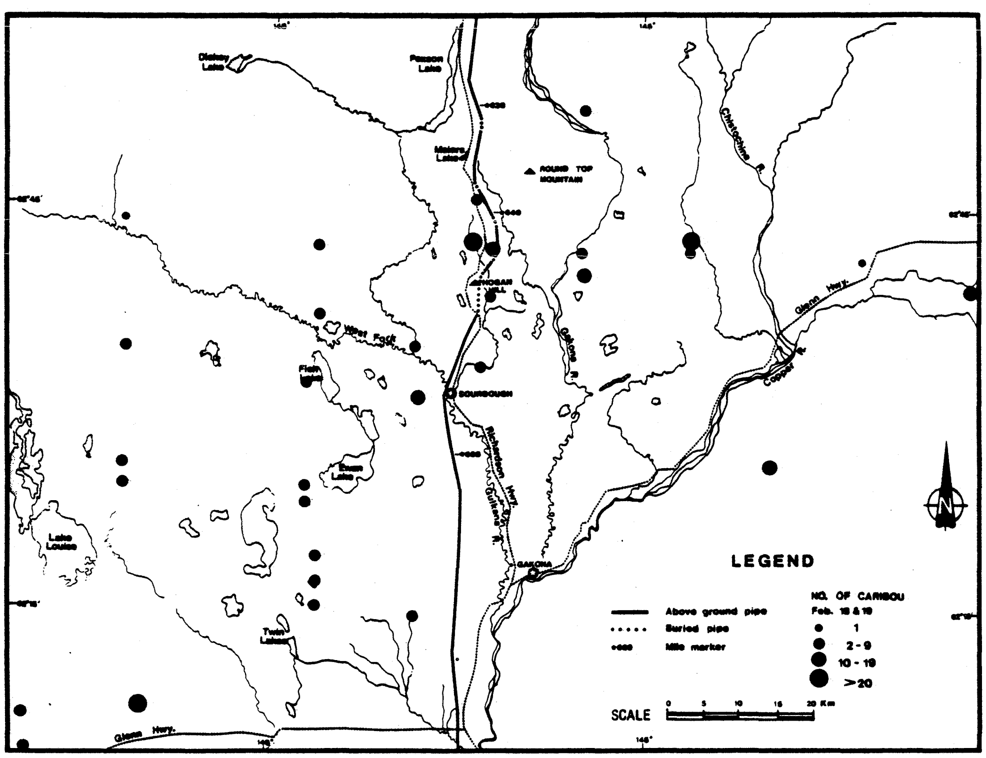


Figure 11. (Continued)

during fall migration (54%, n = 69) than during spring migration (25%, n = 20; $p<0.025$) when meadows were used most (55%, n = 20; $p<0.001$). Caribou were observed in spruce forest more (55%, n = 20) in mid-winter than during migratory periods (29%, n = 89).

Caribou distribution and the location of major trail systems were dependent on season. In spring 1981, migration from the Gakona and Chistochina Rivers drainages westward across TAPS peaked in mid-April. A major shift in caribou distribution was observed between the 22 April and 30 April aerial surveys (Table 5, Figure 11). Heavy east-west trails indicated migration within the survey area was under way by 22 April, mostly south of Hogan Hill.

Spring migration occurred at a similar time in 1981 and 1982, but in 1983 migration occurred considerably earlier. In February 1983, caribou were observed moving across TAPS to the west (Pitcher, pers. comm.). Approximately half of the herd crossed at this time with the remainder crossing in April.

During fall, caribou move east across TAPS in early- to mid-October, although most of the herd swings southwest back across TAPS in late October before moving east across TAPS again in November and December. In fall 1981, 7,000-10,000

Table 5. Numbers of caribou observed east and west of TAPS during aerial reconnaissance surveys, 1981 and 1982.

SURVEY DATE	TRANSECT AREA km^2 (mi^2) EAST	WEST	NUMBER OF CARIBOU OBSERVED EAST	WEST	TOTAL	CARIBOU /100 km^2 EAST	WEST
1981							
22 April	185 (72)	195 (76)	41	20	61	22	10
30 April	106 (42)	132 (52)	34	41	75	32	31
11 Nov.	185 (72)	259 (101)	65	121	186	35	47
2 Dec.	185 (72)	259 (101)	159	75	234	86	29
1982							
18-19 Feb.	430 (168)	290 (113)	57	99	156	13	34

caribou (35-55% of total population) moved east across TAPS in mid-October from northern Lake Louise Flat and then returned across TAPS moving west (Alyeska Security, pers. comm.). Of 124 groups observed crossing TAPS between 24 October and 8 November 1981, 91 (74%) were moving west. Although these movements were not as sudden in 1982 and 1983, the same pattern was evident since more caribou (68%) crossed west in October than in November (24%) during the study period. The 11 November 1981 survey showed a higher density of caribou west of TAPS on the Flat (Table 5, Figure 11). By December, densities were higher to the north and east in the Gakona and Chistochina Rivers drainages, indicating a major eastward movement (Table 5, Figure 11). Trail systems across TAPS were mostly north of

Hogan Hill. By February, caribou were dispersed, mostly at low densities and located on winter range (Figure 11, Table 5). Five groups were observed near TAPS moving both east and west across TAPS.

5.2 CROSSING SITES

5.2.1 Location

Specific sections of TAPS were consistently crossed by caribou during migration although the locations of high use zones changed between spring and fall (Figures 12 and 13).

In spring, most caribou (66%) crossed over a 20 km (12 mi) section (34% of ROW length) of TAPS south of Hogan Hill. The Spring Creek drainage (4 km, 2.5 mi wide) north of Hogan Hill was of secondary (29%) importance and Haggard Creek (1 km, 0.6 mi wide) was used least (5%) (Figure 13). This pattern was consistent in 1982 and 1983. In 1981 snow conditions precluded trail counts but aerial survey data suggest that the same sites were used in 1981.

In fall, most caribou (80%) crossed TAPS over a 20 km (12 mi) section (34% of ROW length) north of and including Hogan Hill (Figures 12 and 13). A few (13%) crossed in the

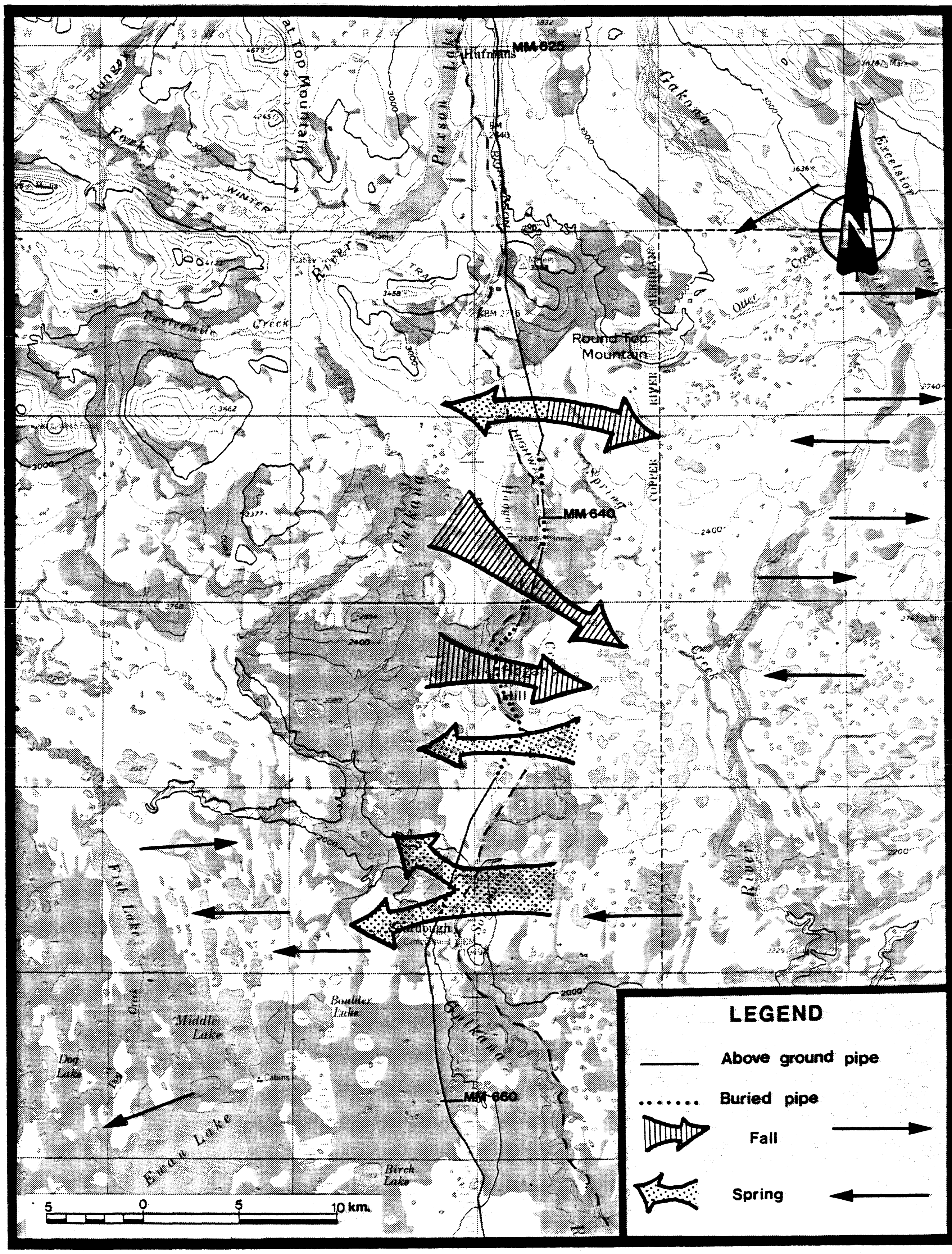


Figure 12. Main caribou crossing zones, spring and fall 1981-1983.

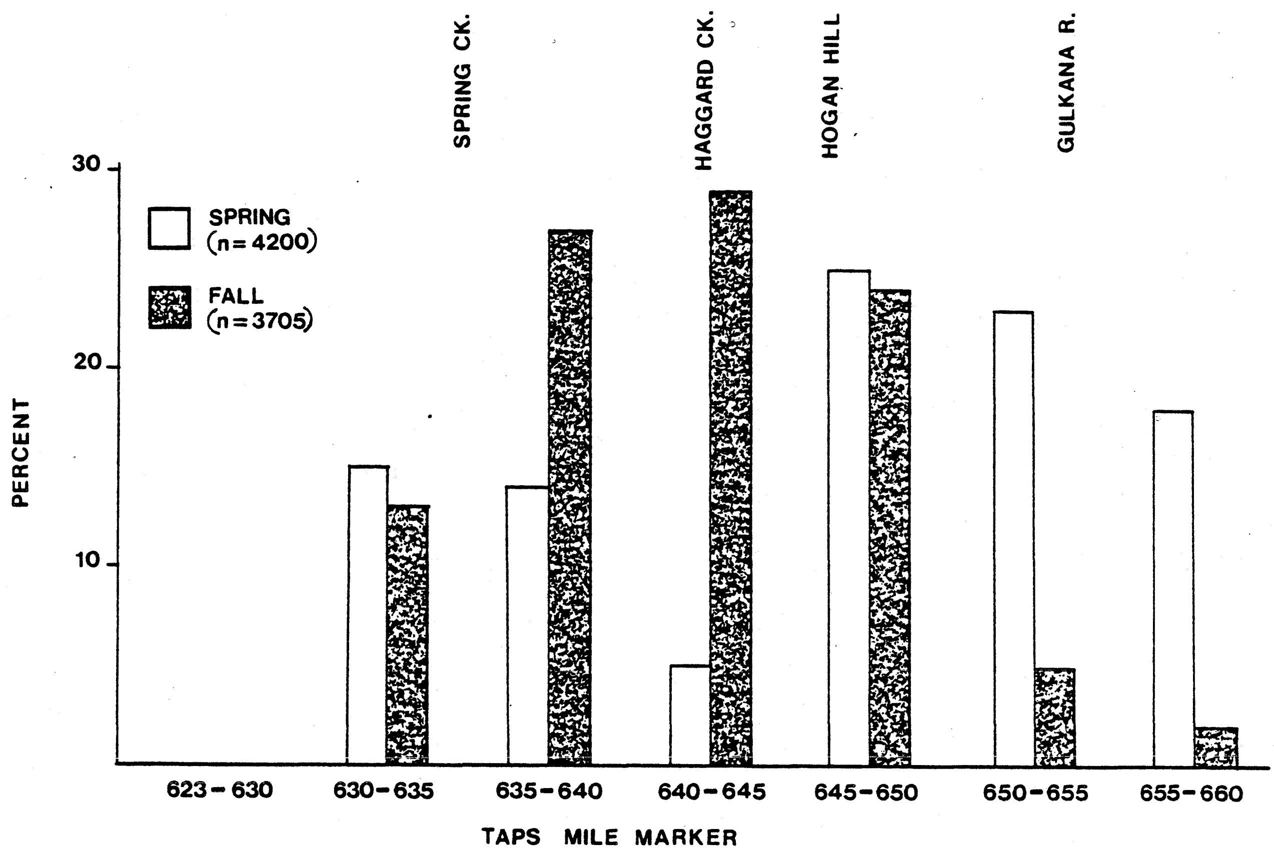


Figure 13. Distribution of caribou trails along TAPS during spring and fall migration, 1981-1983 (n = number of caribou trails).

Spring Creek drainage late in the fall after freeze-up, while only seven percent crossed south of Hogan Hill.

5.2.2 Characteristics

5.2.2.1 Topography

Topographic features associated with crossing sites were similar between years and within either the spring or fall period. However, differences in the location of spring versus fall crossing sites were principally related to topography.

Topographic features associated with spring crossing sites were usually depressed, flat terrain adjacent to uplands (Figure 13). These lowlands are contiguous on either side of TAPS and characterized by high densities of small lakes (wetlands) and meadows (Figure 12).

In the fall, crossing sites were strongly associated with upland and sloped topography between the major lowlands of Spring Creek and the area south of Hogan Hill. These uplands are contiguous with uplands to the west of TAPS and with slopes east of TAPS.

Although these relationships were consistent overall, increased use of the Spring Creek drainage was recorded in late November 1982 (Figure 13). That survey was 2-3 weeks later than all other surveys and took place well after lakes had frozen. Average temperatures were lower in fall 1982 than 1981 and 1983 and snow on the ground was low (Appendix 1). At this time, 56 percent of caribou trails along TAPS were located within the lowlands of Spring Creek and 39 percent on the upland slopes immediately to the south.

5.2.2.2 Vegetation

Caribou trails were not associated with any particular vegetation type. Vegetation types associated with crossing sites reflected topographic differences observed between spring and fall. Spring crossing sites had a preponderance of wetland meadow, most of which is interspersed with coniferous forest (Table 6). Although spring crossing sites represented less than 42 percent of ROW length, 95 percent of wetland meadow along TAPS occurred at these sites.

Fall crossing sites were characterized by upland vegetation types. Deciduous/mixed-wood occurred frequently (83%) within these sites which represented 31 percent of the length of the ROW (Table 6). Wetland meadow was notably scarce at these sites (Table 6).

Differences in vegetation along the ROW and elsewhere in the study area were minimal except for shrubs and wetland meadow. The ROW had more shrub ($p<0.10$) and less wetland

Table 6. Distribution of vegetation types along TAPS in relation to topographic features and pipe mode.

	TAPS LOCATION (MM)									
AREA FEATURE	623.5-633.5 Paxson Area	633.5-636 Spring Creek	636-642 Haggard Ck- Hogan Hill	642-645.6	645.6-647.3 Hogan Hill	647.3-649.1 Special Buried	649.1-652 Above-ground	652-653.8 Special Buried	653.8-660 South Sourdough	TOTAL (Average)
VEGETATION TYPE										
Conifer	54	69	88	43	60	66	73	59	80	(66)
Deciduous/ mixed wood	3	0	1	32	5	0	0	4	<1	(6)
Shrub	42	29	9	22	27	8	16	25	12	(23)
Wet meadow/ lake	<1	2	<1	<1	0	22	10	5	6	(3)
Disturbed	1	0	1	2	9	3	1	8	2	(2)
PIPE MODE										
Above ground (mi)	8.5	2.5	3.0	1.0	0.0	0.0	2.8	0.0	6.2	24
Percent	85	100	50	28	0	0	100	0	100	66
Buried (mi)	1.5	0.0	3.0	2.6	1.7	1.8	0	1.8	0.0	12.4
Percent	15	0	50	72	100	100	0	100	0	34
DISTANCE										
Kilometers	16	4	9.6	5.8	2.7	2.9	4.5	2.9	9.9	58.3
(Miles)	(10)	(2.5)	(6)	(3.6)	(1.7)	(1.8)	(2.8)	(1.8)	(6.2)	36.5
Percent	27	7	16	10	5	5	8	5	17	100

meadow ($p<0.10$) than did the entire study area (Table 7). These differences relate principally to geotechnical considerations for pipeline location since uplands were preferred over lowlands which decreases the occurrence of wet meadows and increases the occurrence of shrubs (see Table 6). Consequently along the ROW caribou trails were located more in shrubs and less in meadows than the occurrence of these types in areas away from TAPS (Table 7).

Table 7. Caribou use of vegetation types within major crossing zones along TAPS in relation to availability of types during spring and fall migration periods (values in parentheses = availability).

VEGETATION TYPE	PERCENT CARIBOU USE SPRING 1982-1983 Mean	Range	FALL 1981-1983 Mean	Range	AWAY FROM TAPS	ALONG TAPS
Conifer	69	66-80	64	43-88	(62)	(66)
	(73)		(69)			
Deciduous-mixed wood	1	0-4	13	1-32	(5)	(6)
	(<1)		(12)			
Shrub	18	8-29	19	9-27	(<u>14</u>)	<u>(23)</u>
	(17)		(16)			
Wet meadow-lake	9	2-22	<1	0-<1	(<u>18</u>)	<u>(3)</u>
	(8)		(<1)			
Disturbed	3	0-8	4	1-9	(1)	(2)
	(2)		(3)			
No. of trails	3,990		2,964			

Comparison of habitat proportions available and used by caribou crossing the TAPS for (a) shrubs, and (b) wetland meadow.
a) Chi-squared test: $X^2 = 2.7668$, df = 1, p = 0.100
b) Chi-squared test: $X^2 = 3.0927$, df = 1, p = 0.081

Comparison of habitat proportions available and used by caribou crossing the TAPS over (a) spring, and (b) fall, and (c) both migration seasons.
a) Chi-squared test: $X^2 = 1.4030$, df = 4, p = 0.816
b) Chi-squared test: $X^2 = 1.2663$, df = 4, p = 0.874
c) Chi-squared test: $X^2 = 1.1561$, df = 4, p = 0.886

Caribou use of vegetation within major crossing zones did not differ significantly (p>0.05) from the availability of vegetation in the same area (Table 7). This observation applied both to spring ($p>0.05$) and fall ($p>0.05$) crossing zones.

No relationship could be found between forage quantity or quality and the frequency of caribou crossings. Caribou frequently foraged on the TAPS ROW especially at the edges where cratering was most evident. Most of the ROW has been seeded with a revegetation seed mix (Appendix 5) but plant cover is highly variable except at the ROW edge (Table 8).

Table 8. Vegetative cover along TAPS ROW, August 1983.

			PERCENT COVER (MEAN ± SE, n = 20)					
LOCATION	PIPE MODE	TAPS MM	PIPE		ROW CENTER		ROW EDGE	
Spring Creek	A/G	635.2	3.7	0.6	9.1	1.4	90.9	9.6
Hogan Hill	A/G	646.5	13.7	2.2*	24.9	3.2*	88.3	4.3
Hogan Hill	B	646.5	110.6	8.2	60.2	5.6	92.5	11.0
Special Burial	B	648.8	26.4	2.4	12.0	1.4	64.6	9.1
Between Special Burials	A/G	651.8	10.6	3.6	18.4	2.4	22.8	3.0
Special Burial	B	652.6	61.6	4.4	55.0	8.8	79.2	8.0

* n = 15.

Sedges (Carex spp.), Equisetum spp. and grasses were abundant at the ROW edges at both pipe modes while virtually absent elsewhere on the ROW. Within the central part of the ROW, buried pipe sections supported four times more plant cover than at above-ground pipe (Table 8).

5.2.2.3 Snow

Snow depth and hardness can influence caribou distribution by affecting their rate of travel and ability to obtain forage. Maximum snow depths during this study were normal or below normal with the exception of November 1981 to January 1982 when snow depth exceeded the normal by 10-20 cm (Appendix 1A). The greatest accumulation of snow occurs by March (50 cm, 20 in) and diminishes rapidly thereafter. Spring snow depths (33 cm, 13 in) are generally two to three times greater than in the fall period (Appendix 1A). Snow depths exceeding 80 cm (32 in) occur infrequently in the Fairbanks area (Appendix 1B) and even less frequently in the study area (Appendix 1A) and it is doubtful that snow accumulation in either spring or fall would restrict caribou passage across the TAPS ROW.

Along TAPS snow depth increased from south to north (Figure 14). Snow was twice as deep in the north compared to the south end of the study area. Greatest snow depths occurred

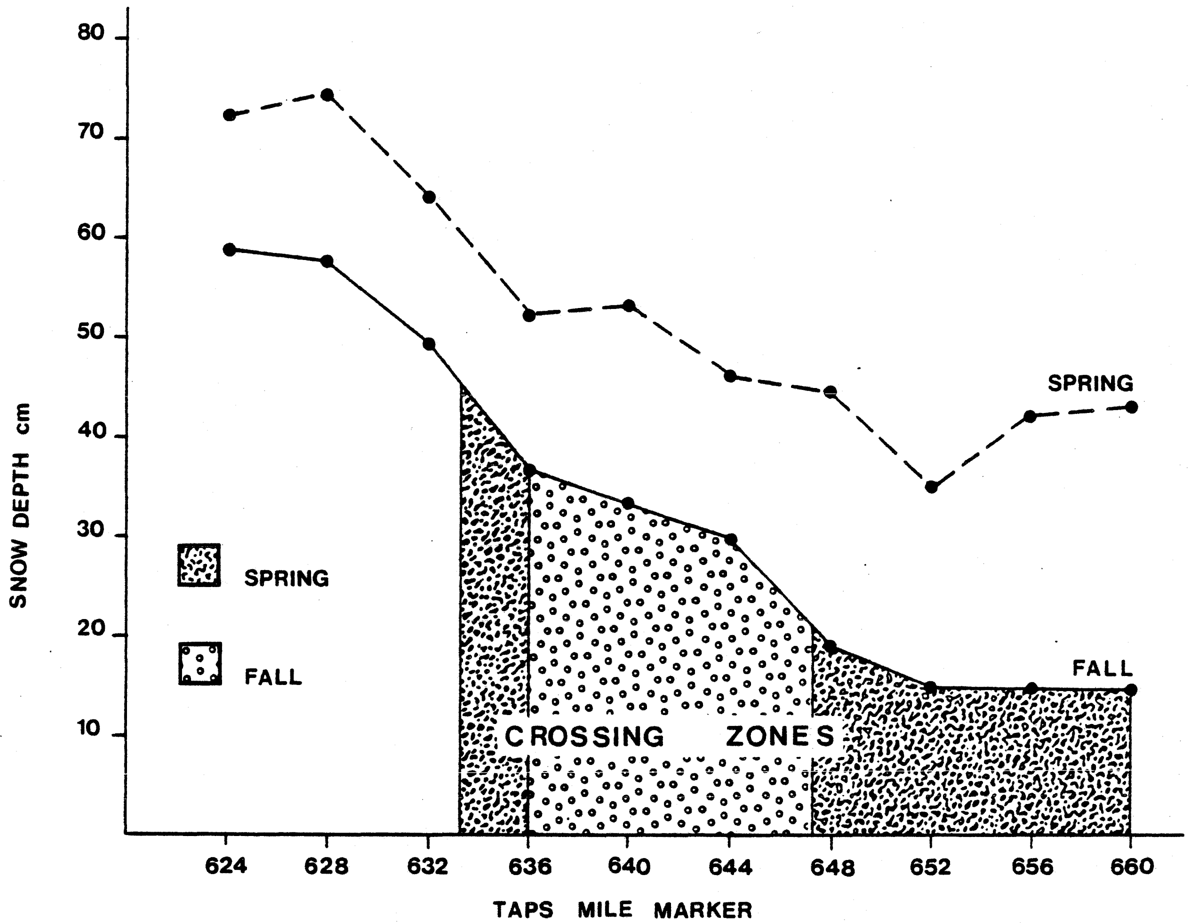


Figure 14. Distribution of snow depths along TAPS in relation to spring and fall migration zones, 1981-1983.

north of Spring Creek (MM 636) and the least snow occurred south of Hogan Hill (MM 646). Snow depths were 32 percent less on the TAPS ROW than in adjacent areas (Table 9).

Snow depth during the spring migration period was low (<44 cm, 17 in) at the major crossing sites south of Hogan Hill. North of this area, snow depths increased to 52 cm (20

Table 9. Snow depths on and off the TAPS right-of-way, 1981-1983.

	SNOW DEPTH (cm) ON ROW	SNOW DEPTH (cm) 10 m OFF ROW
	Mean ± S.E. (n)	Mean ± S.E. (n)
SPRING		
31 March 1983	36.9 ± 1.4 (62)	53.2 ± 2.3 (62)
FALL		
19 November 1982	28.8 ± 1.3 (53)	39.0 ± 2.0 (53)
*21 October 1983	9.4 ± 1.1 (56)	15.8 ± 1.8 (56)
7 November 1983	20.6 ± 1.0 (72)	32.3 ± 2.0 (72)

*MM 632.5 - 660.0

in) in the Spring Creek area and over 70 cm (28 in) near Paxson Lake.

In the fall the same pattern prevailed but the major crossing sites had intermediate snow depths ranging between 25 and 38 cm (10 and 15 in). However, in late October 1983, rain had created a crust on the snow and caribou crossed farther south than in previous years. By November, caribou were again using the upland areas north of Hogan Hill crossing sites. Between Paxson Lake and Haggard Creek (MMs 625-642), the crust would support a man weighing 75 kg (170 lbs) which equates to a hardness of >1.8 kg/cm^2 (Miller 1976), but its hardness diminished south of Haggard Creek. Adult caribou are supported by a crust of >2.1 kg/cm^2 (Miller 1976).

5.2.2.4 Pipe Mode

The distribution of above-ground and buried pipeline is mostly a reflection of geotechnical considerations. Above-ground pipe is most common where frozen soils are present, and buried pipe in well-drained, frost-free soils. However, in two instances the pipeline was refrigerated and buried to accommodate caribou movements south of Hogan Hill (MMs 647.3 - 649.2 and 652.0 - 653.8) (Figure 12, Table 6).

There were differences between seasonal crossing sites and the available pipe mode (above-ground or buried). Spring crossing sites were located in sections of TAPS with a high proportion (76%) of above-ground pipe in contrast to fall crossing sites where most (65%) of the pipe was buried (Table 6). However, it was only between MMs 635 and 655 that caribou had a "choice" of pipe mode. Crossings in this section were made in proportion to occurrence of pipe mode; no selection for either above-ground or buried pipe was evident ($p>0.05$, Table 10).

The distribution of pipe heights between spring and fall crossing zones did not differ (Table 11). Most pipe (91 and 92% respectively) was greater than 1.8 m (6 ft) in height yet caribou crossed pipe at BOP-TOPs ranging from 1.0 m (3.3 ft) to 5.1 m (16.7 ft). The median BOP-TOP at both spring and

Table 10. Percent of all caribou crossings in relation to pipe mode during spring and fall migration periods (seven surveys, 1981-1983).

TAPS SECTION (Mile) (Marker)	PIPE MODE AVAILABILTIY (Percent)		PERCENT OF CARIBOU CROSSING					
			SPRING		FALL		BOTH	
	A/G	B	A/G	B	A/G	B	A/G	B
625-630	100	0	0	0	0	0	100	0
630-635	100	0	100	0	100	0	100	0
635-640	64	36	91	9	66	34	77	23
640-645	24	76	34	66	6	94	11	89
645-650	16	84	1	99	6	94	3	97
650-655	62	38	39	61	67	33	42	58
655-660	100	0	100	0	100	0	100	0
Average	67	33	57	43	39	61	49	51
No. of trails			2400	1800	1452	2253	3852	4053
Average for sections where selection is possible	41	59	48	52	38	62	43	57
			$X^2=2.02$		$X^2=0.37$		$X^2=0.16$	
			$p=0.179$		$p=0.585$		$p=0.692$	

fall crossing sites was 2.3 m and the mean BOP-TOP at which 253 caribou trails crossed the pipe was 2.5 m (S.E. = 0.03).

Table 11. Distribution of pipe heights (BOP-TOP) at spring and fall caribou crossing zones (percent in parentheses).

MIGRATION PERIOD	<1.8 m (6 ft)	1.8-3.0 m (6-10 ft)	>3.0 m (10 ft)	TOTAL 18 m PIPE SECTIONS
Spring	107 (9)	1,024 (84)	82 (7)	1,213 (100)
Fall	33 (8)	332 (82)	42 (10)	407 (100)

5.2.2.5 Predators

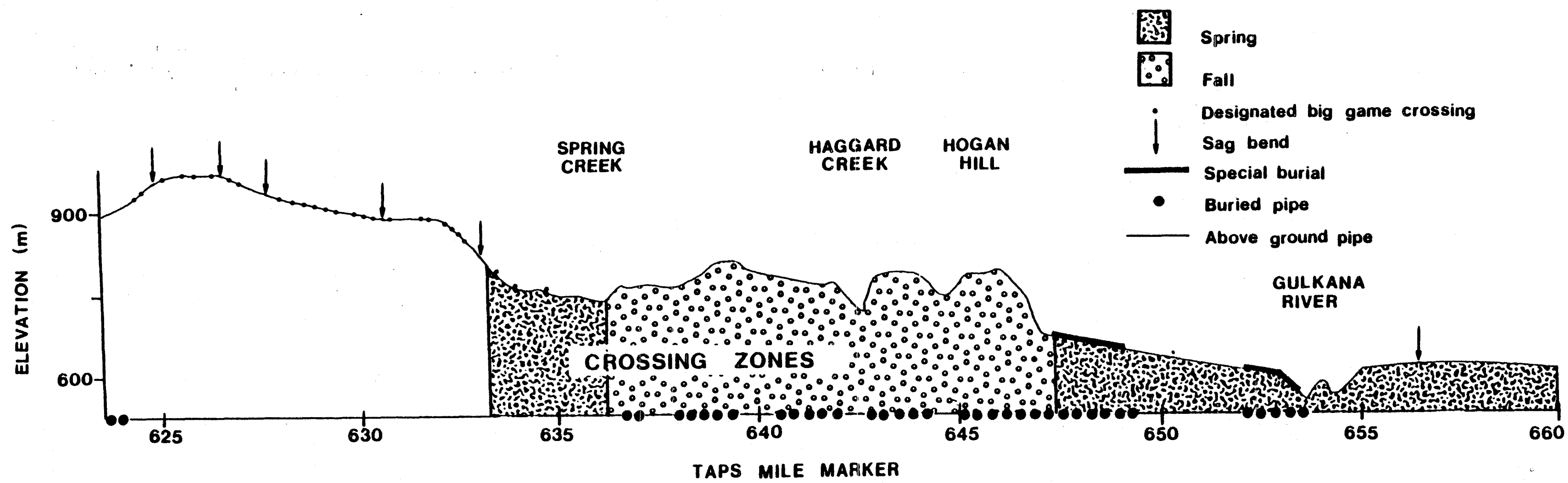
Monitoring of predators is important because of concern that they may disrupt movements of caribou as they approach TAPS and kill more caribou along the ROW than in adjacent areas (Miller 1984, Roby 1978). Wolves and their sign were observed along or adjacent to the ROW throughout the study. In spring, wolf sign (n = 5) was observed in the southern half of the area (MMs 642-659) whereas, in fall, wolf sign (n = 11) occurred throughout the area (MMs 628-660). Most (82%) sign in fall was located north of MM 644 whereas, in spring, most (60%) was located between MMs 651 and 658. Three moose carcasses were located, one at MM 633 in fall and two at MMs 651 and 658 in spring.

Wolf tracks, except in two instances, did not follow the ROW. In fall, wolf tracks were consistently observed over a 1.6 km section of TAPS at MMs 633 and 643 and some of these tracks followed the ROW less than 1.6 km.

5.3 SPECIAL CROSSING STRUCTURES

Special wildlife crossing structures included 30 designated big game crossings, six sag bends and two refrigerated (special) buried sections each 2.9 km (1.8 mi) in length (Figure 15). The two special buried sections were designed especially to facilitate caribou movements.

Designated big game crossings and sag bends were located in the northern third of the study area (Figure 15). Both types of structure are in an area with high snow depth (>60 cm, April 1982) and are associated with conifer (51%) and shrub (49%) vegetation types. Most (74%) are located on ridges with the remainder in valleys. Special buried sections are located in the southern third of the study area which has low snow depth (<40 cm, April 1982), a relatively high (14%) proportion of the wet meadow-lake vegetation type, and flat topography.



SEASON	PERCENT OF TRAILS CROSSING SPECIAL CROSSING STRUCTURES								TOTAL
Spring n = 2[1]	0 (0)	0 N/A (0)	7 0-32[2] (640)	N/A N/A (620)	N/A N/A (210)	96 14-100 (1050)	65 13-88 (900)	1 4 0-33 (730)	41 (4200)
Fall n = 5	0 (0)	0 N/A (0)	2 N/A (500)	N/A N/A (988)	N/A N/A (1093)	54 0-89 (896)	33 0-100 (133)	0 N/A (95)	13 (3705)
Total n = 7	0 (0)	0 (0)	5 (1140)	N/A (1608)	N/A (1303)	76 (1946)	61 (1033)	2 (1825)	29 (7905)

1 Number of surveys
2 Range (percent)

Figure 15. Location and use (percent) of special crossing structures within 8 km (5 mi) sections of TAPS by Nelchina caribou 1981-1983 (number of trails in parentheses).

Within 8 km (5 mi) sections of TAPS where caribou could encounter a special crossing structure, special burials were used most. Of those animals crossing between MMs 645 and 650, 75 percent crossed at the special burial (Figure 15) which accounted for only 35 percent of the section. At the other section between MMs 650 and 655, 61 percent of caribou crossing did so at the special burial (35% of section). In both instances, the proportion of caribou using these structures was greater in spring (82%) than in fall (51%).

Designated big game crossings and sag bends were used very little (<8%) by caribou since most (89%) were outside of major caribou crossing zones.

About 29 percent of the estimated number of caribou crossing TAPS did so at a special crossing structure and most (27%) used special burials (Figure 15). All structures were used less in fall (13%) than in spring (41%).

5.4 CARIBOU RESPONSE TO TAPS

5.4.1 Crossing Success

Based on trail surveys, an estimated 7,905 caribou were known to approach the ROW. All trails but one (3-4 animals) crossed (99.95%). This group of caribou entered the ROW from the west (fall 1982) at a buried pipe section where they foraged and bedded along 40 m of the ROW prior to exiting to the west. Of all trails, 49 percent crossed at above-ground pipe (Table 10)

Direct observations of 149 caribou groups entering the ROW were made in the spring and fall of 1981. All of these groups crossed TAPS.

5.4.2 Approaching and Departing the ROW

Measurements of trails approaching and crossing TAPS indicated that the configuration of caribou trails (changes in orientation over distance) was similar in areas away from TAPS as it was where caribou crossed TAPS (Table 12). A slightly larger average change in orientation occurred where caribou crossed TAPS but the difference was not significant ($t = 1.71$, $df = 270$, $p>0.05$) except at above-ground pipe ($t = 2.54$, $df = 170$, $p<0.05$) where the difference was 7.2 degrees.

Caribou, upon entering the ROW, crossed directly (<25 m lateral movement) in most (92%) instances. However, certain trails (n = 32) that successfully crossed TAPS either (1) approached or departed the pipe on old cutlines (n = 4), (2)

Table 12. Caribou trail configuration (change in orientation over distance) beyond 50 m from TAPS compared to trails crossing TAPS.

PIPE MODE	CHANGE IN BEARING (DEGREES): Approach and Departure 20 m to Pipe			50 m Trail Sections Approaching Beyond 50 m from TAPS		
	Mean	± S.E.	n	Mean	± S.E.	n
Above-ground	24.8	2.1	99	17.6	1.6	73
Buried	24.1	2.9	94	20.9	2.1	70
Both	23.8	1.9	193	19.2	1.9	143

noticeably paralleled the pipe (>25 m) either on (n = 2) or off (n = 5) the ROW, or (3) encountered a transition between above-ground and buried pipe sites (n = 6). The approach and departure sections of these trails at above-ground and buried pipe sites were classified as direct (perpendicular to pipe) or paralleling the pipe for >25 m (Table 13). Caribou approached the pipe directly at a slightly higher frequency (57%) than did caribou approaching parallel to the pipe (43%), but this difference was not significant ($Z = -0.55$, $p > 0.05$). The same pattern was evident for trails departing the ROW (Table 13). Thus, no differences were observed for approach-departure orientations between pipe modes.

Table 13. Approach and departure orientations of caribou trails within 20 m of TAPS crossing at above-ground or buried pipe.

DEPARTURE	PIPE MODE	APPROACH DIRECT	APPROACH PARALLEL	TOTAL
Direct	Above-ground	3	5	8
	Buried	3	5	8
Parallel	Above-ground	7	2	9
	Buried	4	1	5
TOTAL		17	13	30

Paralleling above-ground pipe during approach occurred <u>off</u> the ROW at 5 trails (17%) for an average of 88 m (S.E. = 5, range = 330-160 m). Two trails (7%) paralleled off the ROW approaching buried pipe, but distances were not measured. No paralleling during departure occurred off the ROW for either above-ground or buried pipe.

Paralleling above-ground pipe during approach occurred <u>on</u> the ROW at two trails (7%) for an average of 55 m (S.E. = 25, range = 30-80 m) compared to two trails (7%) paralleling buried pipe for an average of 51 m (S.E. = 1.2, range = 50-52 m). Paralleling on the ROW during departure at above-ground pipe occurred in nine instances (30%) for an average of 111 m (S.E. = 4, range = 30-314 m) compared to five instances (17%) over an average of 52 m (S.E. 14.1, range = 30-100 m) at buried pipe (Table 13).

Caribou followed cutlines that were parallel to or that intersected the ROW. Four trails were noted funnelling through a sag bend after paralleling the pipe along a cutline 30 m off the ROW. At a point perpendicular to the sag bend, they left the cutline and crossed the sag bend, departing directly.

At 35 percent of the above-ground pipe sites (n = 17) a cutline intersected and crossed the ROW at 90 degrees. At these sites, caribou encountering the cutline off the ROW followed it directly across the ROW.

At transition sites, where above-ground pipe turns underground (n = 8), six caribou trails approached directly to the point of transition and crossed the buried pipe directly or paralleled either the above-ground or buried sections on the departure side. The other two trails approached the point of transition after paralleling above-ground pipe and crossed the buried section directly.

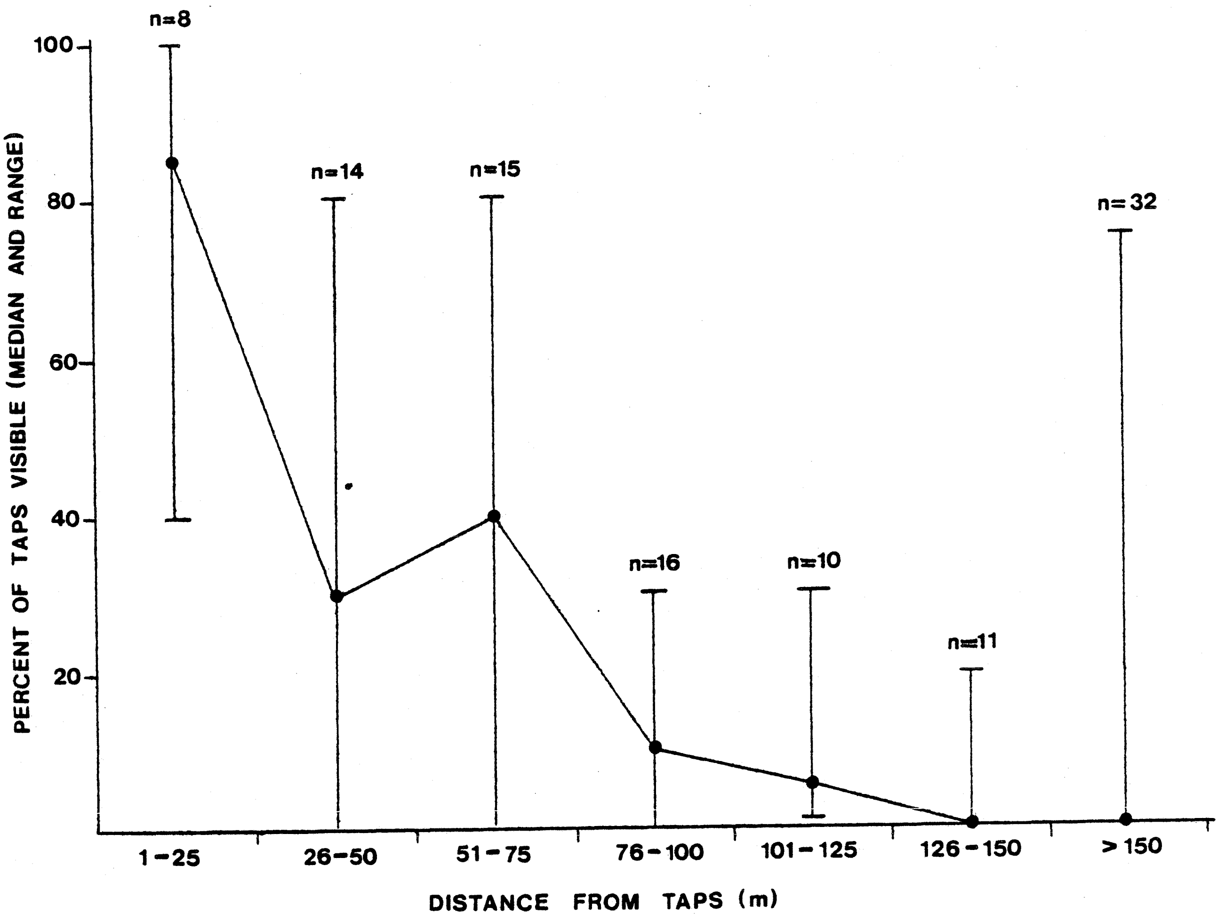


Figure 16. Extent that TAPS is visible in relation to distance away from TAPS.

As caribou approached TAPS, their perception of the open ROW may alter the angle at which they were travelling relative to TAPS. ROW visibility was assessed over distance from TAPS and it was found that visibility declined rapidly over 50 m from the ROW but variability was high depending on forest density (Figure 16). Beyond 125 m (400 ft), the ROW was seldom visible to field workers.

Upon analyzing the angle of caribou trails relative to TAPS ($\bar{x}$ bearing = 4.6°T, S.E. = 3.8°) over distance, no relationship was found either for above-ground ($r = -0.29$, $t = -0.299$, $n = 283$, $p>0.05$) or buried pipe ($r = -0.35$, $t = -0.372$, $n = 214$, $p>0.05$). This observation was consistent between 1 and 500 m away from TAPS. Caribou approached TAPS at an average angle of 50.4 degrees (S.E. = 1.7, n = 497) up to 500 m from the ROW, but variability was high (CV = 53.6%). At 500 m from TAPS, caribou approached at a mean angle of 56.6 degrees (S.E. = 6.2, n = 202) compared to 63.8 degrees (S.E. = 3.8, n = 158) within 20 m of the ROW. This difference is not significant ($t = 0.93$, $df = 358$, $p>0.05$).

During fall caribou approached TAPS at an average bearing (True North) of 92 degrees (S.E. = 1.9, n = 550) whereas, in spring, they approached at an average bearing of 259 degrees (S.E. = 3.6, n = 190).

5.4.3 Caribou Behavior on the Right-of-Way

Direct observations of 145 groups (1,140 caribou) between MMs 637 and 649 on the TAPS ROW were made from 24 October to 8 November 1981. Data for groups (23) that were disturbed by the observer's presence were not used in the analyses. Of the 122 groups (880 caribou) that were not disturbed, 14 percent were at above-ground pipe and 86 percent at buried pipe. All groups crossed TAPS.

Mean size of groups observed was eight (S.E. = 1.2, n = 122) while most groups (77%) were less than 11 caribou (Table 14). The largest group observed was 27 individuals. Caribou spent an average of 7.6 minutes on the ROW before departing regardless of pipe mode (Table 14). Small groups

Table 14. Time spent on the ROW by Nelchina caribou in relation to group size, fall 1981 (n = number of groups).

INDEPENDENT VARIABLE	n	TIME ON ROW (Minutes) MEAN	± S.E.	SIG.[1]	GROUP SIZE MEAN	± S.E.	SIG.[1]
Above-ground	17	8.4	2.2		8.4	1.4	
vs.				nsd			nsd
Buried pipe	105	6.7	0.8		6.9	0.5	
Bull	7	1.7	0.3		3.1	1.2	
vs.				n/a			n/a
Cow	41	5.9	0.8		5.0	0.6	
vs.				nsd			t=4.50,p<0.05
Mixed	50	8.4	1.3		9.0	0.7	

[1] nsd = no significant difference, p>0.05,
n/a = sample size prohibits comparison.

generally spent less time on the ROW than did large groups. Group leadership was assessed in 59 groups and was predominantly adult females (92%). Adult bulls were leaders in five percent and calves in three percent of groups.

While on the ROW, caribou were most often standing (37%) or walking (32%). Feeding activity occurred 23 percent of the time adjacent to, over and under the pipe, and lying only 7 percent (Figure 17).

Differences in frequency of activity were apparent between above-ground and buried pipe modes but none of the differences were significant ($p>0.05$) (Figure 17). Caribou spent more time feeding (44%) and less time standing (28%) at above-ground pipe than at buried pipe (20% and 38% respectively). Caribou were rarely observed lying at above-ground pipe. However, these observations are based on few (17) groups at above-ground pipe compared to buried pipe (105) which limits comparability. Proportions of different caribou groups (male, female and mixed) observed at above-ground and buried pipe were not significantly different (X^2 4.259, df = 2, p = 0.087).

Alarm behavior (run, alert, excitation leap) was observed in 15 groups (12%) consisting of a total of 91 caribou (mean group size = 6.1, S.E. = 1.4, range = 1-17). Four groups were observed at above-ground pipe and 11 at buried pipe. A

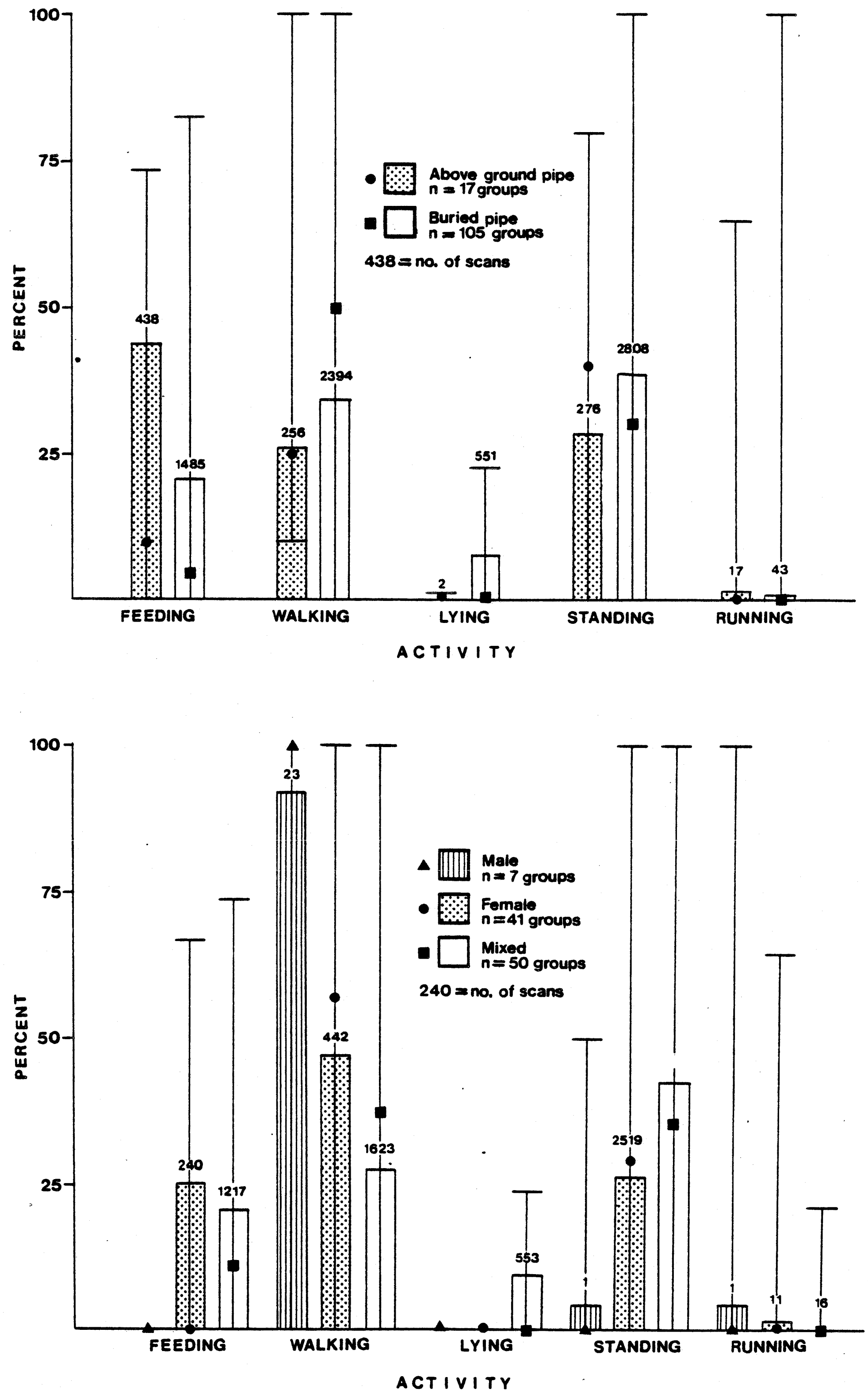


Figure 17. Frequency of caribou activity on the TAPS ROW, fall 1981 (median and range included).

maximum of 41 caribou were observed in some form of alarm behavior, the most common (8 of 15 groups) of which was alert posture (head up, ears erect). Running was observed in six groups and excitation leaps in two groups of which one was elicited by the presence of a wolf. In another instance where caribou ran, they did so in apparent response to other caribou moving onto the ROW. All other (13 of 15 groups) alarm behaviors could not be linked to a specific stimulus.

Of the alarm behaviors observed, alert behavior was the most common (1.1%) and the excitation leap the least common (0.1%), with the total occurrence accounting for 1.4 percent of the time.

6.0 DISCUSSION

Klein (1980) discussed potential consequences of interaction between caribou and pipelines which included increased predation (mortality), loss of range (fewer caribou), reduced dispersal (establishment of other herds) and energetic stress due to deflections and inhibited movements (mortality). All of the caribou and reindeer herds discussed by Klein (1980) have since increased in numbers and their movement patterns have not been disrupted (except in one instance in the Soviet Union when an absolute barrier was created) since the introduction of roads, railways, pipelines and electric transmission lines (Jakimchuk 1980, Klein and Kuzyakin 1982, Bergerud et al. 1984).

Klein (1980:526) believed that disruption of caribou movements by development activity is more likely when populations are at low levels. Although TAPS was built when the Nelchina herd was at a population low (<10,000 caribou), the herd's movements have not been significantly affected. We found no evidence that TAPS impeded caribou movements or altered movement patterns that have been described in the past. Skoog (1968) described Nelchina caribou movements in the early fall as a clockwise swing from the Alphabet Hills to Lake Louise Flat. After the rut (late October, November), caribou undertook an eastward migration across the Richardson Highway/TAPS. Since TAPS bisects the winter range of the herd, caribou commonly used habitats adjacent to TAPS throughout the winter.

We observed caribou in the vicinity of TAPS as early as late September and throughout October. During this period, caribou were observed adjacent to TAPS but they did not show any consistent directional movement until November when eastward movement began. Pitcher (1983) confirmed these observations and estimated that 80 percent of the herd crossed TAPS (Pitcher, pers. comm.).

During the winter of 1982-1983, the Nelchina herd exhibited a movement that has occurred only three times in the past 30 years. Up to 40 percent of the herd moved northeast of the Mentasta Mountains to the vicinity of Tok and Northway on the Alaska-Yukon border (Pitcher 1983). Klein (1980) expressed concern that such movements, which can involve exchange of individuals with other herds, would be adversely affected by the presence of structures such as the Trans-Alaska Pipeline. He stated (Klein 1980:525), "The opportunity for this occurrence, which may be essential to reverse the decline of large herds, will clearly be reduced through the construction of major transportation corridors such as the Trans-Alaska Oil Pipeline and associated haul road." TAPS has been in existence for 10 years and one such movement has occurred. This rate of occurrence does not differ from the historical record.

Klein (1971, 1980), Miller et al. (1972), Banfield (1973), Jakimchuk (1975) and others have expressed concern that structures such as TAPS could alter traditional movements of caribou and affect survival. Klein (1980) suggested that disruptions would be more likely to occur if caribou only encounter obstructions seasonally such as in the case of the Nelchina herd. This concern relates primarily to disruption of pre-calving movements. If caribou are prevented from reaching the traditional calving ground, new calving grounds will be established, but subsequent survival would be lower since optimal habitat is no longer available (Klein 1980).

The traditional calving ground for the Nelchina herd remains intact as does the pattern of spring migration (Pitcher 1982, 1983). Spring migration usually occurred in April with caribou moving from the southeast part of the study area to the west (Skoog 1968, Hemming 1971). The same pattern was observed in 1981 and 1982 but in 1983 most caribou moved west in February. This variability is characteristic of winter and spring movements and may be related to snow conditions (Skoog 1968, Kelsall 1968, Gauthier et al. 1984). Snow depth during the winter of 1982-1983 was more than 30 percent below normal (Appendix 1) and probably accounted for the different timing in 1983.

The locations where caribou crossed the Richardson Highway were not accurately defined prior to the construction of TAPS. Skoog (1968:447) depicted major fall migratory zones in the northern portion of our study area south of Paxson Lake, and spring crossing zones in the vicinity of Sourdough. However, both the Spring Creek drainage and the flat between Hogan Hill and the Gulkana River were recognized as traditional crossing zones prior to TAPS construction (Hemming, pers. comm.). Local residents described major fall crossing zones at Hogan Hill, Haggard Creek and Spring Creek and it was in these areas that hunters in the 1960s concentrated (Chimielowski, pers. comm.).

The same seasonal crossing zones as described above were identified in this study and Pitcher (1983) confirmed our observations through relocations of radio collared caribou from 1981-1983. These zones were characterized by different physical conditions that reflected caribou responses to snow cover and terrain as described in other studies (Kelsall 1960, 1968, Skoog 1968, Miller 1984). Fall crossing zones were characterized by upland topography and vegetation types, whereas spring zones were in lowlands.

In fall prior to freeze-up, caribou are usually found dispersed over uplands and well drained slopes where travelling is easiest; after freeze-up lakes are used as travel routes (Skoog 1968, Kelsall 1968). In spring travel is more restricted to frozen lakes and rivers and in snow-free terrain (Bergerud 1974, Kelsall 1968, Skoog 1968, Miller 1976, Carruthers and Jakimchuk 1981, Pitcher 1983). Fall crossing zones were located on uplands between Spring Creek and Hogan Hill. Caribou crossed TAPS in this zone and showed no preference for vegetation type, pipe mode or pipe height. Upland topography was the only consistent feature associated with fall crossing locations. However, adverse snow conditions may have caused a shift to a more southerly crossing zone in one instance.

During spring migration, caribou travelled in lowlands. Frozen lakes and ponds serve as direct and rapid travel routes as well as escape terrain, unlike in the fall when caribou are forced to swim or move around lakes (Kelsall 1968, Miller 1974, 1975, Bergerud 1978). Deep snow would inhibit or prevent movement to the calving ground and escape from predators so caribou often travel where snow cover is least (Miller 1975, 1976, Kelsall 1968, Skoog 1968, Carruthers et al. 1983). During years of above average snowfall, a later spring migration is expected whereas low snow depths may prompt earlier migration as occurred in 1983.

Special crossing structures were seldom used by migratory caribou since most structures were outside the crossing zones. The apparent differential use of refrigerated burials in spring versus fall reflects different movement characteristics at these seasons. The more diffuse fall migration (Jakimchuk 1980, Carruthers and Jakimchuk 1981) would entail less contact with special burial sections, which are the most heavily used special crossing structures. In spring, snow depths and the impetus of migration to calving grounds result in more directed and channeled movements along traditional routes (Jakimchuk 1980). Special burials were placed at such locations and, as a consequence, are heavily used during spring. In fall, caribou also follow traditional routes of movement but in a more diffuse pattern and in different terrain. They do not seek out special burial but use it only as they encounter those sections. This accounts for the 30 percent difference in seasonal use of these particular structures between spring and fall.

Caribou crossings of TAPS in relation to pipe mode were highly variable. Where options were available, there was no significant ($p>0.05$) preference for buried or above-ground pipe. However, in spring most caribou crossed south of Hogan Hill where use of special buried sections was higher than elevated sections. However, in the Spring Creek drainage, another major spring crossing site, elevated pipe predominated. In fall, caribou selected buried pipe in one instance within the main crossing zone but otherwise they crossed according to availability of pipe mode. In a few instances (8 pipe transitions) where caribou had a choice of crossing at above-ground or buried pipe, they chose buried pipe most of the time.

Most (>90%) above-ground pipe was higher than 1.8 m (6 ft) and caribou on average crossed at BOP-TOP heights of 2.5 m (8.2 ft). An average prime adult bull caribou measures 1.1 m (43 in) at the shoulder and with antlers would stand approximately 1.8 m (6 ft) to the top of its antlers. Less than 10 percent of above-ground pipe is lower than 1.8 m. The distribution of BOP-TOP height was so uniform that selection for a particular BOP-TOP could not be determined. Since caribou crossed at a wide range of BOP-TOP height and, on average, crossed at the median pipe height, we do not feel that caribou selected for a specific range of BOP-TOP heights. The general absence of paralleling behavior on the ROW and the range of BOP-TOP height that were crossed also suggest that caribou crossed above-ground pipe as they encountered it.

Comparable data from other studies are non-existent but examples of caribou and moose crossing above-ground pipe support the hypothesis that factors other than pipe height are more important in determining the location of crossing sites (Eide and Miller 1979, Curatolo et al. 1982). Roby (1978) reported a range of BOP-TOP height from 1.1 to 5.1 m (n = 41) where caribou crossed TAPS, but the availability of pipe heights is not presented. Curatolo et al. (1982) reported equivocal data on caribou selection of pipe heights and concluded that topography may have affected choice of crossing sites. Eide and Miller (1979) studied moose crossings in relation to pipe heights and noted inconsistencies between areas and between their study and that of Van Ballenberghe (1978).

Overall, Eide and Miller's (1979) data show that 83 percent of the pipe is above 1.8 m (6 ft) in height and 84 percent of moose crossed at these heights, but their use of an analysis technique described by Neu et al. (1974) has limitations which create inconsistencies in their results. Johnson (1980:65) discussed a serious shortcoming of this kind of technique by pointing out how conclusions are "critically dependent upon the array of components the investigator deems available to the animals." Eide and Miller (1979) and Van Ballenberghe (1978), by using the technique of Neu et al. (1974), assume that all pipe heights are available to moose, but as Johnson (1980) points out, this is seldom the case. Other features of the animal's environment are also important and the operation of a hierarchical selection process would invalidate this assumption. The inconclusive nature of studies on choice of BOP-TOP heights by caribou and moose reinforces the hypothesis that other factors are more important (Eide and Miller 1979, Curatolo et al. 1982). As we have pointed out, snow depth, topography and seasonal migratory orientation are important in the case of the Nelchina herd.

Both Klein (1980) and Geist (1975) have emphasized energetic costs to caribou of "deflected" movements resulting from encounters with man-made obstacles. Jakimchuk (1980) reviewed the supposition that caribou "deflected" by man-made structures are incurring an energy debt and concluded that caribou have a wide tolerance to allow for environmental contingincies. He hypothesized that "deflection" along linear features (natural or otherwise) is part of an energy conservation adaptation consistent with the hypothesis that caribou follow (on average) the path of least energetic resistance.

We found no evidence of caribou being deflected by TAPS. Caribou approached and crossed TAPS on approximately the same bearing as the direction of spring and fall movements, with no change in orientation as they approached TAPS. Upon encountering the right-of-way, most caribou crossed directly, spending less than eight minutes on the ROW. Similar observations have been made for highways and rights-of-way (Carruthers and Sopuck 1982, Gauthier et al. 1984, Miller 1984). McCourt et al. (1974) and Decker (1976) found that caribou followed cutlines such as the TAPS ROW only if the line was approximately ($\pm$ 15^{o}) oriented in the direction caribou were moving. Fall movements of caribou in this study were generally oriented in an east-northeast direction (060^{o} to 092^{o}) whereas TAPS was oriented generally north (005^{o}) or a minimum of 55 degrees off the course of migratory caribou. This would account for the minimal paralleling behavior observed. A similar relationship prevailed in spring.

Klein (1980) and Geist (1975) both refer to increased physiological costs to an animal that is disturbed by threatening stimuli such as pipelines and roads. Klein (1980:523) suggested that sharp breaks in habitats, such as the TAPS ROW, "...may be reacted to with a high level of alarm," and that the "avoidance response" to man-made features is partially associated with predator avoidance behavior.

Caribou and other ungulates encountering different terrain or vegetation features exhibit different behavior than while moving through uniform habitats (Walther 1969, Henshaw 1970, Urquhart 1971, 1972, Miller et al. 1972, Baskin 1974, Curatolo 1975, Surrendi and De Bock 1976, Klein 1980, Jakimchuk and Carruthers 1983). Such behavior is not necessarily "disturbance" related. Jakimchuk and Carruthers (1983) reported higher frequencies of alert (head up) and alarm (running and excitation leaps) behavior when caribou encountered a lake shoreline after travelling over the frozen lake surface. Henshaw (1970), Miller et al. (1972), Curatolo (1975), and Surrendi and DeBock (1976) observed increased frequencies of alert or investigative behavior in caribou as did Walther (1969) in gazelles encountering changes in habitat features, especially in relation to predator threats. Baskin (1974) described how sheep would not leave a corral if snowfall changed the features of the landscape. In each situation the animal is confronted with a new set of stimuli and the subsequent behavior is composed of elements that have significance to the animal's surroundings (Baskin 1974).

Upon entering the ROW caribou foraged along the edges where sedges and horsetails, a preferred forage especially in the fall, were abundant (Miller 1974, 1976, Bergerud 1978, Roby 1978). Snow depth on the ROW was less than in adjacent areas and, as Miller (1974, 1976) and Jakimchuk and Carruthers (1983) have noted, caribou often feed in areas with less snow cover during migration. This behavior is also a function of caribou encountering a different terrain or vegetation feature which permits foraging (Pruitt 1959, Miller 1974, 1984, Jakimchuk and Carruthers 1983).

Although caribou, upon entering the TAPS ROW, spent some time feeding, the most frequent activities were standing and walking. Animals entering the ROW usually stopped and looked up and down the ROW prior to feeding or walking further. Alarm responses were infrequent, with the alert posture occurring most frequently and within the first couple of minutes after entering the ROW.

Alert and alarm behaviors on the ROW are probably related to predator detection and avoidance. Roby (1978) has suggested that wolves learned to use the Dalton Highway on the North Slope of Alaska to ambush caribou, and Miller (1984) has suggested a similar possibility on the Dempster Highway. We observed wolf sign in the study area that generally corresponded to caribou crossing zones, as did Miller (1984), but only carcasses of moose were found on the ROW. Forested areas adjacent to TAPS were not actively searched to locate wolf sign or carcasses. The only opportunity to find evidence of predator activity was during control trail surveys up to 500 m off the ROW, but no carcasses or sign were observed.

Roby (1978) found seven of 12 caribou carcasses within 200 m of the Dalton Highway, three of which were killed on the road. He assumed all were killed by wolves. Miller (1984) found two caribou carcasses within 20 m of the Dempster Highway, both killed by wolves, one after having been hit by a vehicle. These observations suggest that even though wolves may use a highway or ROW to ambush caribou, kills probably occur in adjacent areas. A wolf-caribou encounter was observed which further supports this suggestion. A cow and calf caribou entered the ROW and were alarmed by a wolf (2 excitation leaps). The caribou ran approximately 200 m north on the ROW before exiting to the east. The wolf continued to walk for a short distance along the ROW then moved off to the east. Apparently the TAPS ROW could be used by wolves to locate prey but its use by caribou as escape terrain in the same sense as natural open areas may be limited by its width. In this situation, caribou have greater security in deep snow which limits the mobility of wolves.

The "spatial confinement" of caribou within a narrow zone of open habitat could encourage animals to cross quickly or not to cross if previous experiences with predators were common (see Miller 1984). Neither behavior was observed in this study; instead, we observed alertness in conjunction with a high frequency of standing. Although caribou are known to travel long distances on narrow (<15 m) cutlines through forested areas (Banfield 1974, McCourt et al. 1974, Decker 1976, Riewe 1979, Carruthers and Sopuck 1982), wolves, on the other hand, infrequently travel on unplowed seismic lines in winter, usually crossing directly when encountering the line (Riewe 1979, 1980). Wolves usually create their own travel runs which are often traditional (Mech 1970) but the extent to which they incorporate man-made features is unknown. Both Roby (1978) and Miller (1984) refer to wolves using highways (hard surface) as travel corridors but the distance travelled is not specified and Bibikov (1980) described the use of logging roads by wolves. Although most wolf tracks on TAPS crossed directly, two areas had numerous wolf tracks. We found no evidence that TAPS contributed to increased mortality of caribou through predation.

The present status of the Nelchina herd is largely a function of management efforts. Prior to and during construction of TAPS, the herd was hunted excessively which, along with natural sources of mortality, caused the herd to decline (Doerr 1980). Upon restricting human harvest of the herd and controlling wolves, the herd began to increase (Bergerud et al. 1984). Since 1973 the herd has increasd at an average annual rate of 13 percent, similar to other Alaska caribou herds such as the Western Arctic herd (Davis et al. 1980, $r = 0.14$,) and the Central Arctic herd (Whitten and Cameron 1983, $r = 0.13$). The arrested decline of the herd occurred during the construction and operation of TAPS which bisects the migration routes of the herd.

The herd continues to migrate as it is has done in the past and crosses the TAPS corridor at least twice annually. The evidence from this study shows that environmental influences such as snow and terrain are more important than the Trans-Alaska Pipeline in determining the migration patterns and crossing locations of the Nelchina caribou herd.

7.0 CONCLUSIONS

1. The Nelchina herd exhibits similar patterns of spring and fall migration to that described prior to the construction of TAPS.

2. Spring migration occurs in mid-April from east to west with most crossings of TAPS occurring between Hogan Hill and the Gulkana River.

3) Fall migration occurs in November and December from west to east with most crossings of TAPS occurring between Hogan Hill and Spring Creek.

4) Fall movements are associated with upland topography and vegetation whereas spring movements are associated with lowlands.

5) Special crossing structures are generally located outside of major caribou crossing zones except for two refrigerated burials which were used by 27 percent of caribou mostly during spring migration.

6) Virtually all caribou that encountered TAPS crossed successfully (99.95%).

7) Pipe mode and height did not influence where caribou crossed TAPS ($p>0.05$).

8) Caribou approached and crossed TAPS without significantly changing their direction of travel.

9) Caribou spent most of their time in the fall (an average of 7.6 minutes) walking and standing while on the right-of-way.

10) There was no evidence that wolves were successfully ambushing caribou along TAPS.

12) Factors governing the population size and seasonal distribution of the Nelchina caribou herd are independent of TAPS and have not been affected by the presence of TAPS within the range of the herd.

8.0 RECOMMENDATIONS

This report reflects a post-construction monitoring study and cannot address questions pertaining to the actual construction period.

Future projects must, of course, be specifically evaluated according to their proposed design and the nature of expected interactions with large mammals. Based on the findings of this study we recommend the following for similar future projects:

1) Determine where major (seasonal) caribou movements will intersect proposed pipeline routes. Ths determination should include data over long periods of time (>30 years) and take into account changes in population size.

2) Where major movement corridors are identified, route selection should be aimed at allowing pipe burial without special facilities or construction of elevated pipeline within the BOP-TOP height ranges successfully crossed by caribou in this study.

3) Local snow conditions should be analyzed with respect to deposition, microclimatic modification and frequency of occurrence of above-normal snow accumulation to ensure adequate crossing windows.

4) Human hunting activity in close proximity to pipelines should not be permitted.

5) Elevated big game crossings and sag bends are not necessary as design features to enable successful caribou crossings of elevated pipelines.

LITERATURE CITED

Altmann, J. 1974. Observational study of behaviour: sampling methods. Behaviour 49:227-267.

Banfield, A.W.F. 1973. Effects of a railway to the arctic on northern wildlife. Unpubl. Ms., Can. Wildl. Service, Ottawa. 30 p.

_______________. 1974. The relationship of caribou migration behaviour to pipeline construction. p.797-804. In: V. Geist and F. Walther (eds.). The Behavior of Ungulates and Its Relation to Management. IUCN Publ., New Series No. 24, Morges, Switzerland.

Baskin, L.M. 1974. Management of ungulate herds in relation to domestication. p.530-541. In: V. Geist and F. Walter (eds.). The Behaviour of Ungulates and Its Relation to Management. IUCN Publ., New Series No. 24, Morges, Switzerland.

Berger, T.R. 1977. Northern frontier, northern homeland. Report of the Mackenzie Valley Pipeline Inquiry, Vols. 1 and 2. Minister Supply and Services, Ottawa. 481 p.

Bergerud, A.T. 1974. The role of the environment in the aggregation, movement and disturbance behaviour of caribou. p.552-584. In: V. Geist and F. Walther (eds.). The Behaviour of Ungulates and its Relation to Management. IUCN Publ., New Series No. 24, Morges Switzerland.

_______________. 1978. Caribou. In: John L. Schmidt and D.L. Gilbert (eds.). Big Game of North America. Stackpole Books, Harrisburg, Pa.

_______________. 1980 A review of the population dynamics of caribou and wild reindeer in North America. p.556-581. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.). Second International Reindeer/Caribou Symposium. Direktoratet For Vilt Og Ferskvannsfisk, Trondheim, Norway.

Bergerud, A.T., R.D. Jakimchuk and D.R. Carruthers. 1984. The Buffalo of the North, caribou and human developments. Arctic (in press).

Bibikov, D.I. 1980. Wolves in the U.S.S.R. Natural History 89(6):58-62.

Bos, G.N. 1973. Project Progress Report. Proj. W-17-4, Job 3.7R, Proj. W-17-6, Job 3.1. Alaska Dept. of Fish and Game. p.19-22.

Bos, G.N. 1974. Project Progress Report. Proj. W-17-6, Job 5.31. Alaska Dept. of Fish and Game. p.10-33.

Bos, G.N. 1975. A partial analysis of the current population status of the Nelchina caribou herd. p.170-180. In: J.R. Luick, P.C. Lent, D.R. Klein and R.G. White (eds.). Proceedings of the First International Reindeer and Caribou Symposium. Biol. Papers, Univ. Alaska. Spec. Rept. No. 1, Fairbanks, Alaska.

Cameron, R.D. and K.R. Whitten. 1980. Influence of the Trans-Alaska pipeline corridor on the local distribution of caribou. p.476-484. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.). Second International Reindeer/Caribou Symposium. Direktoratet For Vilt Og Ferskvannsfisk, Trondheim, Norway.

Carruthers, D.R. and R.D. Jakimchuk. 1981. The distribution, numbers and movements of caribou and muskoxen north of Great Bear Lake, Northwest Territories. Renewable Resources Consulting Services Ltd. for Polar Gas Project, Toronto. 144 p.

Carruthers, D.R. and L.G. Sopuck. 1982. Characteristics of caribou trails in relation to an old, unplowed seismic line on winter range, January and Feburary 1982. Renewable Resources Consulting Services Ltd. for Petro-Canada Limited, Calgary. 47 p.

Carruthers, D.R., S.H. Ferguson and R.D. Jakimchuk. 1983. Distribution of the Bluenose caribou herd during mid-winter 1983 in relation to Petro-Canada's exploration lands. Renewable Resources Consulting Services Ltd. for Petro Canada Limited, Calgary. 63 p.

Caughley, G. 1977. Sampling in aerial survey. J. Wildl. Manage. 41(4):605-615.

Child, K.N. 1973. The reactions of barren-ground caribou (*Rangifer tarandus granti*) to simulated pipeline and pipeline crossing structures at Prudhoe Bay, Alaska. Alaska Cooperative Wildl. Res. Unit. Univ. of Alaska, Fairbanks. 49 p.

Cochrane, W.G. 1963. Sampling Techniques. John Wiley and Sons, Inc. Second Edition. 413 p.

Curatolo, J.A. 1975. Factors influencing local movements and behavior of barren-ground caribou (Rangifer tarandus granti). M.S. Thesis, Univ. Alaska, Fairbanks, Alaska. 149 p.

Curatolo, J.A., S.M. Murphy and M.A. Robus. 1982. Caribou responses to the pipeline-road complex in the Kuparuk oil field, Alaska, 1981. Alaska Biological Research for ARCO Alaska Inc. 62 p.

Davis, J.L., P. Valkenburg and H.V. Reynolds. 1980. Population dynamics of Alaska's western arctic caribou herd. p.595-604. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.). Second International Reindeer/Caribou Symposium. Direktoratet For Vilt Og Ferskvannsfisk, Trondheim, Norway.

Daubenmire, R.F. 1959. Plants and their environment, a textbook of plant ecology. John Wiley and Sons, New York, 2nd ed. 421 p.

Decker, R. 1976. Bluenose caribou herd. A report on the aerial surveillance of the 1976 spring migration. Northwest Territories Fish and Wildlife Service. 27 p.

Doerr, J. 1980. Modelling the population decline of two Alaskan caribou herds. p.611-623. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.). Second International Reindeer/Caribou Symposium. Direktoratet For Vilt Og Ferskvannsfisk, Trondheim, Norway.

Eberhardt, L.L. 1981. Comments on transect methodology. p. 17-39. In: F.L. Miller and A. Gunn (eds.). Symposium on Census and Inventory Methods for Populations and Habitats. For. Wildl. Range Expt. Stn., Univ. Idaho, Moscow.

Eide, S. 1980. Annual report of survey - inventory activities. Part II. Alaska Dept. Fish and Game, Juneau, Alaska.

Eide, S. and S. Miller. 1979. Effects of the Trans-Alaska pipeline on moose movements. Alaska Dept. Fish and Game, Final Report PR W-17-10. 27 p.

Gauthier, D.A., W.K. Brown and J.B. Theberge. 1984. Movement and distribution of the Burwash caribou herd relative to the proposed Alaska Highway Gas Pipeline. In: A. Martell and D. Russell (eds.). First North American Caribou Workshop. In press.

Geist, V. 1975. Harassment of large mammals and birds with a critique of the research submitted by Arctic Gas Study Ltd. on this subject. Report to the Berger Commission. Fac. Environ. Design, Univ. Calgary.

Glenn, L.P. 1967. Annual project segment report. Proj. W-15-R-1, Alaska Dept. Fish and Game, 8-12.

Hemming, J.E. 1971. The distribution and movement patterns of caribou in Alaska. Wildl. Tech. Bull. 1, Alaska Dept. of Fish and Game. 60 p.

Hemming, J.E. 1975. Population growth and movement patterns of the Nelchina caribou herd. p.162-169. In: J.R. Luick, P.C. Lent, D.R. Klein, and R.G. White (eds.). Proceedings of the First International Reindeer and Caribou Symposium. Biol. Papers, Univ. Alaska. Spec. Rept. No. 1, Fairbanks, Alaska.

Hemming, J.E. and L.P. Glenn. 1969. Annual Project Segment Report. Alaska Dept. of Fish and Game. Fed. Aid in Wildl. Rest. Project W-15-R-2, Juneau. 41 p.

Henshaw, J. 1970. Consequences of travel in the rutting of reindeer and caribou (*Rangifer tarandus*). Anim. Behav. 18:256-258.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, California. 1008 p.

Jakimchuk, R.D. 1975. Testimony. In: Proceedings at inquiry. Mackenzie Valley Pipeline Inquiry, before the Hon. Mr. Justice Berger, Commissioner. Allwest Reporting Ltd., Burnaby, B.C.

______________. 1980. Disturbance to barren-ground caribou: a review of the effects and implications of human developments and activities. Prep. for Polar Gas Project by R.D. Jakimchuk Management Associates Ltd., Sidney, B.C. 141 p.

Jakimchuk, R.D. and D.R. Carruthers. 1983. A preliminary study of the behaviour of barren-ground caribou during their spring migration across Contwoyto Lake, N.W.T. Acta Zool. Fenn. 175:117-120.

Johnson, L. 1971. Annual report of Survey - Inventory Activities W-17. Alaska Dept. of Fish and Game. p.17-29.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61(1):65-71.

Kelsall, J.P. 1960. Cooperative studies of barren-ground caribou 1957-1958. Dept. Northern Affairs and National Resources, National Parks Br., Can. Wildl. Serv. Wildl. Manage. Bull. Series 1, No. 15. 145 p.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Canadian Wildlife Service, Monogr. No. 3, Queen's Printer, Ottawa.

Klein, D.R. 1971. Reaction of reindeer to obstructions and disturbances. Science 173:343-398.

____________. 1980. Reaction of caribou and reindeer to obstructions - a reassessment. p.519-527. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.). Proceedings of the Second International Reindeer/Caribou Symposium. Direktoratet For Vilt Og Ferskvannsfisk. Trondheim, Norway.

Klein, D.R. and V. Kusyakin. 1982. Distribution and status of wild reindeer in the Soviet Union. J. Wildl. Manage. 46(3):728-733.

Lentfer, J. 1965. Annual Project Segment Report. Proj. W-6-R-5. Alaska Dept. of Fish and Game. p.10-13.

Luick, J.R., P.C. Lent, D.R. Klein and R.G. White (Eds.). 1975. Proceedings of the First International Reindeer and Caribou Symposium. Biol. Papers, Univ. of Alaska, Spec. Rept. No. 1.

Marcum, C.L. and D.O. Loftsgaarden. 1980. A nonmapping technique for studying habitat prferences. J. Wildl. Manage. 44(4):963-968.

McCourt, K.H., J.D. Feist, D. Doll and J.J. Russell. 1974. Disturbance studies of caribou and other mammals in the Yukon and Alaska, 1972. Renewable Resources Consulting Services Ltd. for Can. Arctic Gas Study Ltd. Biol. Rept. Ser. Vol. 5. 245 p.

McGowan, T.A. 1966. Annual Project Segment Report. Proj. W-6-R-6, Works Plan C and W-15-R01, Work Plan L. Alaska Dept. of Fish and Game. p.12-15.

McIlroy, C. 1972. Annual Report of Survey - Inventory Activities. Proj. W-17-5. Alaska Dept. of Fish and Game. p.184-189.

McIlroy, C. 1975. Annual Report of Survey - Inventory Activities. Proj. W-17-6. Alaska Dept. of Fish and Game. p.13-15.

____________. 1976. Annual Report of Survey - Inventory Activities. Proj. W-17-7. Alaska Dept. of Fish and Game. p.19-25.

Mech, L.D. 1970. The wolf: The ecology and behavior of an endangered species. Amer. Mus. Nat. Hist. Press, Garden City, N.Y. 384 p.

Miller, D.R. 1974. Seasonal changes in the feeding behaviour of barren-ground caribou on the taiga winter range. p.744-755. In: V. Geist and F. Walther (eds.). The Behaviour of ungulates and its relation to management. IUCN Publ., New Series, No. 24. Morges, Switzerland.

____________. 1975. Observations of wolf predation on barren-ground caribou in winter. p.209-220. In: J.R. Luick, P.C. Lent, D.R. Klein and R.G. White (eds.). First International Reindeer and Caribou Symposium. Biol. Papers, Univ. of Alaska, Spec. Rept. No. 1.

____________. 1976. Biology of the Kaminuriak population of barren-ground caribou. Part 3: Taiga winter range relationships and diet. Can. Wildl. Serv. Rept. Ser. No. 36. 42 pp.

Miller, F.L. 1984. Some physical characteristics of caribou spring migration crossing sites on the Dempster Highway, Yukon Territory. In: A. Martell and D. Russell (Eds.). First North American Caribou Workshop. In Press.

Miller, F.L., C.G. Jonkel and G.D. Tessier. 1972. Group cohesion and leadership response of barren-ground caribou to man-made barriers. Arctic 25:192-202.

Miller, F.L., R.H. Russell and A. Gunn. 1977. Peary caribou and muskoxen on western Queen Elizabeth Islands, N.W.T. 1972-74. Can. Wildl. Service Report Series No. 40, Ottawa. 54 p.

National Oceanic and Atmospheric Administration. 1971-1983. National Climatic Center, Asheville, N.C. Vol. 57-69.

Neu, C.W., C.R. Byers and J.M. Peck. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Pegau, R.E. and J.E. Hemming. 1972. Caribou Report, Vol. XII. Proj. Prog. Rept. Proj. W-17-2, W-17-3. 216 p.

Pitcher, K.W. 1982. Susitna hydroelectric project, phase I final report, big game studies, volume IV, caribou. Alaska Dept. of Fish and Game. 101 p.

Pitcher, K.W. 1983. Susitna hydroelectric project, phase II progress report, big game studies, volume IV, caribou. Alaska Dept. of Fish and Game. 43 p.

Pruitt, W.O. 1959. Snow as a factor in the winter ecology of the barren-ground caribou. Arctic 12:153-179.

Riewe, R.R. 1979. Interactions between wildlife, trapper-hunters and seismic lines in the Mackenzie Valley region, N.W.T., Canada. Part I Aubry-Colville Lakes. Dept. Indian and Northern Affairs, Environ. Studies No. 9, Ottawa. 114 p.

____________. 1980. Interactions between wildlife, trapper-hunters and seismic lines in the Mackenzie Valley region, N.W.T., Canada. Part II Fort McPherson. Dept. Indian and Northern Affairs, Environ. Studies No. 12, Ottawa. 28 p.

Roby, D.D. 1978. Behavioral patterns of barren-ground caribou of the Central Arctic herd adjacent to the Trans-Alaska Oil pipeline. M.S. Thesis, Univ. Alaska, Fairbans, Alaska. 199 p.

Selkregg, L. 1974. Alaska Regional Profiles. Vol. 1, South-central Alaska. Univ. Alaska, AEIDC, Anchorage, AK.

Siniff, D.B. and R.O. Skoog. 1964. Aerial censusing of caribou using stratified random sampling. J. Wildl. Manage. 28(2):391-401.

Skoog, R.O. 1960. Annual Report of Progress Investigations Project. Proj. W-6-R-1. Report C-2a. Alaska Dept. of Fish and Game. p.176-181.

____________. 1961. Annual Report of Progress Investigations Project. Proj. W-6-R-2. Report C-2a. Alaska Dept. of Fish and Game. p.13-31.

____________. 1962. Annual Project Segment Report. Prog. W Report C-2a. Alaska Dept. of Fish and Game. p.15-33.

____________. 1963. Annual Project Segment Report, Proj. W-6-R-4. Alaska Dept. of Fish and Game. p.18-19.

____________. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. Thesis, Univ. California, Berkeley. 698 p.

Surrendi, D.C. and E.A. DeBock. 1976. Seasonal distribution, population status and behaviour of the Porcupine caribou herd. Can. Wildl. Serv. Mackenzie Valley Pipeline Investigations. 145 p.

Urquhart, D.R. 1971. Caribou distribution and behaviour in relation to a seismic grid. Progr. Rept. No. 2. N.W.T. Fish and Wildlife Service, Yellowknife, N.W.T. 40 p.

Urquhart, D.R. 1972. Oil exploration and Banks Island wildlife. Game Manage. Div., Northwest Territories Govt. 105 p.

U.S. Dept. of Interior. 1972. The environmental setting of the proposed Trans-Alaska pipeline system. Rept. of Spec. Interagency Task Force for the Task Force on Alaskan oil development. U.S.D.I., Washington, D.C. 446 p.

Van Ballenberghe, V. 1978. Final report on the effects of the Trans-Alaska Pipeline on moose movements. Spec. Rept. No. 23. Joint State/Federal Fish and Wildlife Advisory Team. 40 p.

Viereck, L.A. and C.T. Dyrness. 1980. A preliminary classification system for vegetation of Alaska. U.S.D.A., Forest Serv. Gen. Tech. Rept. PWN-106. 38 p.

Walther, F.R. 1969. Flight behaviour and avoidance of predators in Thomson's gazelle (Gazella thomsoni Guenther 1884). Behaviour 34(3):184-221.

Watson, G.W. and R.F. Scott. 1956. Aerial censusing of the Nelchina caribou herd. Trans. N. Amer. Wildl. Conf. 21: 449-510.

Weeden, R.B. 1971. Oil and wildlife: a biologist's view. Trans 36th N. Amer. Wildl. and Nat. Res. Conf. p. 242-248.

Weeden, R.B. and D.R. Klein. 1971. Wildlife and Oil: a survey of critical issues in Alaska. Polar Record 15(97): 479-484.

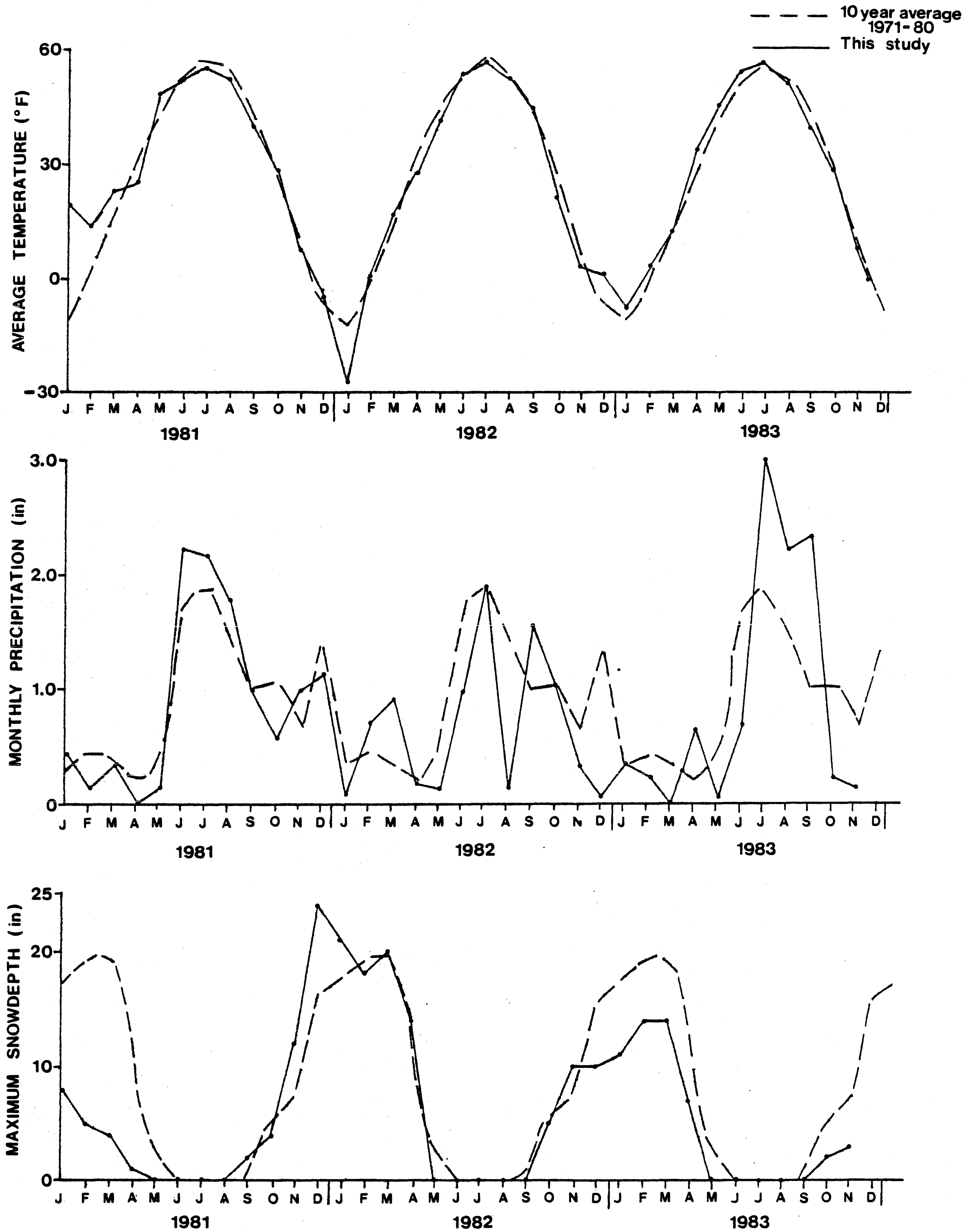
Whitten, K.R. and R.D. Cameron. 1983. Population dynamics of the Central Arctic herd, 1975-1982. Acta Zool. Fennica 175:159-162.

Zar, J.H. 1974. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, N.J. 620 p.

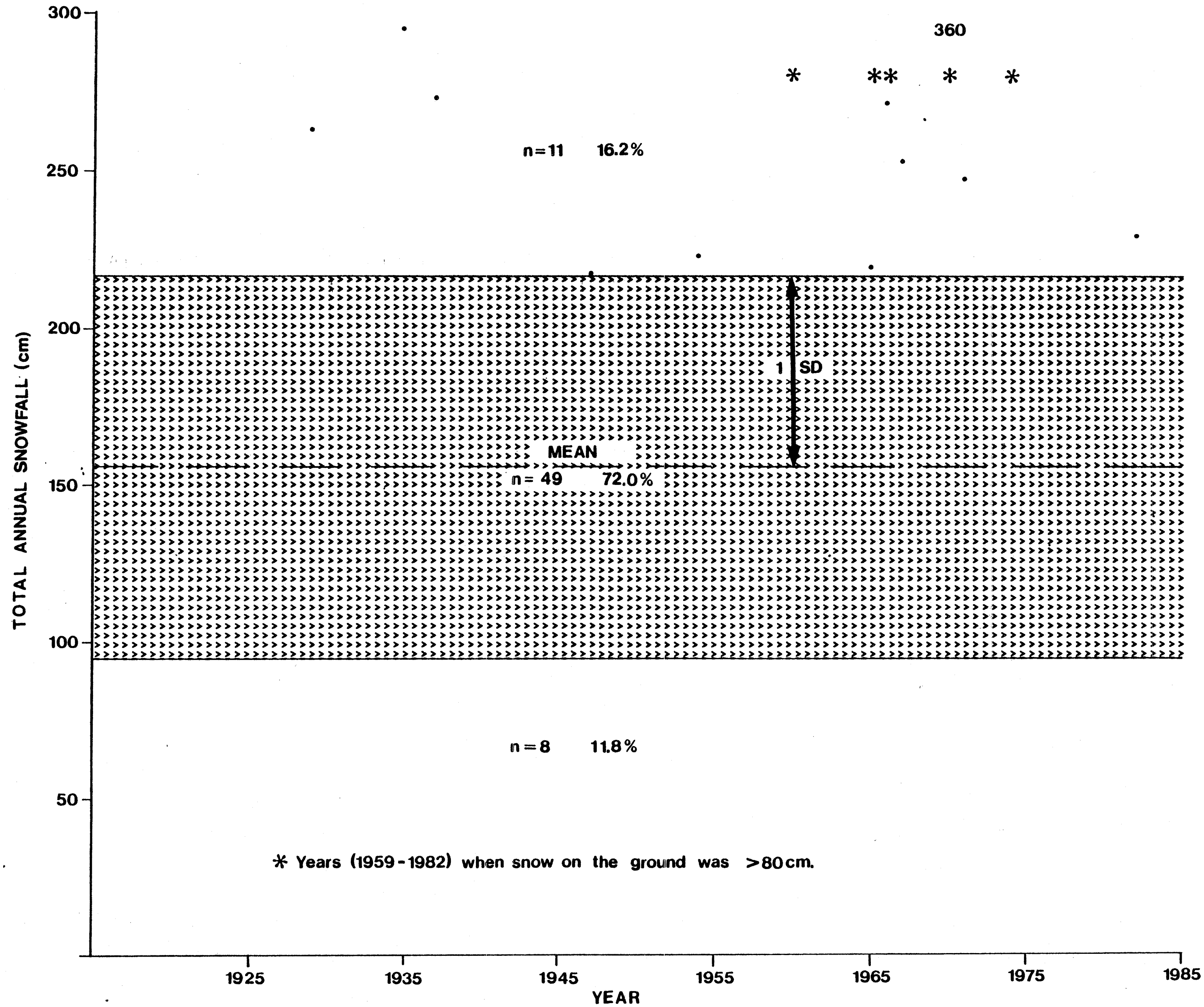
PERSONAL COMMUNICATIONS

J.E. Hemming	U.S. Bureau of Land Management
K.W. Pitcher	Alaska Department of Fish and Game
B. Chimielowski	Resident, Sourdough area.
Alyeska Security	Glennallen, Alaska.

APPENDICES



Appendix 1A. Temperature and precipitation summaries, Gulkana 1981-1983 and 10-year average 1971-1980.



Appendix 1B. Frequency of occurrence of annual snow falls greater than 217 cm (85 in) between 1916 and 1982 and snow-on-the-ground greater than 80 cm (31 in) between 1959 and 1982. (Fairbanks).

Appendix 2. Widths of TAPS Right-of-way, MM 623.5 - 661.0.

AREA	WIDTH (meters) Mean	± S.E.	n
Buried			
623.5 - 624.1	45.2	7.7	2
636.7 - 637.0	35.0	-	1
637.7 - 639.2	35.8	1.4	4
640.3 - 642.1	48.8	9.0	5
642.5 - 644.3	34.3	2.0	6
644.8 - 649.2	34.7	0.8	13
652.0 - 653.5	35.6	1.2	4
Sum of Buried	37.5	1.6	35
Above-ground			
624.1 - 632.0	27.9	0.9	23
632.0 - 636.6	27.6	1.2	14
637.0 - 637.7	25.6	0.7	3
639.2 - 640.3	34.5	4.3	3
642.1 - 642.5	31.8	6.4	2
644.3 - 644.8	22.0	-	1
649.2 - 652.0	25.0	0.6	10
654.7 - 661.0	26.3	0.5	19
Sum of A/G	27.2	0.5	75
Above-ground and Buried	30.5	1.2	110

Appendix 3. Timing of field activities in the Nelchina study area, 1981-1983.

	1981					1982			1983				
DAY	APR	MAY	OCT	NOV	DEC	FEB	APR	NOV	MAR	APR	AUG	OCT	NOV
1		O/P		B	P/F					O			
2				B	A					O			
3				B	O/A					O		O	
4				B						O/P		O/B	
5				O						O/P			
6				O			O						O
7				B			O						O
8				B			O						O
9							O						P
10													P
11				A									
12													
13													
14													
15													
16													
17								O					
18						A		O					
19						A		O					
20								O/P				O	
21								O/P				O	
22	A		O					O				O	
23								O					
24	O/P		B										
25	O/P		B										
26	O/P		B								V		
27	O/P		B	O/F							V		
28	O/P		B	O/F							V		
29	O/P		B	O/F							V		
30	A		B	O/F					O				
31			B	O/F					O				

A = Aerial surveys
B = Behavioral observations
0 = Corridor surveys
P = Control surveys
F = Forward- and back-tracking
V = Vegetation sampling

Appendix 4. Glossary of terms.

DISTURBED:

Referring to land that has been physically altered through man's activity where vegetation cover has not stabilized (excludes burned areas).

CROSSING SUCCESS:

A successful crossing of TAPS by caribou was defined as any caribou that approached the pipe on one side (either buried or above ground) and moved across to the other side.

A crossing was unsuccessful when a caribou approached the pipe on one side and failed to cross the pipe to the other side.

TRADITION:

A continuity of social interactions over long periods of time (generations) reflecting favorable interaction between caribou and their environment.

ALARM BEHAVIOR:

Alert - standing with head high and ears oriented forward.

Excitation Leap - When a caribou suddenly raised both forelegs off the ground.

Run - A gait causing a moderate to fast rate of movement.

GROUP:

An aggregation of animals where behavior and distance relationships imply a functional unit.

Male - adult male animals only.
Female - adult female and sub-adult animals present.
Mixed - at least one adult male and one female one sub-adult present.

LATERAL MOVEMENT:

When a caribou trail moved laterally from a point where it contacted the TAPS right-of-way or pipe for a distance of more than 25 m.

Appendix 5. Species composition and percent cover of vegetation along TAPS ROW at selected sites, August 1983.

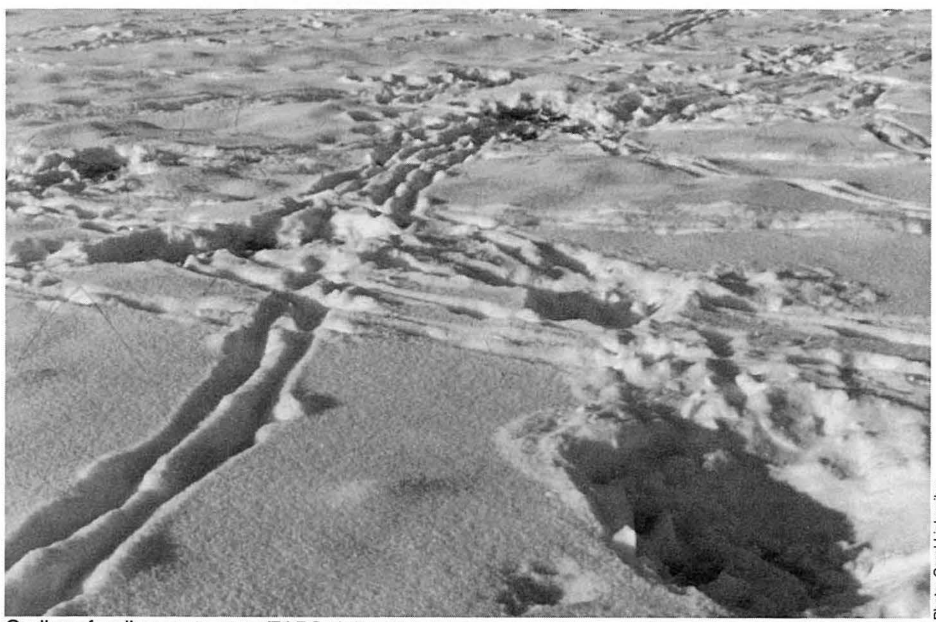
PER CENT COVER

SPECIES	SPRING CREEK A/G			HOGAN HILL A/G			HOGAN HILL B			AMR-1 SPECIAL B			BETWEEN SPECIAL B's A/G			AMR-2 SPECIAL B		
TAPS MM	635.2			646.5			646.5											
	UNDER PIPE	ROW CENTRE	ROW EDGE	UNDER PIPE	ROW CENTRE	ROW EDGE	UNDER PIPE	ROW CENTRE	ROW EDGE	UNDER PIPE	ROW CENTRE	ROW EDGE	UNDER PIPE	ROW CENTRE	ROW EDGE	UNDER PIPE	ROW CENTRE	ROW EDGE
*Arcta red fescue *Festuca rubra*		5.6								10.1	8.3	1.8	8.8	0.8		30.2	19.5	7.0
*Boreal red fescue *Festuca rubra*			36.5	9.5	10.8	9.6	55.5	28.2	23.0									
*Nugget bluegrass *Poa pratensis* / *Sydsport blue *Poa*	0.4	0.4		0.9	1.9	0.2	4.8	2.0	0.1	5.2	2.0		1.3	0.4			5.3	0.2
*Manchar brome *Bramus isermis*			3.7				12.0	4.9					0.2	1.1		8.8	9.8	
*Meadow foxtail *Alopecuris pratensis*			5.3	0.2	6.4	5.1	38.2	15.3	8.6	11.1	1.6	3.5	1.0	3.8	0.2	21.7	19.6	5.2
*Annual rye																		
*Climax timothy *Phleum*															0.2			
Arctagrostis latifolia			1.0			0.5						4.6			4.7			21.5
Willow *Salix spp.*			14.8			6.4	0.3	0.3	24.8			3.4						12.8
Sedge *Carex spp.*						1.5						14.2						11.0
Horsetail *Equisetum spp.*						62.3		9.5	19.6			35.2						13.3

*Alyeska revegetation mix.

1. The TAPS right-of-way with driveable pad and above-ground pipe on vertical support members.

2. Snow-covered TAPS right-of-way at refrigerated burial adjacent to Hogan Hill.



3. Caribou feeding craters on TAPS right-of-way.

4. Caribou trails crossing buried pipe with evidence of feeding along right-of-way edge.