

NORTHERN ALASKA RESEARCH STUDIES

Demographics of Caribou: A Review of Holarctic Populations

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Prepared for

BP Exploration (Alaska) Inc.

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A REVIEW OF HOLARCTIC POPULATIONS**

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Executive Summary

Caribou (*Rangifer tarandus*) occur across the Arctic and Subarctic and, like other species in the North, often experience dramatic changes in abundance over time. In this report, we review factors which affect caribou populations and summarize population trends for several herds across the Arctic.

Caribou population dynamics are complex and influenced by multiple factors. The primary factors which affect caribou populations include population density, predation, range condition, weather/climate, disease/parasites, interaction with domestic reindeer, human hunting and industrial development, and range shifts or dispersal.

Population density and range conditions seem to be most important during summer. Predation of all ages occurs, but predation of calves is most important with regard to population growth. The effects of weather are usually most important in winter when snow or ice may limit access to forage. Overhunting

has decimated some herds, and industrial development may cause loss of habitat. Disease and parasites are a constant factor which generally cause energy loss rather than direct mortality. Range shifts can occur, but are relatively infrequent and unpredictable.

Effects of these factors on individual animals can be documented, but it is difficult to quantify the effect of any one factor on a population. The reason is that multiple factors act simultaneously, and the relative importance of factors may change with time.

A chronology of caribou population sizes across the Holarctic confirms that large fluctuations in numbers occur. Several sources suggest these fluctuations may be cyclical and synchronized among geographic areas. Because of the increasing human presence in the North, it is important to distinguish human-caused and natural population fluctuations. In the case of caribou, natural fluctuations may be much greater than those resulting from human activities.

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Demographics of Caribou: A Review of Holarctic Populations

INTRODUCTION

In summarizing the possible causes of a decrease in the recruitment rate of the George River caribou herd in Quebec and Labrador, Couturier et al. (1990) state: "...the rate of increase of the herd has been negative since 1984. The probable causes of the decline involve the negative effects and interrelation of various factors: decline of the physical condition of the females, habitat deterioration on the current calving grounds (former summer range), increase in energy expenditures related to more extensive movements, delayed birth dates, increase in density within their range, and especially on calving grounds, increase in wolf populations and exceptionally high snow accumulation during the 1980-81 winter." Clearly, caribou population dynamics are complex and influenced by multiple factors (Fig. 1).

Caribou (*Rangifer tarandus*) inhabit tundra and boreal forest habitats across the Holarctic. Caribou, more than any other ungulate, characteristically experience dramatic shifts in abundance over time (Klein 1968, Skoog 1968, Hemming 1975, Doerr 1979, Haber and Walters 1980, Miller 1983, Carruthers and Jakimchuk 1983, Davis et al. 1983, Gates 1985, Meldgaard 1986, Heard and Calef 1986, Davis and Valkenburg 1991, Caughley and Gunn 1993). For example, the Western Arctic Herd of Alaska declined from 250,000 to 75,000 individuals between 1970 and 1976. Likewise, the West Greenland caribou population decreased from 100,000 to 8,000 during the 1970's (Meldgaard 1986). Herds may also abruptly change ranges or migration routes (Skoog 1968). Although drastic fluctuations are common among cari-

bou populations, attributing causal relationships to either short- or long-term population fluctuations is difficult, and opinions vary regarding the relative importance of various factors (Bergerud 1980, Bergerud et al. 1984, Meldgaard 1986, Davis and Valkenburg 1991, Klein 1991). The primary factors that affect caribou population dynamics include population density, predation, range conditions, weather/climate, disease/parasites, interaction with domestic reindeer, human hunting and industrial development, and range shifts or dispersal.

Understanding the natural causes of demographic fluctuations is crucial for interpreting human impacts on populations. In other words, for meaningful impact assessment we need to distinguish human-induced changes from natural fluctuations. We also need to recognize that different human activities may have different impacts. For example, introduction of domestic reindeer will influence wild caribou differently than hunting. It is probable that detecting human-caused, *population-level* effects is difficult or impossible in many cases because of the often dramatic natural fluctuations of caribou numbers (Bergerud et al. 1984). This is an important consideration because of the expanding human presence in the northern areas, and the need to have development compatible with maintaining caribou populations.

In this paper, we describe a preliminary review of caribou population dynamics. Two aspects of caribou demography are reviewed. First, we describe the primary factors influencing caribou populations. Second we summarize caribou population trends for herds across the Holarctic.

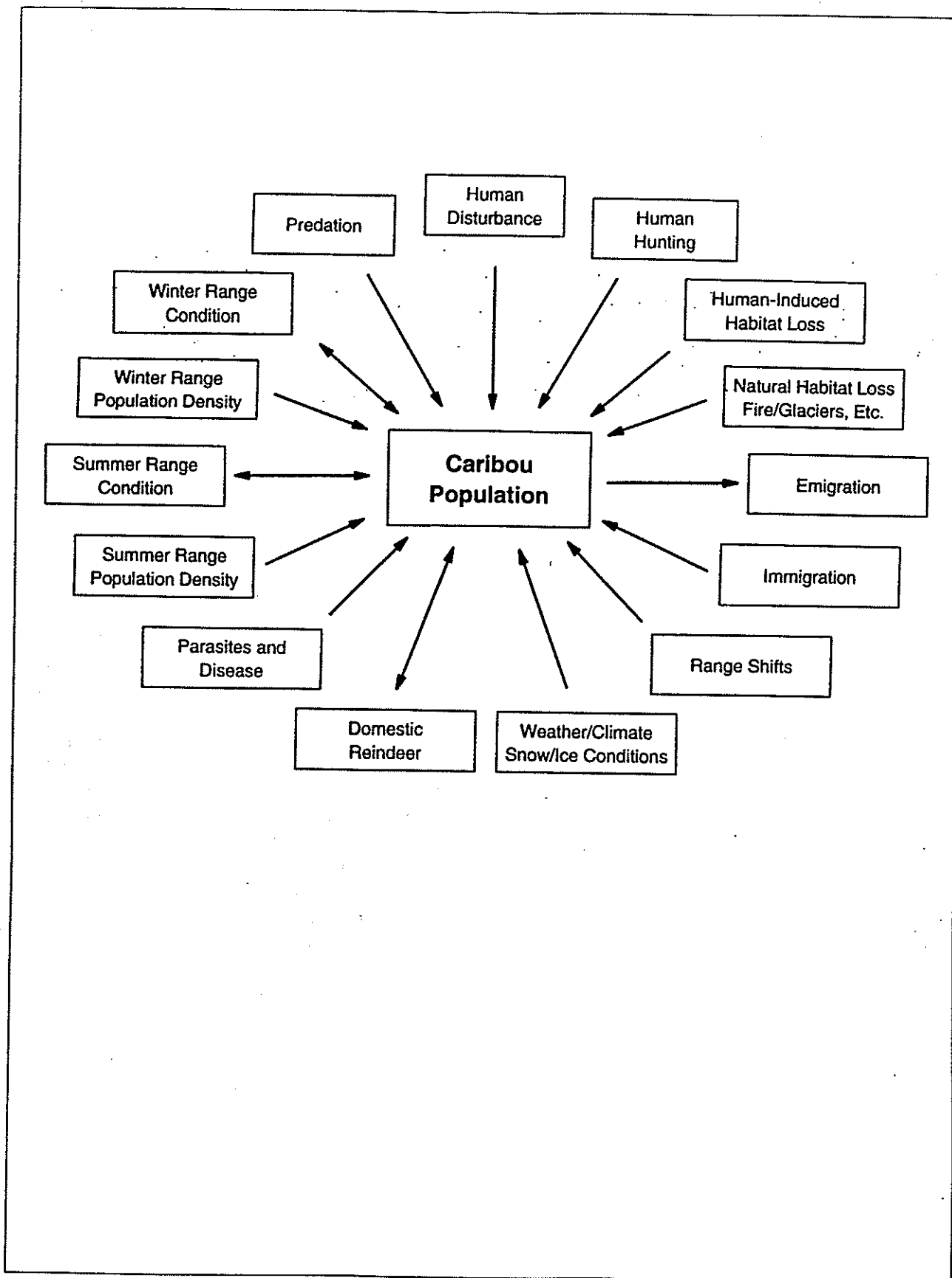


Figure 1. Schematic view of the main factors affecting caribou populations.

FACTORS INFLUENCING CARIBOU POPULATION DYNAMICS

Population Density

In many populations, birth rates and death rates fluctuate as population density changes (Caughley and Sinclair 1994). In other words, as density changes there are intrinsic (density-dependent) mechanisms that alter the population growth rate. Density-independent factors affect birth and death rates independently of population density. For example, weather may affect a population in the same manner regardless of the population density.

It is generally agreed that caribou numbers are not strictly regulated by density-dependent factors. For example, behavior that would cause animals to space themselves does not seem to limit maximum densities or growth rates in caribou (Bergerud 1983, Caughley and Gunn 1993). Extrinsic factors such as predation, weather, and habitat condition are probably more important. However, caribou, like other species of deer, are influenced by population density to some degree (Clutton-Brock et al. 1982, Skogland 1985, Leberg and Smith 1993). Caribou population size will certainly influence factors such as range condition or predator densities, which could have influences on population growth. For example, Crête and Huot (1993) observed that caribou at higher density overgrazed their calving range, were smaller, and had slower-growing calves than caribou in areas of lower density. Valkenburg et al. (1991) observed relatively short mandible lengths (reflecting slower growth) as caribou populations increased over time. Reindeer introduced to St. Matthew Island displayed decreasing body weights as population density increased (Klein 1968).

The Porcupine Caribou Herd (PCH) occurs at higher summer densities than the adjacent Central Arctic Herd (CAH) (Klein 1991), and the PCH has decreased in number while the CAH has continued to grow in the early 1990's (Ballard and Cronin 1995). Although range conditions have not been described in detail, population growth may reflect summer range density.

Predation

Predators of caribou calves include wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), black bears (*U. americanus*), lynx (*Lynx canadensis*), wolverines (*Gulo luscus*), and golden eagles (*Aquila chrysaetos*). Truett et al. (1989) provide a review of caribou neona-

tal mortality, including predation. Predation may result in high calf mortality and poor recruitment (Bergerud 1983, Truett et al. 1989). Relatively high overwinter survival for calves in areas without predators suggests this is particularly important for calves during their first winter (Bergerud 1980). Up to 50% of calves died within six months of birth in areas with predators (Bergerud 1980). Adams et al. (in press a, b) found that predator mortality rates were highest in the neonatal period (15 days old) for the Denali Caribou Herd when wolves and grizzly bears took 20%-46% of collared calves between 1984 and 1991. Crête et al. (1991) reported a high level of predation of caribou calves by black bears in Quebec. Calf survival in an area in British Columbia with wolves was poor compared to an area without wolves (Seip 1992). Wolf predation was the main cause of adult mortality in British Columbia (Seip 1992). Grizzlies also kill adult caribou (Boertje et al. 1988). Bergerud (1980) considered predation the key source of natural adult mortality.

Predation has often been cited as a primary factor influencing caribou population dynamics, although its relative importance has been widely debated (Bergerud 1988, Truett et al. 1989). The role of predation in regulating caribou populations is discussed in a series of papers about the Nelchina Herd of Alaska (Van Ballenberghe 1985, 1989; Bergerud and Ballard 1988, 1989). Van Ballenberghe (1985) concluded that, although the Nelchina herd dynamics have been cited frequently as evidence that wolf predation regulates caribou populations, there were other factors that were more likely responsible in this situation, e.g., adult mortality due to hunting and calf mortality during severe winter weather. Bergerud and Ballard (1988) countered that calf predation by wolves was consistently correlated with changes in population growth rates and concluded that predation was the primary natural factor limiting recruitment. This resulted in a response by Van Ballenberghe (1989) and a rebuttal by Bergerud and Ballard (1989) reiterating their respective positions.

Bergerud (1983) cited inverse correlations between wolf densities and growth rates of caribou populations as evidence that predation is the main limiting factor. In some systems, alternative prey (e.g., moose [*Alces alces*]) may buoy predator numbers. This may result in increased pressure on caribou (Bergerud and Elliot 1986, Seip 1992) which does not allow caribou to increase after densities have been low (Bergerud 1983). Bergerud and Elliot (1986) found that a caribou

population increased in an area of wolf control, but decreased in areas without control. In predator-free areas, introduced caribou populations have grown unchecked until they depleted the range and populations crashed (see Habitat [Range] Conditions/Nutrition below).

Other authors (Haber and Walters 1980; Van Ballenberghe 1985, 1989) have considered as inappropriate the premise of predation as the cause of caribou declines. Haber and Walters (1980) cite examples where herd numbers changed differently than predicted by models of wolf predation limitation. Caughley and Gunn (1993) noted that caribou and other herbivore populations fluctuate widely even in the absence of predators. Haber and Walters (1980) agreed that herds can be kept at low densities by wolf predation; however, they felt that wolf predation could not be responsible for declines from peak numbers, because such declines may occur even when calf survival is good. They suggested that other factors, such as range condition, were more important in regulating caribou populations.

Assessing the impact of predation is difficult because many factors affect predation itself. For example, Bergerud (1980) argued that predation causes caribou populations to reach a stable equilibrium at a level lower than predicted if food were limiting, but he recognized that the balance may be easily upset by other factors. Effects of predation may also vary depending on the duration that caribou are exposed. If the herd is migratory, predation may be a factor during only a portion of the year. Human impacts may also affect predation rates. For example, predator control may allow high survival rates of caribou. It has also been hypothesized that predation could be increased by displacement of caribou (due to industrial development) from traditional calving areas to areas of higher predator densities (Wildlife Management Institute 1991, Whitten et al. 1992, Young et al. 1992).

Habitat (Range) Conditions/Nutrition

Range conditions, especially during winter, have been shown to limit populations of herbivores, including white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), and moose (Mussehl and Howell 1971). However, range relationships for caribou seem to be more complex. Although caribou winter ranges can become depleted, this is well-documented only for insular populations with strict limits on available range (Klein 1968, Leader-Williams 1988). Mainland populations may suffer from harsh winter conditions but not

necessarily depleted ranges. That is, winter forage may be available, but snow and ice conditions may prevent access to it (Bergerud 1978). In contrast, overgrazing of summer and calving ranges, with negative effects on recruitment, has been reported for the George River Caribou Herd in Quebec and Labrador (Crête et al. 1993, Couturier et al. 1990). Although Gaare and Skogland (1980) suggest caribou body size and reproduction relate to winter range quality (specifically lichen mass), Reimers (1983) found that the quality of winter range had a minor effect on body size if summer ranges were of good quality.

Food limitation of boreal-forest caribou populations was proposed in early reports (Leopold and Darling 1953). However, other authors have concluded that this is unlikely to occur (Bergerud 1974, 1983). Very few data exist supporting food limitation through poor range conditions. Yakushkin et al. (1984) speculated that winter range in Taimyr, Russia, limited caribou numbers, although summer range was superabundant. Conversely, Couturier et al. (1990) cite summer range depletion as one of several causative factors influencing a decline in the George River Herd. In Greenland, some biologists have contended that overgrazing influenced population declines, but no convincing evidence to support that claim exists (Meldgaard 1986).

Fire has been suggested as a factor that could influence habitat quality or availability in boreal forests (Fritz et al. 1993). However, lichens, a primary caribou food, are most abundant in forests in mid-seral stages, suggesting that intermittent fires are important for improving range quality. Bergerud (1974) found no evidence of fire affecting population dynamics.

Davis and Valkenburg (1991) suggest that although "caribou in Alaska show signs of resource limitation (i.e., negative feedback to food limitation) that correlate with population size (density)...these responses have not been demonstrated to create measurable population regulation." They suggest that at highest densities, natality may be reduced and mortality increased, but that there is little relationship through much of the range of densities observed in the wild; i.e., range capacity is thought to be affected only at unusually high caribou densities.

In areas without predators, such as islands, where caribou have been introduced, populations have grown rapidly and have reached unusually high densities and overgrazed the habitat (Bergerud 1983). The most widely cited examples are from St. Paul and St. Mat-

thew islands, Alaska, (Klein 1968) and from South Georgia (Leader-Williams 1980). In these areas, populations have increased rapidly, followed by food depletion and subsequent population crashes. Most experts contend that this is unlikely to occur in continental areas (e.g., Meldgaard 1986).

The evidence against food limitation as a regulator of caribou populations includes poor correlations between food availability and population densities or growth rates (Bergerud 1980). While many biologists agree that food limitation could theoretically occur, in most natural situations other factors appear to limit populations; i.e., predation (Bergerud 1980) or climate (Skoog 1968) keeps caribou populations below range carrying capacity. In instances of caribou starvation, food availability appears to be limited by deep snow or ice, not by absolute shortages of forage (Bergerud 1980, 1983; Meldgaard 1986; see Climate/Weather below).

Nutritional constraints can occur when food is limited in availability or quality. This can affect fecundity and recruitment rates. For example, female caribou typically calve for the first time during their third year. If nutrition is particularly good, some females may calve during their second year; and if the diet is poor, they may calve for the first time during their fourth year (Bergerud 1980).

Bergerud (1980) believed that nutritional limitation did not act on natality rates of adult females, because nutritional stress largely occurs during late winter when fetuses are well-developed and not subject to resorption. However, other studies have correlated reproductive performance with body condition (Cameron et al. 1992a, Allaye-Chan and White 1992, Cameron 1993). These studies have shown that females with lower nutritional reserves were less likely to produce calves than females with better nutrition. In addition, calf survival may be lower for calves born to females in poor condition in winter (Bergerud 1980). Poor nutrition resulted in low calf weights and growth rates, and poor productivity and survival were suggested to cause declining caribou numbers (Crête and Huot 1993). Poor female condition due to poor summer range quality was one of several factors thought to result in declines of the George River Herd in Quebec (Couturier et al. 1990, Crête et al. 1993). Displacement of female caribou from traditional summer ranges to suboptimal areas has been suggested as a possible negative effect of arctic oil field development (Cameron et al. 1992a, Cameron 1993).

Climate/Weather

Short-term weather conditions or long-term trends in climate are frequently cited as important factors influencing caribou populations. Klein (1991) noted that caribou and wild reindeer populations across North America and Siberia have been increasing simultaneously in recent years, and favorable weather during the calving period may be partly responsible. Caughley and Gunn (1993) concluded that climatic effects on forage availability contributed to variability in caribou population growth rate. Bergerud (1983) postulated that caribou inhabiting tundra were more susceptible to weather-related mortality and reduced reproduction than forest-dwelling caribou. A longer-term perspective of climate change shows that dramatic population fluctuations and local extinction and colonization are common in northern environments (Sage and Wolff 1986, Cronin 1992).

Van Ballenberghe (1985) attributed increased calf mortality and declines in the Nelchina Caribou Herd to winter severity. Adams et al. (in press b) observed the same trend in the Denali Caribou Herd. Deep snow is frequently cited as a factor which affects the ability of caribou to forage effectively in winter (Bergerud 1978, Couturier et al. 1990). Starvation of caribou, particularly calves, may occur in years of deep snow or heavy ice (Bergerud 1980). In the High Arctic this may be particularly common and keep caribou numbers lower than what would be determined by predation or food supplies (Skoog 1968, Bergerud 1980). Meldgaard (1986) cited examples of starvation due to formation of ice crusts or deep snow, concluding that climate was the primary factor affecting population dynamics. Synchronous fluctuations across broad geographic regions (Meldgaard 1986) support this idea. Snow cover may also affect calving distributions (Whitten et al. 1992).

Weather-related calf mortality (e.g., from wind chill) may occur in early spring, and can destroy an entire calf crop (Kelsall 1968, Bergerud 1978). Delayed migration has occurred in winters with deep snow, and calving in suboptimal locations has resulted (Lent 1966). The susceptibility of calves to harsh spring weather depends on the vigor of the calves at birth, which in turn depends on the mothers' condition following winter. However, there is evidence that populations may shift calving dates to mitigate effects of weather (Kelsall 1968, Bergerud 1980). Adams et al. (in press b) observed delayed calving in years of heavy snowfall and also correlated lower birth rates to winter snowfall. Furthermore, low-birth-weight calves were

more susceptible to predation. Despite the potential for weather-related calf mortality, a review of neonatal mortality (Miller and Gunn 1986) concluded that this was not particularly important except under very severe conditions.

Although most weather-related effects are observed in winter or spring, dry summer weather may affect forage quality or quantity and may have lowered birth rates in interior Alaska herds (ADF&G 1993).

Disease and Parasites

Disease or parasites generally do not have a major influence on population dynamics of caribou. It is thought that caribou are particularly susceptible to diseases when individuals are under stress from some other source. Diseases such as brucellosis (Hollick 1991) and rabies (Dieterich 1982) have been detected in caribou populations, but there is no evidence that such diseases regulate populations. However, meningeal worm (*Parelaphostrongylus tenuis*) infestation is believed to limit caribou numbers and distribution in the southern reaches of the caribou's range (Bergerud 1983). White-tailed deer harbor this parasite, which is frequently lethal to other deer species. Northward expansion of white-tailed deer into Minnesota, Maine, New Brunswick, and Nova Scotia has coincided with decreases in caribou, in part due to meningeal worm infestation (Bergerud 1978).

The skin warble fly and nasal bot fly are serious parasites throughout the range of caribou (Klein 1980). Parasitic fly and insect harassment reduce feeding time and affect habitat use (Downes et al. 1986, Bergerud 1978), influencing subsequent body condition during winter (Meldgaard 1986). On Alaska's North Slope, insect harassment is an important determinant of caribou distributions (Pollard et al. 1992a, b; Pollard and Ballard 1993; Pollard and Noel 1994). These studies found that caribou movements and activity are heavily influenced by the intensity of insect activity. Caribou seek out windy areas on the coast — or on gravel pads and roads in an oil field area — for relief from insects.

Human Factors

Hunting

Numerous instances exist in which human hunting has caused declines in caribou populations. Regulated hunting can be a useful management tool to dampen large fluctuations in caribou numbers and maintain populations within range carrying capacity (Skogland and Mølmen 1980, Bergerud and Ballard 1988).

Hunting pressure by North American Natives before European contact is not thought to have been intense enough to affect caribou population dynamics (Fritz et al. 1993). However, it should be kept in mind that the extinction of many species of Pleistocene megafauna has been attributed to human hunting (Martin and Klein 1984, Owen-Smith 1989). Bergerud (1974) suggested that North American caribou numbers declined during European settlement due to combined effects of human harvest and natural predation. The improvement of firearms in the late 1800's has been suggested as a contributing factor to the decline of Norwegian caribou (Skogland and Mølmen 1980). Whaling ships operating in waters off Alaska and Canada often traded firearms for caribou meat, leading to the decimation of herds near the coast (Banfield 1954).

Numerous examples of overhunting leading to population declines exist from Russia (Syroechkovskii 1984a). Excessive harvest of females brought about a decline of the Taimyr Caribou Herd in Siberia in the 1970's (Klein and Kuzyakin 1982). Van Ballenberghe (1985) and Doerr (1980) attributed hunting to increased adult mortality that contributed to declines in the Nelchina Caribou Herd in Alaska in the 1970's. Heavy hunting, coupled with wolf predation, was identified as an influence in declines in the Western Arctic Caribou Herd in Alaska during the 1970's (Davis et al. 1980). In central British Columbia, hunting and logging are thought to have reduced caribou numbers (Bloomfield 1980). Although hunting pressure was heavy in West Greenland during periods of population maxima, Meldgaard (1986) found no evidence that harvests were excessive or influenced population declines. However, isolated populations in other areas of Greenland may have been decreased through hunting.

Competition with Domestic Reindeer

Klein (1980) reviewed interactions between domestic reindeer and wild caribou. Areas of conflict include reindeer mixing and hybridizing with wild caribou, loss of caribou to reindeer herds, competition for forage between reindeer and caribou, and transmission of disease or parasites. We will refer to domestic or semi-domestic animals as reindeer and wild animals as caribou.

Movement of reindeer into caribou herds in Russia occurs largely during fall, when caribou migrate south, and during the breeding season (Klein 1980). Obviously, this represents a loss to the reindeer herder. To

alleviate such losses, Russian herders historically forced caribou into ranges not used by reindeer (Klein 1980, Syroechkovskii 1984b). This could influence caribou populations through displacement to suboptimal ranges. In Alaska, overall effects of reindeer absorption by wild caribou populations are thought to be minimal (Klein 1980). Klein (1980) felt that relatively small numbers of reindeer mix into caribou herds, although Stern et al. (1980) estimated that it was sometimes extensive. Survival of reindeer within caribou herds is thought to be poor because they may be less wary and thus more susceptible to hunting and predation, and less able to withstand migrations and winter foraging conditions. However, a pinto-colored animal (characteristic of reindeer but not caribou) was sighted among the Beaver Caribou Herd in Alaska in 1969. This was nearly 30 years after a reindeer herd had been abandoned in the area and may represent reindeer able to survive and reproduce in the wild (Hemming 1971).

Loss of reindeer to caribou herds may result in hybridization between the forms. The timing of breeding may influence interactions, since domestic reindeer tend to breed about 2-4 weeks earlier (and hence calve earlier) than caribou. However, it is not known if feral female reindeer change estrus timing to synchronize with their wild counterparts. Klein (1980) concluded that the genetic influence of reindeer on caribou was minimal, and allele frequencies suggest a degree of genetic differentiation of reindeer and caribou in Alaska (Cronin et al. in press). However, alleles at many genetic loci are shared by the two forms (Baccus et al. 1983, Røed and Whitten 1986, Cronin et al. in press), and overall genetic similarity is high. Genetic comparisons with the original Siberian stock introduced to Alaska are necessary for an empirical assessment of the extent of hybridization between reindeer and caribou (Cronin et al. in press).

Forage competition between reindeer and caribou has been suggested by many authors (particularly reindeer herders), but few data exist to assess the extent of interactions (Klein 1980). Caribou feed more selectively than reindeer, primarily due to a larger range unrestricted by herding. As a result, diet overlap is minimized. Reindeer have larger effects on range condition than free-ranging caribou due to relative grazing intensities (Klein 1980).

Transmission of diseases and parasites between reindeer and caribou can occur. However, nearly all parasites and diseases of reindeer also occur in wild caribou populations. Brucellosis can be transmitted be-

tween reindeer and caribou (Syroechkovskii 1984b, Hollick 1991). Also, reindeer introductions can result in passing of parasites to caribou. For example, in Greenland, a wild caribou population was infected with warble and bot flies by an untreated, introduced reindeer herd. However, in most situations, disease or parasite transmission from reindeer to caribou is not likely an important limiting factor, because their frequency is largely tied to health and nutritional status of the population (Klein 1980).

Industrial Development

Logging in boreal forest habitats was thought to affect caribou populations through destruction of important wintering, breeding, calving, or traveling areas (Bloomfield 1980). However, Bergerud (1974) concluded that logging did not greatly affect caribou populations. He found no evidence of regulation by food limitation, which was proposed to be a result of logging. In Russia, forestry and mineral exploration destroy caribou habitat (Syroechkovskii 1984a), potentially impacting populations, although quantitative data are lacking. Agricultural development in southern Russia reduced caribou ranges (Pichagin 1984).

Oil development on Alaska's North Slope did not appear to affect caribou population growth rates of the Central Arctic Herd, relative to other caribou populations (Ballard and Cronin 1995, Cronin et al. submitted a). Surveys have shown heavy use of habitats within, and travel through the oil field complex (Pollard et al. 1992a, b; Pollard and Ballard 1993; Pollard and Noel 1994). Caribou may have benefited from oil field gravel pads and roads, which are used as insect relief areas (Pollard et al. 1992a, b; Pollard and Ballard 1993; Pollard and Noel 1994). Active regulation and mitigation have been instituted to minimize impacts on caribou (Cronin et al. 1994). However, localized changes in calving distribution (Cameron et al. 1992b) and caribou movements (Klein 1991, Cameron et al. 1995) may occur, and there is still concern about possible cumulative effects and habitat loss resulting from oil and gas development (Cameron 1983, Klein 1991, Cameron et al. 1992b, Whitten et al. 1992, Young et al. 1992).

The Snøhetta caribou herd in Norway has survived several stages of development. A railroad was constructed between 1920 and 1925 perpendicular to migration routes. At this time, numbers were low and migration across the railroad stopped. Two hydroelec-

tric dams were constructed near traditional calving areas between 1946 and 1953, and calving areas were abandoned after flooding. The building of another dam in 1974 further reduced summer range. As a result of depletion of winter ranges between the dams and the railroad during expansion of the population between 1947 and 1965, a portion of the herd moved east of the railroad. This renewed migration has continued since 1956, and caribou wintering east of the railroad have higher reproductive rates than those to the west (Skogland and Mølmen 1980).

Range Shifts/Dispersal

Haber and Walters (1980) suggested that dispersal contributed to asynchronous increases and decreases of caribou herds. They noted that sizable fluctuations occur every 60-90 years, so short-term studies would not detect this pattern. Also, in recent years, human harvest of herds at high densities may have influenced dispersal. Haber and Walters (1980) also suggested that immigration of individuals allowed local populations to reach densities that exceeded thresholds in which predation keeps populations below carrying capacity, i.e., "predator pits."

Movements and shifts in caribou distributions are a normal part of their natural history (Bergerud et al. 1984), and repeated local extinction and colonization characterize northern areas during glacial periods (Sage and Wolff 1986, Cronin 1992). Skoog (1968) suggested that exchanges among herds or areas occurred frequently and that all caribou in the Alaska-Yukon area should be considered a single population. Carruthers and Jakimchuk (1986) detected movements between herds on Alaska's North Slope, and suggested that they explained fluctuations in numbers within the Central Arctic region. However, Davis and Valkenburg (1991) found no evidence of Alaska caribou dispersing in response to high densities. They noted that the Southern Alaska Peninsula Herd exceeded a hypothesized dispersal threshold yet did not disperse and subsequently declined, apparently due to food limitation. Van Ballenberghe (1985) detected no ingress or egress that could explain fluctuations in the Nelchina Herd.

In other cases, caribou ranges have been shown to expand when populations are high. For example, in Greenland, Meldgaard (1986) found that caribou distribution increased during periods of high densities. However, he rejected inter-regional movements as an explanation for large population fluctuations.

Meldgaard (1986) found fluctuations were largely synchronous among regions, implying that large-scale climatic factors were similarly affecting all populations. Messier et al. (1988) also observed range expansion of the George River Caribou Herd as the herd increased. Another example of range expansion may be the Central Arctic Herd of Alaska. This herd may have originated as an offshoot of the expanding Western Arctic Herd (Bergerud et al. 1984).

Fidelity of female caribou to calving grounds can be high (e.g., Gunn and Miller 1986, Cameron et al. 1986), but there are instances where this is not the case. Calving ground locations of the Steese-Fortymile Herd of Alaska were annually variable and unpredictable (Valkenburg and Davis 1986). Calving of the Porcupine Caribou Herd occurs over a wide area of the Arctic Coastal Plain, with specific areas varying from year to year (Clough et al. 1987). Seasonal shifts within calving range also occur. Adams et al. (in press b) observed a calving concentration shift in the last portion of the calving period when a wolf pack had denned within the traditional grounds and preyed upon caribou calves born in the early portion of the calving period.

The topic of range shifts and dispersal of caribou populations is confounded by qualitative distinctions of herds, subpopulations, and populations and the scale at which one is considering movements. Individuals may move among herds or areas and may influence population dynamics. The inability to detect large-scale range shifts may be due to their episodic occurrence over long periods of time (Cronin et al. submitted a). Bergerud et al. (1984) noted the difficulty in distinguishing human-caused and natural range shifts.

Summary and Conclusions

While caribou populations are particularly dynamic, population fluctuations occur in many herbivore populations (Clutton-Brock et al. 1991, Fryxell et al. 1991, Caughley and Gunn 1993). Several sources provide complete reviews of large herbivore population dynamics (Fowler 1981, 1987; McCullough 1992). As with caribou, population dynamics of herbivores in general remains a controversial subject when specific population-regulation agents are discussed (Boutin 1992). Even exhaustive analyses recognize that all possible factors have not been incorporated into modeling efforts (Messier 1994).

Herbivore populations are subject to fluctuations, with time lags between influencing factors and population response (Fryxell et al. 1991). Caughley and Gunn

(1993) compared population dynamics of kangaroos and caribou and found remarkable similarities, i.e., long-term aperiodic fluctuations. They attributed these similarities to comparable levels of variability in forage availability, which they in turn tied to highly variable annual weather patterns.

The Arctic is a highly variable environment. Numerous wildlife species inhabiting the Arctic experience high-amplitude, and sometimes predictable, fluctuations in numbers (Akçakaya 1992). A well-known example is the cyclic population trends of snowshoe hares (*Lepus americanus*) and lynx (Keith and Cary 1991). The causes of such cycles are still uncertain. Keith and Cary (1991) also documented cycles of other mammals, related to hare cycles and the variable arctic environment. It should be no surprise that caribou also exhibit broad population fluctuations over time and that these are possibly cyclic (Meldgaard 1986, Couturier et al. 1990, Caughley and Gunn 1993).

Among the many factors that influence caribou population dynamics (Fig. 1), several stand out as relatively important (population density, predation, hunting, range/nutrition, and weather/climate), although their relative impacts are still debated. This is not surprising in light of the possibility that different factors may be acting alone or in concert in different situations. In addition, the factors influencing populations may vary with geography (Bergerud 1983). For example, tundra caribou may be prone to starvation caused by harsh winter weather snow and ice, while those in boreal forests may be limited by predation pressure (Bergerud 1978, 1988). Likewise, food limitation can occur, but appears to occur under specific conditions, such as limited dispersal potential and lack of predators (Klein 1968, Leader-Williams 1980). The effects of predation are also difficult to determine (Bergerud 1983). Because a great deal of movement occurs among areas, there is the question of whether herds are truly distinct (Haber and Walters 1980, Cronin et al. submitted a). Human impacts are often of primary concern and are varied. Reindeer introductions, hunting, and industrial or urban development may all affect caribou depending on many factors.

In light of these complex factors, Haber and Walters (1980) suggest that management of caribou herds based on one factor is inappropriate. Davis and Valkenburg (1991) argue that a "plurality-of-causes" hypothesis may best explain caribou population dynamics, similar to one described for moose (Peek and Eastman 1983). Couturier et al. (1990) proposed that a

combination of factors led to recent decreases in the George River Herd, including poor calf survival, poor adult female condition, poor summer range quality, predation, hunting, and snow conditions. With many complicated factors affecting caribou population dynamics, it is difficult at best, and impossible at worst, to describe the relative importance of each of these factors.

With increasing pressure to develop natural resources and settle northern areas and increasing environmental regulation, it is very important to distinguish human-caused and natural population fluctuations. Caughley (1987) found that, while human impacts (e.g., competition with sheep and hunting) affected kangaroo population densities, the rates of growth were not affected. This suggests that the human impacts are overridden by the effects of weather on forage availability. This may prove to be the rule rather than the exception, and resource managers must learn to put human impacts in perspective against the background of non-human impacts.

SUMMARY OF GLOBAL CARIBOU POPULATION TRENDS

We have reviewed the literature on Holarctic caribou population trends and presented results in the appendices. We have assembled a chronology of events, population sizes, and growth trends for many caribou and reindeer populations from Alaska, Canada, South Georgia Island, Greenland, Iceland, Russia, and Scandinavia. The sources of some of this information are anecdotal historical accounts, not quantitative studies or censuses. This is particularly true for the older references. Because it is often the only information available for certain populations or time periods, we have included it with more recent data, but its accuracy must be considered questionable.

In addition to the chronology, we have graphed population versus time for several of the caribou and reindeer populations. In-depth statistical analyses of these data are beyond the scope of this report. However, the factors responsible for population changes are generally the same as those described in the preceding sections. The data in this section will provide a base for more in-depth study of specific populations, as well as synthetic study of multiple populations.

Figure 2 illustrates the known population growth trends of caribou and reindeer herds through time. Some authors believe these trends are cyclic in nature (Meldgaard 1986). Meldgaard (1986) believes these

Herd/Region	1700	1735	1745	1755	1765	1805	1815	1825	1835	1845	1855	1865	1875	1885	1895	1905	1915	1925	1935	1945	1955	1965	1975	1985	1995		
Greenland-Northeast																											
Greenland-Inglefield Land																											
Greenland-Thule																											
Greenland-Upernavik																											
Greenland-Disko																											
Greenland-Sismilut																											
Greenland-Nuuk																											
Greenland-Qeqertarsuaq																											
Greenland-Paamiut																											
Greenland-Southwest																											
Canada-Caribou																											
Alaska-Porcupine																											
Alaska-Central Arctic																											
Alaska-Western Arctic Herd																											
Alaska-Interior																											
Alaska-Beaver Herd																											
Alaska-Nelchina Herd																											
Alaska-Fortymile Herd																											
Alaska-Delta Herd																											
Alaska-Mt. McKinley Herd																											
Alaska-Kenai Peninsula																											
Alaska-Bering Sea Coast																											
Alaska-Alaska Peninsula																											
Alaska-Unimak Island																											
Alaska-Adak Herd																											
Alaska-Reindeer																											
Alaska-Caribou																											
Russia-Sakhalin																											
Russia-Kamchatka																											
Russia-Irkutsk																											
Russia-Western Sayan																											
Russia-Tomsk																											
Russia-Taimyr/Krasnoyarsk																											
Russia-Pechora River Basin																											
Russia-Kola Peninsula																											
Russia-Reindeer																											
Russia-Caribou																											
Norway-Snohetta																											

Figure 2. Comparative representation of increase (+), decrease (-), and stability (·) of numbers of caribou in various Holarctic herds.

trends are synchronized in herds across Greenland. This may be true in other areas. For example, Alaskan herds generally decreased in the mid- to late-1800's, increased after the turn of the century, and fluctuated somewhat ever since. Many herds (e.g., Central Arctic,

Western Arctic, and Nelchina) have increased from the mid-1970's to present. Because censuses have increased in accuracy and frequency in the last few decades, it is difficult to quantify fluctuations over previous periods.

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Appendix A

Population Trends of Alaskan Caribou and Reindeer Herds

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Figure A-13	Number of reindeer in the Hagemeister Island Reindeer Herd by year

Table A-1. Chronology of events in Alaska caribou and reindeer. See Figure A-1 for regions and herd locations.

Year	Event	Trend/Factor
1867	Caribou numbers begin to decrease over a large part of Alaska (Murie 1935).	Decrease/?
1886	Interior herds were not seen beyond Tanana, but caribou were numerous from Bristol Bay south (L.M. Turner in Murie 1935).	
1888	Caribou are more or less continuous on the mainland from a point across from Kodiak, around the Alaska Peninsula, including Unimak Island, and along the Bering Sea and Arctic coasts (E.W. Nelson in Murie 1935).	
1891	Sixteen reindeer are imported from Cape Serdze and South Head, Siberia to the Seward Peninsula (Rutherford et al 1922). Between 1891 and 1902, 1,280 reindeer are imported predominantly at Teller, Alaska (Palmer 1934).	Increase/ Introduce Reindeer
1892	171 reindeer are imported from Cape Serdze and South Head, Siberia to the Seward Peninsula (Rutherford et al 1922).	Increase/ Introduce Reindeer
1893	127 reindeer were purchased from Siberia (Rutherford et al 1922).	Increase/ Introduce Reindeer
1895	Footrot outbreak in reindeer herds. When moved to higher grounds, the disease subsides (Rutherford et al 1922).	Short-term Decrease/ Disease
1896	Footrot outbreak in reindeer herds. When moved to higher grounds, the disease subsides (Rutherford et al 1922).	Short-term Decrease/ Disease
1903	Reindeer number 6,505, the Russian government banned the export of reindeer, and the effects of inbreeding were being seen in Alaskan reindeer (Rutherford et al. 1922).	Increase/?
1920	Caribou at the Canada/U.S. border are estimated at 60,000 (Murie 1935).	
1921	Large numbers of reindeer are lost to caribou herds due to loose herding practices (Bailey and Hendee 1926).	Short-term* Decrease/Poor Herding
1922	Reindeer in Alaska number 200,000 (Rutherford et al. 1922).	Increase/ Improved Herding
	Large numbers of reindeer are lost to caribou herds due to loose herding practices (Bailey and Hendee 1926).	Short-term* Decrease/Poor Herding
1924	The number of caribou in Alaska is estimated at 1 million (Murie 1944).	
1930	Reindeer peak near 600,000 in this decade followed by a rapid reduction due to poor herding practices and severe winters. Loss to caribou continues. (Klein 1980) Centers of abundance for northern herds (including those crossing the Brooks Range) are southeast of Anaktuvuk Pass and between the head of the Porcupine and Peel rivers on the U.S./Canadian border (Murie 1935).	Decrease*/ Unmanageable
1932	1932 is a hard winter with deep crusted snow (Murie 1944).	?/ Harsh Snow Conditions
1934	One million domestic reindeer from Barrow south to Kodiak has forced caribou out of this area (Palmer 1934).	Decrease/ Competition With Reindeer
1935	A group of reindeer is transported by driving to the MacKenzie River Delta. Many are lost to the wild. (Klein 1980) Interior herds seem to be stable at a time when many other herds are dwindling (Murie 1935).	Decrease*/ Loss to Caribou Stable/?
1940	There are 250,000 reindeer in the state of Alaska in the early 1940's (Palmer 1944).	
1956	Winter '56/'57 is severe with deep crusted snow south of the Brooks Range (Hemming 1971).	?/ Harsh Snow Conditions
1971	Caribou in Alaska number in excess of 600,000 (Hemming 1971).	
1995	There are currently 900,000 caribou (P. Valkenburg, pers. comm.) and approximately 30,000 reindeer (D. Tomlin, pers. comm.) in the state of Alaska.	

*Decrease of reindeer by loss to wild caribou herds suggests numbers in wild caribou herds may increase, depending on the fitness of reindeer.

Table A-2. Chronology of events in the caribou and reindeer herds of the Alaska Peninsula and Aleutian Islands. See Figure A-1 for regions and herd locations.

Year	Event	Trend/Factor
1880	Caribou on Unimak Island begin a 20 year decline due at least in part to overhunting (Murie 1935).	Decrease/ Hunting
1884	Caribou are numerous [approximately 20,000 (Abbott 1993)] at the base of the Alaska Peninsula (I. Petroff in Murie 1935).	
1885	Beginning in the late 1880's, migrations between Unimak Island and the mainland Alaska Peninsula are not seen as they were in the 1860's and will not be seen until 1916 when a few animals are spotted crossing the water (I. Petroff in Murie 1935).	Decrease/ (Dispersal)
1888	Caribou are more or less continuous on the mainland from a point across from Kodiak, around the Alaska Peninsula, including Unimak Island, and along the Bering Sea and Arctic coasts (E.W. Nelson in Murie 1935).	
1894	Only a few hundred animals remain on Unimak Island. Decreased hunting activity apparently allows the herd to increase. (Murie 1935)	Increase/ Decreased Hunting Pressure
1904	Easternmost observation of Alaska Peninsula caribou is Becharof Lake (W.H. Osgood in Murie 1935).	
1905	Unimak Island caribou numbers peak (Murie 1935).	Increase/?
1908	Unimak Island caribou numbers decline, but seem to stabilize and peak in subsequent years (Murie 1935).	Decrease/?
1916	A few caribou were seen migrating from the mainland peninsula to Unimak Island (Murie 1935).	Altered Migration/?
1920	Before 1920, anecdotal and circumstantial evidence indicates caribou were numerous on Deer and Unga Islands and at least present on Amak Island, but no live caribou remain on these islands (Murie 1935).	Decrease/?
1925	Unimak Island population of 7-10,000 caribou is faring better than the mainland Peninsula population (Murie 1935).	
1929	A series of volcanic eruptions on the Alaska Peninsula lasts through 1931 possibly resulting in a shift of caribou from the southwest to the northeast (Powers 1958 and Skoog 1968 in Hemming 1971).	Decrease/Range Shift?
1932	A few animals migrate from the Peninsula to Unimak Island (Murie 1935).	Increase/ Altered Migration
	Domestic reindeer are introduced to the Alaska Peninsula (Rood 1945 in Hemming 1971), but last only a few years due to previous overgrazing by caribou and extreme icing and snow in the winter of '38/'39 (Burdick 1940 and Rood 1942 in Hemming 1971).	Decrease/ Reindeer Introduction; Overgrazing; Snow and Ice
1935	Caribou are dwindling on the Alaska Peninsula. Only 2 herds at the western end numbering no more than 5,000 total remain (Murie 1935).	Decrease/ Overgrazing?
	Migrations on/to/from the Peninsula are no longer apparent. Only local movements are observed. (Murie 1935)	Decrease/ Altered Migration
1938	Extreme icing and snow on the Alaska Peninsula in winter of 1938-39 (Burdick 1940 and Rood 1942 in Hemming 1971).	?/ Harsh Snow Conditions
1940	Alaska Peninsula herd reaches a low of 2,500 animals in this decade (Nelson 1949 in Hemming 1971).	Decrease/ Overgrazing?
	Remaining reindeer on the Alaska Peninsula are abandoned in this decade (Hemming 1971).	?/ Reindeer Abandoned
1949	Alaska Peninsula herd begins a steady increase lasting at least until 1971 (Hemming 1971).	Increase/?
1958	23 caribou calves from the Nelchina caribou herd are transplanted to Adak Island (Hemming 1971).	?/ Caribou Introduction
1960	Caribou calves transplanted to Adak in 1958/59 produce first crop of calves (Hemming 1971).	Increase/ Successful Introduction
1963	Alaska Peninsula herd numbers more than 10,000 (Abbott 1993).	Increase/?
1967	Adak caribou number 189 (Hemming 1971).	Increase/No Predators and Good Range

Table A-2 (Cont'd)

Year	Event	Trend/Factor
1968	Alaska Peninsula herd numbers 12,500 (Hemming 1971).	Increase/?
	Unimak Island herd numbers 1,500 (Hemming 1971).	Increase/?
1971	Adak herd occupies the entire island except for the Navy Station on the NE side (Hemming and Glenn 1968 in Hemming 1971).	Increase/Range Expansion
1975	Caribou number 5,000 on Unimak Island (Irvine 1976 in Abbott 1993).	Increase/?
1981	Caribou on the Alaska Peninsula number 16,000 (Abbott 1993).	Increase/?
1983	Caribou number 300 on Unimak Island (Abbott 1993).	Decrease/?
1984	Caribou on the Alaska Peninsula number 20,000 (Abbott 1993).	Increase/?
1986	Caribou on the Alaska Peninsula number 30,300 (Williams and Heard 1986).	Increase/?
	Caribou on Adak number 420-500 (Abbott 1993).	Increase/?
1989	Caribou on the Alaska Peninsula number 24,000 (Abbott 1993).	Decrease/?
1990	Caribou on the Alaska Peninsula number 24,000 (Abbott 1993).	Stable/?
	Caribou on Adak number 500 (Abbott 1993).	Stable/?
1991	Caribou on the Alaska Peninsula number 20,300 (Abbott 1993).	Decrease/?
	Caribou on Adak number 535 (Abbott 1993).	Stable/?
1992	Caribou on the Alaska Peninsula number 19,800 (Abbott 1993).	Decrease/?
	Caribou on Adak number 437 (Abbott 1993).	Decrease/?
1993	Caribou on the Alaska Peninsula number 20,300 (Abbott 1993).	Increase/?
	Caribou on Adak number 700 (Abbott 1993).	Increase/?
1995	There are 5,000 domestic reindeer on Unimak Island (D. Tomlin, pers. comm.).	
	Caribou on Adak number 800 (Abbott 1993).	Increase/?

Table A-3. Chronology of events in the reindeer and caribou herds of the Bering Sea Coast and Seward Peninsula. See Figure A-1 for regions and herd locations.

Year	Event	Trend/Factor
1866	Caribou herds number in the thousands along Norton Sound (Murie 1935).	
1878	Caribou number in the thousands on Nunivak Island. Hunters begin hunting on Nunivak Island, because there are no caribou on the mainland (Murie 1935).	Decrease/ Hunting
1885	Caribou are described as being extremely plentiful along the lower Yukon-Kuskokwim Delta area (Murie 1935).	
1886	Interior herds were not seen North of Tanana, but caribou were numerous from Bristol Bay south (L.M. Turner in Murie 1935).	
1888	Numbers are greatly down from 1860's levels in the Norton Sound area (Murie 1935).	Decrease/ Hunting
1891	Sixteen reindeer are imported from Cape Serdze and South Head, Siberia to the Seward Peninsula (Rutherford et al 1922). Between 1891 and 1902, 1,280 reindeer are imported predominantly at Teller, Alaska (Palmer 1934).	Increase/ Introduction of Reindeer
1892	171 reindeer are imported from Cape Serdze and South Head, Siberia to the Seward Peninsula (Rutherford et al 1922).	Increase/ Introduction of Reindeer
1893	127 reindeer were purchased from Siberia (Rutherford et al 1922).	Increase/ Introduction of Reindeer
1895	Footrot outbreak in reindeer herds. When moved to higher grounds, the disease subsides (Rutherford et al 1922).	Short-term Decrease/ Disease
1896	Footrot outbreak in reindeer herds. When moved to higher grounds, the disease subsides (Rutherford et al 1922).	Short-term Decrease/ Disease
1899	The only evidence of caribou on the Seward Peninsula are scattered antlers. No live animals remain. (Murie 1935)	Decrease/ ?
1903	Reindeer number 6,505, the Russian government banned the export of reindeer, and the effects of inbreeding were being seen in Alaskan reindeer (Rutherford et al. 1922).	Increase/ Herding
1910	Only 25 caribou remain on the Yukon-Kuskokwim Delta (Murie 1935).	Decrease/?
1914	Only 5-10 caribou remain on the Yukon-Kuskokwim Delta (Murie 1935).	Decrease/?
1921	From 1921-23, only a few caribou are seen on the Seward Peninsula at times when they join reindeer herds (Murie 1935).	Decrease/ ?
1924	Caribou trails remain as the only evidence that large caribou herds once used the Yukon-Kuskokwim Delta (Murie 1935).	Decrease/?
1925	Experimental crosses of reindeer and caribou on Nunivak Island begin (Palmer 1934).	?/Reindeer x Caribou Crossbreeding
1934	One million reindeer from Barrow south to Kodiak has forced caribou out of the entire Bering Sea coast and Seward Peninsula (Palmer 1934).	Decrease/ Competition with Reindeer
1935	Area from Bristol Bay to the Seward Peninsula has too few caribou to consider as a herd (Murie 1935). No caribou remain on the Yukon-Kuskokwim Delta (Murie 1935).	Decrease/? Decrease/Locally Extinct
1944	29 yearling reindeer from Nunivak Island are placed on St. Matthew Island by the U.S. Coast Guard (Klein 1968).	Introduced
1957	Reindeer on St. Matthew Island have multiplied rapidly to number 1,350 and outsize their counterparts on Nunivak Island (Klein 1968).	Increase/ Superior Range
1963	St. Matthew Island reindeer continue to multiply rapidly (they now number 6,000), but are showing signs of poor condition (Klein 1968). Mulchatna herd numbers 5,000 (Skoog 1963 in Hemming 1971).	Increase/?
1964	U.S. Coast Guardsmen, while on a recreational hunt on St. Matthew Island, report only 50 live animals remained after the severe winter of 1963/64 (Klein 1968).	Drastic Decrease/ Overgrazed Range; Starvation
1965	71 reindeer from Nunivak Island are introduced to Hagemeister Island (Lay 1994).	Increase/ Introduction of Reindeer
1966	Only 42 animals remain of the St. Matthew Island reindeer herd. There are no calves, and only one bull remains. (Klein 1968)	Decrease/?

Table A-3 (Cont'd).

Year	Event	Trend/Factor
1967	73 additional reindeer are introduced from Nunivak Island to Hagemeister Island (Lay 1994).	Increase/ Introduction of Reindeer
1968	While wintering, Mulchatna herd crosses the Kvichak River for the first time since 1900 (Hemming 1971).	Increase/ Winter Range Expansion
1980	20,000 reindeer are on the Seward Peninsula (Klein 1980).	
1986	Andreafsky/Kilbuck Mountain caribou herd numbers 400 (Williams and Heard 1986).	
1990	During the winter of 1990/91, several hundred reindeer on Hagemeister Island die for unknown reasons (Lay 1994).	Decrease/?
1991	During winter 1991/92, more Hagemeister reindeer die bringing the total over the past 2 winters to over 800 animals dead of unknown cause (Lay 1994).	Decrease/?
1992	276 additional Hagemeister animals die, 95% of which are bulls. Dead animals show signs of starvation and lichen ranges are found to be depleted. However, non-lichen ranges and live animals are in good condition. (Lay 1994)	Decrease/ Starvation
	650 reindeer on Hagemeister Island are shot by the USFWS, 120 are removed from the island alive, and 193 animals are left on the island (Lay 1994).	Decrease/ Deliberate Extermination
1993	An attempt to eliminate all reindeer from Hagemeister Island includes removing 293 live animals and shooting 135. However, some animals remain. (Lay 1994)	Decrease/ Deliberate Extermination
	The Kilbuck Mountain caribou herd numbers 2,584 while the status of the Andreafsky is unknown (Abbott 1993).	
1995	There are 900 reindeer on St. Paul Island, 100 on St. George Island, 6-700 on Nunivak Island, and 21,000 on the Seward Peninsula (D. Tomlin, pers. comm.).	

Table A-4. Chronology of events in the caribou and reindeer herds of the Arctic Coast between Kotzebue and Demarcation Point. See Figure A-1 for regions and herd locations.

Year	Arctic Coast	Trend/Factor
1888	Caribou are more or less continuous on the mainland from a point across from Kodiak, around the Alaska Peninsula, including Unimak Island, and along the Bering Sea and Arctic coasts (E.W. Nelson in Murie 1935).	
1900	There is suspected mixing of eastern Canadian and Porcupine caribou herds on mutual winter range in the McKenzie River bottoms before 1900 (Hemming 1971). Porcupine caribou herd shifted southwest away from the coast during the early 1900's (Harrison 1908 and Porsild 1945 in Hemming 1971). Hemming theorizes a westward shift in migration paths as a result of this inland movement (Hemming 1971).	?/Exchange Between Herds; Range Overlap ?/ Summer Range Shift
1901	Before 1901, caribou were plentiful west of the Colville River on the Arctic plain. From 1901-05, hunters had to go east of the Colville River for caribou. (Murie 1935)	Decrease/ Summer and Fall Range Shift
1911	Signs of caribou were observed at the headwaters of the Colville River, and natives confirm this as a dependable hunting area for caribou (Murie 1935).	
1920	Caribou at the Canada/U.S. border are estimated at 60,000 (Murie 1935). Since 1900, caribou migrating through Anaktuvuk Pass moved east once arriving on the North Slope of the Brooks Range (Hemming 1971). Before 1920, the Western Arctic Herd was small and stayed in the western Brooks Range, and the Porcupine Caribou Herd occupied the central Brooks Range (Hemming 1971). After 1920, caribou migrating through Anaktuvuk Pass moved westward once they reached the Slope. This corresponds with a time of increase in the Western Arctic Herd. (Hemming 1971)	Change in Migration/?
1921	The Arctic Slope of the Brooks Range is caribou range, but is not used extensively from 1921-23 (Murie 1935). Caribou are scarce near Wainwright (Bailey and Hendee 1926). Lemmings, hares, and foxes are abundant near Wainwright (Bailey and Hendee 1926).	Decrease/? Decrease/?
1922	Caribou are once again scarce near Wainwright (Bailey and Hendee 1926). Lemmings, hares, and foxes are abundant near Wainwright (Bailey and Hendee 1926).	Decrease/?
1923	Natives believe caribou are increasing on the North Slope (Murie 1935).	Increase/?
1925	Caribou are not seen within 30-40 miles of the coast on the Colville River during the mid-20's, but they are common in the general watershed and at the headwaters between the Colville and the Utokok River (Murie 1935).	Decrease/Range Shift
1934	One million reindeer on ranges from Barrow south to Kodiak has forced caribou out of this area (Palmer 1934).	Decrease/ Competition
1935	A group of reindeer is herded to the MacKenzie River Delta. Many are lost to the wild. (Klein 1980) A large portion of the Porcupine herd calved near Arctic Village and most calves died in heavy snow and cold (Scott 1953c in Hemming 1971). Caribou numbers in the Colville watershed seem to be increasing (Murie 1935).	Decrease/ Harsh Snow and Cold Increase/?
1947	The Western Arctic Herd begins to increase in the presence of reindeer from Barrow to Selawik (Klein 1980).	Increase/?
1948	The Western Arctic Herd is estimated at 119,000 animals (Hemming 1971).	
1950	Since 1950, the Western Arctic Herd winters primarily south of the Brooks Range (Hemming 1971). A major forest fire on the Porcupine Caribou Herd winter range between the Eagle, Porcupine, and Bell Rivers. Few caribou use the area in 1950-51. (Hemming 1971)	Winter Range Shift/Increase? Decrease/ Habitat Loss By Fire and Range Shift
1956	Deep, crusted snow of the winter of '56/'57 prevented many animals of the Western Arctic herd from crossing the Brooks Range (Hemming 1971). Large numbers of the Porcupine herd crossed the Brooks Range unusually far to the west, between the Sagavanirktok and the N. Fork of the Chandalar and wintered in the Big Lake/Chandalar area (Hemming 1971).	?/Altered Migration; Harsh Snow Conditions ?/Altered Migration; Range Shift

Table A-4 (Cont'd)

Year	Arctic Coast	Trend/Factor
1957	Many caribou stayed north of the Brooks Range in the Chandler/Etiviluk River areas for no apparent reason. The majority of caribou still migrated southward. (Hemming 1971)	?/Altered Migration; Range Shift
	Large numbers of the Fortymile herd moved north with the Porcupine Caribou herd after overlapping on winter grounds (Skoog 1964 in Hemming 1971).	?/Exchange Between Herds; Range Overlap
1958	As in 1956, large numbers of the Porcupine herd crossed the Brooks Range between the Sagavanirktok and the N. Fork of the Chandalar and wintered in the Big Lake/Chandalar area (Hemming 1971).	?/Altered Migration; Range Shift
1960	Natives believe Kotzebue Sound caribou have become smaller since the 1940's, possibly a result of crossing with reindeer (Klein 1980).	Decreased Body Size/ Hybridization with Reindeer
1961	The Porcupine caribou herd numbers 110,000 (Abbott 1993).	
1962	Heavy snow forces Western Arctic herd calving as far south as the Kobuk River (Lent 1966).	?/Range Shift; Harsh Snow Conditions
1964	Porcupine herd numbers 140,000 and appears to be increasing (Hemming 1971).	Increase/?
	As in 1957, large numbers of the Fortymile herd moved north with the Porcupine Caribou herd after overlapping on winter grounds (Skoog 1964 in Hemming 1971).	?/Exchange Between Herds; Range Overlap
1965	Some Western Arctic herd calving occurs far to the south between Walker Lake and Ambler River with no apparent environmental reason (McGowan 1966).	?/Range Shift
1970	Western Arctic Herd is estimated at 242,000 (Klein 1980).	Increase/?
1972	Porcupine herd numbers 99,959 (Hemming 1971).	Decrease/?
1976	Western Arctic Herd is estimated at 75,000 (Klein 1980).	Decrease/?
1977	Porcupine herd numbers 105,000 (Abbott 1993).	Increase/?
1978	Alaska Department of Fish and Game designates 5,000 animals as the Central Arctic caribou herd and estimates the Western Arctic herd numbers 106,635 (Abbott 1993).	Increase/?
1980	Western Arctic herd numbers 138,000 (Abbott 1993).	Increase/?
1981	Central Arctic herd numbers 8,537 (Abbott 1993).	Increase/?
1982	Porcupine herd numbers 125,174 (Abbott 1993).	Increase/?
	Western Arctic herd numbers 171,699 (Abbott 1993).	Increase/?
1983	Porcupine herd numbers between 135,284 (Abbott 1993) and 150,000 (Williams and Heard 1986).	Increase/?
	Central Arctic herd numbers 12,905 (Abbott 1993).	Increase/?
1986	Western Arctic herd numbers 229,433 (Abbott 1993).	Increase/?
1987	Porcupine herd numbers 165,000 (Abbott 1993).	Increase/?
1988	Western Arctic herd numbers 343,167 (Abbott 1993).	Increase/?
1989	Porcupine herd numbers 178,000 (Abbott 1993).	Increase/?
1990	Western Arctic herd numbers 415,692 (Abbott 1993).	Increase/?
1991	Central Arctic herd numbers 19,046 (Abbott 1993).	Increase/?
1992	Porcupine herd numbers 160,000 (Abbott 1993).	Decrease/?
	Central Arctic herd numbers 23,444 (Abbott 1993).	Increase/?
1995	Porcupine herd numbers 160,000 (P. Valkenburg, pers. comm.).	Stable/?

Table A-5. Chronology of events in the caribou and reindeer herds of Interior and Southcentral Alaska. See Figure A-1 for regions and herd locations.

Year	Event	Trend/Factor
1840	Large herds roam over the area which is now occupied by only 2 small herds (the Beaver herd and the Sunshine herd) (Abbott 1993).	
1884	Caribou are numerous in the Kobuk River area (S.B. McLenegan in Murie 1935).	
1886	Interior herds were not seen north of Tanana, but caribou were numerous from Bristol Bay south (L.M. Turner in Murie 1935).	
1898	There are no caribou in the Kobuk River area. This coincides with a time of few mountain sheep. (J. Grinnell in Murie 1935)	Decrease/?
1900	Early this decade, few caribou of the Beaver herd remain in the Beaver and Sischu Mountains (Hemming 1971).	Decrease/?
1907	Red foxes are extremely numerous on the Kuskokwim River. A rabies epizootic reduces the fox population. (Murie 1944)	
1910	Arctic foxes are seen unusually far to the south in the Brooks Range near Anaktuvuk Pass during low lemming abundance (Rausch 1951).	
1911	From 1911-1920, wolves and caribou are scarce in the Anaktuvuk Pass area. Caribou migration routes are assumed to have changed (Rausch 1951).	Decrease/ Altered Migration?
1913	No caribou remain on the Kenai Peninsula (Spencer and Hakala 1964).	Extirpated/ Habitat Loss Due to Fires and Overhunting (Allen 1901 in Hemming 1971).
1916	Wolves are scarce in the Mt. McKinley Park area until 1925 even though caribou are plentiful and hunting pressure is low (Murie 1944).	Increase/ Decreased Predators
1920	Before 1920, moose were plentiful in the Mt. McKinley Park area (Murie 1944). The Fortymile caribou herd is estimated at greater than 500,000 animals (Hemming 1971). Caribou are abundant near the head of the Anaktuvuk River (Murie 1935).	
1921	The Yukon/Tanana herd is estimated at 568,000 caribou (Murie 1935). Caribou and wolves were scarce in the upper Fortymile area (Murie 1935).	Increase/? Decrease/?
1922	A reindeer herd is driven through Mt. McKinley Park and some animals are lost to the caribou herd. The reindeer are subsequently abandoned near the caribou wintering range and are assumed to have joined the caribou. No effects are observed. (Murie 1944) Moose are scarce in Mt. McKinley Park (Murie 1944). Caribou and wolves return to the upper Fortymile area after a year of absence (Murie 1935).	Decrease/ Abandonment of Reindeer to the Wild Increase/Range Shift
1923	Moose continue to be scarce in Mt. McKinley Park (Murie 1944).	
1924	Yukon-Tanana caribou migrate farther south than normal to Whitehorse (Murie 1935).	??/Altered Migration
1925	A disease is killing caribou in the Mt. McKinley region, but no details are given (Murie 1944). The Yukon-Tanana herd migrates further south than normal (Murie 1935).	Decrease/ Disease ??/Altered Migration
1927	Moose in Mt. McKinley Park have increased in the west, but are still scarce in the east where market hunting pressures are greater (Murie 1944).	
1928	In the absence of wolves from 1916-1925, the number of Dall sheep in Mt. McKinley Park increase to the point of overpopulation (Murie 1944). Moose are plentiful in Mt. McKinley Park in both the east and west (Murie 1944).	
1929	A hard winter reduces the Dall sheep population in Mt. McKinley Park (Murie 1944).	??/Harsh Winter
1930	The Yukon/Tanana herd is estimated to have 568,000 caribou, and 1930's center of abundance for caribou in Alaska straddles the western Yukon Territory and central Alaska border (Murie 1935). The Delta caribou herd forms as possible strays from the Fortymile herd on the central North Slope of the Alaska Range (Skoog 1968 in Hemming 1971).	New Herd Formation/ Straying; Range Shifts

Table A-5 (Cont'd).

Year	Event	Trend/Factor
1930 (Cont'd)	Twitchell reindeer herd is well-established in the Kuskokwim Mountains west of McGrath, but abandoned by the 1940's (Hemming 1971). (Same area as Beaver caribou herd)	?/Abandonment of Reindeer to the Wild
	Chisana herd formed, possibly from the Fortymile herd migrations in the area during the 1920's-30's (Hemming 1971).	New Herd Formation/ Straying; Range Shifts
	The centers of abundance for northern herds (including those crossing the Brooks Range) are southeast of Anaktuvuk Pass and between the head of the Porcupine and Peel rivers on the U.S./Canadian border (Murie 1935).	
1931	25-30,000 caribou are estimated to inhabit the Alaska Range (3,000 west of Mt. McKinley) (Murie 1935).	
	The Mount McKinley herd ceases wintering in the Broad Pass area and winters mainly near Lake Minchumina until 1961 (Hemming 1971).	?/Winter Range Shift
1932	1932 is a hard winter with deep crusted snow particularly hard on moose in Mt. McKinley National Park (Murie 1944).	?/Harsh Snow Conditions
	Dall sheep decline in Mt. McKinley Park during severe winter (Murie 1944).	?/Harsh Snow Conditions
	Wolves increase through 1941. Sheep numbers seem to be stable throughout this period. (Murie 1944)	
	Mentasta caribou herd forms as a remnant of the Fortymile herd when that herd ceases using the area (Skoog 1968 in Hemming 1971).	New Herd Formation/ Range Shift
1933	Moose begin a decade of increase. Hunting pressures are down. (Murie 1944)	
1935	Interior herds seem to be stable at a time when many other herds are dwindling (Murie 1935).	
	Snowshoe hares are abundant in Mt. McKinley Park until the late 30's (Murie 1944).	
1936	Arctic foxes are seen south of the Brooks Range near Anaktuvuk Pass during low lemming abundance (Rausch 1951).	
1938	Mice are extremely abundant in Mt. McKinley Park, but decline over winter (Murie 1944).	
1939	Mice are scarce in Mt. McKinley Park (Murie 1944).	
1940	Mt. McKinley herd is estimated to contain 20-30,000 caribou (Murie 1944).	
	Wolves are at saturation levels in Mt. McKinley Park (Murie 1944).	
	Red foxes are abundant in Mt. McKinley Park (Murie 1944).	
	Mice are abundant in Mt. McKinley Park (Murie 1944).	
	Snowshoe hares are scarce throughout the early 1940's in Mt. McKinley Park (Murie 1944).	
	Mt. McKinley herd calves farther to the east than usual (Murie 1944).	?/Calving Range Shift
	Fortymile herd is estimated at 10-20,000 animals during this decade, a decline from 500,000 in the 1920's (Hemming 1971).	Decrease/Range Shift?
	Twitchell reindeer herd in the Kuskokwim Mountains west of McGrath are abandoned in the 1940's (Hemming 1971). (Same area as Beaver caribou herd)	Decrease/ Reindeer Abandoned to Wild
1941	Mt. McKinley herd calves farther to the east than usual (Murie 1944).	?/Calving Range Shift
	Mice are abundant in Mt. McKinley Park (Murie 1944).	
	Arctic foxes are seen south of the Brooks Range near Anaktuvuk Pass during low lemming abundance (Rausch 1951).	
1945	High ptarmigan mortality in the Anaktuvuk Pass area (Rausch 1951).	
1946	Snowshoe hares are abundant near the John River. Soon after this high, lynx numbers decline. (Rausch 1951)	
1947	Fortymile herd begins a southeast shift in calving that lasts 2 decades. The area starts out in the White Mountains northwest of the Steese highway and shifts completely southeast of the highway to the Tanana Hills. (Hemming 1971)	?/Calving Range Shift
	Arctic foxes are seen south of the Brooks Range near Anaktuvuk Pass during low lemming abundance (Rausch 1951).	

Table A-5 (Cont'd).

Year	Event	Trend/Factor
1948	Nelchina herd numbers 20,000 (Hemming 1971). Fortymile herd increases through the early 50's to 50,000 (Hemming 1971).	Increases/?
1949	There are late southward migrations of caribou in the Anaktuvuk Pass area (Rausch 1951). Brown lemmings and tundra voles are scarce in the Anaktuvuk Pass area while narrow skulled voles remain abundant until a sharp decline in September 1951 (Rausch 1951).	?/Altered Migrations
1950	Migrant short-eared owls are abundant in the Anaktuvuk Pass area due to high vole numbers (Rausch 1951). Wolf numbers are high in Savioyok Valley coinciding with high moose and sheep densities (Rausch 1951).	
1952	Fortymile winter ranges change annually up to at least 1971 (Hemming 1971). Small numbers of the Beaver caribou herd remain in the Kuskokwim Mountains west of McGrath (Scott 1952 in Hemming 1971) in same area as the Twitchell reindeer herd that was abandoned in the 1940's (Hemming 1971).	?/Winter Range Shift ?/Feral Reindeer Survive?
1954	Fortymile herd has an unusual migration of 2 round trips in one year (Skoog 1956 in Hemming 1971).	?/Altered Migration
1956	The winter 1956/57 is severe with deep crusted snow south of the Brooks Range (Hemming 1971).	?/Harsh Snow Conditions
1957	After overlapping on winter range, 30,000 Fortymile caribou move north with the Porcupine caribou herd (Skoog 1964 in Hemming 1971). Delta Caribou herd numbers 1,000-1,500 and is increasing (Olson 1957 in Hemming 1971).	Increase/ Exchange Between Herds; Range Overlap Increasing
1958	The Fortymile caribou herd migrated far to the east for winter and many calved in the Yukon Territory, but returned to traditional calving grounds the following year (Hemming 1971).	?/Calving Range Shift
1961	Mount McKinley herd winter range spreads between the Kantishna and Nenana Rivers and to the foothills between the Little Tonzana River and Slippery Creek (Hemming 1971).	?/Winter Range Expansion
1962	Heavy snowfall delayed the Fortymile caribou herd migration and calving occurred enroute (Hemming 1971).	?/Calving Range Shift
1963	Mount McKinley herd numbers 12,000 (Skoog 1963 in Hemming 1971). Delta herd numbers greater than or equal to 5,000 animals (Skoog 1963 in Hemming 1971). Beaver Caribou herd numbers 3,000 (Skoog 1963 in Hemming 1971). Chisana herd numbers 3,000 (Skoog 1963 in Hemming 1971).	
1964	After overlapping on winter range, a large number of Fortymile caribou move north with the Porcupine caribou herd (Skoog 1964 in Hemming 1971). A late thaw causes most of the Nelchina herd cows to calve enroute between the upper Nenana River and traditional calving areas (Lentfer 1965 as in Hemming 1971).	Increase/ Exchange Between Herds; Range Overlap ?/Calving Range Shift
1965	Fortymile herd ceases the southeast shift in calving that began in 1947. The area started in the White Mountains northwest of the Steese highway and shifted completely southeast of the highway to the Tanana Hills. (Hemming 1971) Mentasta herd numbers 5,000 (Lentfer 1965 in Hemming 1971). Nelchina herd shifts to using the Wrangell Mountains for wintering which overlaps with the distribution of the Mentasta herd (Hemming 1971). 15 caribou were reintroduced to the Kenai Peninsula near the Chickaloon River (Hemming 1971). An additional 29 caribou were introduced to the Kenai Peninsula near Watson Lake (Sterling) (Glenn 1967 in Hemming 1971).	?/End to Calving Range Shift ?/Winter Range Shift /Reintroduction of Caribou /Reintroduction of Caribou

Table A-5 (Cont'd).

Year	Event	Trend/Factor
1969	A pinto animal was spotted among the Beaver Caribou herd where reindeer had been abandoned in the 1940's (Hemming 1971).	/Reindeer Survival in Wild
1970	The Nelchina herd numbers 60,000. The general range has not changed since the 1930's, and calving occurs on the same calving grounds, but shifts within the range has occurred. (Hemming 1971)	
1971	The Mount McKinley herd numbers less than 10,000 (Hemming 1971).	Decrease/?
1975	Introduced Kenai Peninsula caribou number 339 (Abbott 1993).	Increase/?
1976	The Fortymile caribou herd numbers between 5,740 and 8,610 (Abbott 1993).	
1977	Kenai Peninsula caribou number 193 (Abbott 1993).	Decrease/?
1986	The Fortymile caribou herd numbers 15,307 (Abbott 1993).	Increase/?
1988	Kenai Peninsula caribou number 568 (Abbott 1993).	Increase/?
	The Fortymile caribou herd numbers 19,975 (Abbott 1993).	Increase/?
1989	Kenai Peninsula caribou number 558 (Abbott 1993).	Stable
1990	The Fortymile caribou herd numbers 22,766 (Abbott 1993).	Increase/?
	The Beaver and Sunshine Mountain herds number 1,700 (Abbott 1993).	
1991	Kenai Peninsula caribou number 611 (Abbott 1993).	Increase/?
1992	Kenai Peninsula caribou number 761 (Abbott 1993).	Increase/?
	The Fortymile caribou herd numbers 21,884 (Abbott 1993).	Decrease/?
	The Beaver and Sunshine Mountain herds number 1,500 (Abbott 1993).	Decrease/?
	The Sunshine Mountain herd used fall ranges unusually far to the south (Abbott 1993).	?/Fall Range Shift

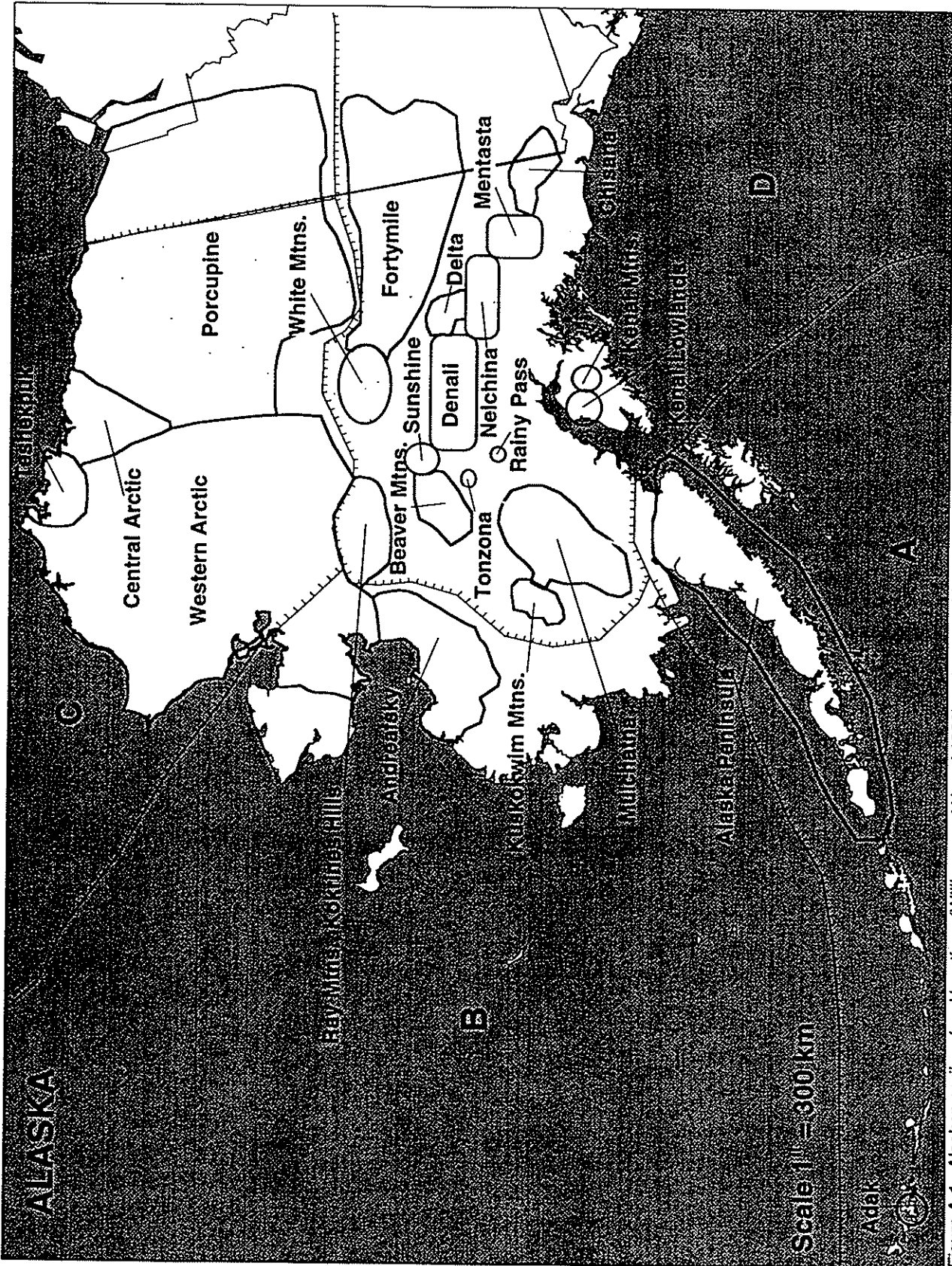


Figure A-1. Alaskan caribou herd locations (Williams and Heard 1986) and geographic regions as separated in Tables A-2 through A-5. Geographic regions: A, Alaska Peninsula and Aleutian Islands, B, Bering Sea Coast and Seward Peninsula, C, Arctic Coast, D, Interior and Southcentral.

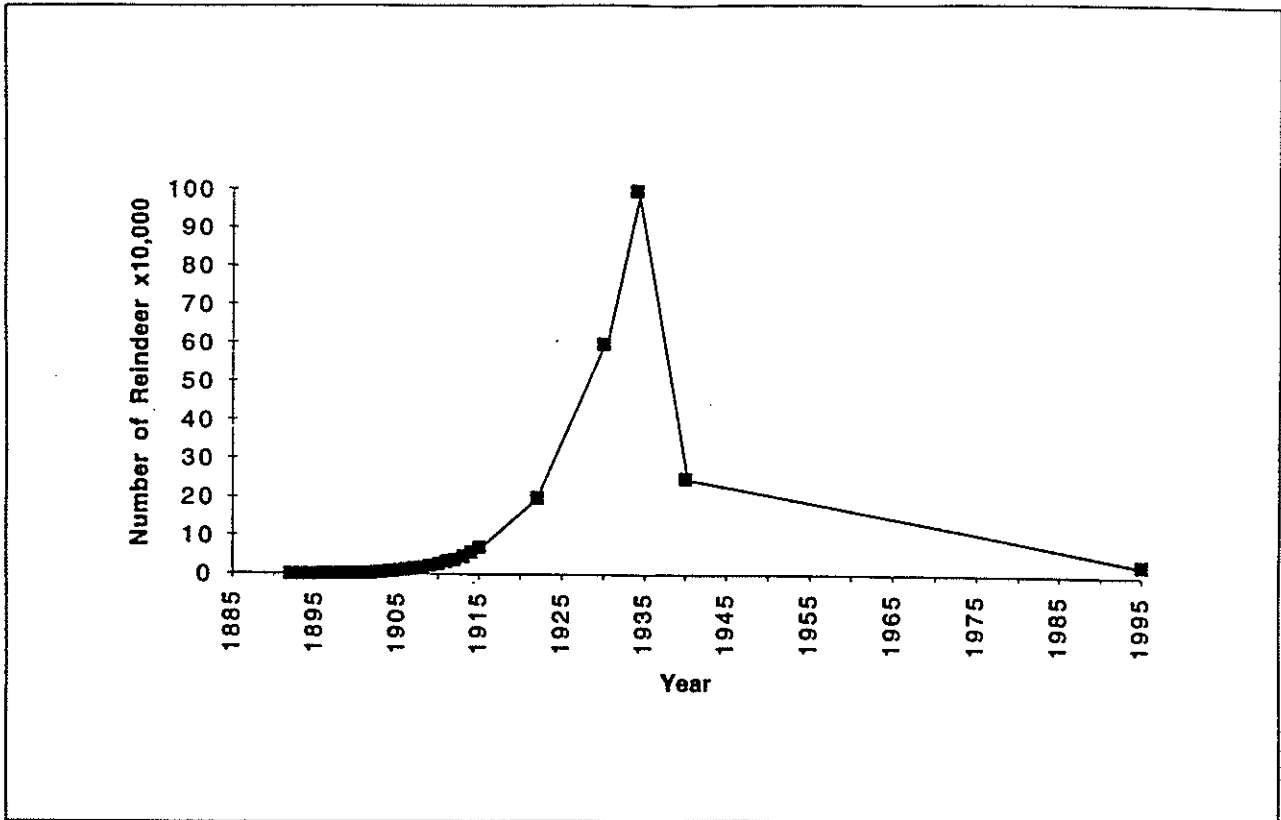


Figure A-2. Number of reindeer in Alaska by year (data from Table A-1 [pre-1916 data according to Rutherford et al. 1922]).

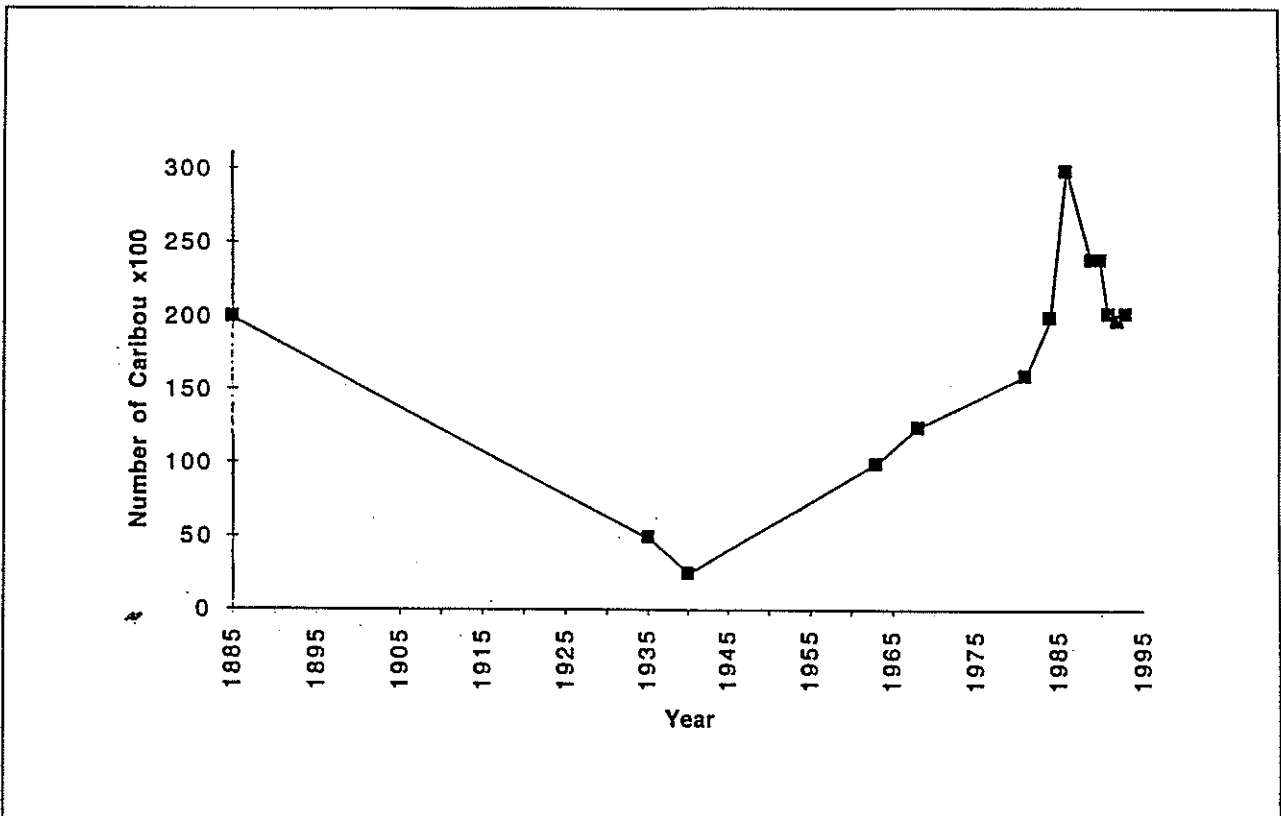


Figure A-3. Number of caribou in the Alaska Peninsula herds by year (data from Table A-2).

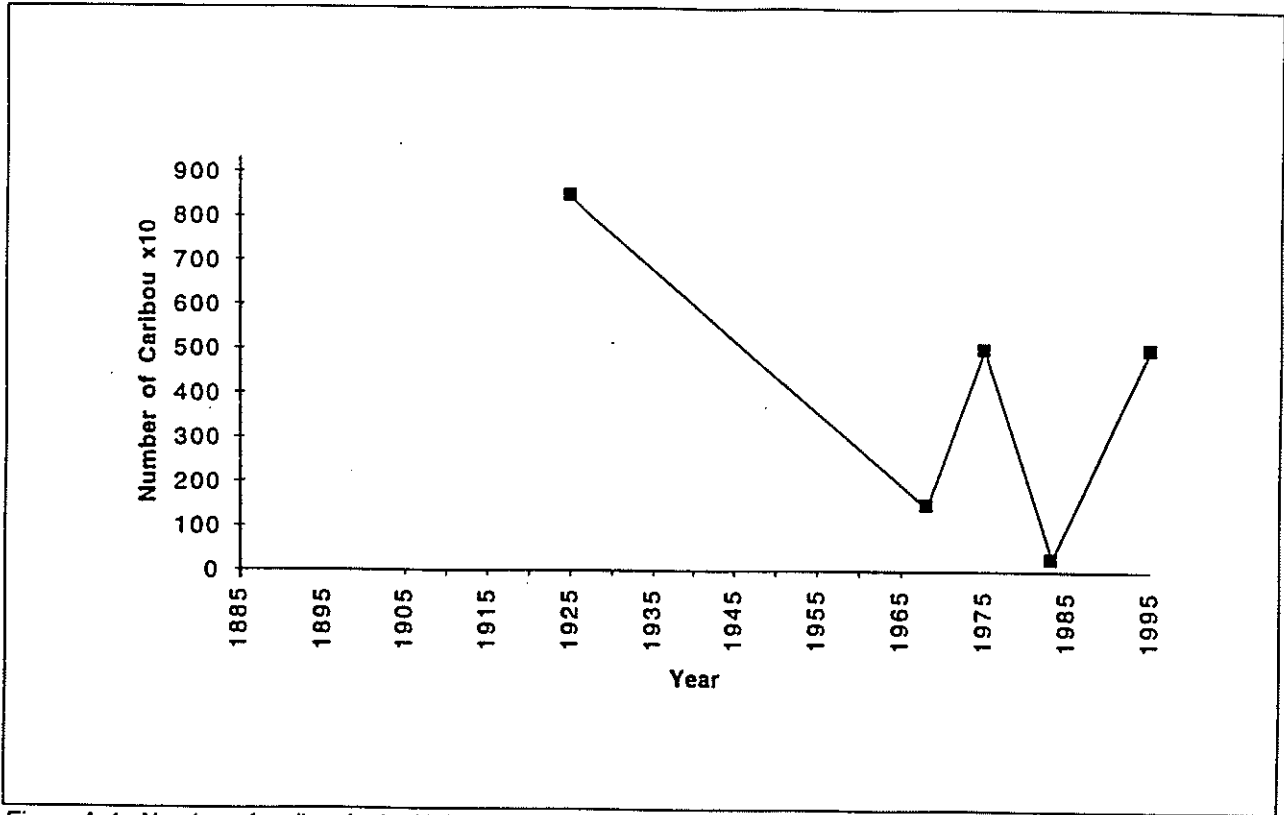


Figure A-4. Number of caribou in the Unimak Island Herd by year. 1995 data reflect the current population or reindeer. Caribou have been documented on Unimak Island in recent years (Abbott 1993), but quantitative data are not available (data from Table A-2).

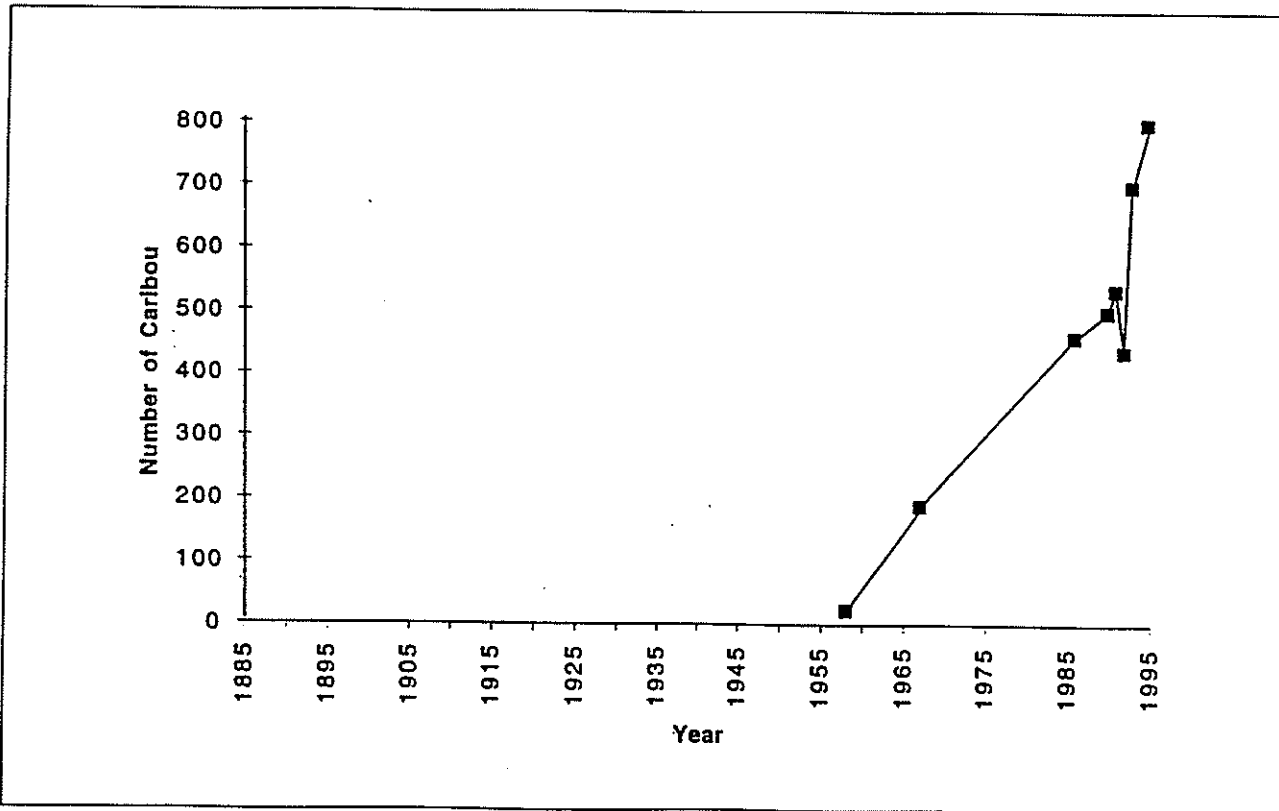


Figure A-5. Number of caribou in the Adak Island herd by year (data from Table A-2).

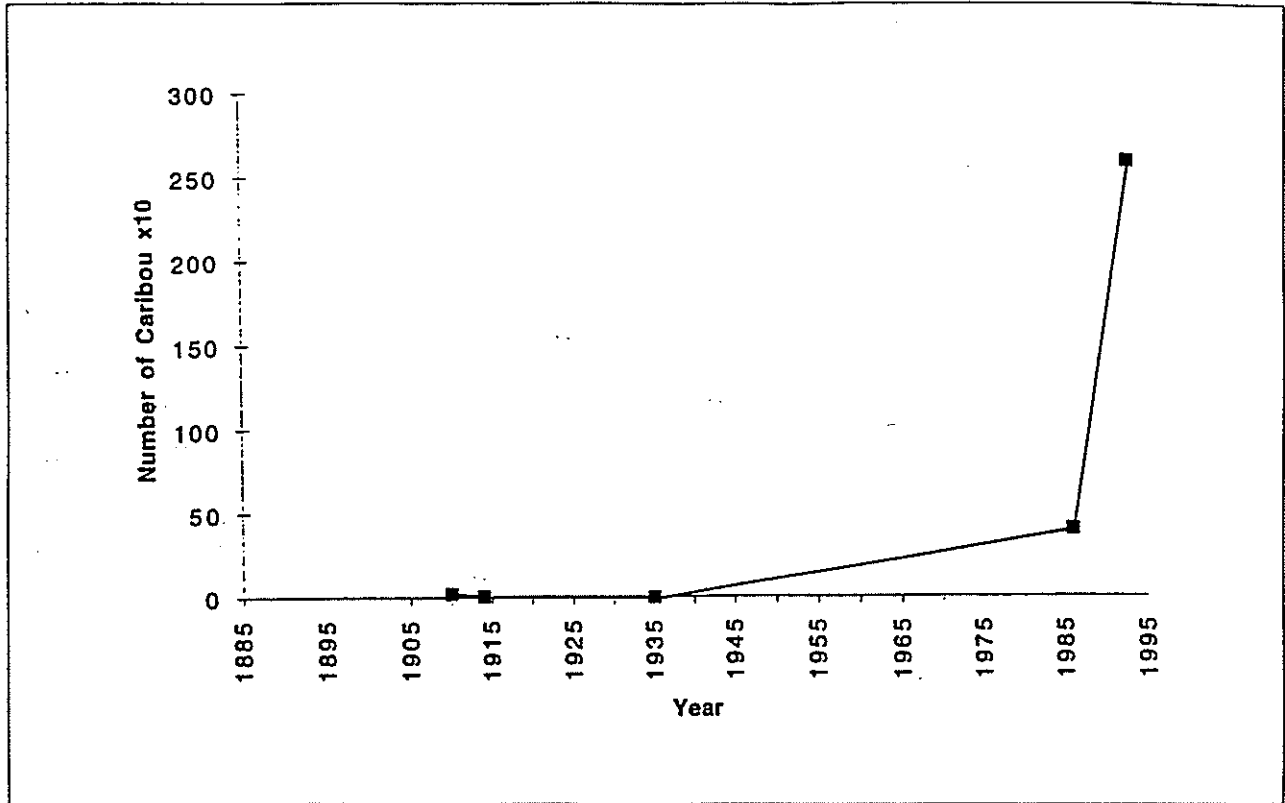


Figure A-6. Number of caribou in the Yukon/Kuskokwim Delta by year. Data for the Yukon-Kuskokwim Delta were available only for the Andreatsky Herd in 1986 (Williams and Heard 1986) and for the Kilbuck Mountains Herd (Abbott 1993). (Data from Table A-3).

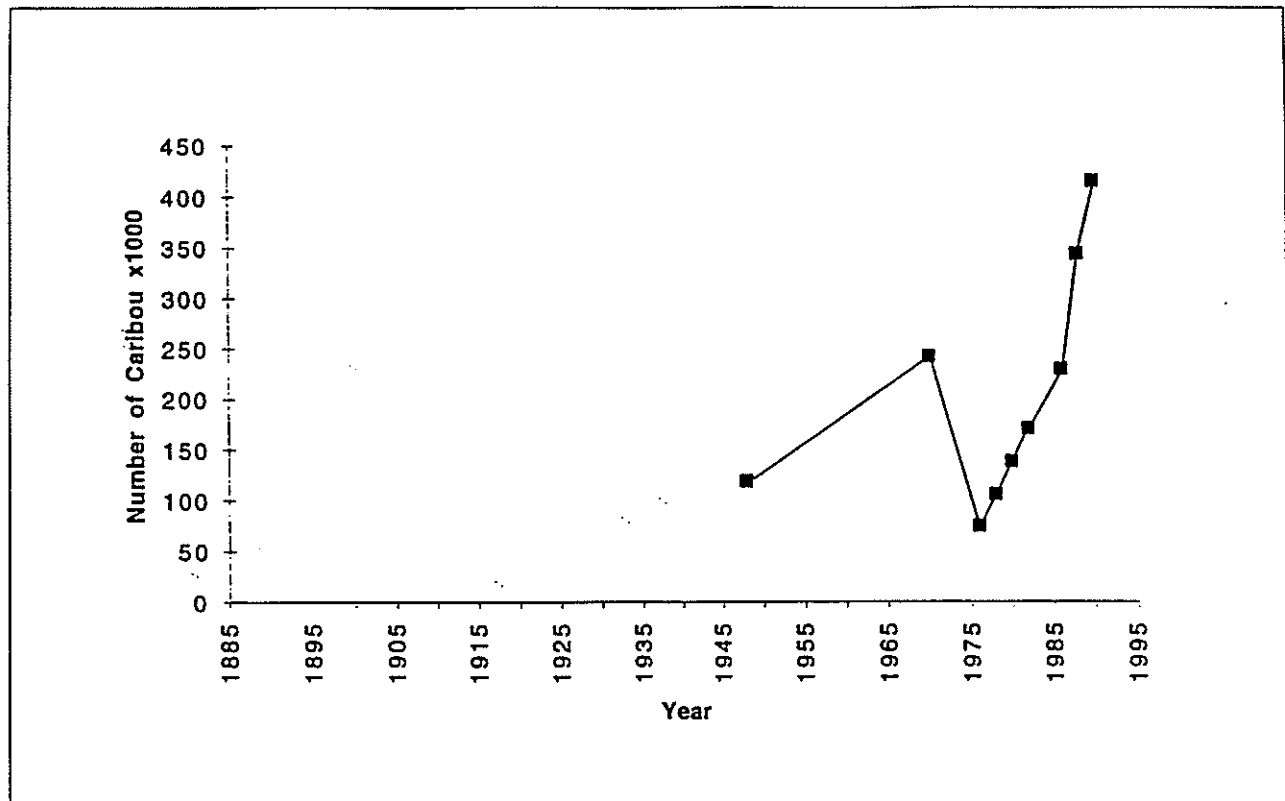


Figure A-7. Number of caribou in the Western Arctic Caribou Herd by year (data from Table A-4).

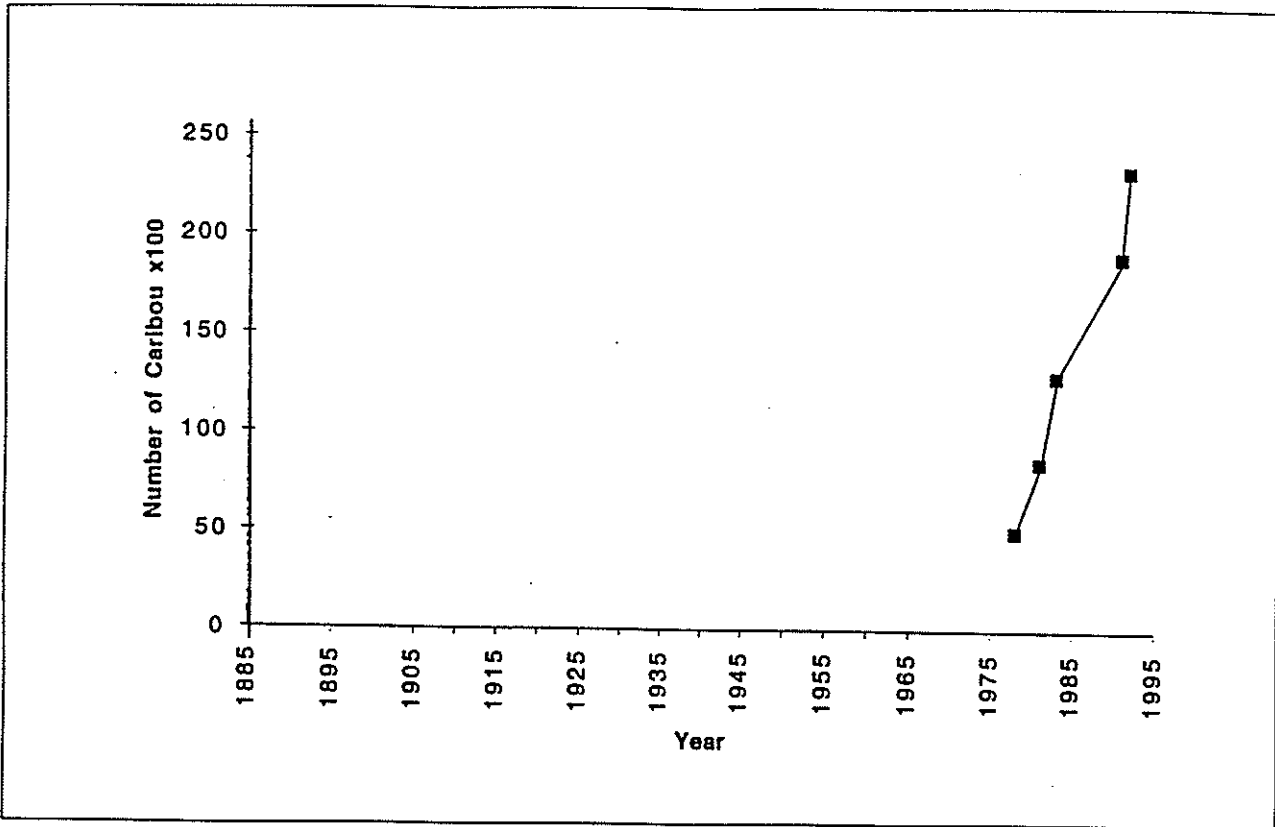


Figure A-8. Number of caribou in the Central Arctic Caribou Herd by year (data from Table A-4).

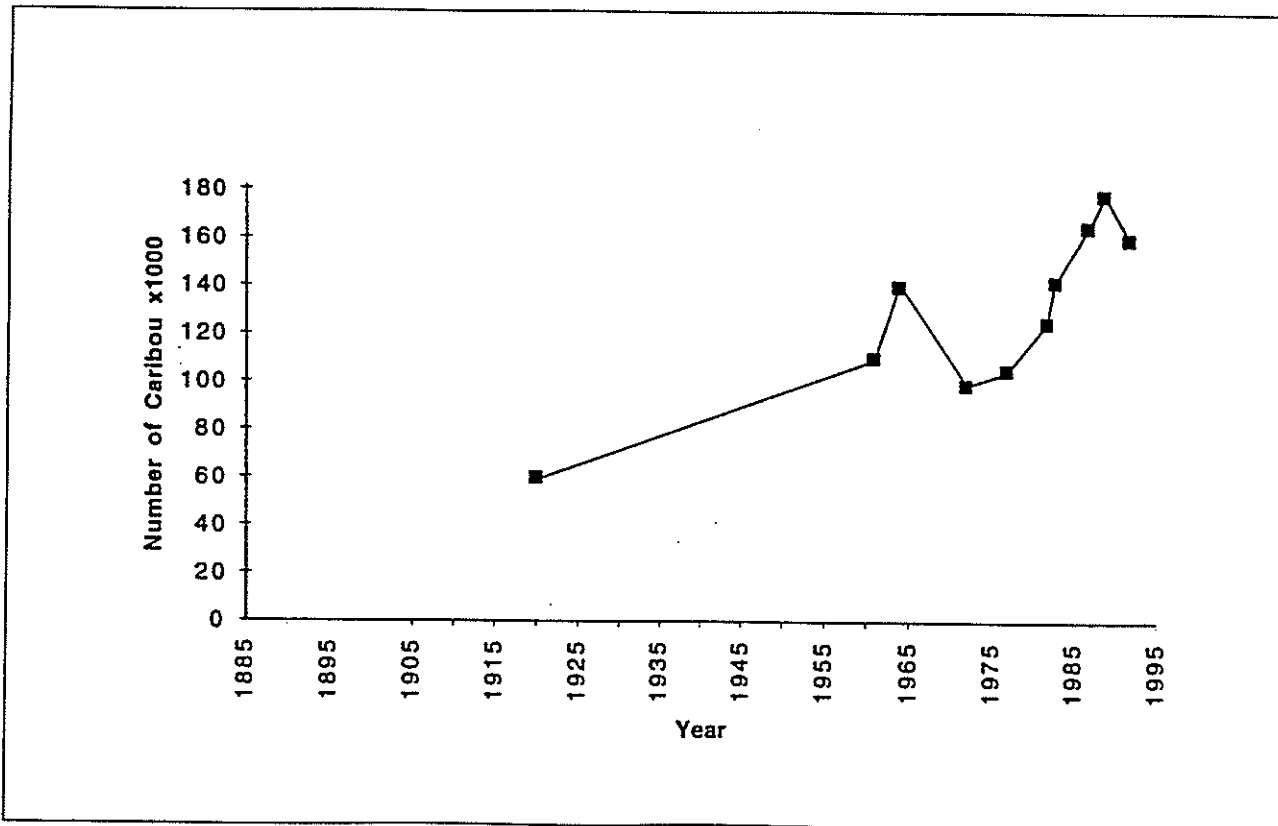


Figure A-9. Number of caribou in the Porcupine Caribou Herd by year (data from Table A-4).

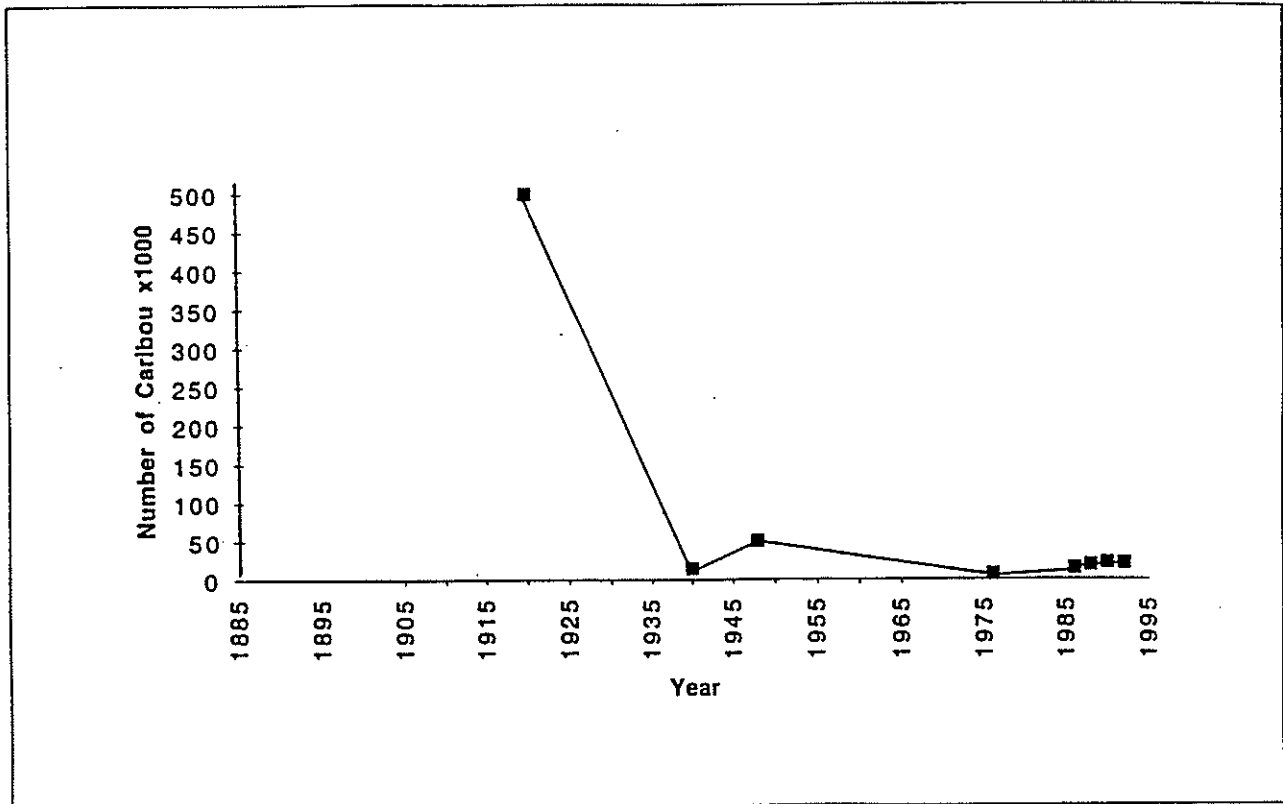


Figure A-10. Number of caribou in the Fortymile Caribou Herd by year. The large decrease between 1920 and 1940 indicates the extensive range shifts and fragmentation of the Fortymile Herd characteristic at that time (data from Table A-5).

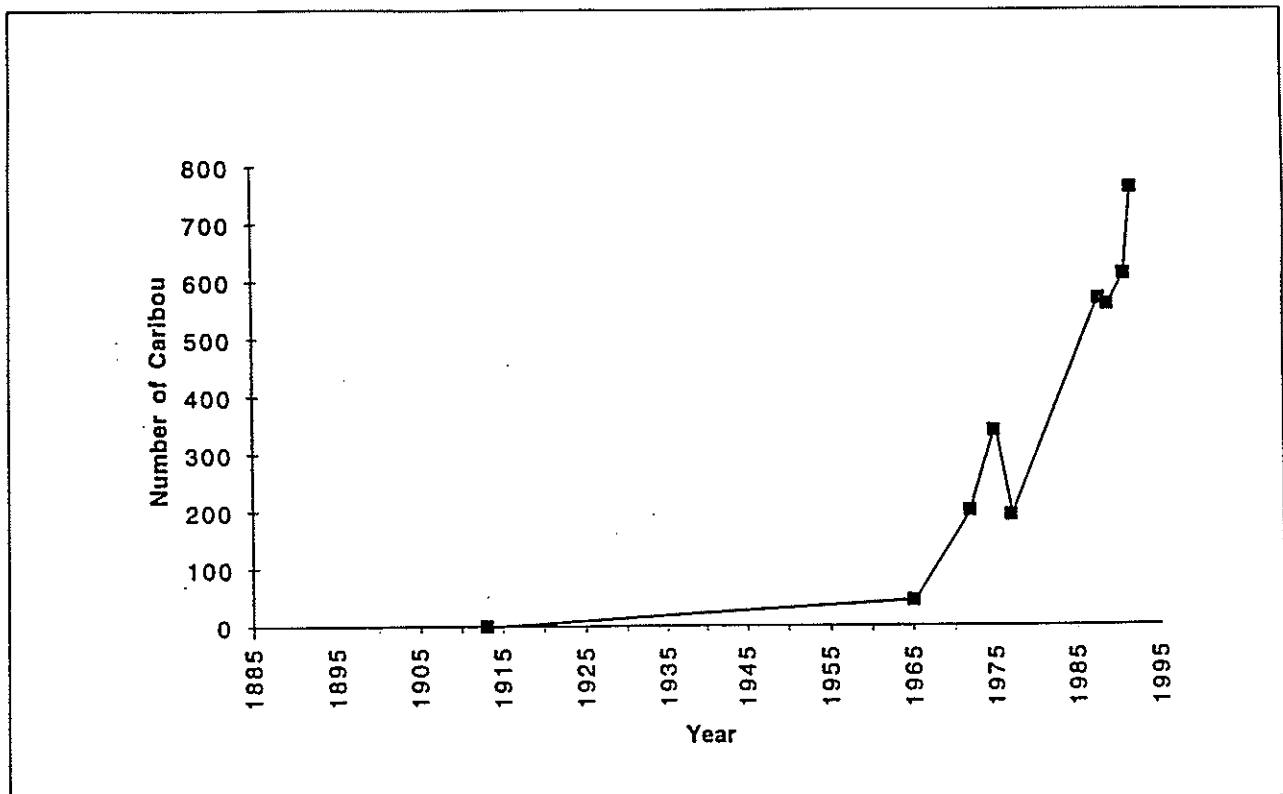


Figure A-11. Number of caribou in the Kenai Peninsula caribou herds by year. Data reflect lumped data for all four herds on the Kenai Peninsula (data from Table A-5).

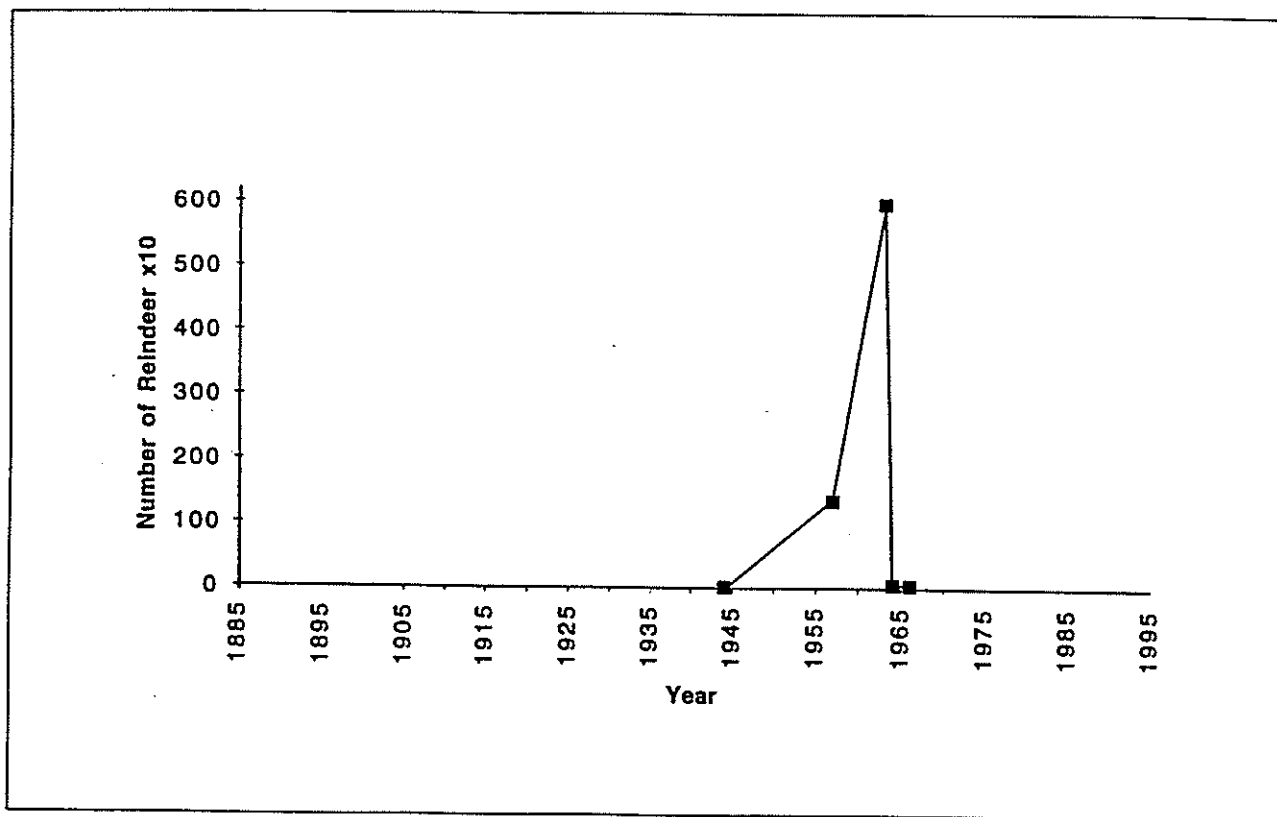


Figure A-12. Number of reindeer in the St. Matthew Island Reindeer Herd by year (data from Table A-3).

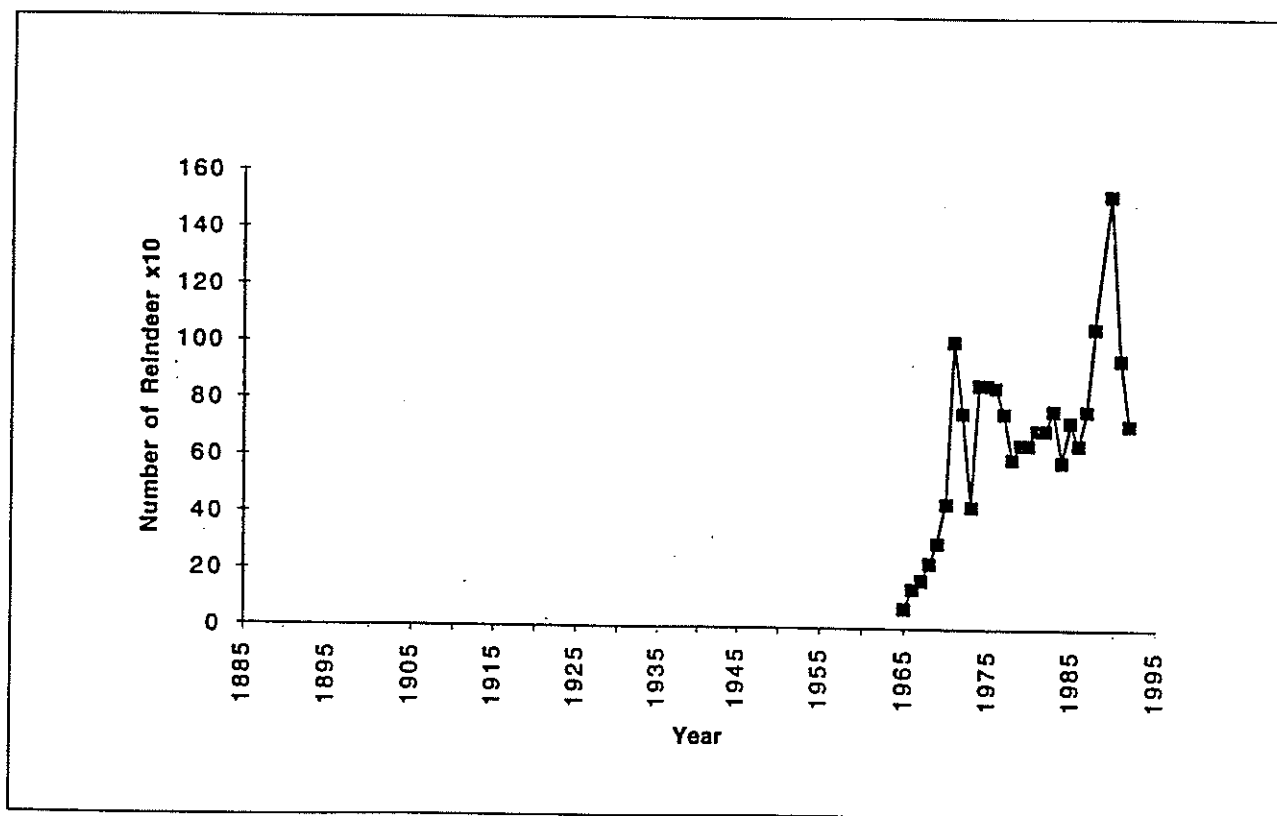


Figure A-13. Number of reindeer in the Hagemeister Island Reindeer Herd by year (data taken from Table A-3 [annual estimates not in Table A-3 taken from Lay 1994]).

Appendix B

Population Trends of Russian Caribou and Reindeer Herds

TABLE

Table B-1 Chronology of events in the wild caribou and domestic reindeer herds of Russia

FIGURES

Figure B-1 Caribou herds of Russia according to Williams and Heard (1986)
Figure B-2 Number of reindeer in Russia by year
Figure B-3 Number of caribou in Russia by year
Figure B-4 Number of caribou in the Eastern Kola Peninsula Herd, Russia, by year
Figure B-5 Number of caribou in the Western Kola Peninsula Herd, Russia, by year
Figure B-6 Number of caribou in the Taimyr/Krasnoyarsk Herds, Russia, by year
Figure B-7 Number of caribou in the Ostrovnoe Island Herds, Russia, by year
Figure B-8 Number of reindeer in the Wrangel Island Herd, Russia, by year
Figure B-9 Number of caribou in the Sakhalin Island Herd, Russia, by year

Table B-1. Chronology of events in the wild caribou and domestic reindeer herds of Russia. See Figure B-1 for regions and herd locations.

Year	Event	Trend/Factor
900	Domestication of reindeer begins (Syroechkovskii 1974).	
1600-1700	Domestic reindeer number approximately 1 million (Syroechkovskii 1974).	
1800	Caribou decline throughout this decade as reindeer herders eliminate caribou to make room for reindeer. The Komi-Ishma area caribou in the west are particularly reduced. (Syroechkovskii 1974)	Decrease/ Competition
1880	In the late 1880's caribou roam throughout the Tomsk region (Pichagin 1974).	
1920	The period from 1920-1940 is the beginning of a shift consumption from wild caribou to domestic reindeer (Syroechkovskii 1974).	
1926	The 1926/27 estimate for the number of caribou in far north Russia is 400,000 (Syroechkovskii 1974). Reindeer on the Kamchatka Peninsula number 257,000 (Vershinin et al 1974).	
1929	The Western segment of the Kola Peninsula caribou herd numbers only 99 animals (Semenov-Tyan-Shanskii 1974).	
1930	Caribou decline for the next 3 decades (Syroechkovskii 1974). Caribou which were continuous throughout Tomsk in the late 1880's, are now in small isolated groups and number few (Pichagin 1974).	Decrease/? Decrease/ Habitat Fragmentation
1932	Western segment of the Kola Peninsula caribou herd numbers 210 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
1934	Taimyr caribou number between 300,000 and 400,000 (Yakushkin et al 1974).	
1936	The Western segment of the Kola Peninsula caribou herd numbers 365 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
1940	The caribou population is at 300,000-350,000 (Syroechkovskii 1974). Anecdotes and first attempts at aerial surveys indicate a sharp decrease in the Taimyr caribou population for reasons unknown. "The data do seem to indicate that the phenomenon of self-regulation of population occurred." (Yakushkin et al 1974) The Western segment of the Kola Peninsula caribou herd numbers 942 animals (Semenov-Tyan-Shanskii 1974). There are approximately 1,000 taiga dwelling caribou in the upper reaches of the Pechora River in this decade (Sokol'skii 1974). A group of reindeer from Chukchi is taken to establish a herd on Wrangel Island. By 1974, these animals revert to wild types, being heavier and grazing as caribou do. (Kishchinskii 1974)	Decrease/? Decrease/? Increase/?
1945	World War II eliminated reindeer herding in the western Kola Peninsula and wild caribou quickly expanded over the area (Semenov-Tyan-Shanskii 1974). Reindeer on the Kamchatka Peninsula number 196,200 (Vershinin et al 1974).	Increase/ Reduced Competition Decrease/?
1948	Wrangel Island population is established with reindeer from Chukchi (Kishchinskii 1974).	
1949	Western segment of the Kola Peninsula caribou herd numbers 437 animals (Semenov-Tyan-Shanskii 1974).	Decrease/?
1950	Aerial surveys of caribou are first performed (Syroechkovskii 1974). Caribou population begins recovery for unknown reasons (Syroechkovskii 1974). Large numbers of people abandon small industrial settlements in the 1950's and move to large settlements freeing up taiga for caribou to repopulate (Syroechkovskii 1974). Reindeer on the Kamchatka Peninsula number 193,500 (Vershinin et al 1974).	Increase/? Increase/ Human Settlement Abandoned
1951	A large portion of the taiga dwelling caribou in the upper reaches of the Pechora River move out of the survey area which was a sanctuary (Sokol'skii 1974). The Western Kola Peninsula caribou begin a 15 year span of extreme increase (Semenov-Tyan-Shanskii 1974).	?/Range Shift Increase/?

Table B-1 (Cont'd).

Year	Event	Trend/Factor
1955	Caribou population continues recovery for unknown reasons (Syroechkovskii 1974).	Increase/?
1956	Caribou are protected under law (Syroechkovskii 1974).	
1957	The Western segment of the Kola Peninsula caribou herd numbers 1,964 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
	Reindeer on the Kamchatka Peninsula number 120,400 (Vershinin et al 1974).	Decrease/?
1958	Eastern segment of the Kola Peninsula caribou herd numbers 1,400 animals (Semenov-Tyan-Shanskii 1974)	
1959	Taimyr population numbers 110,000 (Pavlov 1974).	
1960	There are approximately 600 taiga dwelling caribou in the upper reaches of the Pechora River in this decade. Migrations stopped due to low numbers and grazing competition with 2-3,000 reindeer (Sokol'skii 1974).	Decrease/ Altered Migration; Competition with Reindeer
1961	There are 103,000-136,816 reindeer in Krasnoyarsk (Syroechkovskii 1974).	
	The Western segment of the Kola Peninsula caribou herd numbers 4,397 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
1962	There are 103,900-163,370 reindeer in Krasnoyarsk (Syroechkovskii 1974).	Increase/?
	The Eastern segment of the Kola Peninsula caribou herd numbers 3,559 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
1963	A survey of Krasnoyarsk estimates 103,900 caribou (Syroechkovskii 1974).	Decrease/?
	This is the last year that the western Kola Peninsula caribou population occurs completely within the Lapland Sanctuary as numbers increase and pasture quality declines (Semenov-Tyan-Shanskii 1974).	Increase/ Range Shift, Range Deterioration
	Eastern segment of the Kola Peninsula caribou herd numbers 3,600 animals (Zakharov 1974).	Stable
	Western segment of the Kola Peninsula caribou herd numbers 5,600 animals (Zakharov 1974).	Increase/?
1964	Krasnoyarsk survey estimates 120,000 caribou (Syroechkovskii 1974).	Increase/?
	From now on, only 9-47% of the western Kola Peninsula caribou population is seen within the Lapland Sanctuary (Semenov-Tyan-Shanskii 1974).	Increase/ Range Shift
1965	Krasnoyarsk survey estimates 120,000 caribou (Syroechkovskii 1974).	Stable/?
	Ostrovnoe Islands caribou number 17-18,000 (Kishchinskii 1974).	
1966	Krasnoyarsk survey estimates 250,000 caribou (Syroechkovskii 1974).	Increase/?
	Taimyr caribou population consists of 88 herds and 210,300-252,000 individuals (Pavlov et al 1974).	Increase/?
1967	A survey of Krasnoyarsk estimates 250,000 caribou (Syroechkovskii 1974).	Stable
	The Yamalo-Nenetsk region has 3,920 caribou in two populations: western Nadym'sk with 1,372 caribou and eastern Purovsk-Krasnonsel'kupsk with 2,548 caribou (Makridin and Pavlov 1974).	
	The Western segment of the Kola Peninsula caribou herd numbers 12,633 animals (Semenov-Tyan-Shanskii 1974).	Increase/?
1968	A survey of Krasnoyarsk estimates 250,000 caribou (Syroechkovskii 1974).	Stable/?
	Taiga dwelling caribou in the upper reaches of the Pechora River are heavily preyed upon by wolves (Sokol'skii 1974).	Decrease/ Predation
	Eastern segment of the Kola Peninsula caribou herd numbers between 7,880 animals (Semenov-Tyan-Shanskii 1974) and 8,300 animals (Zakharov 1974).	Increase/?
	Sakhalin caribou number 1,500-1,700 and are decreasing due to shrinking habitat, hunting pressures, and competition with reindeer for range (Zagorodskii and Reimers 1974).	Decrease/ Habitat Loss; Hunting; Competition with Reindeer

Table B-1 (Cont'd).

Year	Event	Trend/Factor
1969	A survey of Krasnoyarsk estimates 340,000 caribou (Syroechkovskii 1974).	Increase/?
	Two surveys of the Taimyr caribou population estimate numbers of 292,200-333,000 animals (Pavlov et al 1974).	Increase/?
1970	In the Taimyr caribou herd, only 62% of cows had calves with them at the end of July (Yakushkin et al 1974).	
	Reindeer on the Kamchatka Peninsula number 170,800 (Vershinin et al 1974).	Increase/?
1971	Krasnoyarsk survey estimates 340,000 caribou (Syroechkovskii 1974).	Stable/?
	Total number of caribou on the Kola Peninsula is 34,000-35,000 (Zakharov 1974).	Increase/?
1972	The Eastern segment of the Kola Peninsula caribou herd numbers 12,000 animals (Zakharov 1974).	Increase/?
	The Western segment of the Kola Peninsula caribou herd numbers 22,000 animals (Zakharov 1974).	Increase/?
1973	In Yakutia, tundra caribou number 95,000 (Bulunskoe=20,000; Ostrovnoe=17-28,000; Yano-Indigirsk=45-50,000; right bank Indigirsk=10,000) and reindeer number 145,000 (Egorov and Popov 1974).	
	Ostrovnoe Islands caribou number 17-28,000 (Egorov and Popov 1974).	Increase/?
1974	A survey of Krasnoyarsk estimates 337,000 caribou (Syroechkovskii 1974).	Stable/?
1975	A survey of Krasnoyarsk estimates 386,000 caribou (Syroechkovskii 1974).	Increase/?
1976	Russia has 600,000 caribou and 2,400,000 reindeer (Syroechkovskii 1974).	
	Taimyr/Evenkia caribou number 350,000 and are currently the world's largest herd (Krutorogov 1974).	Decrease/Stable
1977	Taimyr herd's growth rate is slowing (10.5%) probably due to severe climate and increased population size (Yakushkin et al 1974).	Slow Pop. Growth/ Climate; Population Density
	There are 4,000 tundra caribou in the Nenetsk national region (Petrovskii 1974).	Stable
1978	In western Russia, caribou are localized in Komi (3,000 forest caribou), the Kola Peninsula, Karelia, and Arkhangel'sk (forest caribou numbering 4,000), and Perm (180 caribou) (Petrovskii 1974).	
	Predators are negligible on the western Kola Peninsula. 71% of caribou deaths occur in the winter. The only control is hunting, but area is relatively inaccessible and more popular for elk hunting. (Semenov-Tyan-Shanskii 1974).	Increase/ Lack Predators
1979	The density of reindeer equals that of caribou in both herds of the Kola Peninsula (Semenov-Tyan-Shanskii 1974).	
	Taiga dwelling caribou in the upper reaches of the Pechora River are subject to poaching and shrinking habitat from logging activities (Sokol'skii 1974).	Decrease/ Habitat Loss from Logging; Hunting
1980	The range of caribou used to be continuous throughout Yakutia. It is now broken up into 5 distinct breeding grounds, brought about by the intentional elimination of caribou from the grounds in between to make room for reindeer (Egorov and Popov 1974).	/Elimination of Caribou by Reindeer Herders
	In Yakutia, taiga caribou number 100,000 and reindeer number 200,000 (Egorov and Popov 1974).	Stable
1981	The caribou of Tomsk number approximately 4,000 (Pichagin 1974).	
	Caribou of western Sayan number between 950 and 1,000, but fluctuate widely from year to year. Range used to be continuous, but now consists of 3 distinct pockets with decreasing range due to "adverse human intervention." (Sokolov 1974)	/Range Loss from Human Impacts
1982	Western Sayan population has decreased 30-40% over the last 50 years due mainly to unrestricted hunting (Sokolov 1974).	Decrease/ Hunting
	Tuvin caribou number 3,000 and reindeer in the same region number 12,000. There are accounts of reciprocal straying between reindeer and caribou. (Bashanov 1974)	/Mixing of Reindeer and Caribou
1983	Caribou of Irkutsk number 12-13,000 after a ten year increase nearing winter range capacity (Grigor'ev and Leont'ev 1974).	Increase/?

Table B-1 (Cont'd).

Year	Event	Trend/Factor
1974 (Cont'd)	Caribou of Chita number only 1-2,000 while 15,000 reindeer occupy the majority of suitable habitats (Metel'skii 1974).	/Reindeer and Caribou in Competition
	Caribou of Khabarovsk number 10-11,000 and less than 40/year are killed by hunters (Merzlyakov 1974).	
	Caribou on the Kamchatka Peninsula number 10,000 over 5 centers of population with predators being more numerous in the south. Recent decreases from hunting, elimination by shepherds, and competition with reindeer (Vershinin et al 1974).	Decrease/ Hunting; Competition with Sheep and Reindeer
	The Ostrovnoe Islands of Kotel'nyi and Faddeev are nearing capacity of 18-20,000 animals and Lyakhovsk (population 7-8,000) and Novaya Sibir' (population 5-6,000) are not near capacity (Kishchinskii 1974).	Increase/?
	Wrangel Island is near capacity at 3-4,000 feral animals which were established from reindeer from Chukchi in 1948 (Kishchinskii 1974).	Increase/?
	Sakhalin caribou have little or no room to expand due to shrinking habitat (Zagorodskii and Reimers 1974).	Stable/Habitat Loss
1979	Taimyr herd numbers 475,000 after commercial slaughter of the herd began (Klein 1980).	Increase/ Commercial Harvest of Caribou
1980	There are 900,000 wild caribou and 2.5 million domestic reindeer in Russia (Klein 1980).	Increase/?

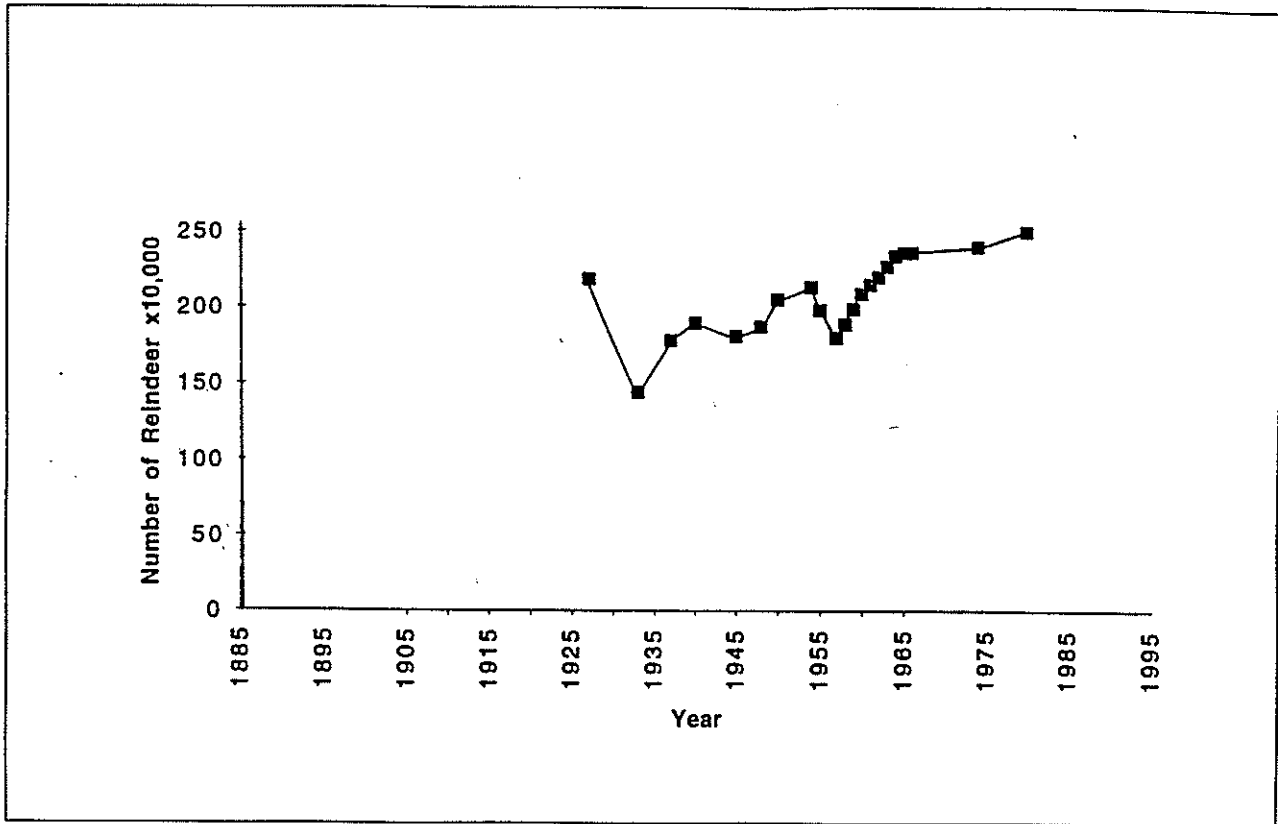


Figure B-2. Number of reindeer in Russia by year (from Syroechkovskii 1974:12).

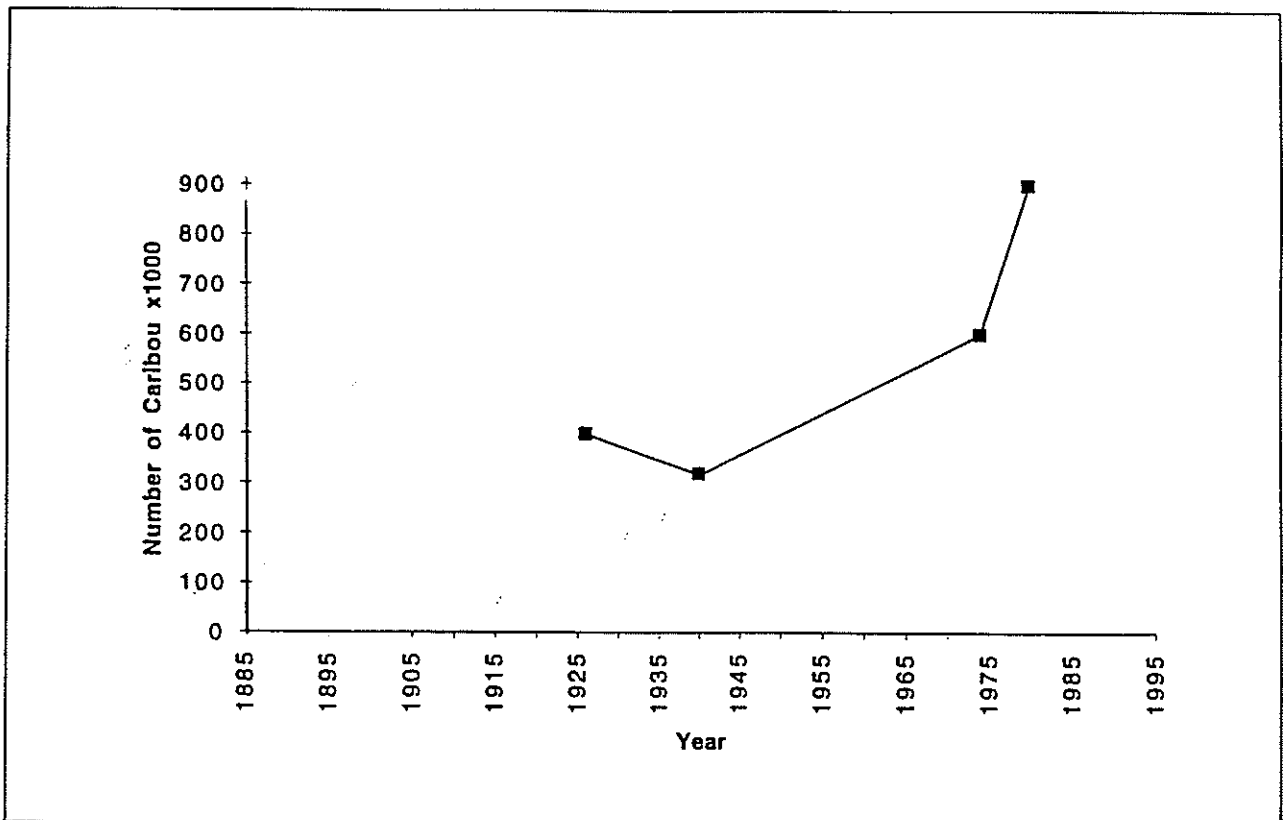


Figure B-3. Number of caribou in Russia by year (data from Table B-1).

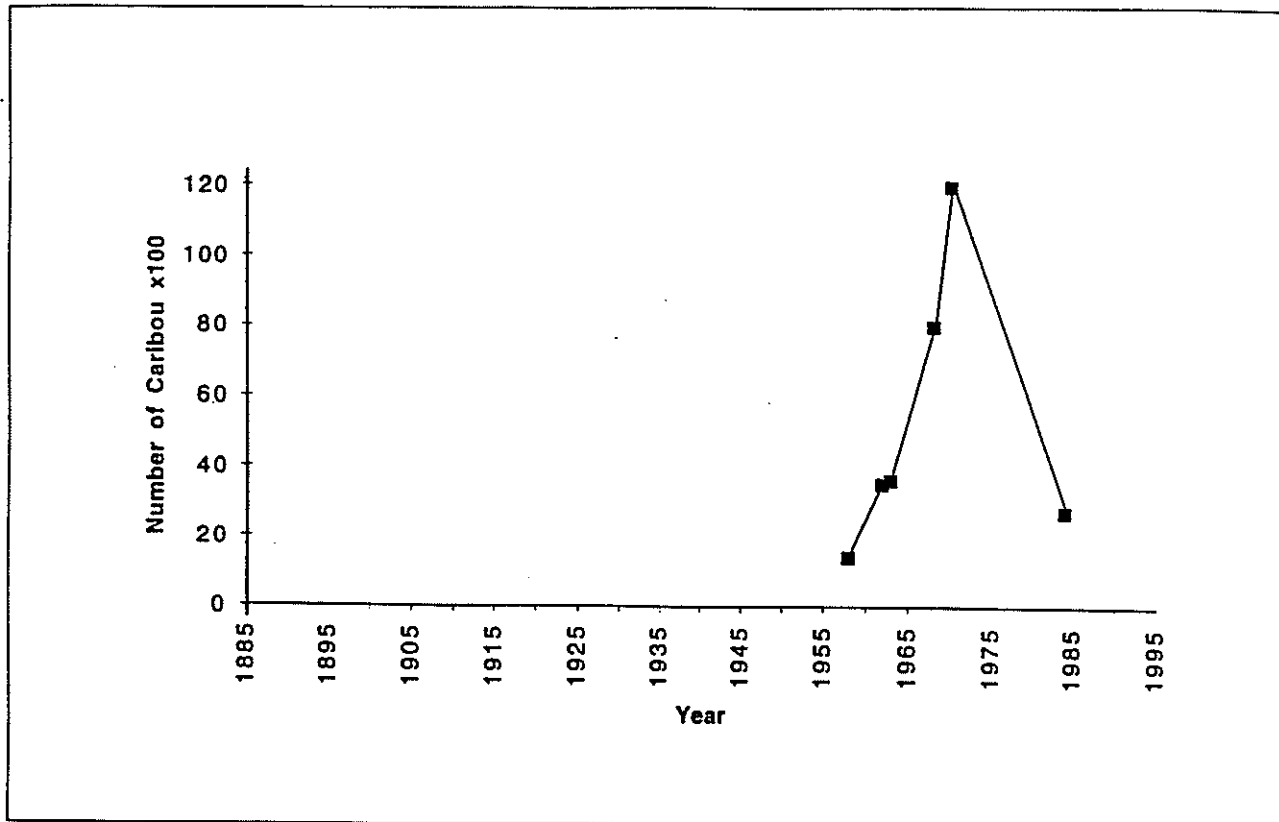


Figure B-4. Number of caribou in the Eastern Kola Peninsula Herd, Russia, by year (data from Table B-1).

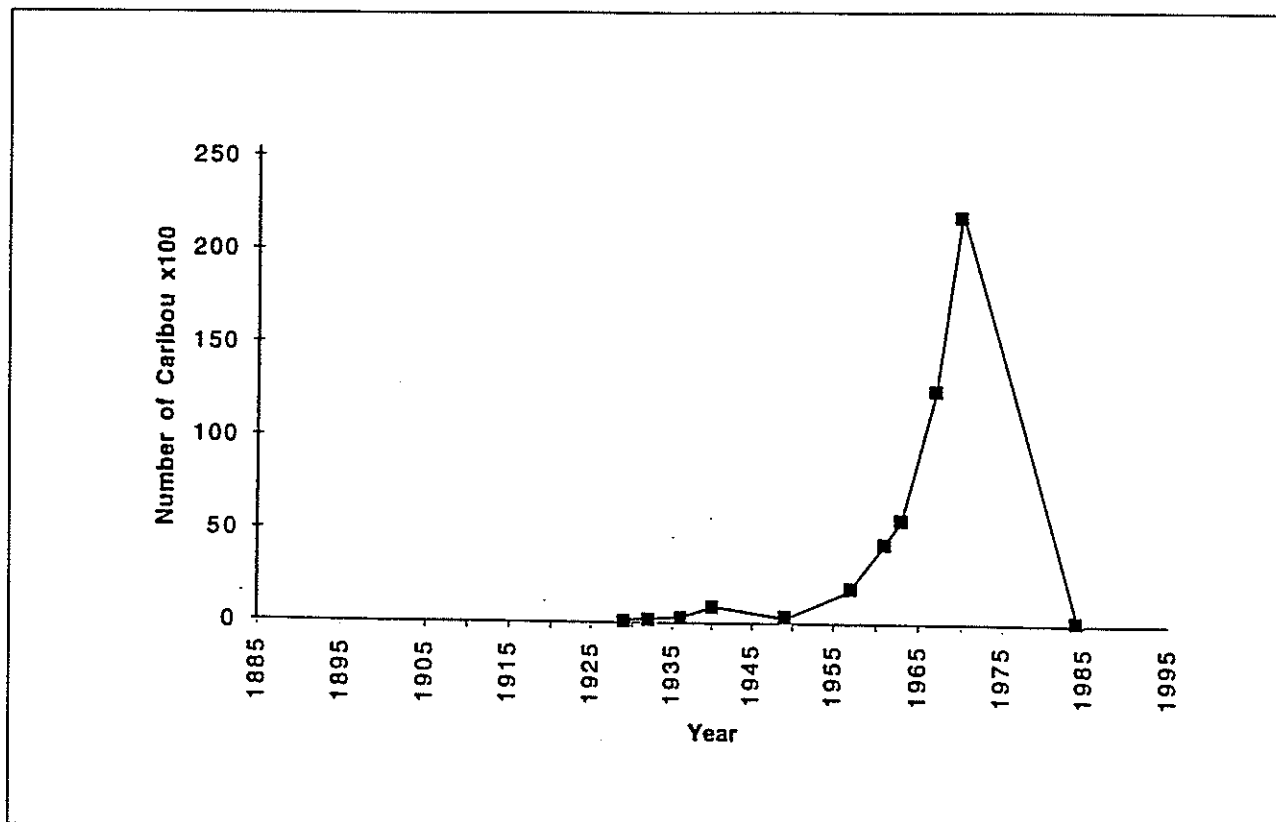


Figure B-5. Number of caribou in the Western Kola Peninsula Herd, Russia, by year (data from Table B-1).

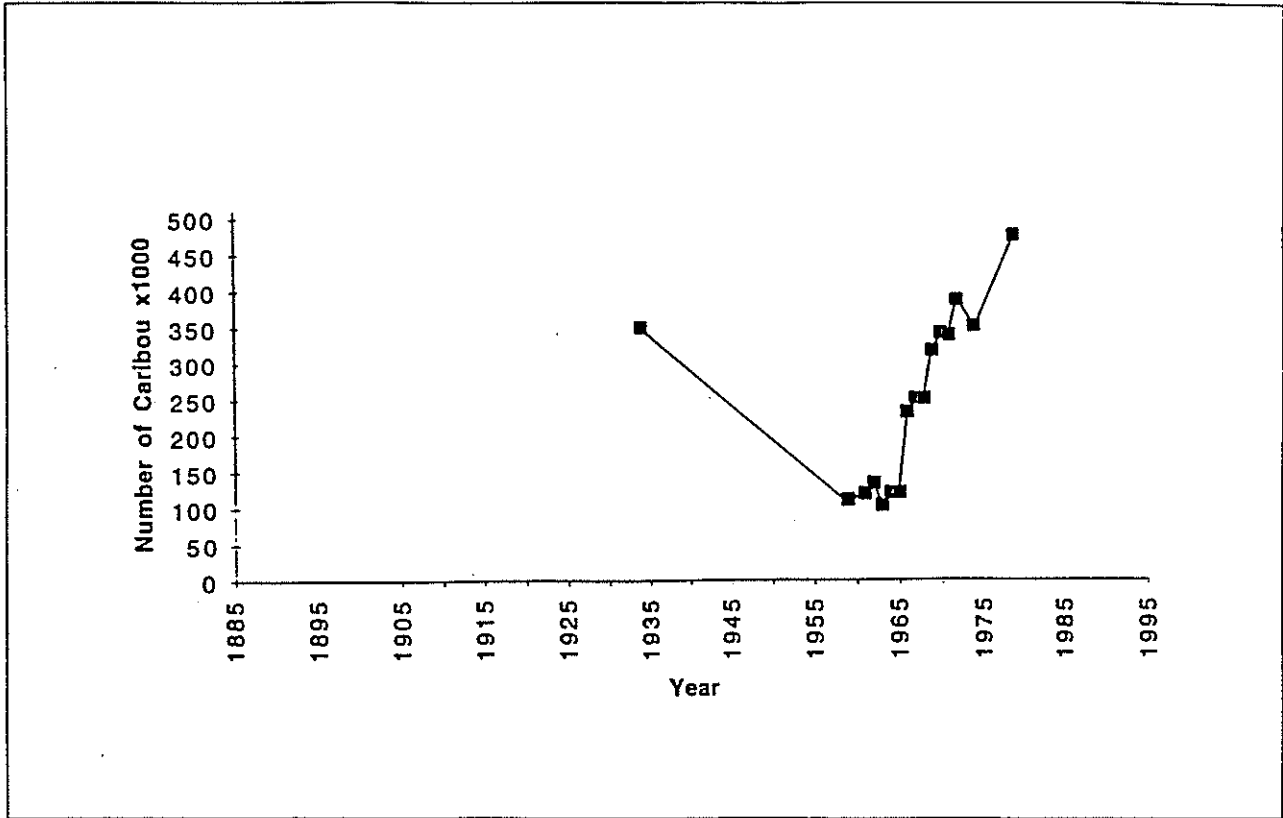


Figure B-6. Number of caribou in the Taimyr/Krasnoyarsk herds, Russia, by year (data from Table B-1).

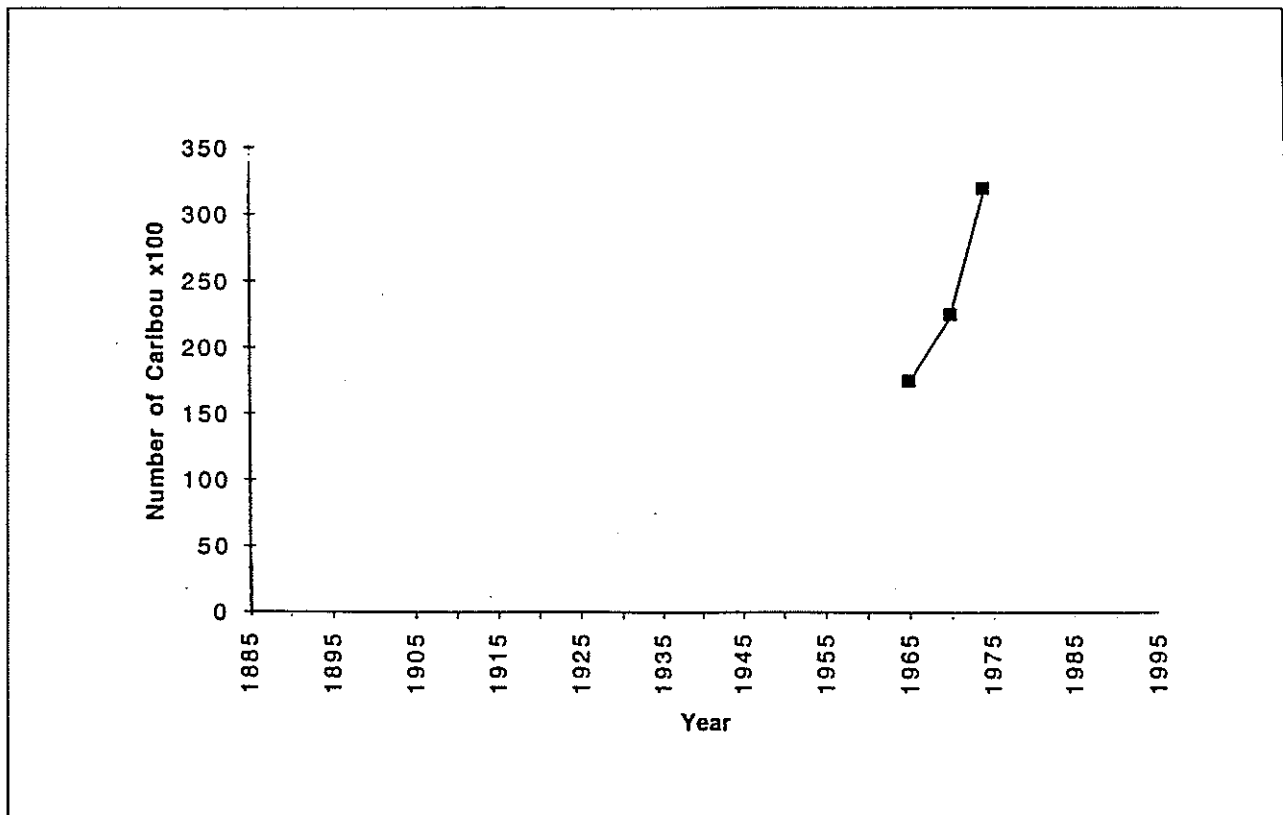


Figure B-7. Number of caribou in the Ostrovnoe Island herds, Russia, by year (data from Table B-1).

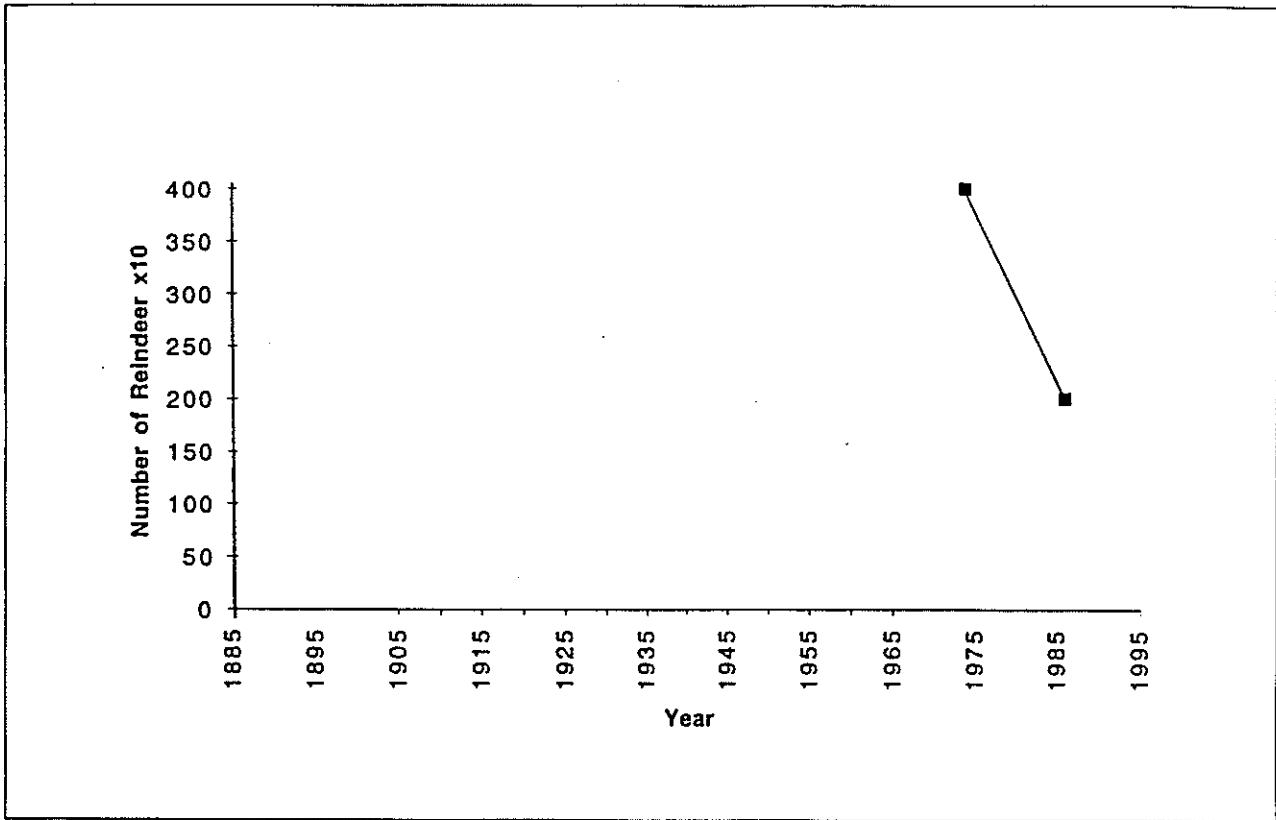


Figure B-8. Number of reindeer in the Wrangel Island Herd, Russia, by year (data from Table B-1).

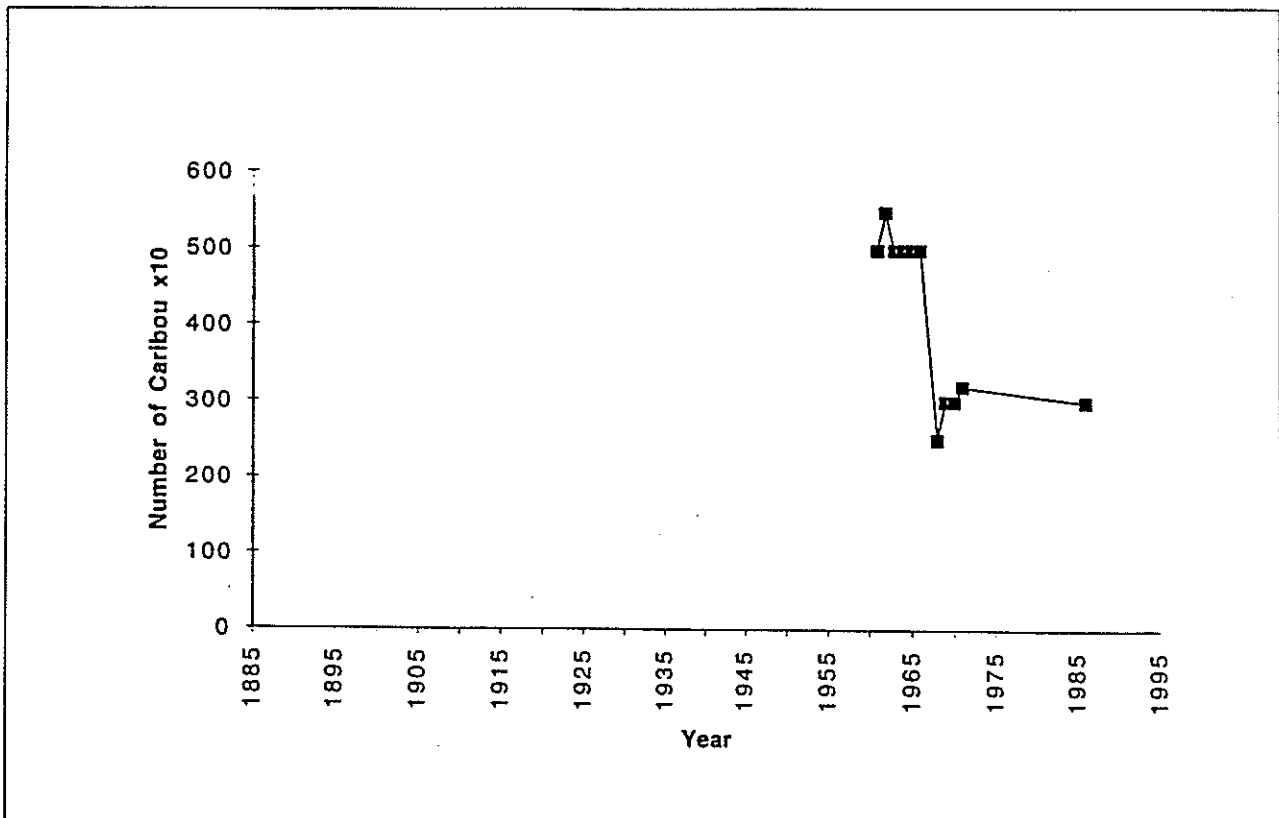


Figure B-9. Number of caribou in the Sakhalin Island Herd, Russia, by year (data from Table B-1).

Appendix C

Population Trends of Scandinavian Caribou and Reindeer Herds

TABLE

Table C-1 Timeline of events in the caribou and reindeer herds of Scandinavia

FIGURES

Figure C-1 Map of southern Norway showing the location of the Snøhetta Caribou Herd
Figure C-2 Total number of caribou in Norway by year
Figure C-3 Number of caribou in the Svalbard Island Herds by year

Table C-1. Timeline of events in the caribou and reindeer herds of Scandinavia. See Figure C-1 for herd locations.

Year	Event	Trend/Factor
1350	The Black Death reduces human populations to the point that labor necessary to perform caribou hunting drives is not available. Pitfalls become the major caribou hunting tool. (Skogland and Molmen 1980)	
1625	Firearms are used to take caribou (Skogland and Molmen 1980).	
1755	Norwegian caribou herds were in good condition to this point, but from now on decline in condition and numbers (Skogland and Molmen 1980).	Decrease/?
1860	Wild caribou are extinct in Sweden (Anderson and Luick 1979).	Local Extinction/?
	During the late-1800's rifles are greatly improved and Norwegian caribou are reduced as a result (Skogland and Molmen 1980).	Decrease/ Hunting
1900	Wild caribou are extinct in Finland (Anderson and Luick 1979).	Local Extinction/?
	Caribou are eliminated from North of Dovre Mountain in Norway due to hunting and domestic reindeer farming (Anderson and Luick 1979).	Decrease/ Hunting; Competition with Reindeer
1920	Snøhetta, Norway caribou number only a few hundred and migrations cease over the next five years. This coincides with the completion of a railroad perpendicular with the migration route (Skogland and Molmen 1980).	Decrease/ Altered Migration From Railroad Blockage
1925	Svalbard reindeer (<i>R.t. platyrhynchus</i>) are protected by law when they number only 500 (Punsvik et al. 1980). They number 1,000 according to Oritsland et al (1980).	
1930	Caribou in Norway begin 49 year increase, requiring protection from hunting at times (Anderson and Luick 1979).	Increase/ Controlled Harvest
1939	Reduced hunting pressures before and during World War II allow Snøhetta, Norway caribou to increase (Skogland and Molmen 1980).	Increase/ Decreased Hunting
1945	An army artillery range is placed next to the railroad in Dovrefjell, Norway encompassing 10% of the entire Snøhetta range (Skogland and Molmen 1980).	
1946	Large hydroelectric dams are constructed in the Aursjoen and Osjoen areas (Snøhetta herd range) of Norway over the next 7 years (Skogland and Molmen 1980).	
1947	Snøhetta caribou in Norway begin an 18 year increase in numbers and begin depleting ranges (Skogland and Molmen 1980).	Increase/Range Depletion Begins
1953	Last major caribou calving (800 cows/6,000 total) by Snøhetta herd west of Aursjoen and Osjoen, Norway (Skogland and Molmen 1980).	Calving Range Shift/Human Development
	Winter ranges of Snøhetta herd in Norway are depleted (Skogland and Molmen 1980).	/Winter Range Depletion
1956	Snøhetta caribou number 15,000 (Skogland and Molmen 1980).	
	Heavy snow forces a few hundred Snøhetta caribou east of the railroad tracks. A third of the population continues to use the area for wintering from now on and has a higher reproductive rate. (Skogland and Molmen 1980)	/Winter Range Shift; Heavy Snow Conditions
1957	Power lines and additional roads are constructed in Snøhetta herd's western ranges (Skogland and Molmen 1980).	
1960	There are 180,000 domestic reindeer in Norway (Anderson and Luick 1979).	
	A hunt of the Snøhetta herd over the next five years is held to prevent overuse of ranges. Lichen biomass east of the railroad is 18x greater than that west of the railroad. Winter starvation is high. (Skogland and Molmen 1980)	Decrease / Depleted Winter Range
1961	By 1961/62, the Snøhetta, Norway caribou herd had reached a considerable size (since 1953) and winter ranges were depleted of lichens (Skogland and Molmen 1980).	/Depleted Winter Range
	Power lines and additional roads are constructed on the Snøhetta herd range and caribou abandon the area for calving and begin 6 years of decline (Skogland and Molmen 1980).	Decrease/ Calving Range Shift; Human Development
1968	There are 40-50,000 caribou in Norway (Anderson and Luick 1979).	
1969	Roads to the dams on Snøhetta range are completed (Skogland and Molmen 1980).	

Table C-1 (Cont'd).

Year	Event	Trend/Factor
1974	An additional hydroelectric project is constructed in the western Snøhetta range of Norway, but at a time when low caribou numbers prevent any apparent effects (Skogland and Molmen 1980).	
1976	Svalbard reindeer number 11,000 (Punsvik et al. 1980).	Increase/?
1980	Svalbard reindeer number 12,000 (Ortislund et al. 1980).	Increase/?
1984	Snøhetta caribou herd numbers 2,800 (Williams and Heard 1986).	Stable
1985	Svalbard reindeer number 8,850 (Williams and Heard 1986).	Decrease/?

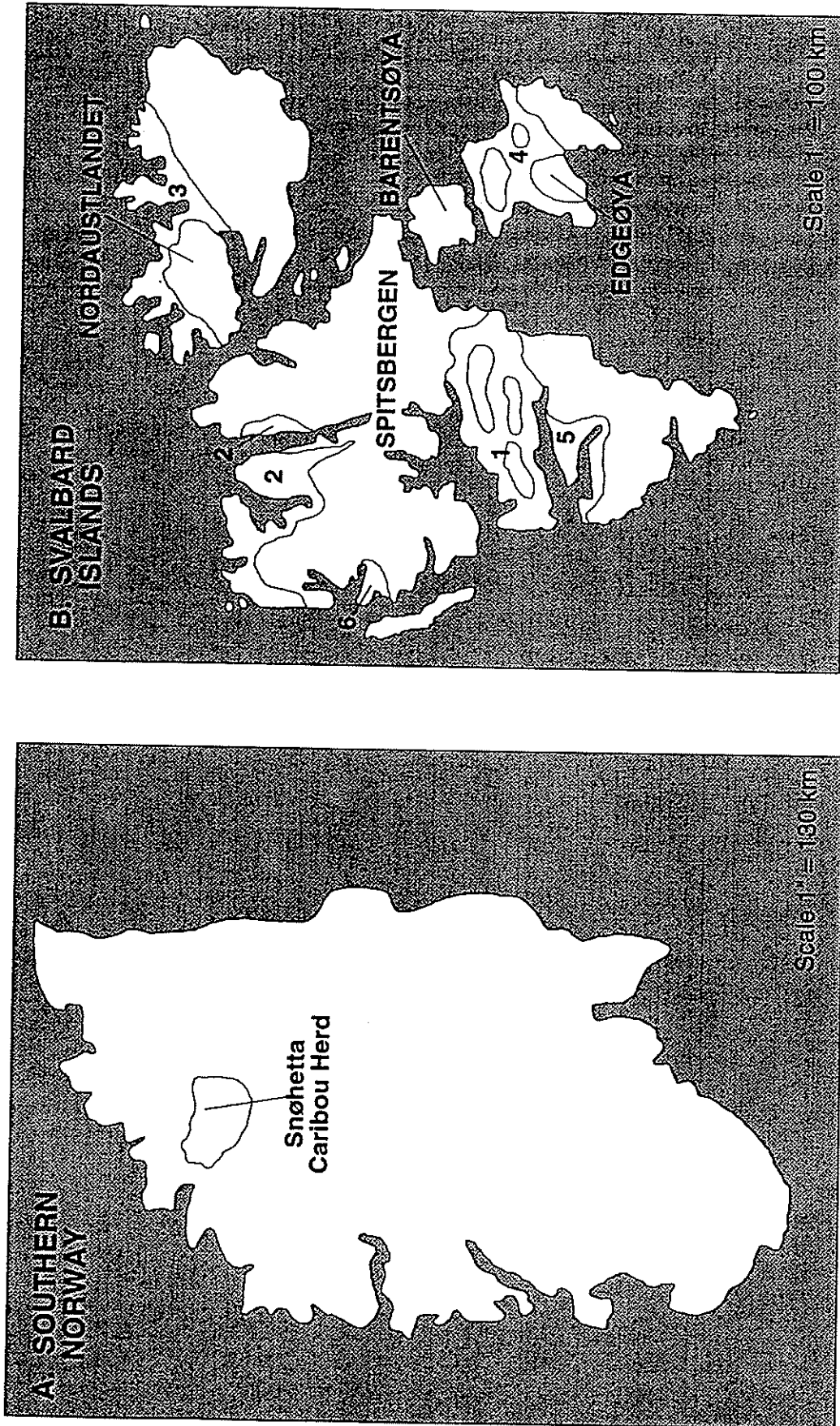


Figure C-1. A. Map of southern Norway showing the location of the Snøhetta caribou herd. B. Svalbard Islands with locations of individual herds numbered 1 to 6 (Williams and Heard 1986).

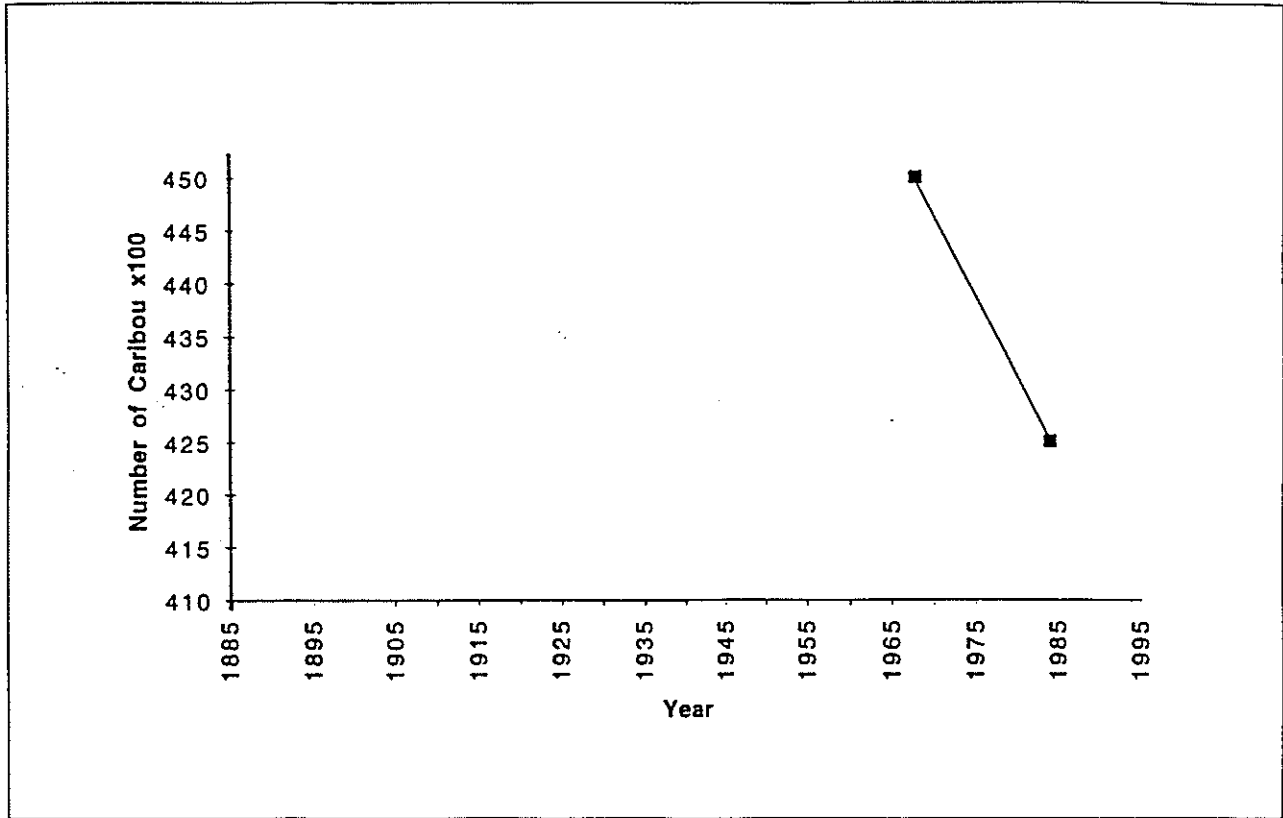


Figure C-2. Total number of caribou in Norway by year (data from Table C-1).

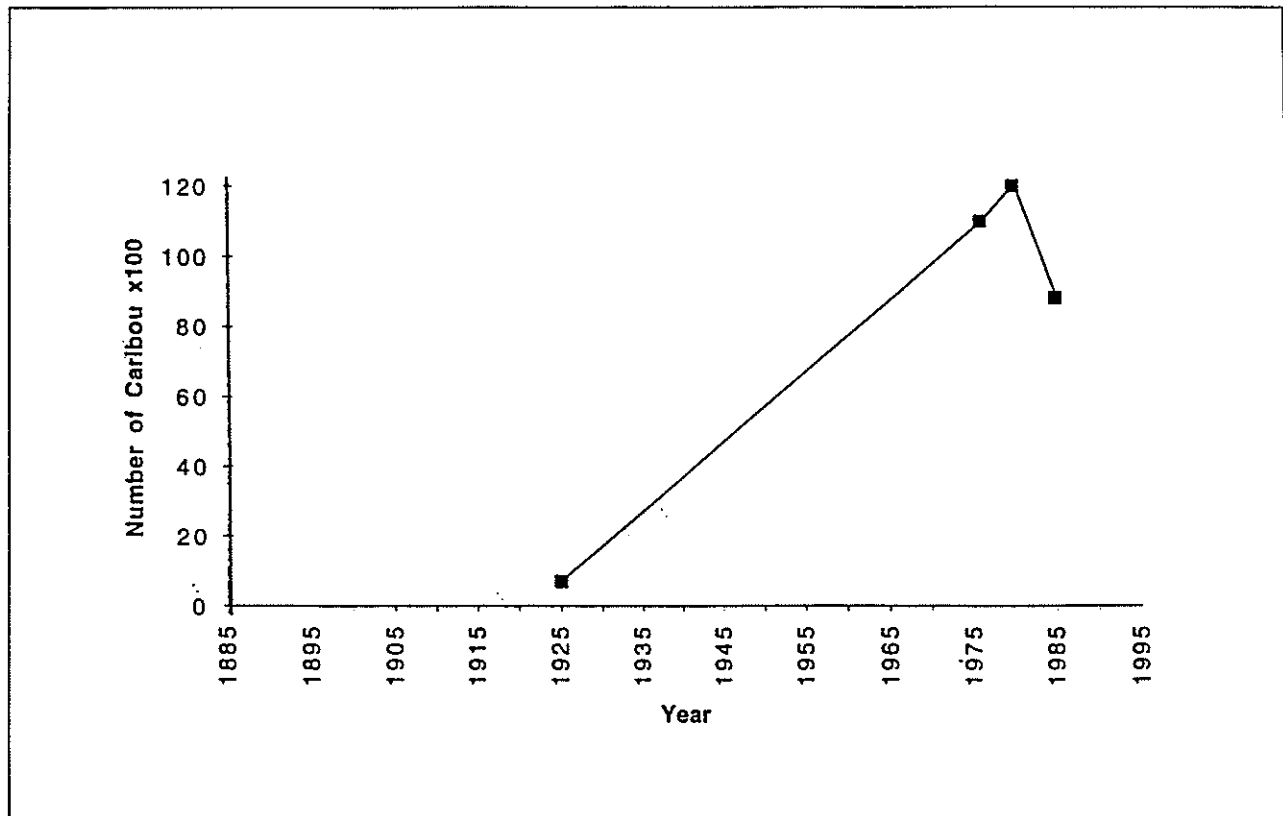


Figure C-3. Number of caribou in the Svalbard Island herds by year (data from Table C-1).

Appendix D
Population Trends of Greenland and Iceland
Caribou and Reindeer Herds

TABLE

Table D-1 Chronology of events in the caribou and reindeer herds of Greenland and Iceland

FIGURE

Figure D-1 Greenland regional caribou range division

Table D-1. Chronology of events in the caribou and reindeer herds of Greenland and Iceland. All events are for Greenland unless Iceland is specifically mentioned. See Figure D-1 for herd locations.

Year	Event	Trend/Factor
6000 B.C.	Small Peary caribou (<i>R.t. pearyi</i>) migrate to Greenland from Ellesmere Island (Meldgaard 1986).	Increase/ Immigration; Colonization
2000 B.C.	Larger Greenland caribou (<i>R.t. groenlandicus</i>) migrate across Nares and/or Davis Strait to northern Greenland (Meldgaard 1986).	Increase/ Immigration; Colonization
1500 B.C.	Both <i>R.t. pearyi</i> and <i>R.t. groenlandicus</i> are thriving in Greenland (Meldgaard 1986). Caribou found in the Nuuk region are smaller than modern <i>R.t. pearyi</i> (Meldgaard 1986).	Increase/ Colonization
1000 B.C.	<i>R.t. pearyi</i> are extinct in Greenland (Meldgaard 1986).	Local Extinction/?
300 A.D.	Dwarf caribou from NE or SW Greenland colonize isolated area of Ammassalik (Meldgaard 1986).	Colonization
700	Evidence of Greenland and Peary caribou in the Inglefield Land area for the next 600 years (Meldgaard 1986). Evidence of caribou in Ammassalik for the next 500 years (Meldgaard 1986).	Recolonization of Peary Caribou
1000	Caribou in Nuuk are similar in size to present day caribou (Meldgaard 1986). Evidence of caribou hunting in the Sismiut area (Meldgaard 1986).	Body Size Increased From 1500 B.C.
1100	Dwarf caribou of Ammassalik are extinct (Meldgaard 1986).	Local Extinction/?
1200	Evidence of caribou in the Upernavik area for the next 650 years (Meldgaard 1986). Evidence of caribou in the Melville Bugt (Meldgaard 1986). Evidence of caribou in Washington Land until 1700, but not since then (Meldgaard 1986).	Local Extinction/?
1300	Evidence of caribou in the Melville Bugt (Meldgaard 1986).	
1350	Evidence of caribou in Northeast Greenland for the next 450 years (Meldgaard 1986).	
1400	Evidence of caribou in the Thule area for the next 200 years (Meldgaard 1986).	
1700	Evidence of caribou on the Island of Disko and in Nugssuaq before 1700 (Meldgaard 1986). Caribou are numerous on the Island of Disko (Meldgaard 1986).	
1741	Written accounts of declining caribou in Southwest Greenland (Meldgaard 1986).	Decrease/?
1750	Caribou in the Nuuk region are declining (Meldgaard 1986). Caribou begin decline on Island of Disko (Meldgaard 1986).	Decrease/? Decrease/?
1751	Caribou are declining in Paamiut (Meldgaard 1986).	Decrease/?
1757	Caribou are decreasing and scarce in Sismiut until 1770 (Meldgaard 1986).	Decrease/?
1771	Iceland's feral reindeer are established from Norwegian domestic stock over the next 16 years (Anderson and Luick 1979).	Introduction of Reindeer
1795	Caribou in the Nuuk region remain in low numbers until 1820 (Meldgaard 1986).	
1800	Caribou are extinct on Island Disko sometime this century (Meldgaard 1986). There is some mention of caribou in Nugssuaq early this century (Meldgaard 1986). Evidence of caribou in the Thule region for the next 100 years (Meldgaard 1986).	Local Extinction/?
1820	Caribou are plentiful in Qeqertarsuatsiaat for the next 25 years (Meldgaard 1986). Sismiut region experiences a dramatic increase in caribou for the next 2 decades (Meldgaard 1986).	Increase/?
1823	Nuuk region caribou begin a dramatic increase lasting until 1830 (Meldgaard 1986). Caribou bones and antlers, but no live caribou in the Northeast Greenland area (Meldgaard 1986).	Increase/? Local Extinction/?
1828	Few caribou remain in Paamiut (Meldgaard 1986).	Decrease/?
1830	Nuuk region caribou remain numerous until 1850 (Meldgaard 1986).	

Table D-1 (Cont'd)

Year	Event	Trend/Factor
1840	Caribou increase around Paamiut (Meldgaard 1986).	Increase/?
	Caribou are increasing near Upernavik (Meldgaard 1986).	Increase/?
1845	Caribou in Qeqertarsuatsiaat begin a sharp decline (Meldgaard 1986).	Decrease/?
1849	Caribou peak near Upernavik (Meldgaard 1986).	Increase/?
1850	Southwest Greenland caribou are extinct (Meldgaard 1986).	Local Extinction
	Caribou again decrease around Paamiut (Meldgaard 1986).	Decrease/?
	Caribou decrease in Nuuk and Qeqertarsuatsiaat (Meldgaard 1986).	Decrease/?
	Sismiut caribou population crashes and remains low until 1890 (Meldgaard 1986).	Decrease/?
1853	Caribou are plentiful in the Inglefield Land area for the next 20 years (Meldgaard 1986).	
1858	Caribou have decreased more than 90% since 1849 in Upernavik (Meldgaard 1986).	Decrease/?
	Some accounts of caribou in the Melville Bugt area (Meldgaard 1986).	
1860	Caribou are hunted in the Arsuk Fjord area (Meldgaard 1986).	
	Caribou numbers remain low in Nuuk region until 1954 (Meldgaard 1986).	
1869	Live caribou are sighted in Northeast Greenland (Meldgaard 1986).	Recolonization
1871	Upernavik caribou numbers remain low (Meldgaard 1986).	
1880	Caribou are hunted in the Arsuk Fjord area (Meldgaard 1986).	
1884	Caribou are extinct in the Ammassalik region (Meldgaard 1986).	Local Extinction/?
1885	Caribou in the Nuuk region begin a 15 year increase (Meldgaard 1986).	Increase/?
1888	Qeqertarsuatsiaat caribou begin to increase through 1900 (Meldgaard 1986).	Increase/?
1890	Caribou are extinct in the Arsuk Fjord area (Meldgaard 1986).	Local Extinction/?
	There's a general increase in caribou across southern Greenland (Meldgaard 1986).	Increase/?
	Upernavik caribou begin a small 10 year increase (Meldgaard 1986).	Increase/?
1893	Caribou in Northeast Greenland begin a decline related to wolf predation (Meldgaard 1986).	Decrease/ Predation
1900	Dwarf Northeast Greenland caribou are extinct (Meldgaard 1986).	Local Extinction/?
	Caribou in Nuuk region begin a decline through 1927 (Meldgaard 1986).	Decrease/?
	Beginning of decline of Thule caribou (Meldgaard 1986).	Decrease/?
	Inglefield Land caribou disappear near this time (Meldgaard 1986).	Local Extinction/?
1910	Caribou increase around Paamiut (Meldgaard 1986).	Increase
	Caribou numbers are small in the Nugsuaq region (Meldgaard 1986).	
	Few caribou are in the Melville Bugt area (Meldgaard 1986).	
1912	No caribou seen in North Greenland (Meldgaard 1986).	Local Extinction/?
1914	Caribou are sighted in Inglefield Land for first time since turn of the century (Meldgaard 1986).	Recolonization
1915	Qeqertarsuatsiaat caribou peak and decline in the next 10 years (Meldgaard 1986).	Decrease/?
	Upernavik caribou begin a 17 year decline (Meldgaard 1986).	Decrease/?
1916	Regional extinctions of caribou occur in the Thule area until 1939 (Meldgaard 1986).	Decrease/?
1919	Caribou of Paamiut begin a decline that continues until 1925 (Meldgaard 1986).	Decrease/?
1920	Caribou in the Melville Bugt are extinct (Meldgaard 1986).	Local Extinction
1922	Three caribou are sighted in North Greenland (Meldgaard 1986).	Recolonization
1924	Northeast Greenland caribou are extinct (Meldgaard 1986).	Local Extinction/?
1925	Caribou around Paamiut remain low until 1970 (Meldgaard 1986).	
1940	Small area of Melville Bugt is repopulated, but does not last (Meldgaard 1986).	Unsuccessful Recolonization
1948	Caribou in Nugsuaq reach a high of 500 (Meldgaard 1986).	

Table D-1 (Cont'd)

Year	Event	Trend/Factor
1952	Warble and bot flies are introduced to Greenland with an importation of domestic reindeer (Meldgaard 1986).	/Introduced Reindeer with Parasites
1960	Qeqertarsuatsiaat caribou are plentiful for the next 2 decades (Meldgaard 1986). Caribou in Nuuk region begin increasing and stay numerous through present day (Meldgaard 1986). Beginning of dramatic 10 year increase and peak in the Sisimiut region (Meldgaard 1986).	Increase/? Increase/?
1965	9 domestic reindeer released in Thule region, but current status is unknown (Meldgaard 1986).	Introduction of Reindeer
1966	Last hunter-killed caribou is reported in Upernavik (Meldgaard 1986).	Local Extinction/ Hunting?
1968	10 domestic reindeer from the Itivnera herd are released on the Island of Disko (Meldgaard 1986). Only 20 animals remain of the Nugssuaq region (Meldgaard 1986). 10 domestic reindeer from Itivnera are released in the Nugssuaq region (Meldgaard 1986). The total west Greenland caribou number 100,000 in the late-60's (Thing 1980).	Introduction of Reindeer Decrease/? Introduction of Reindeer
1971	Twenty-two domestic reindeer from the Itivnera herd are released in the Ammassalik region (Meldgaard 1986).	Introduction of Reindeer
1972	Caribou around Paamiut increase slightly (Meldgaard 1986).	Increase/?
1973	48 reindeer from the Itivnera domestic herd are introduced to Southwest Greenland near Qingua (Meldgaard 1986).	Introduction of Reindeer
1974	Fifty reindeer from the Itivnera domestic herd are introduced to Southwest Greenland near Qingua (Meldgaard 1986).	Introduction of Reindeer
1977	Start of a decline lasting through 1984 in Sisimiut caribou (Meldgaard 1986). Northwest Greenland caribou are probably extinct (Roby et al. 1984 in Ferguson and Gauthier 1992).	Decrease/? Local Extinction/ ?
1980	138 feral reindeer are sighted on the Island of Disko near the release point of 10 reindeer in 1968 (Meldgaard 1986). Only 20 caribou remain in the Nugssuaq region. Meanwhile, the feral reindeer herd has increased to 250 (Meldgaard 1986). Ammassalik feral reindeer herd numbers 80 after the introduction in 1971 (Meldgaard 1986). West Greenland caribou are experiencing a rapid decline (Thing 1980).	Increase/ Reindeer Survive in Wild Decrease-Increase/ Reindeer in Competition with Caribou Increase/? Decrease/?
1982	Qeqertarsuatsiaat caribou herd numbers 300, but the presence of dead calves and adults suggests a recent downturn (Meldgaard 1986).	Decrease/?
1983	Feral reindeer herd at Qingua numbers 600 after introduction of 50 animals in 1974 (Meldgaard 1986).	Increase/?
1986	Two caribou herds remain at Paamiut, totalling 600 small animals with poorly developed antlers (Meldgaard 1986). Upernavik caribou are either very rare or extinct (Meldgaard 1986). No caribou are sighted in North Greenland, but it is within straying distance of Ellesmere Island (Meldgaard 1986).	Decrease/? Local Extinction/ ?
1989	A winter range shift from Ellesmere Island brings a large number of Peary caribou to NW Greenland where hunters kill 100 animals (Ferguson and Gauthier 1992).	Range Shift/ Colonization

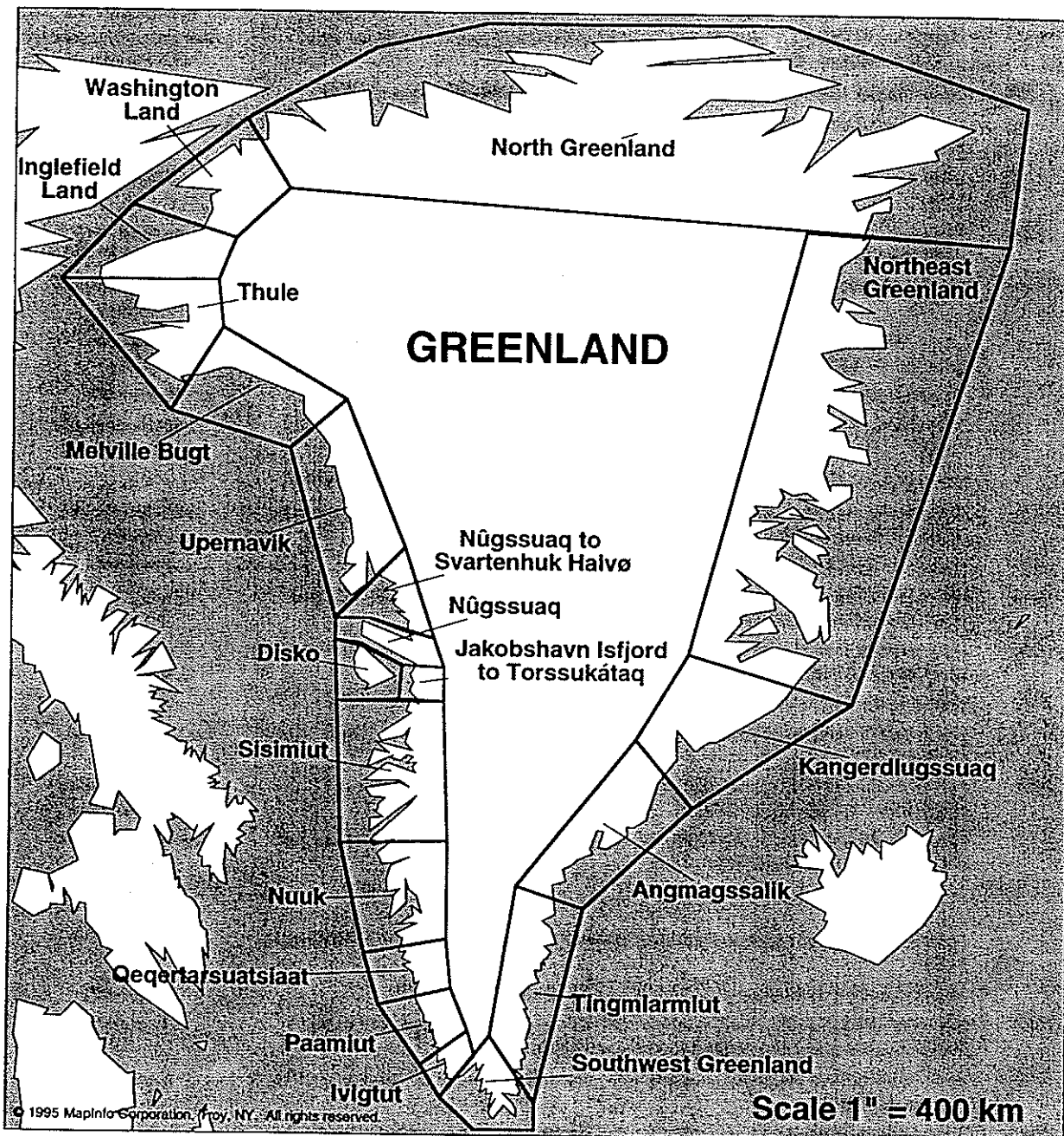


Figure D-1. Greenland regional caribou range division (Meldgaard 1986). This map was produced using MapInfo® software. MapInfo is a registered trademark of MapInfo Corporation.

Appendix E Population Trends of Canadian Caribou and Reindeer Herds

TABLE

Table E-1 Chronology of events in the caribou and reindeer herds of Canada

FIGURES

Figure E-1 Four Canadian caribou herds for which historical status is known
Figure E-2 Total number of caribou in Canada by year
Figure E-3 Number of caribou in the George River Herd, Canada, by year
Figure E-4 Number of caribou in the Kaminuriak Herd, Canada, by year
Figure E-5 Number of caribou in the Beverly Herd, Canada, by year

Table E-1. Chronology of events in the caribou and reindeer herds of Canada. See Figure E-1 for herd locations.

Year	Event	Trend/Factor
1833	Caribou fail to appear at Reliance during the winter of 1833/34 (Clarke 1940).	Decrease/?
1850	Few caribou are seen between Coppermine and the Kent Peninsula for the next 100 years, although there are reports of large numbers animals in some years (Banfield 1954).	Decrease/?
	Decrease in caribou from the Gulf of Boothia to Melville Peninsula begins and continues through the turn of the century (Banfield 1954).	Decrease/?
	Large numbers of caribou are present from Sherman Inlet to Boothia Peninsula and King William Island throughout the rest of this century (Banfield 1954).	Increase/?
1880	Caribou are plentiful in the central interior this year, but suddenly disappear after forest fires on southern ranges (Rutherford et al 1922).	Decrease/Habitat Loss From Fire; Disease?
1892	Reports of cannibalism among starving natives are recorded for the next 27 years (Rutherford et al 1922).	
1900	Caribou numbers from McKenzie to Coppermine decrease until 1950 (Banfield 1954).	Decrease/?
	Canadian caribou are estimated to number 1.75 million (Banfield 1954).	
1902	Measles outbreak compounded with starvation kills 100 Natives at Fort George on St. James Bay (Rutherford et al 1922).	
1908	250 domestic reindeer from Lapland are imported to St. Anthony, Newfoundland (Rutherford et al 1922).	Increase/ Introduction of Reindeer
1911	Caribou numbers decrease for the next 8 years in the Coronation Gulf area (Clarke 1940).	Decrease/?
	50 reindeer from the St. Anthony herd are transported to Fort Smith on the Slave River, but most are lost or die enroute and remaining female animals are unsuccessful (Rutherford et al 1922).	
1912	Domestic reindeer at St. Anthony number 1,200, but are suffering from a bronchial disease and poaching (Rutherford et al 1922).	Decrease/ Disease & Hunting
1918	The remaining St. Anthony reindeer are transported to Lobster Bay and multiply rapidly (Rutherford et al 1922).	Increase/ New Range
	Rabbits, ptarmigan, and other food is scarce in the interior. Caribou had not been seen since 1880 (Rutherford et al 1922).	
1919	Rabbits, ptarmigan, and other species continue to be scarce in the interior (Rutherford et al 1922).	
1922	Caribou have declined in recent years on the Arctic coast (Rutherford et al 1922).	Decrease/?
1925	Migrations between Victoria Island and King William Island cease over the next 5 years (Clarke 1940). Clarke (1940) assumes this population is extinct, but does mention herds still on Victoria Island.	/Altered Migrations
	Five year construction of the Hudson Bay Railway begins with no apparent impacts on caribou migration (Banfield 1954).	Stable/ Railroad Construction
1937	Hanbury herd numbers 1-200,000 animals (Clarke 1940).	
1940	A few caribou are sighted crossing the Coronation Gulf, and the author suggests that migrations may have resumed (Clarke 1940).	Increase/ Altered Migrations
1950	Caribou are rare or absent from Sherman Inlet to Boothia Peninsula and King William Island (Banfield 1954).	Decrease/?
1954	Banfield (1954) estimates Canada's caribou population at 670,000. He states the tundra supports as many caribou as ever, but that there are decreased migrations and caribou inhabit the southern limits of their winter ranges to a greater extent.	/Winter Range Shift
1970	Queen Elizabeth Island caribou begin a decline over the next 2 decades, while neighboring Bathurst Island caribou increase (Ferguson and Gauthier 1992).	Decrease?/ Increase?
1979	All barren-ground herds are increasing with the exception of the Bluenose herd which is stable through 1984 (Williams and Heard 1986).	Increase/?

Table E-1 (Cont'd)

Year	Event	Trend/Factor
1980	Most Canadian caribou herds are increasing (Ferguson and Gauthier 1992).	Increase/?
1983	Canadian barren-ground caribou number 1.83 million (Williams and Heard 1986).	Increase/?
1987	George River caribou herd peaks at 680,000 and begins a decline through 1992 (Ferguson and Gauthier 1992).	Decrease/?
1989	Peary caribou of Ellesmere Island undergo a mass emigration to Northwest Greenland (Ferguson and Gauthier 1992).	Decrease/ Emigration; Range Shift
1991	Canada's caribou number 1.9-2.6 million and most herds are stable or decreasing. Domestic reindeer number 13,600. (Barren-ground caribou number 1.66 million.) (Ferguson and Gauthier 1992)	Increase/?
	The Bluenose herd is increasing while other Northwest Territories barren-ground herds have stabilized (Ferguson and Gauthier 1992).	Increase/?
	Severe declines are noted on Coats and Banks Islands (Ferguson and Gauthier 1992).	Decrease/?
	Introduced caribou on Southampton Island are increasing (Ferguson and Gauthier 1992).	Increase/?
	Peary caribou on Queen Elizabeth Island are listed as endangered (from a threatened status) (Ferguson and Gauthier 1992).	Decrease/?

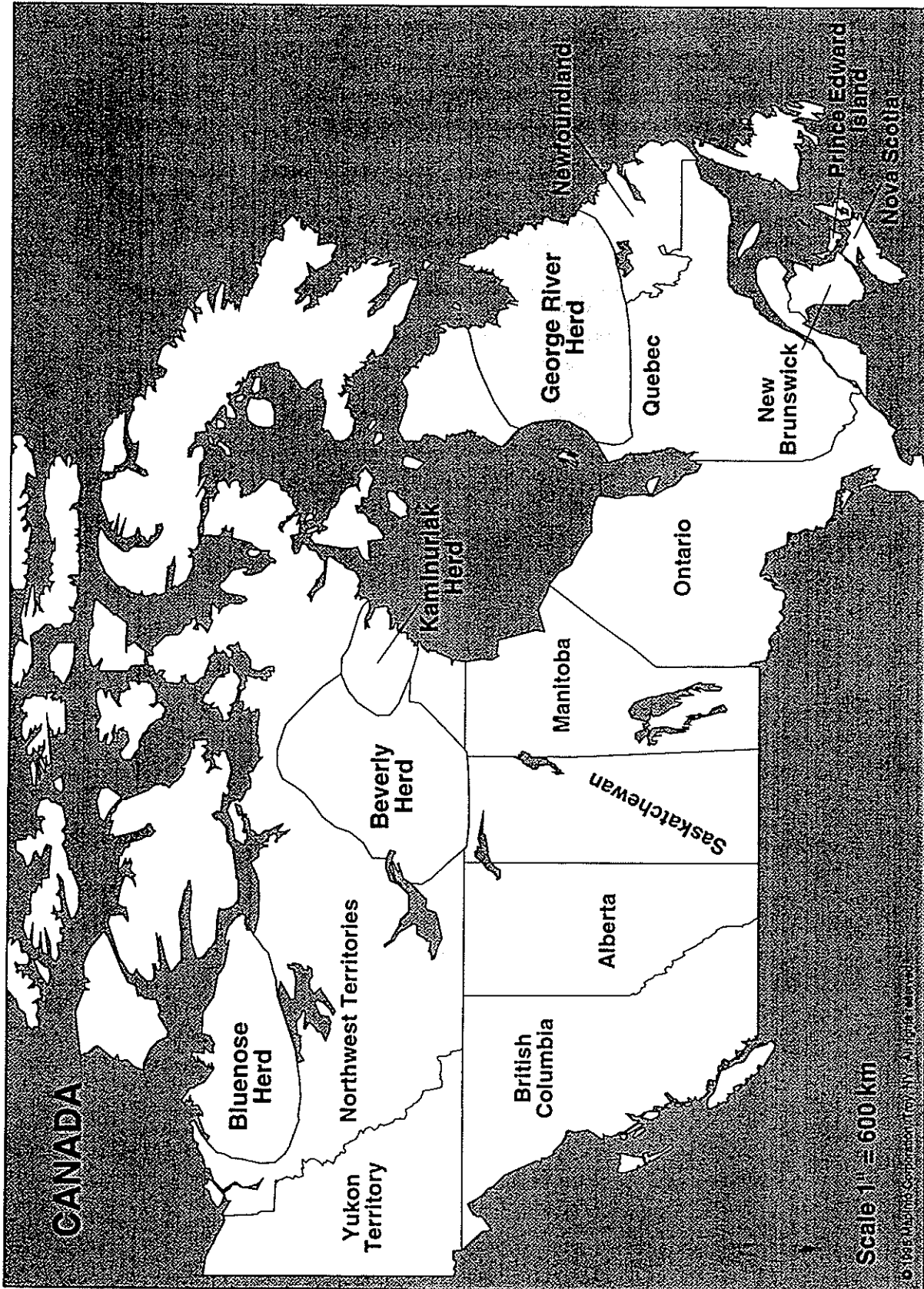


Figure E-1. Four Canadian caribou herds for which historical status is known: Bluenose Herd (Northwest Territories), Beverly Herd (Northwest Territories), Kaminuriak Herd (Northwest Territories), and George River Herd (Quebec and Newfoundland) (Ferguson and Gauthier 1992). This map was produced using MapInfo® software. MapInfo is a registered trademark of MapInfo Corporation.

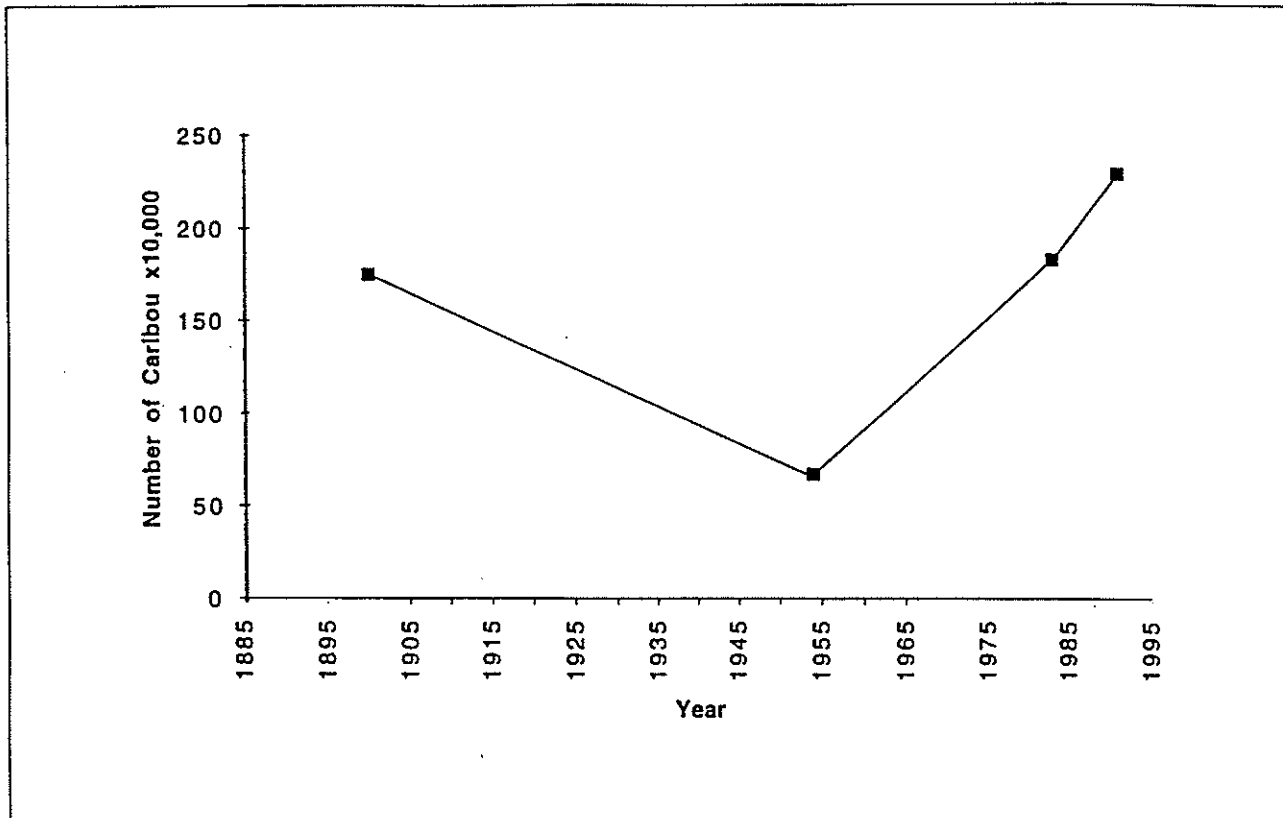


Figure E-2. Total number of caribou in Canada by year (data from Table E-1).

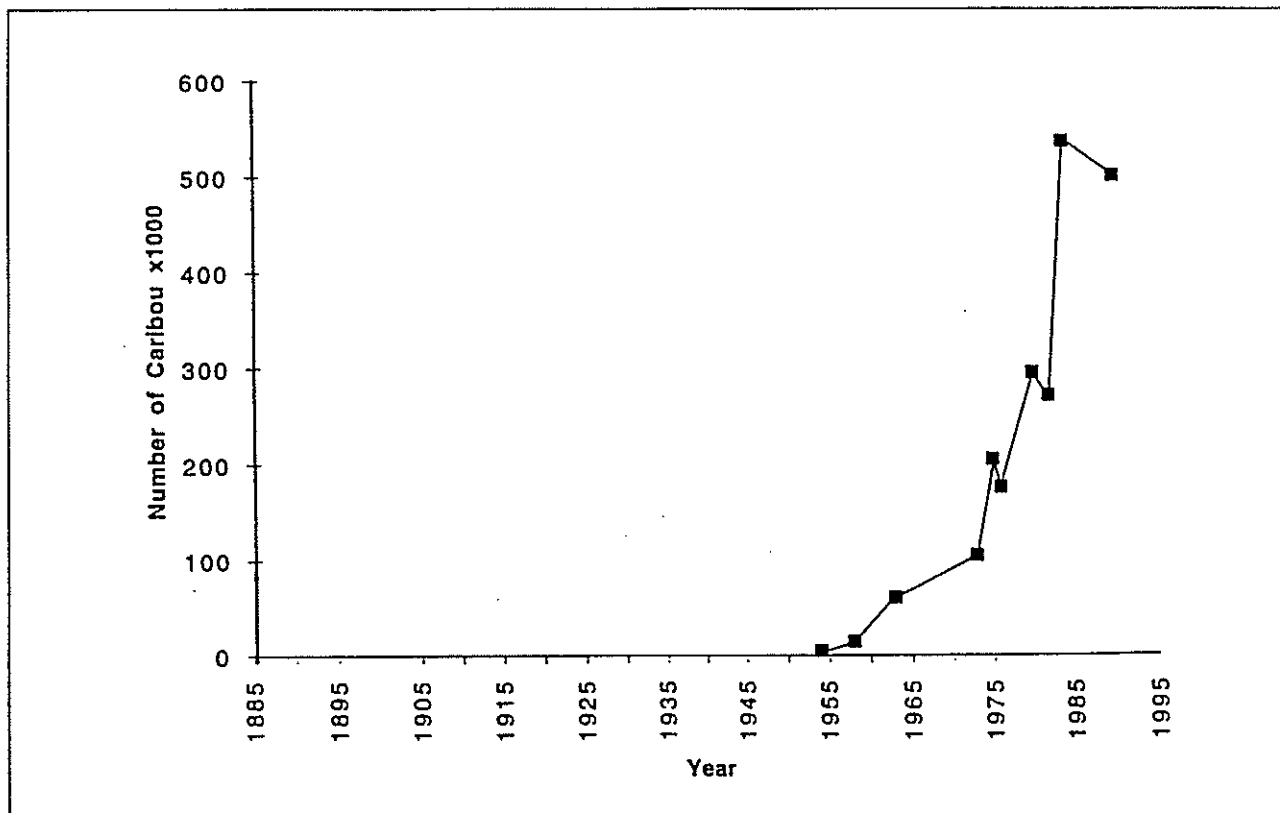


Figure E-3. Number of caribou in the George River Herd, Canada, by year (data from Messier et al. 1988).

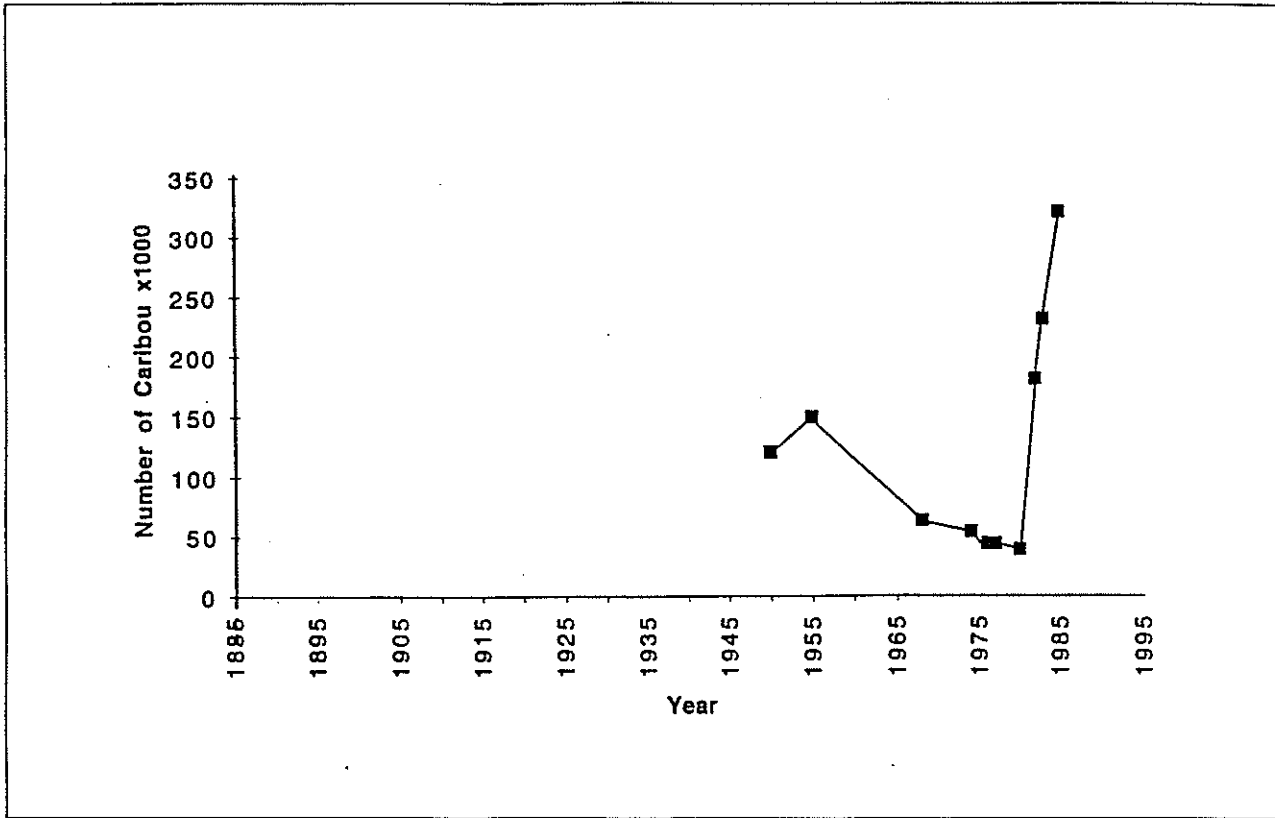


Figure E-4. Number of caribou in the Kaminuriak Herd, Canada, by year (data from Heard and Calef 1986).

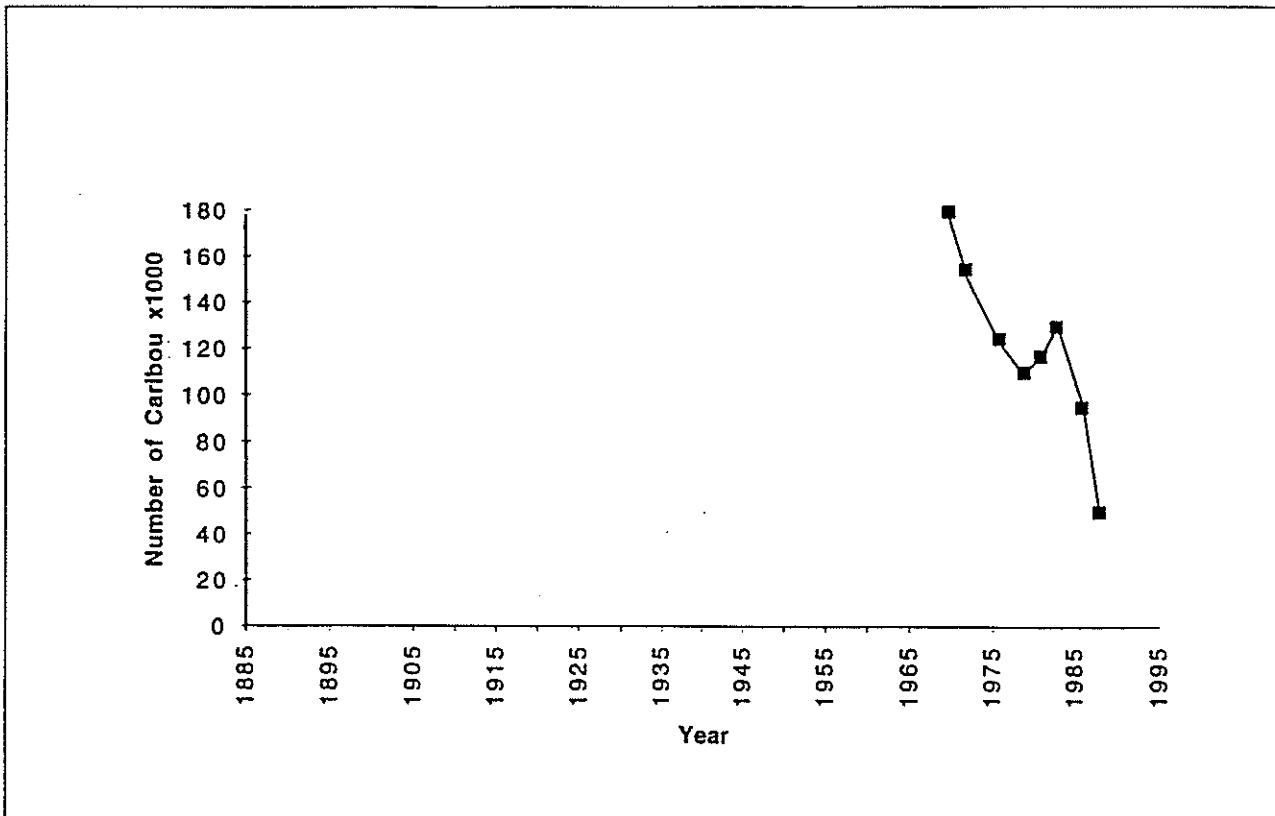


Figure E-5. Number of caribou in the Beverly Herd, Canada, by year (data from Caughley and Gunn 1993).

Appendix F
Population Trends of South Georgia, Antarctica
Caribou and Reindeer Herds

TABLE

Table F-1 Chronology of events in the reindeer herds of South Georgia, Antarctica

FIGURES

Figure F-1 Range locations of South Georgia reindeer herds
Figure F-2 Number of reindeer in the Barff and Royal Bay, South Georgia, herds by year
Figure F-3 Number of reindeer in the Busen, South Georgia, herd by year

Table F-1. Chronology of events in the reindeer herds of South Georgia, Antarctica. See Figure F-1 for herd locations.

Year	Event	Trend/Factor
1911	10 reindeer are established on the Barff Peninsula and 5 are landed at Busen from Norwegian domestic stock (Leader-Williams 1988).	Introduction of Reindeer
1917	Reindeer at Busen multiplied to 20, but all are killed in a snowslide after this year (Leader-Williams 1988).	Decrease/ Accident: Snowslide
1920	The Barff herd now numbers 120 (Leader-Williams 1988).	Increase/?
1922	Barff herd now numbers 300 (Leader-Williams 1988).	Increase/?
1925	7 Norwegian reindeer are introduced to Busen (Leader-Williams 1988).	Introduction of Reindeer
1928	Barff herd numbers between 550 and 700 (Leader-Williams 1988).	Increase/?
1940	Busen herd growth is limited due to poaching from the nearby whaling station (Leader-Williams 1988).	Increase/ Limited by Hunting
1950	Barff herd exhibits a decline not attributable to hunting and tussock range is showing signs of overgrazing (Leader-Williams 1988).	Decrease/ Overgrazing?
	Busen herd begins increase as poaching decreases (Leader-Williams 1988).	Increase/?
1953	Barff herd numbers 2,000 (Leader-Williams 1988).	Increase/?
	Busen herd numbers 40 (Leader-Williams 1988).	Increase/?
1957	Barff herd numbers 4,000 (Leader-Williams 1988).	Increase/?
	Busen herd numbers 100-200 (Leader-Williams 1988).	Increase/?
1958	Reindeer number 4,000 on South Georgia (Anderson and Luick 1979).	
1961	Barff herd fragments and forms a new herd at Royal Bay (Leader-Williams 1988).	/Range Shift; New Herd Formed
1972	Barff herd numbers 1300 (Leader-Williams 1988).	Decrease/?
	Royal Bay herd numbers 800 (Leader-Williams 1988).	Increase/ ?
1973	Busen herd numbers 800 and is decreasing (Leader-Williams 1988).	Decrease/?
1976	Barff herd numbers 1,000 and is decreasing (Williams and Heard 1986).	Decrease/?
	Royal Bay herd numbers 550 and is stable (Williams and Heard 1986).	Stable
	Busen herd numbers 450 and is decreasing (Williams and Heard 1986).	Decrease/?

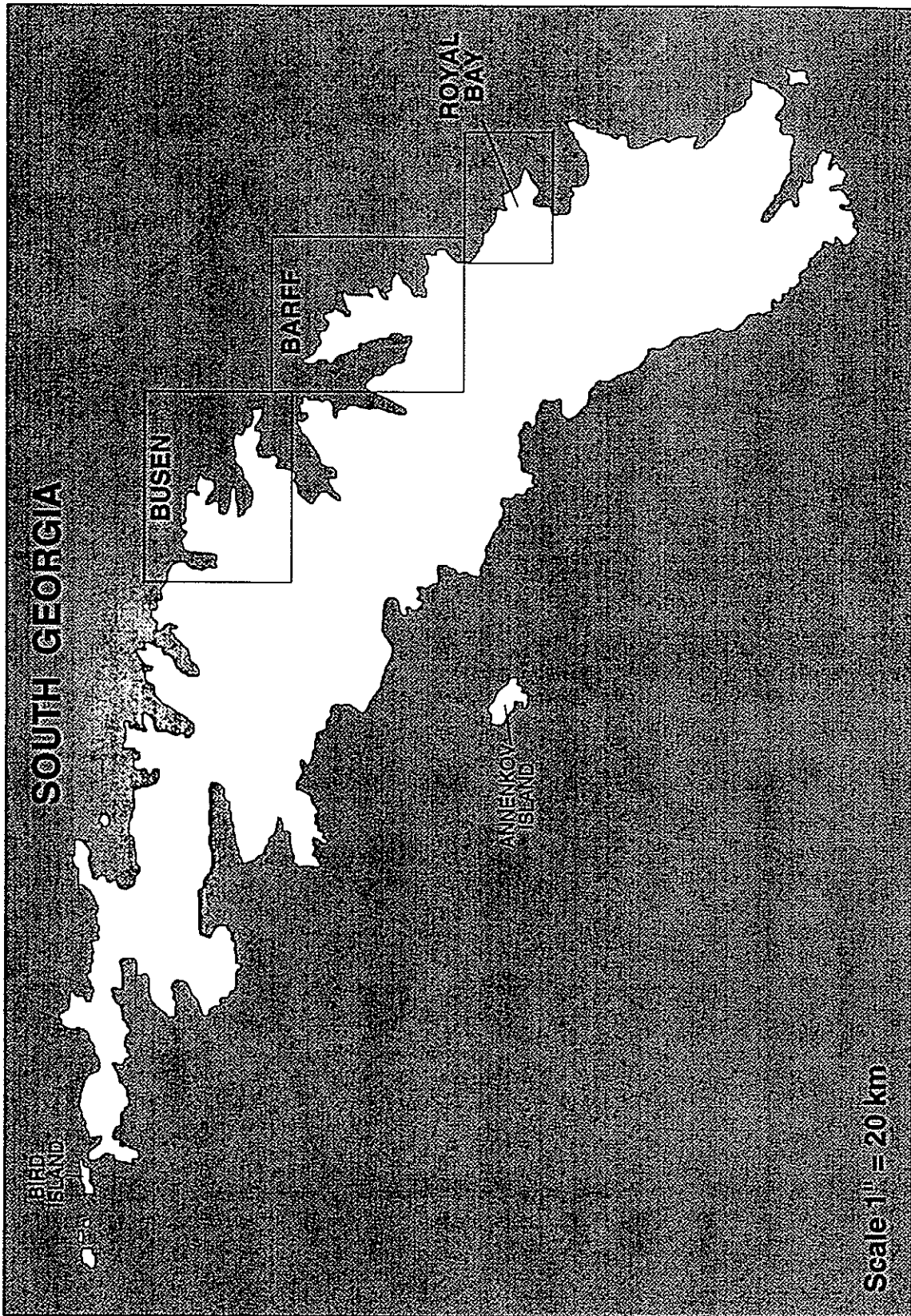


Figure F-1. Range locations of South Georgia reindeer herds (Leader-Williams 1988).

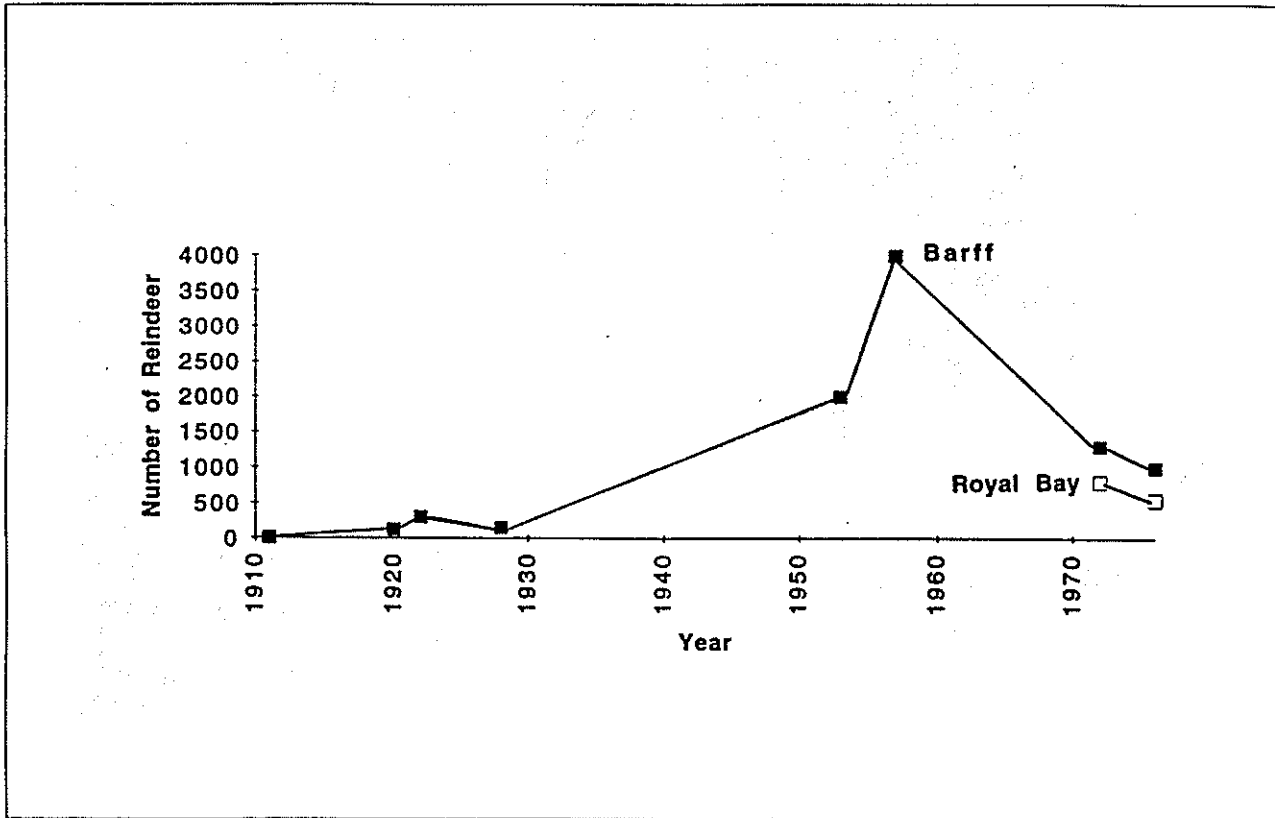


Figure F-2. Number of reindeer in the Barff and Royal Bay, South Georgia, herds by year. Note that the Royal Bay Herd fragmented from the Barff Herd in 1961 (data from Table F-1).

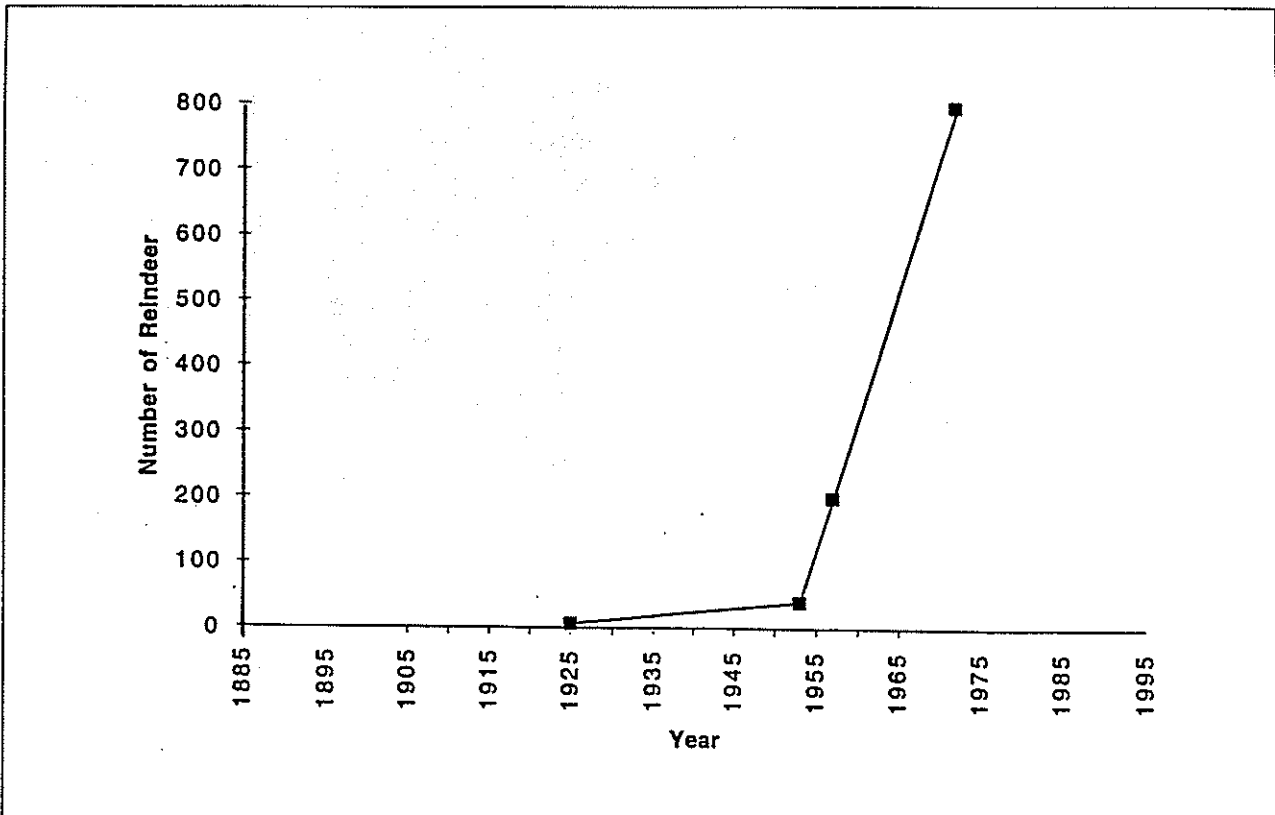


Figure F-3. Number of reindeer in the Busen, South Georgia, Herd by year (data from Table F-1).

Appendix G

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