THE DEMOGRAPHY OF YUKON'S FINLAYSON CARIBOU HERD 1982 - 1987

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Yukon
Renewable Resources

Progress Report

The Demography of Yukon's Finlayson Caribou Herd, 1982 to 1987

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1. INTRODUCTION

1.1 Perspectives

Disturbance to Yukon's woodland caribou (Rangifer tarandus caribou) herds, brought about by increasing human developments, require that many of these populations be managed intensively. The management objective for most caribou populations is to balance the survival of calves with the mortality of caribou older than calves to maintain desired numbers for human use. This task is often difficult as caribou populations are characterized by low productivity and high natural mortality (Bergerud 1978b). As a rule there is little surplus for the combined effects of heavy hunting, (in particular unregulated subsistence hunting), and undisturbed predator-caribou interactions. As a result, the influence of human use has generally led to population declines by causing excessive mortality. Due to this factors, downward trends in caribou numbers have been observed in British Columbia (Bergerud 1978a), Alberta (Edmonds and Bloomfield 1984), Alaska (Davis et al. 1978, 1979, Davis and Valkenburg 1985) and Yukon (Farnell and McDonald 1985).

The techniques used to manage caribou have been a subject of concern with often conflicting opinion (C.F. Bergerud 1983, and Van Ballenberge 1985). Yet in the final analysis, the options available to manage caribou populations for a harvestable yield are limited. Factors influencing caribou demography include hunting, predation, forage, climate, disease/parasites, accidents and windchill on calves (Kelsall 1968, Skoog 1968). We believe that among these factors, the chief causes of woodland caribou mortality in Yukon are hunting, made possible by road access, and predation, principally by wolves. This assumption is supported by the findings of other management and research studies on woodland caribou in Canada (Bergerud 1978b; Bergerud and Elliot 1985; Fuller and Keith 1981; Edmonds and Bloomfield 1984; Elliot et al. 1984; Gauthier 1984 and 1986; Page 1985) and on barrenground caribou (Rangifer tarandus granti) in Alaska (Davis et al. 1978, 1979, Davis and Valkenburg 1983a, 1983b, 1985; Gasaway et al. 1983). Wildlife managers, responsible for maintaining caribou numbers at desired levels, can apply direct management strategies to reduce hunter and predator mortality, but have no practical methods to alter the influences of food availability, severe weather, disease and parasites on caribou mortality.

For the purpose of managing woodland caribou, we define a "herd" as a discrete population of animals that inhabit a common winter range (Farnell and Russell 1984). The seasonal movements and distributions of several Yukon caribou herds have been monitored by intensive radio-telemetry studies (Farnell and McDonald 1987a). Findings from this work, and other studies, (Farnell and Russell, 1984; Hatler 1986) indicate a strong home range loyalty for the species. Thus for at present densities at least, major changes in caribou numbers cannot be explained by population shifts between herds as earlier theorized by Skoog (1968) and Haber (1977).

1.2 Background

Presented here are the interim findings from a management program directed at providing a harvestable surplus by increasing the population size of Yukon's Finlayson caribou herd (FCH). The FCH has been studied by the Department of Renewable Resources since 1982, when initial radio-telemetry investigations identified this herd as a major woodland caribou population inhabiting the east-central Yukon (Fig. 1). Demographic studies in 1982 suggested a population size of between 2000-2500 caribou (Farnell 1982). The mean calf percentage in fall was 9.8% and the annual harvest was estimated to be 250 caribou, about 10% of the herd. Native subsistence hunters were taking the majority of these animals during winter from the Robert Campbell Highway which transects the FCH traditional winter range (Fig. 1). Our status assessment predicted that this herd was likely declining by 11% annually due to low productivity combined with high natural and human caused mortality (Farnell 1982).

1.3 Objectives

In 1982, a management strategy was adopted to increase the population size to a level that could sustain the 1982 hunter demand (ie. 5000 animals at 4-5% harvest). The management strategy taken addresses excessive harvest and wolf predation by:

1) restricting the sport hunter harvest to bulls only in Game Management Subzones within the home range of the FCH.

2) effectively encouraging native subsistence hunters to reduce their harvest of FCH caribou and select for bulls.

3) using aerial hunting techniques, annually reducing the regional wolf population to below 30% of the pre-reduction level for a period of five years.

4) guaging caribou population response by monitoring population size, recruitment, and adult natural mortality.

This intensive program provides other caribou managment benefits by:

1) advancing methods to influence the harvest practices of native subsistence users through voluntary and cooperative management programs.

2) developing a reliable means of estimating population sizes, recruitment and natural mortality for woodland caribou.

3) increasing our knowledge of northern woodland caribou/wolf interactions we may refine various management strategies directed to other Yukon woodland caribou herds.

4) testing the hypothesis (Haber 1977) that wolf inter-pack social restraint suppress wolf productivity at higher predator-prey equilibrium densities we may in the long-term verify that higher prey equilibriums will support true harvestable surpluses with no predator management, (Van Ballenberge 1985).

Two papers discussing results from this project were presented at the 3rd. North American Caribou Workshop, help at Chena Hotspring, Alaska on November 3-5, 1987. The paper entitled "The Influence of Wolf Predation on Caribou Mortality in Yukon's Finlayson Caribou Herd", by R. Farnell and J. McDonald, assessed factors limiting population growth in the FCH. The paper entitled "Utility of the Stratified Random Quadrat Sampling Census Technique for Woodland Caribou" by R. Farnell and D. Gauthier, discussed the reliability of estimate derived census over the total count technique. Both manuscripts were submitted for presentation in the workshop proceedings and their abstracts appear in Appendix IV.

2. STUDY AREA

2.1 Physiography, Vegetation and Climate

The 19,000 km^2 study area corresponds to the home range boundary of the FCH in east-central Yukon (Fig. 1), and is roughly bordered by the North Canol Road to the west, the St. Cyr Range of the Pelly Mountains to the south and the Logan Range of the MacKenzie Mountains to the north and east. Oswald and Senyk (1977) provide detailed descriptions of this area, which forms portions of the Pelly River, Mayo Lake-Ross River and Itsi Mountains ecoregions. Most of the FCH winter range lies in the Pelly Plateau and Tintina Trench, where the terrain consists of rolling upland plateaus, hills and small tableland mountain groups separated by generally broad U-shaped valleys. Valleys are vegetated by open black spruce (Picea mariana) and lodgepole pine (Pinus contorta) forests. Well-drained upland areas are dominated by white spruce (Picea glauca) and aspen (Populus tremuloides) forest. Paper birch (Betula papyrifera) is scattered throughout the lowlands and alpine fir (Abies lasiocarpa) is common in the subalpine. Lakes are common in the central study area, providing important travel areas for wintering caribou and wolves.

The St. Cyr Range in the southern study area is moderately high relief over 1500 m. The extensive subalpine zone is found from valley floors to 1350 m and is mainly vegetated by dwarf birch (Betula sp.) and willow (Salix sp.). Lichens, sedge (Carex sp.) tussocks, ericaceous shrubs and willow dominate the alpine tundra (Oswald and Senyk 1977).

The southern flank of the Logan Range, which forms the north and eastern portion of the study area, is characterized by rugged high peaked mountains. Most terrain is above treeline (1350-1500 m) and subalpine willow and birch form the prevalent communities.

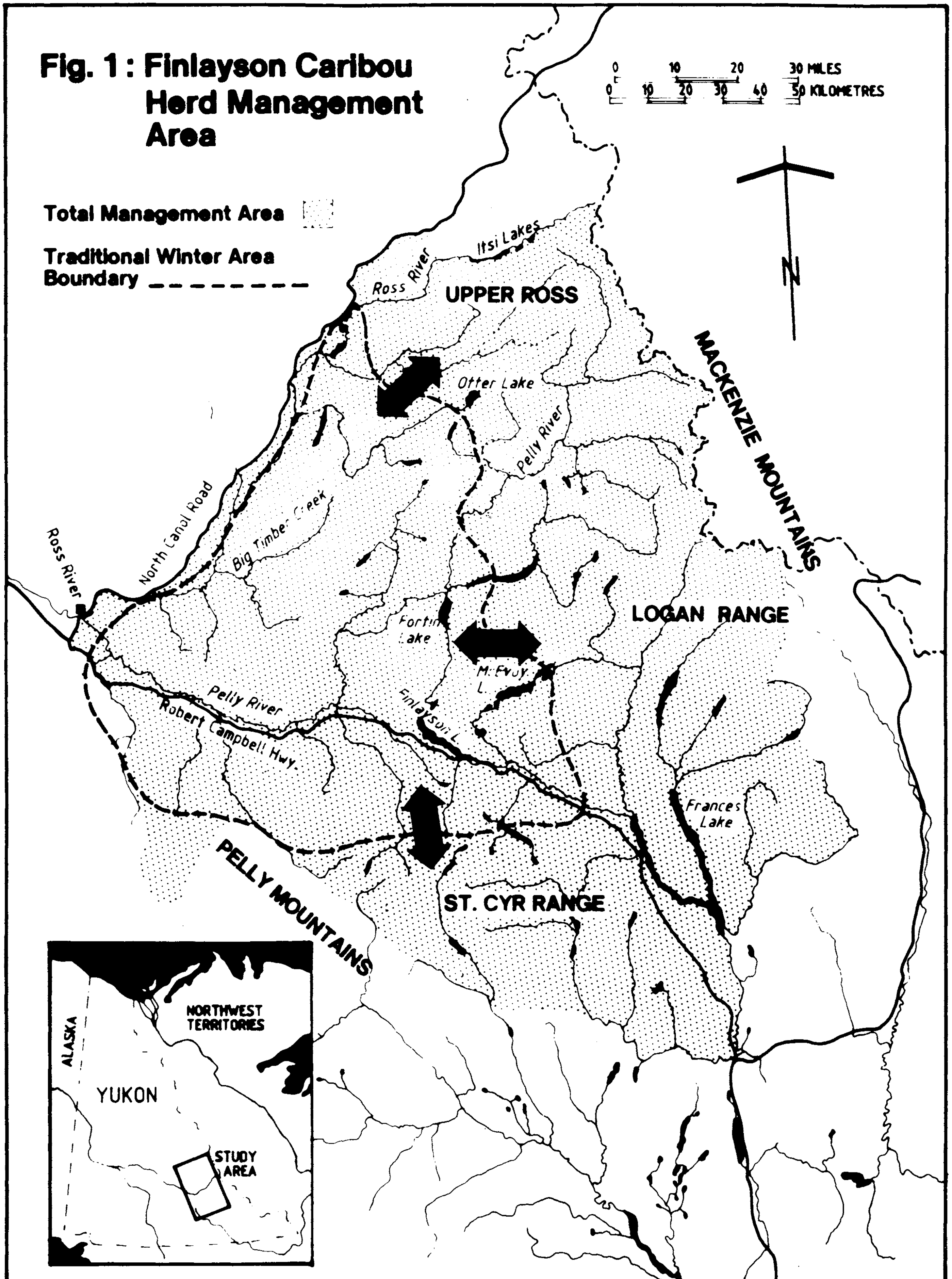


Fig. 1: Finlayson Caribou Herd Management Area

Precipitation increases from southwest to northeast in the study area. The St. Cyr Mountains receive about 400-500 mm annually and the northeastern study area receives 750 mm in the Logan Mountain foothills (Oswald and Senyk 1977).

2.2 Ungulate Populations

The FCH is the only caribou population in the study area. Seasonal movements and distribution patterns of the FCH are characterized by a traditional winter range located within the Pelly River - Ross River lowlands (Fig. 1). During spring migration the herd disperses from this winter range over a 180^{o} arc to mountainous calving sites and summer ranges in three relatively distinct regions. The St. Cyr region generally contains about two-thirds of the FCH from spring to fall; the Logan Mountain and upper Ross regions contain the remaining caribou. Rut takes place during early October along alpine plateaus in juxtaposition to summer and winter ranges. The annual return of caribou to the winter range varies with weather conditions, but usually occurs sometime between November and January. The seasonal movements and distribution of the FCH have been the subject of intense study since 1982 (Farnell and McDonald, 1987a.).

Moose (Alces alces) are common throughout the study area. During early winter, moose concentrate in post-rutting groups in the subalpine shrub zones of most upper tributaries of the Mackenzie and Pelly Mountains (Farnell and Nette 1981). During late winter, deep snow conditions likely cause moose to move down from the subalpine areas (Markel and Larsen 1982) to lowland riparian and burn areas, often mixing with wintering caribou in the study area lowlands (Farnell and Nette 1981).

A small population of approximately 100 mountain sheep (*Ovis dalli stonei*) inhabit portions of the central St. Cyr Range (Lortie *et al.* 1978).

2.3 Predator Populations

Large predatory mammals in the study area are wolves (*Canis lupis*), grizzly (*Ursus arctos*) and black bear (*Ursus americanus*), coyotes (*Canis latrans*), fox (*Vulpes vulpes*), wolverine (*Gulo gulo*), and lynx (*Lynx lynx*).

3. METHODS

3.1 Study Design

Ideally, population studies should measure the influences of all limiting factors to explain observed population fluctuations, and thus provide a high degree of control over future population trends. Investigations of this scope are limited however, by the practical constraints of measuring some parameters and, in particular, the financial resources available. In consideration of these limitations, our study design incorporated two principal assumptions. They were that; 1) the factors manipulated (human harvest and wolf predation) are the primary factors dictating FCH population dynamics, and that; 2) the influences of all other population limiting factors remain constant over the duration of this study. If our assumptions are correct, then reduced mortality due to hunting and wolf predation should cause the FCH to increase rapidly. We therefore predit, that in the short-term (1-2 years), calf recruitment will improve by increasing and adult natural mortality will improve by decreasing, and in the long-term (5-7 years), subsequent population estimates will detect an increase in herd size. The study therefore proceeded on three fronts:

1) Manipulations - include an assessment of reduced caribou harvest and wolf predation.

2) Effects of manipulations on Caribou Demography - measurements of population size, recruitment, and adult natural mortality were used to guage FCH population response to management actions.

3) Effects of environmental parameters on demography - late winter snow depth and food habits were monitored to assess winter severity and food limitation as limiting factors that are assumed to remain constant over the duration of the study.

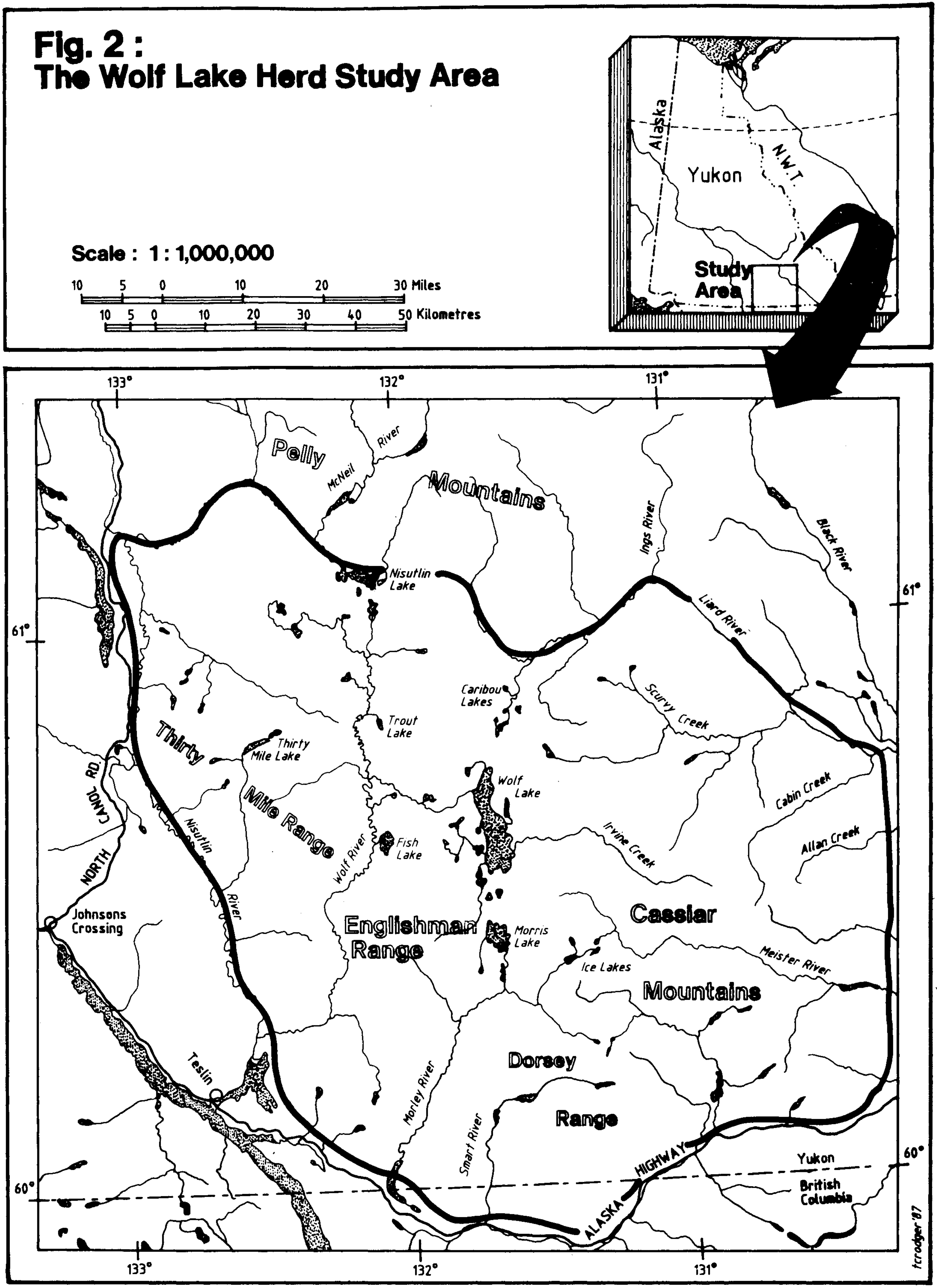
The Wolf Lake caribou herd inhabits an area of similar physiography and climate immediately south of the FCH management area (Farnell and McDonald 1987b), (Fig. 2). Caribou and wolf inventory surveys were flown in the Wolf Lake area incidental to this study in 1985 and 1986. The Wolf Lake herd recruitment, and area wolf population levels provide a non-wolf reduction control for our analysis.

3.2 Manipulations

3.2.1 Caribou Harvest

The harvest pattern for the FCH is characterized by three components:

Fig. 2 : The Wolf Lake Herd Study Area



1) Fall harvest - licensed resident and guided non-resident hunters take caribou over the regular hunting season from August 1 to October 31.

2) Winter harvest - unlicensed native hunters, mostly from Ross River, take caribou during the trapping season (November - March) for their immediate needs while on traplines.

3) Spring harvest - native hunters from all communities hunt during spring break and Easter holiday (generally mid-march and early April) when the entire family can participate in a hunt to secure large numbers of caribou for a stock of summer meat.

An accurate estimate of caribou harvest from the FCH is made difficult by the amount of unregulated native subsistence hunter use. The Robert Campbell Highway, which bisects the herds traditional winter range, provides access to the herd from five, primarily native, communities - Ross River, Watson Lake, Carmacks, Pelly Crossing and Mayo.

The annual period used to determine FCH harvest is August 1, when the regular hunting season begins, to April 30, when native harvest is finished. To the best of our knowledge, no hunting takes place outside of these dates.

Harvest restrictions were uniformly imposed in the fall of 1983. The management action adopted to reduce and alter the composition of harvest from the FCH by non-native hunters was to restrict the bag from "one caribou of either sex" to "one male only" during the regular hunting season (August 1 to October 31), for game management subzones within the home range of the herd. For native hunters, a voluntary harvest reduction and a stronger selection for males was agreed upon, through a series of formal and informal meetings with native bands.

The sparse human population and confined access in the region has made possible calculating the annual harvest by a direct count of all caribou killed. Since the fall of 1983, conservation officers closely monitored the activities of non-native hunters and recorded their kills. The winter native harvest by trappers was recorded by a staff member who patrolled the area from a base of operations located central to these activities. Since 1983, the spring native harvest was determined annually by highway patrols and aerial reconnaissance flights conducted by conservation officers. The data collected represent a minimum count of caribou numbers taken by both non-native and native hunters with no correction for wounding losses (considered low). It is felt that our harvest records are sufficiently accurate for caribou demographic analysis.

3.2.2 Wolf Estimates and Reduction

Estimates of the wolf population size in the FCH management area were made by repeated aerial fixed wing and helicopter surveys during late winter from 1983 to 1987, (Stephenson 1978). This estimate was supported by observations from ground personnel (staff technician) stationed in the area over the winter period.

Wolves have been reduced in the FCH management area in each year from 1983 to 1987. We attempted to remove entire packs by shooting them from a helicopter. Some wolves were harvested by hunters and trappers and contributed to the reduction. Shot wolves were retrieved whenever possible and pelts were skinned, stretched, dried and sold on the open fur market. Carcasses were necropsied to determine condition indices, reproductive history and food habits. A detailed description of wolf inventory and reduction methods, and wolf necropsy results is found in Hayes and Farnell (1985, 1986 and 1987).

A wolf survey was completed in the Wolf Lake area in 1985 to determine the validity of the wolf population as a control for the FCH wolf reduction (Hayes and Bowers 1987).

3.3 Effects of Manipulations on Caribou Demography

3.3.1 Population Size

The population size parameter is an essential need for harvest management, and is difficult to determine for woodland caribou herds. This is largely due to the widely dispersed seasonal movement and distribution behavior of the species. A count during late winter, when the FCH is aggregated within a confined distribution (Appendix I), using a modification of the stratified random block sampling method employed to count moose in Alaska (Gasaway et al. 1985) and Yukon (Larsen 1982), provides a statistically reliable estimate of population size.

Surveys were flown to estimate the size of the FCH during optimal weather conditions (clear skies following a 20 cm snowfall), on March 15 to 22, 1986. The technique entailed three phases: delineation; stratification; and census. The delineation phase involved a fixed-wing survey to establish a survey area encompassing the herds entire late winter distribution. The survey was also supported by a radio-tracking flight to confirm the presence of all radio-collared caribou from the herd within this survey area. The stratification phase consisted of an extensive fixed-wing survey over the entire survey area to classify sample units (SU) averaging 13.8 km^2 into two strata: primary (numerous caribou present) and secondary (few caribou present). The classification of SU's was based on the abundance of tracks and the direct observation of caribou. The census phase involved a thorough (3.7 min./km^2) helicopter survey in all the primary SU's, and a sample of randomly selected SU's in the secondary strata.

Caribou were sexed and aged using the criteria set out by Farnell and Russell (1984). Survey units were systematically surveyed from east to west across the primary strata portion of the herds distribution to reduce the probability of counting caribou twice. The movements of 28 radio-collared caribou were monitored to assess movements during the survey. Two aircraft were used simultaneously for both the stratification and census surveys. To generate an observability correction factor for caribou missed during the 3.7 min/km^2 a subsample within primary SU's was intensively searched at a rate of 11.4 min/km^2. We assume that all caribou were seen on the intensive survey. All data were plotted on 1:50,000 maps. The formula and Hewlett Packard (HP)-97 program developed by Gasaway et al. (1985), were used to finally calculate the population size.

3.3.2 Recruitment and Population Composition

Woodland caribou are socially segregated by sex and age throughout most of the year. Representative composition counts are thus difficult to obtain. Counts made during the fall breeding season, when the herd is most homogeneously mixed and calves are easily distinguished from others, provide a relative indicator of calf recruitment but do not provide an absolute measure of population structure. Three potential inaccuracies prevent fall counts from depicting empirical observation of herd structure:

1. Some yearlings and young males are invariably counted as adult females, resulting in inflated numbers of adult females.
2. Males may be disproportionately distributed across the breeding grounds resulting in biases when herd composition surveys are clumped or when sample sizes are small.
3. Not all calves are seen on surveys as they are eclipsed by adults.

The result of potential inaccuracies serve to underestimate calf percentages and conceal true offspring abundance. Therefore changes in calf percentages should be used to identify trends in recruitment and not absolute changes in abundance.

Calculation of unbiased sex and age ratios were obtained during the FCH population estimate in March 1986, and provided our best estimate of actual recruitment (10 month olds) and population structure. The percentage of calves in March 1986, was compared to the preceeding October 1985 estimate to assess the minimum degree to which recruitment is underestimated during fall, given no mortality between periods.

A preliminary fixed-wing radio-tracking survey was flown to relocate radio-collared caribou during the breeding season in October. A helicopter was then used to classify a sample of caribou across the entire herd distribution, as determined by the radio-collar relocations. Caribou were distinguished as adult female, calf, yearling, immature bull, or mature bull using the characteristics described by Farnell and Russell (1984). Classification counts were made from helicopter overflights on small groups (less than 50 caribou) and from the ground with 20X spotting scopes on large groups. Counts were recorded with hand-held, multiple-place tally registers. Fall composition counts were conducted annually from 1982 to 1986.

Fall composition surveys employing identical timing and methods were conducted on the Wolf Lake caribou herd in 1985 and 1986 (Farnell and McDonald 1987b). The Wolf Lake herd recruitment levels were used as a control in our assessment of FCH response to wolf reduction.

3.3.3 **Adult Natural Mortality**

During this study, 52 radio-collars were placed on a sample of mostly adult female caribou (4 males, 48 females), (Farnell and McDonald 1987a). To ensure an adequate sample size, we deployed 18 radio-collars during late winter 1982, four in 1982, and 10 each year in the late winters of 1984, 1985 and 1986. These caribou were all captured by the net-gun capture method (Farnell and Russell 1984, Barret et al. 1982). Caribou were not predisposed to predation as a result of the use of drugs. Radio-collars were constructed of heavy machine belting to which hermetically sealed transmitters were attached, and most radios contained movement sensitive mortality switches (Telonics Inc., Mesa, Arizona). A highly visable vinyl covering was sewn to each radio-collar.

Radio-collared caribou were relocated from fixed-wing aircraft (C-185 and C-206) from 1982 to 1987 during four lifecycle periods: calving (early June), post-calving (mid-July), rut (early October) and late winter (early March). When a mortality was detected audibly or by virtue of a stationary signal between flights, the site was accessed by helicopter and we attempted to determine the cause of death.

The natural mortality rate (excluding man-caused mortality) of adult female caribou was calculated using a formula derived by Gasaway (1983). Animal periods are used to estimate mortality rather than actual numbers of individuals, as caribou were not always observed for complete periods (ie. transmitter failures). The formula underestimates mortality rates if there is a seasonal peak in mortality at the end of the observation period, or if radio transmitters fail. Because the formula averages out mortality over the entire observation period a seasonal peak at the beginning of the period will magnify the rate and cause mortality to be overestimated. The method in all probability does not reflect the true natural mortality rate of all non-calf sex and age classes but does reflect trends. We acknowledge that our radio-collar sample is small in relation to FCH population size, but it remains our best evaluation of this important parameter.

3.4 Effects of Environmental Parameters on Caribou Demography

3.4.1 Winter Severity

Winter severity is an important factor affecting caribou survivorship, (Russell and Martell, 1984), and snow conditions become increasingly severe for caribou as winter progresses. A comparison of the severity among winters was assessed by sampling the late winter snowdepth, at 8 permanent stations along the Robert Campbell Highway, which served as an east-west transect across the winter range of the FCH (Fig. 1). The depth of snow on the ground was measured between 5 and 12 March from 1983 to 1986. Snowdepth data collected by Water Resources of Canada at Ross River between 26 February and 5 March, from 1975 to 1985, was used to compare the severity of winters during the study period with the decade average. The snowdepth at Ross River is also indicative of snow conditions on the FCH winter range. Because the depth of snow on the ground in

March generally decreases by April (8% or 3.5 cm), March levels probably represent the maximum average snowdepth condition influencing caribou movement and activities.

3.4.2 Food Habits

The composition of the late winter diet can provide a crude evaluation of the range condition (Martell and Russell 1987) when combined with food availability (snowdepth). The late winter food habits of the FCH were examined by composite fecal sample collections made at various locations within the herd's winter distribution during all years of the study. Each composite sample contained 20 fecal pellets, one from each of 20 fresh pellet groups.

Fecal samples were analyzed at the Composition Analysis Laboratory at Colorado State University, Ft. Collins. The relative density of plant fragments was based on 100 fields per sample. The microhistological analyses of caribou samples were tabled, indicating the percentages for each category. The accuracy of fecal analysis is influenced by differential digestion among the major food groups (Holechek et al. 1982), and is a qualitative estimate of the late winter diet rather than actual proportions ingested. The rumen turnover rate for caribou during winter is about two days (White and Trudell,1980). Therefore, fecal collections should be representative of the food intake for 20 caribou, each over a much broader area than the actual collection sites. A dietary comparison was made between the FCH and the highly productive Porcupine herd to assess relative range quality.

4. RESULTS

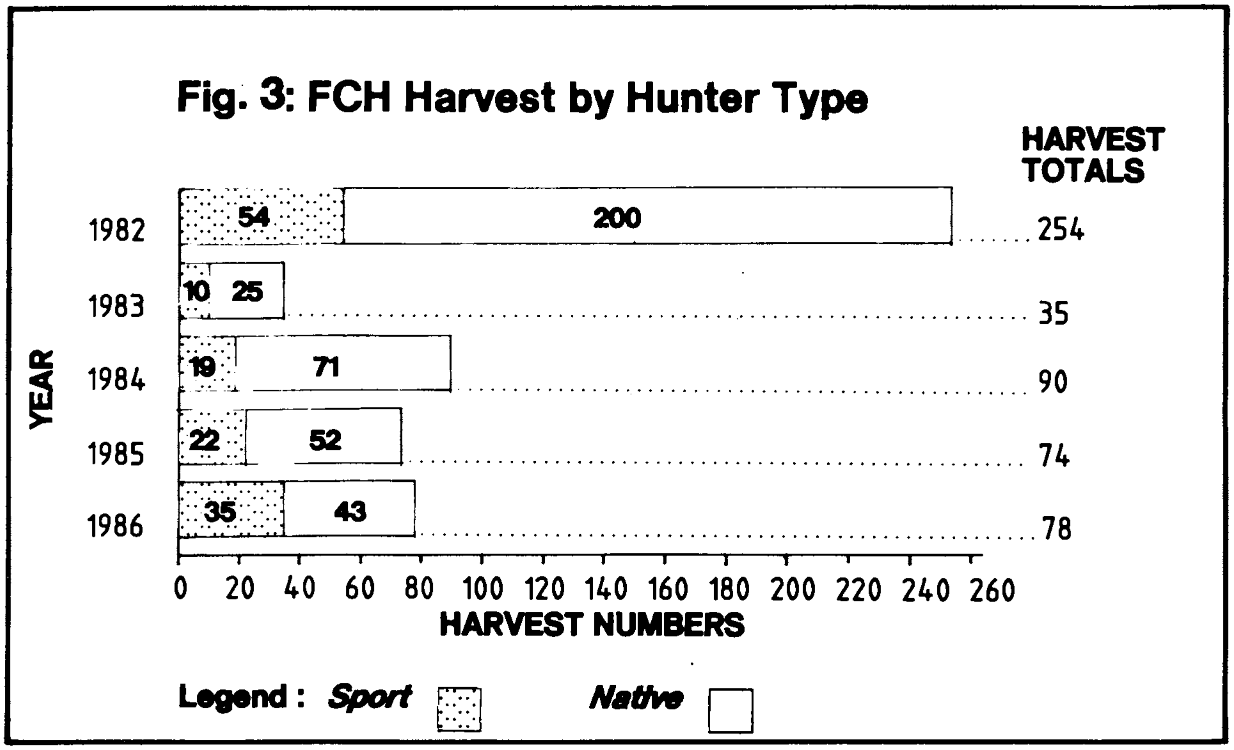
4.1 Manipulations

4.1.1 Harvest

Since harvest reductions were implemented in 1983 the annual harvest has decreased by 73% and has averaged 69 (31% non-native, 69% native) caribou, (Fig. 3). Since 1983 the composition of the non-native harvest has changed from 78% male/22% female (Farnell 1982) to exclusively male caribou. Interviews with native hunters indicated that the composition of their harvest was mostly female caribou prior to 1983, but since establishing a cooperative management scheme with the principal Indian Band, the composition of the native harvest changed to about 50% males/50% females by the 1985-86 harvest period (Hammond Dick, Band Chief pers. comm.).

We are satisfied that this reduction in harvest will contribute substantially to increase adult female survivorship and subsequently herd growth through increased calf production. To further restrain harvest from present levels could lead to an unknown degree of

Figure 3. FCH Harvest by Hunter Type



illegal kill by non-natives and/or a breakdown in communication with native groups. The present level of harvest therefore should be viewed as a pressure valve moderating demand for the interim period required to meet the project's stated goal.

4.1.2 Wolf Estimates and Reduction

Initial wolf densities in the study area (11.3 wolves/1000 km^2) were similar to those reported in central Alaska (Gasaway 1983, and Haber 1977), and elsewhere in Yukon (Hayes et al. 1985). Our reduction efforts were not uniformly effective until after the second year of wolf removals in 1984, when the wolf population was suppressed to 16% of the pre-reduction level (Table 1), (Appendix II). Since then the wolf population has recovered at a fairly constant rate ($x = 2.50 \pm .10$) and well above the intrinsic rate of increase (1.15 to 1.46) calculated by Keith (1983). The rate of increase in the wolf population has accellerated as wolf numbers declined because it takes fewer individuals to give a greater change in proportions at extremely low population levels. Ingress undoubtedly played a major role in wolf population recovery, however, and since 1984 has necessitated an average annual removal of 49 wolves to maintain an average density of 1.77 wolves/1000 km^2 after removals. The intensity of our reduction efforts have remained relatively constant over the duration of the study and probably represent the optimal return for effort spent. To further reduce this wolf population beyond the levels achieved since 1984 would likely require a substantial increase in effort.

Table 1. Wolf population removal data and status for 1983 to 1987 (see also Hayes and Farnell 1984, 1985 and 1987).

Date	No. Wolves Alive	Dead	% Wolves remaining	Density /1000 km^2	Recovery Rate
1983:					
before removals	215	-	-	11.3	
after removals	110	105	51	5.5	
1984:					
before removals	140	-	-	7.3	1.27
after removals	34	106	16	1.8	-
1985:					
before removals	83	-	-	4.4	2.44
after removals	34	49	16	1.8	-
1986:					
before removals	83	-	-	4.4	2.44
after removals	31	52	14	1.6	-
1987:					
before removals	82	-	-	4.3	2.64
after removals	37	45	17	1.9	-

We are confident that a substantial wolf reduction has been achieved. In addition to our surveys, other sources of information verify the conclusion. Investigations linked to this study and aimed at studying the demographics of a suppressed wolf population have shown a significant decrease (P 0.05) in mean pack size, an increase in the incidence of male/female pairs, a dramatic decrease in the incidence of pups, and an increase in the proportion of young aged adult (3 years old) wolves, (Hayes and Farnell, 1987). These characteristics are indicative of a depressed population, and representative of a 'sink' re-colonized by dispersing wolves (Hayes and Farnell, 1987). The magnitude of the wolf reduction is also supported by the observations of virtually all trappers in the study area who have reported a profound decrease in the incidence of wolves on their traplines. Outfitters and native hunters have also found wolves to be sparse within the study area since the initiation of wolf reductions.

Wolf reduction activities in the Finlayson management area appeared to have little measurable effect on reducing adjacent wolves in the range of the Wolf Lake caribou herd (Hayes and Bowers 1987). Wolf surveys flown in this area during 1985 found a density of 9.3 - 10.5 wolves/1000 km^2 (Table 3). This density compares very closely to the 1983 Finlayson pre-reduction density of 11.3 wolves/1000 km^2 (Table 1), and was twice as great as the Finlayson pre-reduction density (4.4 wolves/1000 km^2) during the winter of 1985. We conclude from Hayes and Bowers (1987) survey results that the influence of wolf predation on Wolf Lake caribou herd demography was likely not affected by Finlayson wolf reductions, and was representative of undisturbed wolf-caribou interactions.

4.2 Effects of Manipulations on Caribou Demography

4.2.1 Population Size

4.2.1.1 A survey area of 1182 km^2 was established within the Pelly and Ross River lowlands (Fig. 4). Radio-tracking flights confirmed the presence of all radio-collared caribou (n=28) within this area. Intensive aerial reconnaissance for wolf control immediately prior to this survey (February 26 to March 13) did not locate caribou or recent caribou sign outside of this area.

The survey area was subdivided into 85 SU averaging 13.8 km^2 in size. When stratified, there were 39 primary and 46 secondary SU, comprising 44% and 56% of the survey area respectively (Table 2). The sampling intensity was 68% with 100% in the primary strata and 41% of the secondary strata being sampled.

The search intensity averaged 3.7 min/km^2 during the census flights. There was no appreciable difference in search intensity between strata during the census. Eight intensive survey areas within SU were selected and flown at three times the survey intensity (11.4 min./km^2) to estimate a sightability correction factor. It was assumed that all caribou were seen in the eight intensive survey areas.

Figure 4. The survey area and survey unit stratification used to estimate the population size of the FCH, March 1986

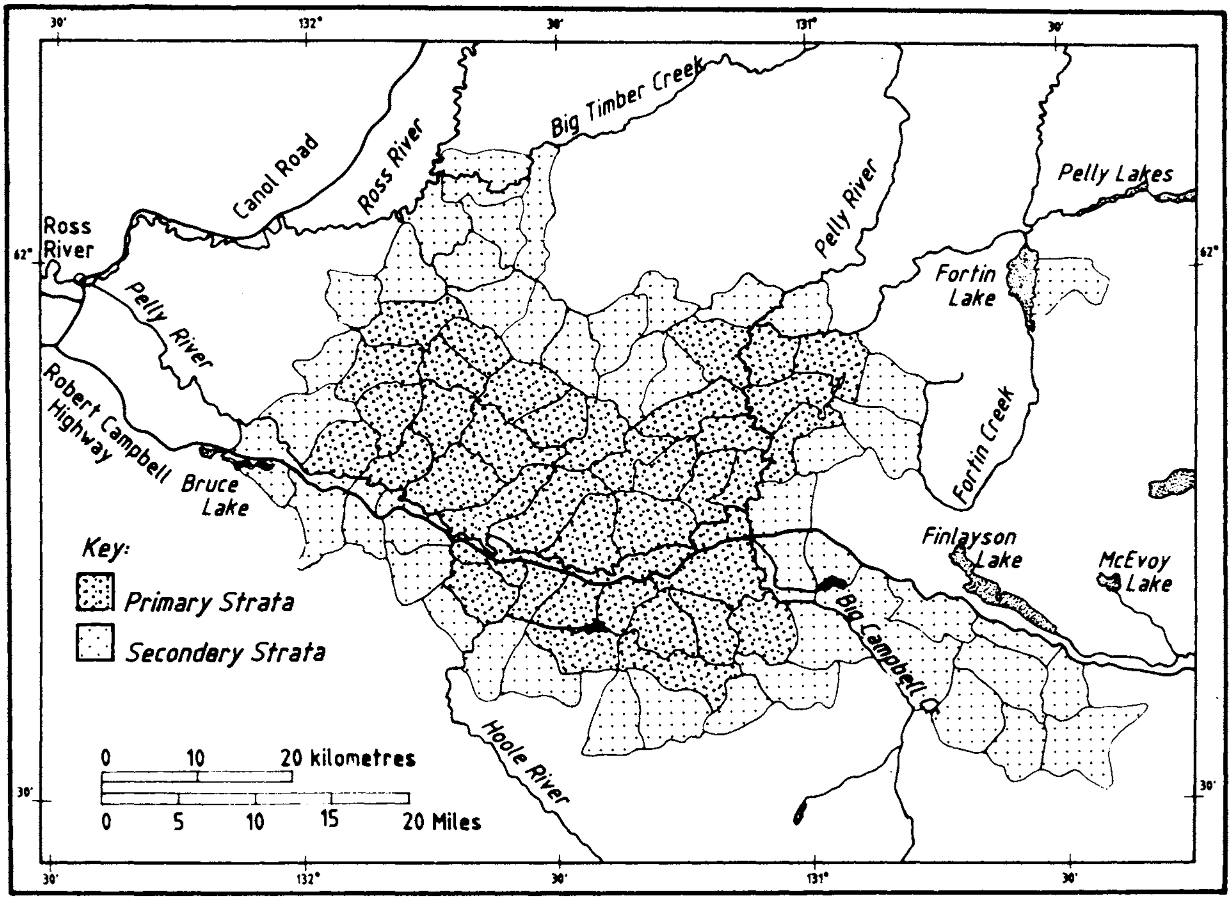


Fig. 4 : The survey area and survey unit stratification used to estimate the population size of the FCH, March 1986.

Even though radio-tracking flights on March 16 and 18 detected movement across SU boundaries for 10 (36%) of 28 radio-collars (Fig. 5), we believe the problems of double counting or missing caribou were low and likely cancelled each other out. SU were relatively large in size (13.8 km^2), thereby reducing the boundary effect, and we surveyed adjacent SU systematically from east to west.

A total of 1767 caribou were counted in the primary strata, and 125 in the secondary strata (Table 2). The estimated population for the survey area was 3067 ± 413 at 95% confidence limits. The estimated sightability correction factor for caribou missed during the survey was 1.49. The random block sampling method of estimating woodland caribou population sizes prove acceptably accurate, cost effective ($48,000, Appendix III), and is presently our method of choice.

Table 2. Summary of caribou survey data for FCH population estimate, March 1986.

Strata	Sample Units Sampled	Sample Units Total	Area (km^2) Sampled	Area (km^2) Total	Caribou Observed	Population* Estimate
Primary	39	39	519.5	519.5	1767	2640
Secondary	19	46	290.0	662.8	125	427
Total Area	58	85	809.5	1182.3	1892	3067 ± 413

* Population estimate from Gasaway _et al._ (1985) with a sightability correction factor of 1.494

Figure 5. Radio-collar movements during the FCH population estimate survey, March 1986.

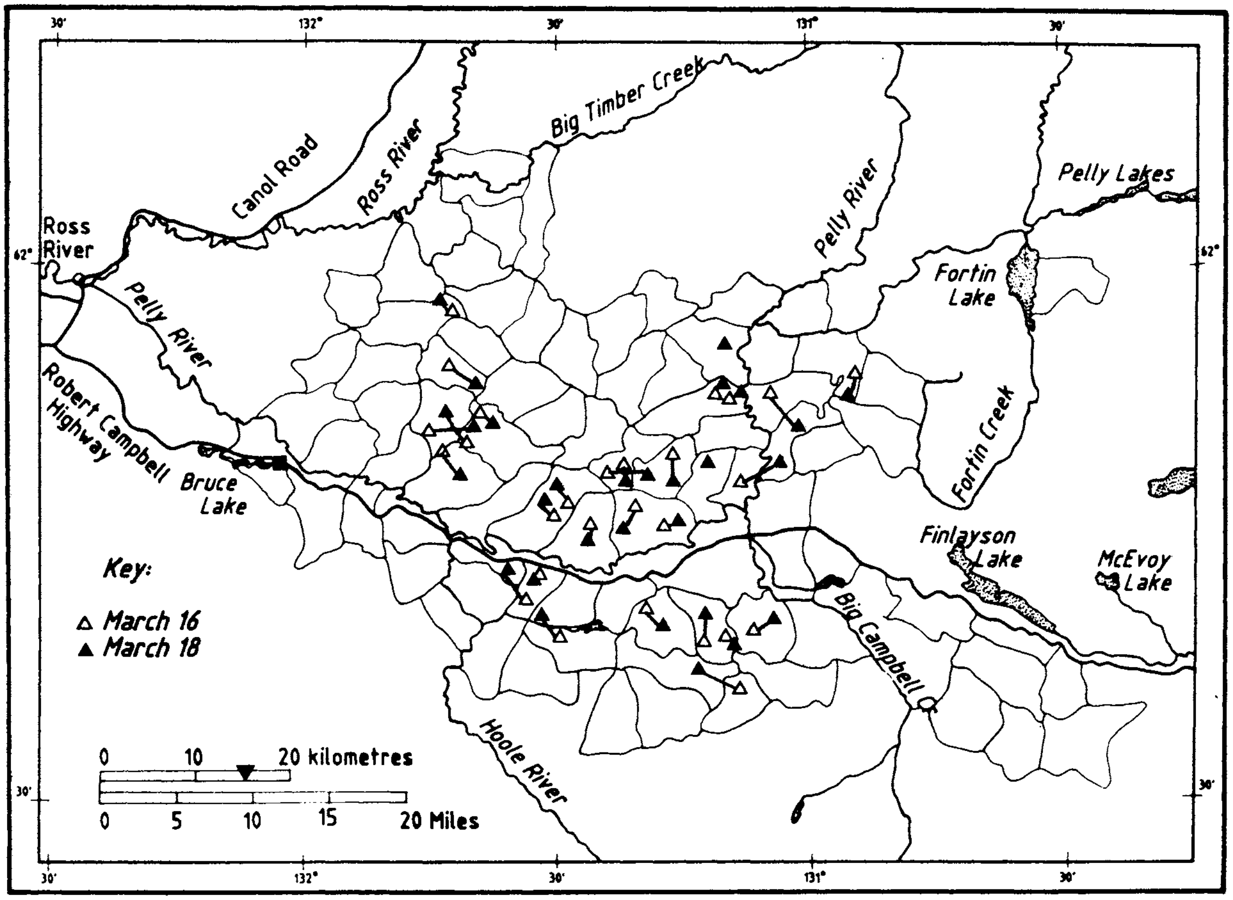


Fig. 5 : Radio–collar movements during the FCH population estimate survey, March 1986.

4.2.2 Recruitment and Population Structure

The percentage of calves in the herd increased during fall counts from 9.8% in 1982 to 14.9% in 1983 after a 49% reduction in wolf numbers (Table 3). When wolf reductions exceeded 84% of pre-reduction numbers from 1984 to 1987, the percentage of calves averaged 20.1%. These percentages represent a 52% and 113% increase in the proportions of calves in the herd during fall in 1983 and after 1984 respectively.

Table 3. Composition of the FCH and Wolf Lake herd during fall surveys, 1982-1986.

	Experimental Area							Control Area
Date	Adult Cows	Calves	Yearling	Bulls	Total	Percent Calves	Calves per 100 cows	Percent Calves Wolf Lake Herd
Pre Wolf Control								
1982	719	121	56	335	1231	9.8	17	-
Post Wolf Control								
1983	330	113	82	234	759	14.9	34	-
1984	611	226	90	305	1272	20.9	44	-
1985	262	131	75	190	658	19.9	50	9.0
1986	454	205	132	256	1047	19.6	45	12.4

Percent calves in the fall was negatively correlated with the late winter wolf densities ($r=-0.97$, $P = 0.01$), (Fig. 6). Wolf reduction, therefore, appeared to improve calf survival.

Figure 6. Relationship between percent calves in the fall and late winter wolf densities.

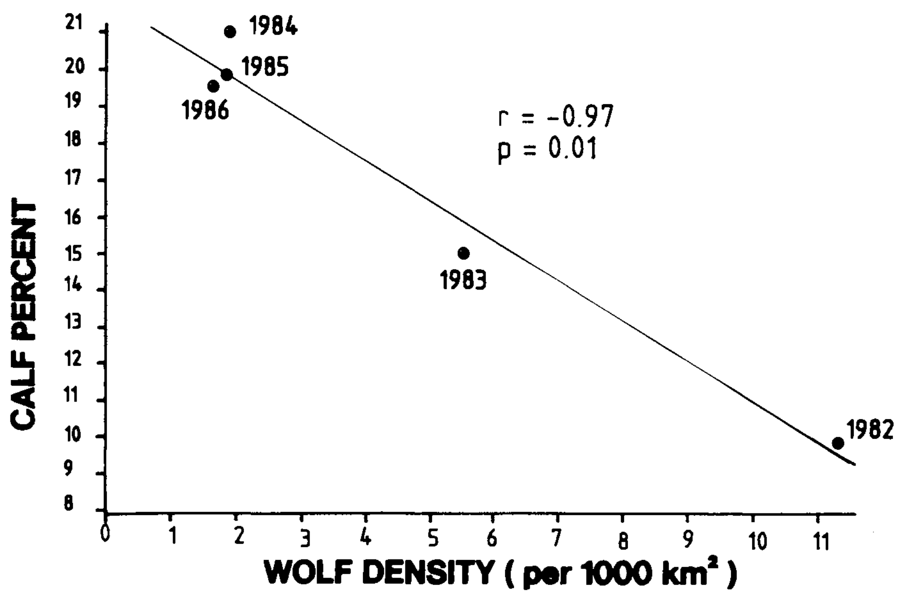


Fig. 6 : Relationship between percent calves in the fall and late winter wolf densities

The percentage of calves in the fall for an adjacent caribou herd, the Wolf Lake herd, was used as a control, as wolves were not disturbed in this area. In 1985 and 1986 respectively the percentage of calves in the fall were 9.0% and 12.4% (Table 3) and were significantly less (P 0.05) (T-test of mean calf proportions) than for the FCH during this period. This finding suggests that the improved calf survival for the FCH after 1984 was not due to a regional woodland caribou demographic trend, and supports our conclusion that wolf reduction improved FCH calf survival.

When compared, the percentage of calves estimated during October 1985 (19.6%) was below and outside the confidence intervals of the mean unbiased percentage of calves calculated later during the March 1986 census (x = 22.1%, range 20.9-23.3%), (Table 4). We expected the percentage of calves during fall 1985 to be greater than that found during March 1986, and given no over winter mortality should have been at least 22.1%. In consideration of this comparison, we conclude that our fall composition counts underestimated recruitment rates. Fall sampling error may have served to underestimate the recruitment of calves by at least 2% of the total population between fall and winter counts, and probably even more considering that some overwinter mortality of calves likely took place. This finding is likely due to observers missing some calves that are eclipsed by adults. In this case, observers needed to miss a mere 13 calves out of a sample of 658 caribou in the fall of 1985 to underestimate recruitment by 2%.

Table 4. The unbiased composition of the FCH calculated from the March 1986 population estimate at 95% confidence level

	Adult Females (22 mo)	Calves (10 mo.)	Adult Males (22 mo)
Corrected no. of caribou	1482 ± 196	678 ± 102	868 ± 175
Percentage of population[1]	48.3 ± 1.7	22.1 ± 1.3	28.3 ± 3.3
Ratio per 100 females	-	45.7 ± 1.7	58.5 ± 9.2

[1] 1.3% were unclassified

Male:female ratios in unexploited or lightly hunted caribou herds are usually about 60-70:100 (Kelsall 1968, Skoog 1968). The male:female ratio calculated from the March 1986 population estimate (58.5/100) (Table 4), is representative of an unexploited population, or indicate that harvesting has been in proportion to the abundance of caribou. We know that the FCH has supported a large kill. The long-term take of caribou from the FCH must therefore have been weighted towards female caribou, as they naturally occur in greater abundance than males. Prior to 1985-86 native hunters selected for female caribou during winter, and we conclude that their harvesting practices must have removed large numbers of females for the male:female ratio to remain that of a lightly hunted herd. The present harvest management scheme encourages the take of males over females to promote herd growth. If this scheme is effective, then we predict that the ratio of males in the herd will decrease somewhat due to hunting.

4.2.3 **Adult Natural Mortality**

The natural mortality rate, excluding hunting of adult caribou has been estimated by tracking the death rate of a small (1% of herd) sample of 52 radio-collared adult females since 1982. In total 20 radio-tracking flights were flown and provided 479 contacts with radio-collared caribou. Not all caribou were observed over complete periods because transmitters failed. But the use of animal periods rather than actual numbers of individuals in Gasaway's (1983) formula eliminates this problem and provides data equivalent to complete records for individuals. Sixteen caribou died from various possible causes over the duration of this study. The calculated rate for the sample of radio-collared caribou prior to wolf reductions was 27.7% (5/18) in the 1982-83 (Fig. 7). The annual mortality rate decreased slightly to 24.2% (3/17) in 1983-84 after supression of wolf numbers to 49% and further decreased to a mean of 11.1% per year from 1984 through 1987 when wolf numbers were further reduced. The mean adult natural mortality of radio-collared caribou has decreased by 60% after a substantial wolf reduction was established in 1984. The adult natural mortality rate of radio-collared caribou decreased significantly (p 0.01) and is positively correlated with the late winter density of wolves (r=0.93) (Fig. 8). Therefore, wolf reduction appeared to improve adult survival by decreasing adult natural mortality.

Predators were implicated in all known mortalities (Fig. 7). Wolf predation was implicated in at least eight (50%) cases, bear predation was attributed to two (13%) cases, and an unknown predator caused one (6%) death. We were unable to determine the possible causes of death in five (31%) cases. There was a seasonal peak in natural mortality as most radio-collared caribou died during spring between March and June (85% n=12/16) than at any other season. Suggesting that woodland caribou may be vulnerable to predation and other natural causes of death following the hardships of winter, and/or when snow conditions become favorable for predators. This seasonal peak in mortality at the beginning of the observation period likely caused adult mortality to be consistently over-estimated in our evaluation.

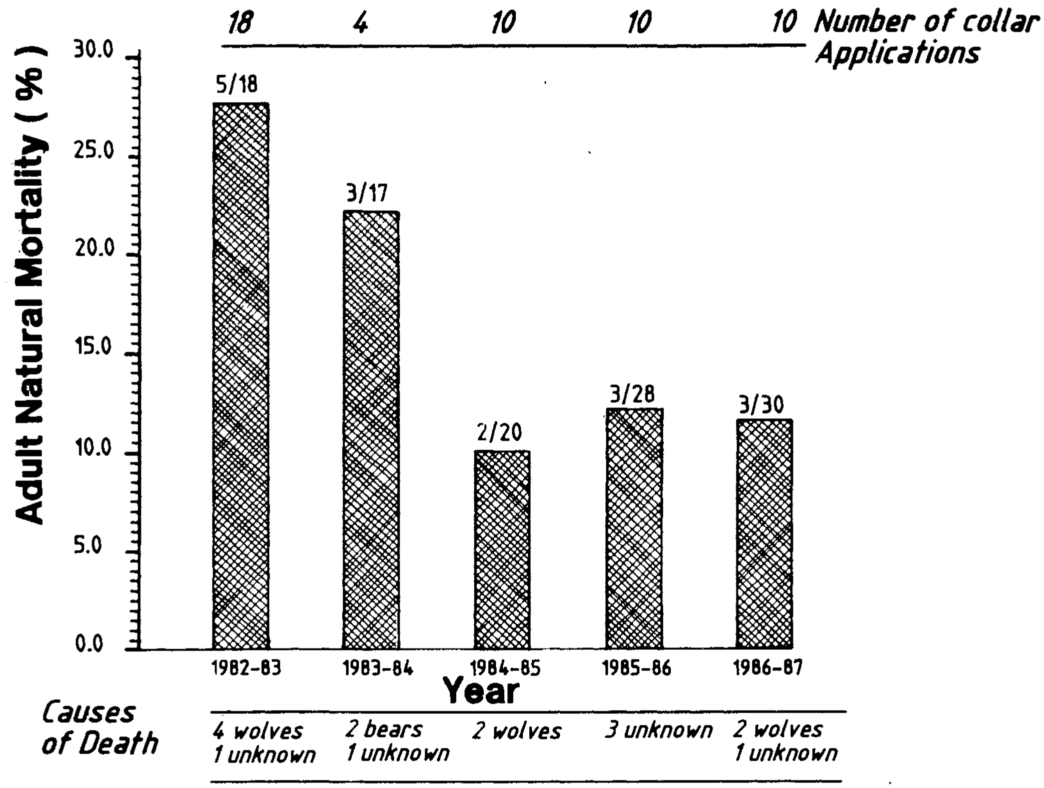


Fig. 7 : FCH Adult Natural Mortality Rate using radio-collar survivorship, March 1982 to March 1987.

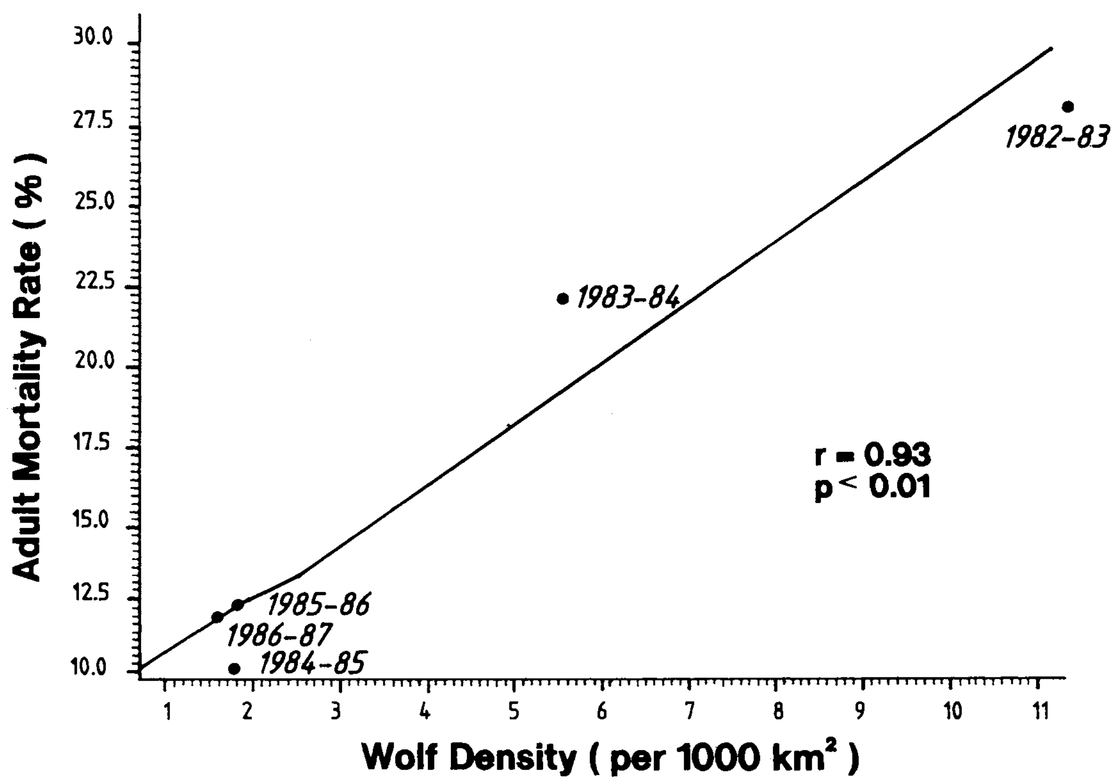


Fig. 8 : Relationship between the adult natural mortality rate and late winter post-reduction wolf density.

4.3 Effects of Environmental Parameters on Caribou Demography

4.3.1 Winter Severity

The late winter snowdepths observed over the study period were favorable for caribou. The mean snowdepth sampled at 8 stations on the FCH winter range was 41.5 ± 11.3 cm between 1983 and 1986, slightly deeper (+4.4 cm) than the 11 year average snowdepth sampled at Ross River by Water Resources of Canada (Fig. 9). The depth of snow on the FCH winter range was less than depths critical for solitary animals to dig craters (50 to 60 cm) and far less than depths critical for caribou herds (80 to 90 cm) (Russell and Martell 1984).

Figure 9.

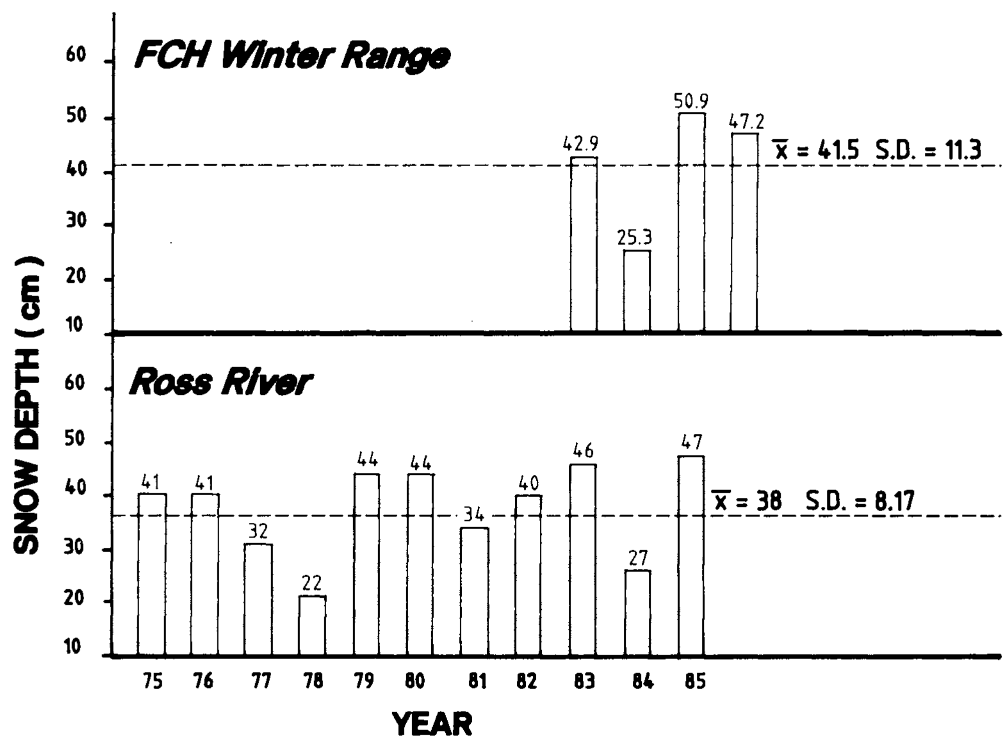


Fig. 9 : The mean snowdepth measurement on the FCH winter range during March, compared to snowdepth data measured at Ross River, Yukon by Water Resources of Canada.

4.3.2 Food Habits

In general, the winter diet of the Finlayson caribou herd, as reflected in fecal samples (Table 5), is similar to that reported for other caribou populations wintering in taiga (Russell and Martell, 1984). The diet was predominantly composed of lichens (primarily

Table 5. Average percentages (+SE) of discerned plant fragment in fecal samples collected from the range of the FCH, 1982-1986, compared to those collected from the range of the Porcupine herd, 1979-82 by Martell and Russell (1987).

Plant genus or Group	Finlayson 1982-1985 n=8		Porcupine 1979-1982 n=15	
Moss		0.83 ± 0.99		7.4 ± 1.50
Fruticose Lichens		62.6 ± 12.3		66.3 ± 3.36
<u>Cetrarai</u> - type	5.1 ± 2.53		12.1 ± 1.76	
<u>Cladonia</u> - type	54.6 ± 16.43		48.4 ± 3.72	
Stereocaulon	2.9 ± 3.74		5.8 ± 1.38	
Foliose Lichens (<u>Peltigera</u>)		10.4 ± 9.35		6.2 ± 2.57
Mushrooms		1.0 ± 2.61		-
Horsetails (Equisetum)		4.4 ± 3.91		2.8 ± 0.68
Graminoids		9.5 ± 6.79		2.4 ± 0.38
<u>Carex</u>	8.6 ± 6.7		1.3 ± 0.32	
<u>Eriophorum</u>	0.3 ± 0.42		0.4 ± 0.29	
<u>Poa</u>	0.6 ± 1.46		-	
Deciduous Shrubs (<u>Salix</u>)		1.8 ± 2.99		2.3 ± 0.54
Evergreen Shrubs		9.5 ± 4.07		12.4 ± 2.63
<u>Dryas</u>	-		0.6 ± 2.3	
<u>Ledum</u>	3.5 ± 2.26		1.1 ± 0.25	
<u>Picea</u>	2.2 ± 1.25		1.3 ± 0.41	
<u>Vaccinium</u>	3.4 ± 2.90		9.3 ± 2.31	
Forbs		0.2 ± 0.40		0.3 ± 0.10

Cladonia - type). Graminoids (grass-sedge) were the second most important component of the diet, followed by evergreen and decidious shrubs. Herbs and moss were slightly represented in the late winter diet of the FCH.

The FCH probably has a better late winter diet compared to the food habits of the Porcupine caribou herd in Yukon (Martell and Russell 1987), (Table 5), and the Porcupine herd is a highly productive and increasing population (Whitten 1986). While proportions of lichen in the diets of both herds are similar the incidence of moss is much lower (.83%) and the incidence of graminoids greater (13.78%) for the FCH. A high incidence of moss in the diet is considered to be indicative of poor range (D. Russell pers. comm.) and graminoids are considered highly digestabled compared to other vascular plants and are rich in protein and phosphorus (Klien 1982). High protein and mineral intake during late pregnancy leads to a higher milk yield in cows and subsequent increased birth weight and growth of calves.

In summary, we believe that nutritional factors, as measured by Snowdepth (food availability) and diet remained constant over this period and did not play a key role in the demography of the FCH.

5. MANAGEMENT IMPLICATIONS

5.1 Conclusions

We conclude that the observed increase in survival of caribou during this study is directly attributable to a decrease in predation by wolves. Consideration of winter severity does not explain the dramatically improved survival of caribou, but does not rule out that favourable snow conditions may have maximized survival. We also conclude that the harvest of caribou from the FCH has decreased dramatically, and that the present level and composition of this harvest, in combination with the increased survival of caribou from wolf control, will cause the herd to increase. If a 12% annual rate of increase can be achieved by these measures, then the herd should increase to 5000 caribou by 1990.

We believe that harvest management and wolf reduction are the only management options available to increase the FCH to a population size able to sustain a 1982 harvest level. The next logical question then becomes, what will happen when the wolf population recovers? We predict that woodland caribou populations, if maintained at high numbers, can sustain predation from undisturbed wolf populations and moderate levels of human harvest. The emphasis of the FCH management program should therefore gradually shift away from the intensive management of wolves to the intensive regulation of harvest during subsequent years. The wolf population recovery should be monitored after the wolf reduction phase of the program is complete to document how wolf numbers respond to an enriched prey base. The population size of the FCH should be estimated after several years of wolf recovery and harvest management to test the adequacy of our management strategy. In the end we hope to prove that we can sustain a large population of woodland caribou for the benefits of human use without periodic wolf control.

5.2 Recommendations

1. That the present harvest management strategy be maintained until 1990, when the take of caribou can be liberalized but limited by a quota system to ensure that an allowable increment is not exceeded. This can be achieved for the non-native hunter kill by legislation (ie. permit hunt authorization, registration hunt, season limitation), and the native hunter kill by a harvest ticket system administered by the Ross River Indian Band. The imposition of a quota on the FCH harvest will likely require the development of a management agreement with the bands. The agreement should allocate the take of caribou between native and non-native hunters, and between bands. The agreement should provide for options to regulate the harvest of caribou in response to desired demographic trends for what is considered optimal benefit, (ie. take the allowable increment, sustain further herd growth).

2. That further wolf reductions be carried out to maintain the wolf population in the FCH management area at below 30% of pre-reduction level for 1987-88, and 1988-89. The FCH management area wolf population should be surveyed annually from 1987 to 1994 to gain a better understanding of the dynamics of

predator-prey relationships and the upper equilibrium concept that is theorized.

3. That monitoring of FCH demographic (recruitment counts, and adult natural mortality rates) and environmental (late winter snow depth and food habits) parameters continue to be monitored until 1990. These measurements are needed to advance our understanding of woodland caribou population dynamics and to complete our experiment in intensive management. Results will also set criteria by which we can base management strategies for other Yukon caribou herds.

4. That a duplicate population size estimate employing the random block stratification sampling method be carried out in 1990 to determine the status of herd recovery. Then again in 1994 to insure that the herd is demographically stable at future harvest levels with no wolf control, and to test for validity in the upper equilibrium concept as theorized by us.

LITERATURE CITED

Barret, M., Nolan J. and L. Roy. 1982. Evaulation of a hand held net-gun to capture large mammals. Wildl. Soc. Bull. 10:108-114.

Bergerud, A.T. 1978a. The status and management of caribou in British Columbia. Fish and Wildl. Branch Rep., Minist. of Recr. and Conserv. Victoria, B.C. 150 pp.

____________. 1978b. Caribou. Pages 83-101 in J.L. Schmidt and D.L. Gilbert, eds. Big Game of North American (Ecology and Management). Stackpole Books, Harrisburg, Pa.

____________. 1979. A review of the population dynamics of caribou and wild reindeer in North America. In Proc. 2nd Int. Reindeer-Caribou Symp., Roros, Norway, 1979. Direkturatet for vilt og Ferskvannsfisk, Trondheim. Edited by E. Reimers, E. Gaare, and S. Skjenneberg, pp. 556-581.

____________. 1983. The Natural population control of caribou. In Symposium on natural regulation of wildlife populations. For., Wildl., and Range Exp. Sta., Univ of Idaho, Moscow. Edited by F.L. Bunnell, D.S. Eastman and J.M. Peek. pp 14-61.

____________., R. Jakimchuck and D. Caruthers. 1984. The buffalo of the north: Caribou (rangifer tarandus) and human developments. Arctic Vol. 37, No 1 (P7-22)

____________., and Elliot, J.P., 1985. Dynamics of caribou and wolves in Northern British Columbia. Can. J. Zool. Vol. 64, 1986.

Davis, J.L., R. Shidelar, and R.E. LeResch 1978. Fortymile Caribou Herd Studies. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Report. Proj. W-17-6 and W-17-7. Juneau. pp 151.

__________., P. Valkenburg, and Reynolds, H.V. 1979. Population Dynamics of Alaska's Western Arctic Caribou Herd. In Proc. 2nd Int. Reindeer-Caribou Symp., Rovos, Norway, 1979. Direktoratet for Vilt. og Ferskuannsfisk, Trondheim. Edited by E. Reimers, E. Gaaves,a nd S. Skjenneberg pp. 599-604.

__________., and Valkenburg, P. 1983. Qualitative and quantitative aspects of natural mortality of the Western Arctic caribou herd. Progress Report. Project W-22-1, Job 3.24 R. Juneau, Alaska.

__________, and P. Valkenburg 1983. Demography of the Delta Caribou Herd under Varying Rates of Natural Mortality and Harvest by Humans. Alaska Deptment of Fish and Game. Fed. Aid in Wildl. Rest., Progress Reprot, Project W-22-1, Juneau, Alaska. pp 50.

__________., and P. Valkenburg 1985. Demography of the Delta Caribou herd under varying rates of natural mortality and harvest by humans. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Rep. Proj W-21-2, W-22-1, W-22-2, W-22-3 and W-22-4. Juneau pp. 49.

Edmonds, E.J. and M. Bloomfield 1984. A Study of Woodland Caribou (Rangier trandus caribou) in West Central Alberta, 1979 to 1983. Alta. Ener. And Nat. Res., Fish and Wildl. Div. pp. 203.

Elliot, J.P., D. Eastman, D. Hatter, and I. Hatter, 1984. Northern B.C. Wolf-Caribou Study. B.C. Ministry of Environment, Wildlife Branch, Victoria, B.C.

Farnell, R. and T. Nette. 1981. Moose/Caribou investigations in the MacMillan/Howard Pass development area. Progress Reprot. Y.T.G. Depart. of Renewable Resources, Whitehorse Y.T.

___________, 1982. Investigations into the status of the Finlayson caribou herd, March 1981 to October 1982. Interim Report. Yukon Fish and Wildlife Branch, Whitehorse, Yukon

___________, and D. Russell, 1984. Wernecke Mountain Caribou Studies, 1980-1982. Final Report. Yukon Fish and Wildl. Branch, Whitehorse pp. 62.

___________, McDonald, E.J. 1985. The Finlayson caribou management project a summary of current information from 1982 to 1985. Y.T.G., Dept. of Renewable Resources. Progress Report.

___________, and McDonald 1987a, in prep. Seasonal movements and distribution of Yukon's Finlayson Caribou herd. Final Report. Y.T.G., Dept. of Renewable Resources.

___________, Farnell, R. McDonald, E.J. 1987b, in prep. An inventory of Yukon's Wolf Lake Caribou Herd. Final Report. Yukon Department of Renewable Resources. Whitehorse, Yukon

Fuller, T.K. and Keith, L.B. 1981. Woodland caribou population dynamics in northeastern Alberta. J. Wildlife Management. 45(1):197-213

Gasaway, W.C., Stephenson, R.O., Davis, J.L., Sheperd, R.E., and Burris, O.E. 1983. Interrelationships of wolves, prey, and man in interior Alaska. J. Wild. Mgt, Wildlife Monograph. No 84.

___________, DuBois, S.D., Reed, D.J., 1985. Estimating moose population parameters from aerial surveys. Manual. A.D.F.&G. Fairbanks, AK.

Gauthier, D.A., 1984. Population Limitation in the Burwash Caribou Herd, Southwest Yukon. Ph.D. Thesis. University of Waterloow, Waterloo, Ontario.

___________, and Theberge, J.B. 1986. Wolf predation in the Burwash caribou herd, southwest Yukon. Fourth Inter. Reindeer/Caribou Sym. Editor: A. Gunn, F.L. Miller, S. Skjenneberg, Whitehorse, Yukon. Canada.

Gilbert, S. 1989. Survival of radio-collared Porcupine caribou, 1983-1986. Final draft Y.T.G. Fish and Wild. Br. Whitehorse, Yukon.

Haber, G.C. 1977. Socio-ecological dynamics of wolves and prey in a subarctic ecosytem. Ph.D. Thesis. University of British Columbia, Vancouver, B.C.

Hatler, D.F. 1986. Studies of radio-collared caribou in the Spatsizi wilderness park area, British Columbia, 198-84. Spatsizie Ass. for Bio. Research, Smithers, B.C.

Hayes, R. and Bowers, K. 1987. Wolf population inventory in the Wolf lake area, South-central Yukon Territory, 1985. Y.T.G., Dept. of Renewable Resources, Whitehorse, Yukon.

____________, and Farnell, R. 1985. Wolf population research and management studies in the Yukon Territory. Part 2. Finlayson caribou herd management area. 1983 Annual Report. Y.T.G. Dept. of Renewable Resources, Whitehorse, Y.T.

____________, Merchant, P., Baer, A. 1985. Wolf population research and management studies in the Yukon Territory. Part I. The southwest Yukon. 1983 Annual Reprot. Y.T.G. Dept. of Renewable Resources, Whitehorse, Yukon

__________, and Farnell, R. 1986. Wolf population research and management studies in the Yukon Territory. Part 2. Finlayson Caribou Herd Management area. 1984 Annual Report. Y.T.G. Dept. of Renewable Resources, Whitehorse, Y.T.

____________, and Farnell, R. 1987. Wolf population research and management studies in the Yukon Territory. Part 2. Finlayson Caribou Herd Management Area. 1985 - 1987 Progress Report. Y.T.G. Dept. of Renewable Resources, Whitehorse, Y.T.

Holechek, J.L. Vavra, M., and Pieper, R.D. 1982. Botanical composition determination of range herbivore diets: a review. Journal of Range Management 35:309-315.

Keith, L.B., 1983. Population dynamics of wolves. pgs. 66-77 in L.N. Carbyn (ed.) Wolves in Canada and Alaska, their status, biology and management. Can. Wildl. Serv. Rep. Ser. 45, Ottawa.

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

Klein, D.R. 1982. Fire lichens and caribou. Journal of Range Mangement. Vol. 35 No. 3., Pg 395

Larsen, D.G. 1982. Moose inventory in the southwest Yukon Final Report. Yukon Dept. of Renewable Resources. Whitehorse, Y.T.

Lortie, G.M., Hoefs, M., Wagner, T., Klassen, W., Mychasiw, L. 1978. Wildlife inventories in G.M.Z. 8 and G.M.Z. 10, Yukon Territory, with and evaluation of present levels of sheep harvest. Yukon Wildlife Branch. Whitehorse, Y.T.

Markell, R., and Larsen, D.G. 1982. MacMillan Pass fall and winter moose surveys. 1981/1982. Yukon Dept. of Renewable Resources, Whitehorse, Y.T.

Martell, A.M. and Russell, D.M. 1982. Mortality rate in the Porcupine caribou herd. Third Inter. Reindeer/Caribou Sym. Editor: Erkki Pulliainen. Dept. of Zoology, Univ. of Oulu. Helsinki, Finland.

__________, and Russell, D.E. 1987. Winter ecology of the Porcupine caribou herd, Yukon. II. Seasonal diets. Submitted to Arctic.

Miller, F.L. 1974. Biology of the Kaminuriak population of barren-ground Caribou, Part 2. Canadian Wildlife Service Report Series, November 31. Ottawa.

Oswald, E.T. and J.P. Senyk, 1977. Ecoregions of the Yukon Territory. Fisheries and Environment Canada, Victoria. 115 pp.

Page, R.E. 1985. Early caribou calf mortality in N.W. British Columbia. M. Sc. thesis, University of Victoria, Victoria, B.C.

Russell, D.E. and Martell, A.M. 1984. Winter range ecology of Caribou (Rangier tarandus). Northern Ecology and Resource Management. Ed. R. Olson et. al., The Univ. of Alberta Press.

Skoog, R.O. 1968. Ecology of caribou (Rangifer tarandus granti) in Alaska. Ph.D. Thesis., Univ. of California, Berkeley, CA. 699 pp.

Stephenson, R.O. 1978. Characteristics of exploited wolf populations. Alaska Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-17-3 through W-17-8. 21 pp.

Valkenburg, P. Davis, J.L. 1987. Population Status of the Fortymile caribou herd and identification of limiting factors. ADF&G., Federal Aid in Wildlife Restoration. Research Progress Report. Juneau, Alaska.

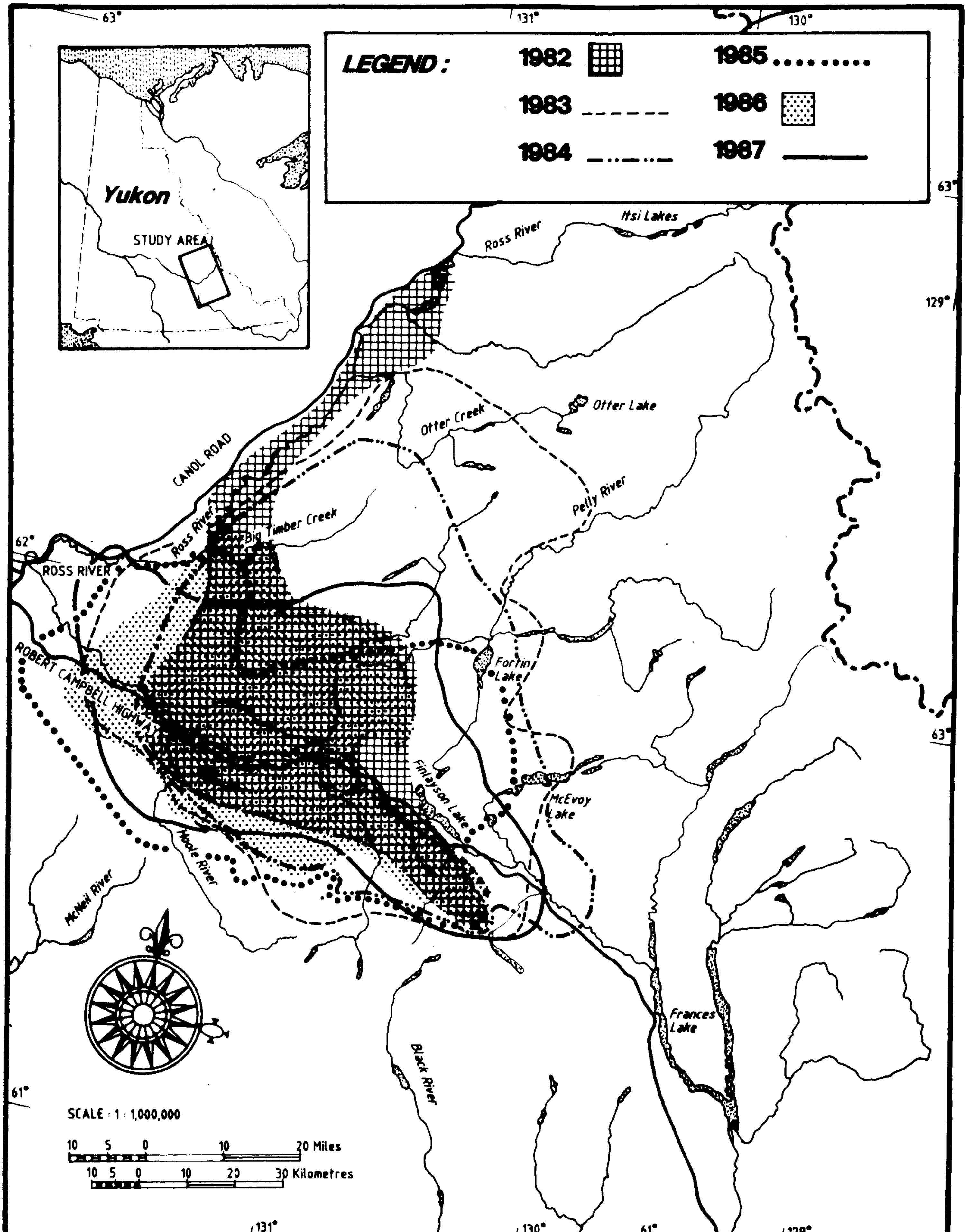
Van Ballenberghe, V. 1985. Wolf predation on caribou. The Nelchina herd case history. J. Wildl. Mgmt. 49:711-720.

White, R.G. and Turdell, J. 1980. Patterns of herbivory and nutrient intake of reindeer grazing tundra vegetation, pp. 180-195, In Reimers et al. 1980.

Whitten, K.R. 1986. Population status and trend of the Porcupine caribou herd, 1982-1985. Alaska Dep. of Fish and Game Inter. Rep. in G.W. Garner and P.E. Reynolds, eds. 1986 update reprot baseline study of the fish, wildlife, and their habitats, U.S. Fish and Wildl. Serv. Anchorage, AK.

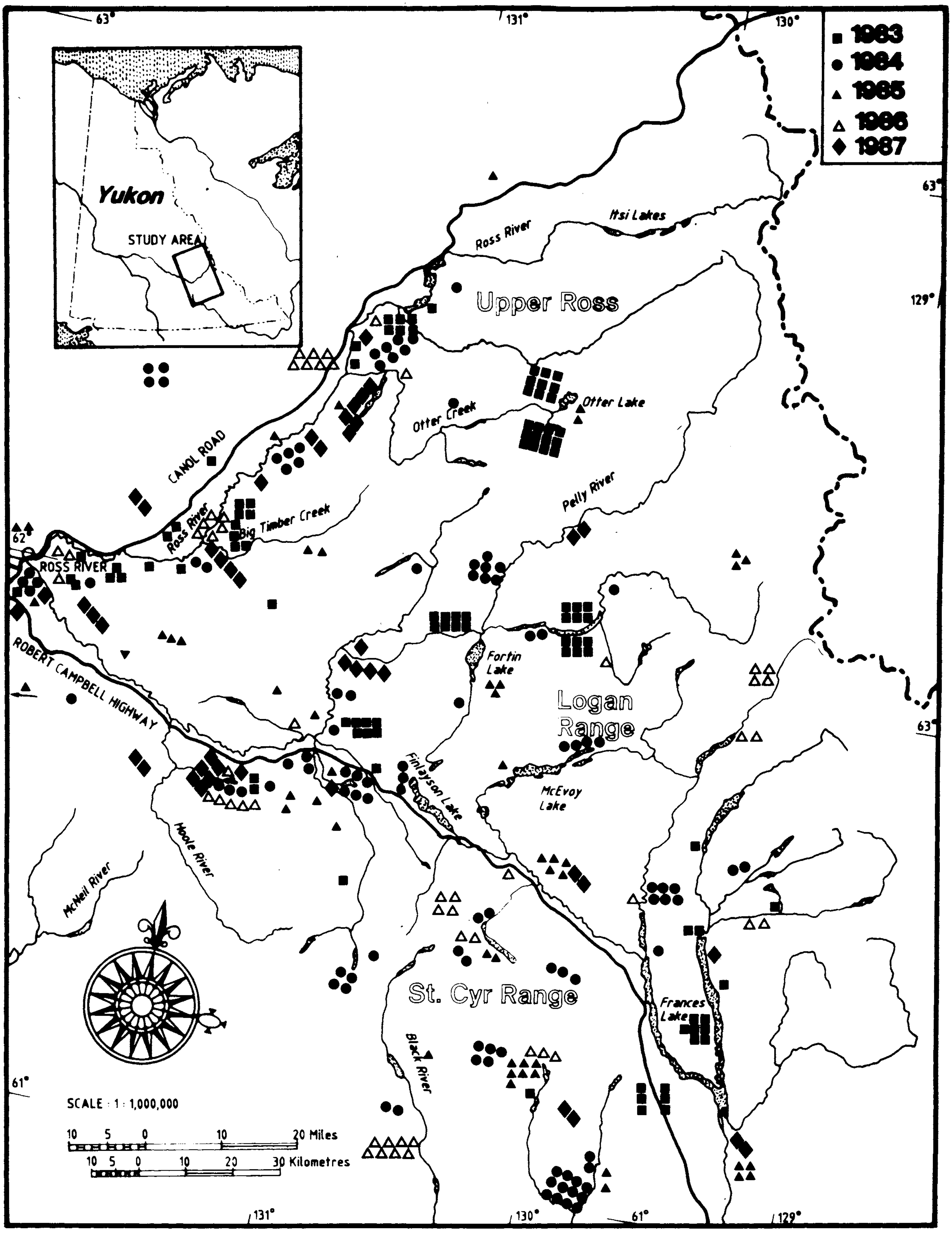
Appendix I

The winter range distributions of the Finlayson Caribou herd from 1982 to 1987


LEGEND:
1982
1983
1984
1985
1986
1987
Yukon
STUDY AREA
Itsi Lakes
Ross River
Otter Lake
Otter Creek
CANOL ROAD
Pelly River
Big Timber Creek
Ross River
ROSS RIVER
ROBERT CAMPBELL HIGHWAY
Fortin Lake
Finlayson Lake
McEvoy Lake
McNeil River
Hoole River
Black River
Frances Lake
SCALE : 1 : 1,000,000
10 5 0 10 20 Miles
10 5 0 10 20 30 Kilometres
63°
131°
130°
129°
62°
61°

Appendix II

Location of wolves killed from 1983 to 1987


1983
1984
1985
1986
1987
Yukon
STUDY AREA
Upper Ross
Ross River
Itsi Lakes
Otter Lake
Otter Creek
CANOL ROAD
Pelly River
Big Timber Creek
ROSS RIVER
ROBERT CAMPBELL HIGHWAY
Fortin Lake
Logan Range
Finlayson Lake
McEvoy Lake
Hoole River
McNeil River
St. Cyr Range
Black River
Frances Lake
SCALE : 1 : 1,000,000
10 5 0 10 20 Miles
10 5 0 10 20 30 Kilometres
63°
131°
130°
129°
62°
61°

Appendix III

O & M cost of the FCH Population Estimate Survey, March 1986

O & M Cost of FCH Population Estimate Survey, March 1986

	cost x 1000	% Total
Aircraft		
[1]Fixed wing (stratification)	5.8	12
[2]Fixed wing (radio-tracking)	2.0	4
[3]Helicopter (census)	33.4	69
Personnel		
Stratification flights - 12 man-days	-	
Radio-tracking flights - 3 man-days	-	
Census flights - 36 man-days	-	
Map preparation - 8 man-days	-	
Analysis and report - 102 days	-	
Food and Lodging	4.8	10
Maps	1.1	2
Miscellaneous	1.0	2
Total	$48.1	100%

[1] 24 hrs. x $240.00 (C-185 + Maule)
[2] 20 hrs. x $100.00 (PA-18)
[3] 83.4 hrs. x $400.00 (2 B-206)

Appendix IV

Abstracts of Two Papers Presented at the 3rd. North American Caribou Workshop, Chena Hotsprings, Alaska, in Nov. 3-5, 1987

The Influence of Wolf Predation on Caribou Mortality in Yukon's Finlayson Caribou Herd

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Abstract: Mortality from manageable factors (hunting and wolf predation) was reduced to increase the population size of Yukon's Finlayson caribou herd. The influence of wolf (*Canis lupus*) predation on this caribou (*Rangifer tarandus caribou*) population was assessed by monitoring the response in caribou calf recruitment (the percentage of calves during fall), and adult natural mortality trends as key variables driving population dynamics. We assumed that the influence of wolf predation on caribou mortality would be evident if other factors not considered remained constant over the duration of this study. Between 1983 and 1987 wolves were reduced by aerial hunting to less than 80% of their pre-reduction level. Subsequently, recruitment increased by 205% after 1984. The adult natural mortality rate, estimated by the death rate of a radio-collared sample of mostly female caribou, decreased by 60% (n=16/52) after 1984. The relationship between these variables and the density of wolves was significantly (p 0.01) correlated. We conclude that wolf predation was the chief cause of mortality for this caribou population.

The Utility of the Stratified Random Quadrat Sampling Census Technique for Woodland Caribou in Yukon

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Abstract: It has proven notoriously difficult to obtain demographic data on woodland caribou (*Rangifer tarandus tarandus*) populations occupying forested environments. Total census counts, fail to provide adequate population data. Sample derived estimates provide greater potential for providing useful data.

We report on an adaptation of a stratified random quadrat aerial census technique originally developed by Gasaway *et al.* (1986) to census moose (*Alces alces*) in Alaska. The adapted technique was applied to two caribou herds (the Wolf Lake and Finalyson herds) in south-central and east-central Yukon in the winter of 1986 and 1987. We compare the population estimates derived from the stratified random technique with earlier attempts to census the herds using total census techniques, and conclude that estimates based on the stratification technique are more reliable than those of the total census approach. In addition, we assess the sightability bias inherent in surveying caribou in forested environments and compare population estimates using a sightability correction factor with those in which the sightability correction factor is not used. We conclude that population estimates that fail to include a correction for sightability bias consistently and significantly underestimate population numbers.

Finally, we assess the relationship of the number of quadrats sampled in the stratification technique to the associated precision estimates. We conclude that it is not always necessary for managers to survey all quadrats in the high density stratum.

Key Words: Caribou, Wolf Lake herd, Finlayson herd, census technique.