AN INTERJURISDICTIONAL MANAGEMENT PLAN

FOR THE

PORCUPINE CARIBOU HERD

FIRST DRAFT

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Prepared for the Department

of Renewable Resources

by

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INTRODUCTION

This document is a prototype interjurisdictional management plan for the Porcupine Caribou Herd prepared for by the Yukon Department of Renewable Resources for use by whatever organization is eventually created to manage the herd. As such it is an attempted holistic approach to caribou management that recognizes jurisdictional boundaries but treats the Porcupine Herd and its range as single units that are largely independent of human territories. Although it is expected that modifications to the plan will be necessary depending upon the particular nature of the management body employing it, still it is felt that the background information and management principles provided in this plan are basically correct and will remain essentially intact. Therefore in the interim, this version will be used by the Yukon Department of Renewable Resources, in consultation with other management agencies and interest groups, to guide its management policies and actions regarding the Porcupine Herd. As part of such consultation efforts, this draft will be circulated among appropriate organizations for comments and suggestions that will be incorporated in a subsequent redraft.

The concept of a management plan with respect to its value and functions is sometimes difficult to appreciate even for many wildlife managers. A good management plan should be like a shop manual for a complex machine. The manual first describes the machine and how it works, followed by diagnosis and repair instructions, ending with a detailed maintenance schedule. The analogous parts of this plan are first, the Natural History and Status sections which summarize current knowledge of the Porcupine Herd; second, statements of major management concerns related to the herd plus the Goals, Objectives and Strategies sections which establish how the herd should be managed; and third an Implementation

Schedule which unites all the previous considerations into a specific plan of action for a stated number of years.

The chief advantage of a management plan is that it is a means of dealing with all aspects of wildlife management in an orderly fashion. Such a system frees managers to concentrate on particular duties with the confidence that other aspects of caribou management will be dealt with in a due course. Without a plan, managers tend to fret continually about all of their problems (or as many as they can remember at one time). This approach tends to be frustrating, inefficient and sometimes even counterproductive. Other benefits of a well ordered and thorough management plan are:

1. A means of justifying particular management actions;
2. A framework upon which to plan research and funding;
3. A means of assessing management progress and effectiveness;
4. A means of ensuring continuity in management policies and duties regardless of staff changes;
5. A handy reference for new staff and for supervisors not particularly acquainted with Porcupine Caribou management.

Finally a management plan is the ideal document for public education and involvement in Porcupine Caribou management. This plan or its successors should form the basis for public discussions concerning the Porcupine Herd and also for industrial negotiations which impinge on these caribou and their range. It should also become the foundation for international agreements concerning the herd and for the coordination of international research and management projects.

TAXONOMY

All existing caribou belong to the tarandus species and separate Rangifer genus of the deer family (Cervidae) in the order of even-toed ruminants (Artiodactyla). Porcupine caribou together with the migratory barren-ground caribou of Alaska compose the subspecies granti.

The other four current subspecies in the genus refer to the arctic mainland in the Northwest Territories (groenlandicus), the arctic island (pearyi), woodland and mountain (caribou), and reindeer (tarandus) types.

The classification of caribou has a complex history of alternating subdivision and amalgamation with attendant controversies over proper nomenclature. The most thorough analysis was produced in 1961 by A.W.F. Banfield and has since been considered by the majority as the definitive version.

The earliest fossil evidence of caribou comes from Germany and has been dated to about 440,000 years ago (Banfield, 1961). It has been suggested that caribou reached Alaska before the next to last glaciation (Illinois) and persisted in North America throughout both the Illinois and Wisconsin Glaciations in the Alaska-Yukon refugium as well as in a tundra belt at the south edge of the ice sheet during the latter glaciation.

The extinct species Rangifer muscatinensis has been linked to various fossil forms from the Wisconsin age and is tentatively considered to be the progenitor of both the modern groenlandicus and granti subspecies (Banfield, 1961).

Description

Caribou are deer which have become highly adapted to survival in regions of prolonged snow coverage and low temperatures. Unlike the feet of most other deer, theirs have blunt toes, crescent-shaped, sharp-edged hooves and functional dew claws (Russell and Martell, 1983). These features together with a heavy growth of bristly-like hairs surrounding the hoof and toes that can bend almost horizontally, enable the caribou to partially "float" on soft snow (Russell and Martell, 1983). Other distinctive adaptations to cold and snow are a blunt, fully furred muzzle; valvular nostrils; short, heavily furred ears; a short well furred tail and a compact body covered with a thick coat of hollow guard hairs and fine crinkly underfur (Banfield, 1974).

Porcupine caribou are among the smaller of the North American subspecies. Mature males average 113 cm to the shoulder and 125 kg in weight, while mature females are substantially smaller at 103 cm and 89 kg respectively (Yukon Wildlife Branch, 1983). By comparison males of the larger subspecies in central Alaska, northern British Columbia, Ungava and Quebec weigh 181 - 272 kg and females are usually 91 - 136 kg (Bergerud, 1978).

The coat colour of Porcupine caribou varies seasonally and individually but generally these animals are considerably darker than those in the High Arctic and somewhat lighter than the mountain and woodland subspecies. The most typical colour pattern in winter consists of a dark face, back, flanks and dorsal tail surface; a light neck, belly, rump, under surface of the tail and hindquarters, dark legs with white "socks" just above the hooves.

Caribou are the only deer that produce antlers in both sexes. The proportion

of antlered females varies greatly among North American herds (Bergerud, 1978) with the Porcupine Herd belonging to the upper extreme having about 95-97% of females with antlers (A. Martell, pers. comm.). Bulls begin to develop antlers around March and employ them during rutting contests in October when the antlers are full size and out of velvet (Banfield, 1974). Older males begin to shed their antlers by early November while yonger ones may keep them until February (Banfield, 1974). Cow antlers do not commence growth until the summer months and are retained throughout the winter when they may be used in the defence of feeding craters from larger but antlerless bulls (Banfield, 1974).

Behaviour

Porcupine caribou, like the rest of their genus, are highly gregarious, pursuing daily and seasonal activities (except parturition) either in small groups, large bands or massive aggregations. Consequently, they exhibit both individual and group responses to varying situations often with the latter evolving from the former, such as the selection of migration trails, the initiation of river crossings and the response toward predators.

Prerutting and rutting behaviour is similar to that of other deer in which bulls vocalize, execute threat displays and spar among each other with their antlers (Banfield, 1972; Kelsall, 1968). Such engagement can result in injuries and even fatalities at times (Calef, 1981; Bergerud, 1978), although most contests terminate with little or no apparent damage (Kelsall, 1968). Dominant bulls pursue and mate with cows in the large mixed bands comprising

all age and sex classes which are usually migrating southward during the rut (Calef, 1981; Kelsall, 1968). Subdominant males present in such bands are prevented from mating with cows by the constant vigilance of the dominant bulls (Calef, 1981; Kelsall, 1968). Energy demands upon activity rutting bulls are extreme and a dramatic loss of condition is associated with this period (Calef, 1981).

Calving is probably the only major solitary activity that Porcupine caribou regularly engage in. Although pregnant cows reach the calving grounds in large groups, parturient females isolate themselves for the period required to give birth and attend the calf until it is mobile (Calef, 1981; Kelsall, 1968; Banfield, 1972). Thereafter, most cows, calves and many yearlings usually coalesce into large post-calving aggregations (Bente and Roseneau, 1978; Yukon Wildlife Branch, 1979; Whitten and Cameron, 1980).

Migratory behaviour of Porcupine caribou has been extensively documented mainly as an aspect of distribution and movement studies. Such observations may be summarized as follows:

a) Initial migratory movements often coincide with major environmental changes such as rapid temperature declines plus snowstorms in the fall (Thompson, 1979; Surrendi and De Bock, 1976) and early thaws with consequent snow loss in the spring (Thompson and Roseneau, 1978).
b) The direction, duration and speed of migrations are strongly influenced by travelling conditions which in turn are related to weather patterns (Surrendi and De Bock, 1976; Thompson, 1979; Whitten, 1982).

c) Caribou follow contours in hilly terrain, traversing side hills rather than travelling perpendicularly (Le Resche, 1975).

d) Caribou tend to travel in narrower lanes in steep terrain and to spread out on a broader front in flatter areas (Le Resche, 1975).

e) Caribou tend to course natural features such as rivers, steep slopes and cut banks for some distance before crossing them, regardless of the relative ease of crossing at the point of first encounter (Le Resche, 1975).

f) Caribou tend to follow previous caribou trails, their inclination to do so being in direct relation to the age of the trails (Le Resche, 1975).

g) During winter, caribou frequent frozen lakes and water courses for travelling and resting (Surrendi and De Bock, 1976).

h) Traditional water crossings are used by the Porcupine Herd.

i) Porcupine caribou movement rates peak during the spring migration, the post-calving period and the fall migration. Movement rates are lowest during the calving period, August dispersal and winter. Average movement rates are greater during the post-calving period than during either seasonal migration (Russell, H. and Farnell, 1981).

j) In conjunction with movement behaviour, other activity patterns such as feeding and resting vary considerably during the year. In October and November, about 35% of the non-bedded time is spent in walking and trotting while for other months, from December through March, these activities decrease from 14% to 4% of the non-bedded time. Feeding intensity on the other hand is higher during the same four months than in either October - November or April. Such behavioural variations constitute energy budgeting strategies by Porcupine caribou to adjust costly activities such as walking and trotting in relation to food supply (Russell and Martell, 1980).

Behaviour toward industrial facilities and disturbances by Porcupine caribou can only be described so far as obvious short-term reactions to some elements of industrial developments and activities. These may be summarized as follows:*

a) Escape responses to aircraft disturbance increased dramatically when exposure was below approximately 75 m (Surrendi and De Bock, 1976).

b) Seasonal variations in response to aircraft disturbance was evident among Porcupine caribou. Peaks of sensitivity occurred in spring and early winter with the most sensitive period being June. By contrast, the greatest contrast to overflights occurred in July (Surrendi and De Bock, 1976).

c) Caribou in open habitats (arctic tundra, alpine areas, frozen lakes) reacted less to overflights then did animals in heavily forested areas (Surrendi and De Bock, 1976).

d) Porcupine caribou have little difficulty crossing the Dempster Highway under light to moderate snow conditions. Caribou use the highway for travel as they would a frozen river (Russell, 1982).

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*See also Dempster Highway Section.

e) Avoidance of the Dempster Highway will occur if the road is associated with significant wolf predation (Russell, 1982).

f) At 1982 levels of traffic, the Dempster Highway is perceived by Porcupine caribou as a slightly negative element (Russell, 1982).

g) Caribou react more negatively to vehicles approaching at high speeds (Horejsi, 1981).

h) Disturbed caribou frequently crossed the Dempster Highway at night after traffic ceased (Surrendi and De Bock, 1976).

i) Caribou approaching the Dempster Highway in forested areas seemed more apprehensive than those doing so in open areas (Surrendi and De Bock, 1976).

j) Caribou quickly associate the Dempster Highway with hunting and consequently avoid sections of it where hunting has occurred (Russell, 1982).

SEASONAL DISTRIBUTION AND MIGRATION

It may be said of the Porcupine Herd that it is in continual motion. It is also true that the herd seldom exhibits uniformity in the timing and direction of its movements but functions rather as a composite of individuals and groups which choose from a variety of movement options throughout the year. Still, with rare exceptions, a basic pattern of annual distribution does occur that by convention has been subdivided into the seasonal categories of spring migration calving ground distribution, post-calving movements, August dispersal, fall migration and winter distribution.

Each phase, however, being subject to considerable variation, cannot be described in full detail but only according to its major features. It must be stressed that such descriptions do not represent the "norm", an attribute which caribou movements unfortunately do not possess, and that major deviations, while anomalous to the theoretical standard cannot be interpreted as abnormal, particularly since reliable documentation covers only the past 13 years of the herd's history which may total in the thousands.

Given the above considerations and constraints, the distribution of the Porcupine herd is presented as follows:

1. Winter Range

The winter distribution of the Porcupine Herd may be considered as the area occupied between the fall and spring migrations. The duration of winter range occupancy therefore varies in length depending upon the end of the preceeding fall migration (mid-November to mid-December)* and the beginning of the following spring migration (mid-January to mid-May)*.

Although some historical records of wintering caribou in the Yukon do exist (Thompson and Roseneau, 1978), their relevance is compromised by the lack of distinction made prior to 1970 between Porcupine caribou and those of adjacent migratory herds. Such sitings are included in this summary, however, since the majority likely pertain to the Porcupine Herd and hence expand the history of the herd's winter range. Historical records of caribou wintering in northern Yukon are as follows:

a) Along the Arctic Coast in the vicinity of Herschel Island (Franklin, 1828; Jackson, 1892-1908; Russell, 1898; Harrison 1908; Olson, 1959).
b) Richardson Mountains (Isbister, 1845; Posild, 1945; McEwen, 1956).
c) North of Porcupine River (Soper, 1951; McEwen, 1952a, 1952b).
d) Along the Porcupine River from Old Rampart House to LaPierre House and to its headwaters (Murie, 1935).
e) Upper Porcupine drainage (McEwen, 1956).
f) "Well south" of the Porcupine River (Munro, 1953).
g) In the northern Ogilvie Mountains (Olsen, 1958; Keele, 1910; Clarke, 1944).
h) In the Black River drainage of Alaska and Yukon (Hemming and Pegau, 1970).
i) Old Crow Flats (Kevam, 1970).
j) Whitefish Lakes area (Kevam, 1970).
k) Northern Richardson Mountains west of Aklavik (Hemming, 1971).

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*See spring and fall migration sections.

Winter range surveys have been flown annually since 1970-71 either for general distribution data or in conjunction with radio-tracking studies. The compiled results from all these investigations produce a total winter range for the Porcupine Herd encompassing borderline areas of the N.W.T., most of the Yukon north of Dawson and a substantial portion of north-eastern Alaska from east of Fairbanks to the Arctic Coast (Fig. 1) (Thompson and Roseneau, 1978; Yukon Wildlife Branch, 1980c; Yukon Wildlife Branch, 1981d; Whitten, 1982; Yukon Wildlife Branch, 1983). Within this vast area, Porcupine caribou may winter in a number of regions, with concentrations over the past 13 years being most common in a) the Ogilvie Mountains, b) the Chandalar region and c) the Richardson Mountains (Thompson and Roseneau, 1978; Whitten, 1982; Yukon Wildlife Branch, 1983). Sometimes most of the herd will be located in one region while at other times, a few large separate concentrations may exist or alternatively caribou may be broadly dispersed in varying concentrations throughout the winter range (Thompson and Roseneau, 1978; Yukon Wildlife Branch, 1983). A further complexity is that "new", i.e. previously undocumented distributions may arise such as in 1982 when part of the herd wintered southwest of the Yukon River in what was previously considered to be the exclusive winter range of the Forty-mile Herd (Whitten, 1982).

Winter distributions also vary greatly in the amount of local movement that occurs within the general wintering region occupied. Winter range selection is stongly associated with prevailing snow conditions, which when they deteriorate, induce caribou to seek better feeding areas (Russell and Martell, 1983). Thus some winters entail considerate local movements due to extensive unfavourable snow conditions, while in other winters with

generally favourable conditions, local movements are small (Whitten 1982, Surrendi and De Bock, 1976). Similarly, dispersal over the winter range is greater when snow conditions are generally favourable but can be very limited when conditions are generally unfavourable (Surrendi and De Bock, 1976). Extensive winter range shifts may also occur.

Another factor influencing winter range occupancy may be the particular fall migration route taken (Whitten 1982) which lead caribou to certain traditional winter ranges.

Considering the variation in winter range occupation and movements that are possible, it is very risky to attempt delineations of major winter range areas (Thompson and Roseneau, 1978) based on accumulated survey data which seldom depicts the total range used for the entire winter season in any year. Consequently such ranges are best referred to by name alone lest such calculations become misleading.

Since the aforegoing winter range description is of necessity complex and apt to be confusing, it is perhaps easier to perceive winter range use by this herd as a sequence of decreasing probabilities as follows:

1) Most Porcupine caribou will winter south of the Arctic coast and within their known range.

2) The majority of the herd will winter in or near the Ogilvie mountains with lesser numbers wintering in both or either the Chandalar and Richardson regions and scattered groups elsewhere up to the Arctic coast.

3) The majority of the herd will winter in either the Cahndalar or Richardson region with lesser numbers in the Ogilvie region and one or other of the former regions and scattered groups elsewhere up to the Arctic coast.

4) Almost the entire herd will be located in one of the major winter ranges with few animals elsewhere.

5) The herd will be widely dispersed in scattered groups of varying size throughout most of its winter range.

6) In addition to any of the above, a significnt number of caribou will winter in a previously undocumented area.

2. Spring Migration

Among barren-ground caribou, the spring migration has been differentiated from winter movements by appearing "direct and purposeful" as well as "goal oriented" (Kelsall 1968). This migration is initiated by the pregnant cows which are destined for the calving grounds. Bulls and many juveniles may start later than the cows (Russell, H. and Farnell, 1981) and use different routes which generally take them to "staging areas" of the periphery of the calving grounds (Farnell 1979b). All such movements are usually most apparent in April and May but they have been recorded as early as February and March (Thompson 1978, Whitten and Cameron, 1982). With the advantage of radio-tracking it has been shown that cows may begin to drift northward as early as January (Russell, H. and Farnell, 1981). Steady travelling however seldom precedes significant snow loss which usually occurs in April

or May but may vary as much as a month or more among years (Thompson and Roseneau, 1978). In springs with extremely late snowmelt, the migration may be delayed to the extent that some cows calve enroute to the calving grounds.

The spring migration is considered to have ended when the last cows reach the calving grounds which is usually in early June, or later when the migration has been delayed. Thus the spring migration covers an entire potential period of about five months from mid-January to mid-June during which the greater movements are undertaken in April and May. Even after calving is underway many bulls and yearlings may still be moving northward or drifting towards the calving grounds (Yukon Wildlife Branch 1980f, Yukon Wildlife Branch 1981b).

Spring migration paths used by Porcupine caribou are numerous and also highly variable among years. They may however be grouped into three or four major routes or corridors which seem to be widest at the southern end and more constricted towards the north (Thompson 1978). Within each corridor the paths chosen in any given year are largely determined by prevailing snow condiions (McCourt et al., 1974). The major corridors may be described as follows:

a) The Old Crow Route:

Originally designated in 1974, (Jakimchuk et al., 1974) this route has been consistently used by most or part of the herd since 1971 when accurate monitoring began (Thompson and Roseneau, 1978; Farnell 1979b; Russell and Farnell, 1980; Yukon Wildlife Branch, 1981b; Whitten and

Cameron, 1982). The Old Crow Route gathers trails from widely dispersed winter ranges in the Ogilvie Mountains from north of Dawson eastward to the Hart River (Fig. 2) and funnels them through the Keele range across the Porcupine River east and west and Old Crow, through the Old Crow Flats to eventually join the Richardson Route in the vicinity of the Western Barn Mountains (Thompson 1978).

The migration along the Richardson Route typically occurs in two waves, the first representing animals that wintered north of the Peel River and the second being composed of those wintering south of the Peel River which are often delayed by more severe snow conditions (Thompson 1978).

b) The Western Route

First described as a separate route in 1976 (Surrendi and De Bock, 1976), this small route has since been included in the Old Crow Route (Thompson and Roseneau, 1978) but may deserve special attention in view of the 1979 and 1982 spring migrations in which caribou wintering in the Tatonduk River drainage traversed the same route described in 1976 until it converged with the Old Crow Route near the upper Salmon Fork River (Fig. 1), (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983b).

c) Richardson Route:

Also designated first in 1974 (Jakimchuk et al., 1974) this route has apparently been used by the majority of Yukon wintering caribou four times in the past twelve years (Thompson 1978, Yukon Wildlife Branch 1983b). In the remaining years, the proportion of Yukon wintering

animals following the Richardson Route has ranged from a few thousand animals (Thompson 1978) to nearly half of the Yukon wintering herd (Roseneau et al., 1975). Originating in the Wind, Bonnet Plume, Snake and Arctic Red river areas this route crosses the Peel River and follows the long axis of the Richardson Mountains to the Fish Creek-Rapid Creek-Blow River area where it turns northwest along the Barn and British Mountains to the Alaska border (Fig. 2) (Thompson 1978).

d) The Chandalar Routes:

Sometimes also referred to as the Arctic Village - South Brooks Range Route (U.S. Dept. Interior and U.S. Fish and Wildlife Serv. 1982, U.S. Fish and Wildlife Serv. 1983), this route had been used only by Porcupine caribou wintering in the Arctic Village region until 1982 when a substantial portion of the herd moved northwards through previously undocumented spring migration territory to link up with the Chandalar Route and the Old Crow Route in the general vicinity of Bear Mountain (Fig. 2).

The longer Chandalar Route leads northeast from Chandalar Lake across the East Fork of the Chandalar River towards the British Mountains in the vicinity of the Firth River (Fig. 2) (U.S. Fish and Wildlife Serv. 1983), Yukon Wildlife Branch 1983). Alternatively, caribou may travel northwards from the Chandalar region to reach the Arctic Coast of Alaska via a number of mountain passes in the Brooks range, the most heavily used pass being at the head of the East Fork of the Chandalar River (U.S. Dept. of State 1980, Whitten et al 1982, Roseneau et al 1974).

It should not be misconstrued from the preceding route descriptions that all Porcupine caribou traverse these entire routes every spring. Rather, the length of each route travelled depends upon the late winter distribution of various herd segments such that some animals, for example those wintering in the northern Richardson Mountains, travel only a small portion of the route compared to those wintering in the Peel River region. As for caribou which winter on or near the Arctic Coast there may be little or no distance remaining between them and the calving grounds. The migratory behaviour of such animals remains undocumented but it is conceivable that they remain virtually stationary throughout the spring migration period.

A major obstacle to migrating caribou is hazardous watercrossings where injuries, drownings and hunting may occur. For the Porcupine herd on its spring migration the principal rivers to be crossed are the Porcupine, Blow, Babbage and Firth rivers (Thompson 1978, Yukon Wildlife Branch 1983). Caribou often cross at traditional sites on these rivers where topographical features seem to foster such efforts (D. Russell, R. Farnell, pers. comm.). For caribou which winter on or near the North Slope there may be little or no distance between them and the calving grounds. The migratory behaviour of such animals remains undocumented but it is conceivable that they could remain virtually stationary throughout the spring migration period.

Another important aspect of the spring migration is that many other trails exist between the major migration corridors although such routes appear to be "only sporadic and rather inconsistent with regard to the general routes

that are followed" (Thompson 1978). Also the major routes depicted in Figure 2 should be considered as a map of potential pathways in which an endless variety of combinations is possible. For example in 1982, most animals wintering in the Ogilvie Mountains moved up the main trunk of the Ogilvie route but turned westward south of Old Crow and met up with the latter part of the Chandalar Route (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983).

A graphic perception of the Porcupine Herd's spring migration could be to imagine it as a giant amoeba gradually shifting its mass northward by a process that entails the rapid streaming of cytoplasm in some sections while elsewhere the cytoplasm is hardly moving at all or is slowly flowing in different directions yet the overall effect is one of coordinated reorganization that eventually transfers the cell to a position along the coastal regions of Yukon and northeast Alaska. Each spring this shift occurs in a unique combination of cytoplasmic withdrawals and amalgamations but always produces a similar distribution by early June.

3. Calving Ground Location

Since 1971 annual calving ground surveys of the Porcupine herd indicate that calving has occurred throughout the Arctic Slope from the Canning River, Alaska to Shallow Bay, N.W.T. and as far south as the northern drainages of Old Crow Flats (Fig. 3) (LGL Ltd. 1982, Yukon Wildlife Branch 1979b, Yukon Wildlife Branch 1982, U.S. Dept. of Interior and U.S. Fish and Wildlife Service 1982). Within this general area, the calving ground boundaries have shifted annually often excluding areas east of the Babbage River but always including a central portion between the upper Jago River

and the Firth River. Also, each year the calving herd has been concentrated in one or more high density areas and distributed in varying but lesser densities in the remainder of the calving ground. Over the last 12 years three core areas have been located between the Katakuvuk River, Alaska and some distance east of the Firth River, Yukon (Fig. 3) (LGL Ltd. 1983, Yukon Wildlife Branch 1982). The composition of the calving herd also varies from areas where bands are almost exclusively adult females to other parts where bands contain more juveniles and some bulls (Yukon Wildlife Branch 1981c, Yukon Wildlife Branch 1979b). It should also be noted that the calving ground is never completely occupied by calving caribou at any time but that it represents the total area in which calving caribou move during the calving period (U.S. Fish and Wildlife 1980).

Although most calving usually takes place in the foothills of the Brooks Range and the British Mountains (U.S. Dept. of State 1980, LGL Ltd. 1982) it may sometimes occur across the coastal plain to the shoreline of the Arctic Ocean (Yukon Wildlife Branch 1981c, LGL Ltd. 1982). It has been suggested that factors influencing annual calving ground locations may include winter range distributions of the previous winter, the timing of spring migration and routes taken as well as the progress of the snowmelt (Yukon Wildlife Branch 1979b). Such considerations have prompted the prediction that early spring migrations will result in most calving occurring in Alaska whereas late spring migrations would shift the calving grounds into Yukon (Surrendi and De Bock, 1976; U.S. Dept. of Interior, 1983). Within the general North Slope region, the choice of specific calving areas may be related to snowmelt conditions which, when late, may

make the comparatively snow free uplands of the Arctic Slope initially preferable for calving but, when early, may expose the coastal plain sufficiently for calving or at times may produce a shift from the foothills to the plains as the snowmelt progresses (Yukon Wildlife Branch 1979b, 1980f, 1981c). It has also been observed that earlier arrivals on the calving ground may not occupy its remotest areas and that some cows coming later may actually penetrate further into the calving grounds.

During the calving period most of the bulls, many juveniles and some dry cows, become located on the southern and eastern peripheries of the calving ground and/or some distance south of it (Fig. 4) (Martell 1982, Yukon Wildlife Branch 1979b, 1982). Two commonly mentioned "staging areas" for the bull segments are the Firth and Babbage River regions (Farnell 1979b, LGL Ltd. 1982).

Based on past documentation it appears that consistent features of the calving ground distribution are:

a) that a portion of the calving ground will be located between the upper Jago and Firth Rivers;
b) that the composition of the calving herd will vary from nearly exclusive adult female bands to mixed groups including cows, juveniles and some bulls;
c) that most of remaining Porcupine caribou will be located on the southern or eastern peripheries of the calving herd or some distance south of it;

d) that the timing, origination and progress of the spring migration likely determines the particular location of the calving grounds;

e) that relative snow conditions on the North Slope may influence the choice between the foothills and the coastal plain as the major calving area.

4. Summer Movements

During the summer, the movements and behaviour of the Porcupine herd usually involves two phases referred to as post-calving aggregation and August dispersal. These are described separately as follows:

a) Post-calving aggregation:

Immediately following calving the Porcupine herd is arranged with the majority of non-calving groups situated east and south of the calving herd. This relative positioning occurs annually regardless of the particular location of the calving ground. In some years when the calving herd is located across the Alaska-Yukon border, the non-calving segments will be generally further east and south in Yukon. If the calving ground is mainly in Alaska, the non-calving segments may be concentrated on the Alaska-Yukon border, still east of the calving herd but much further westward than in the previous example (Yukon Wildlife Branch 1983c). By mid June cows and calves have begun to form "nursing bands" that continue to grow in size until practically all the females and their young are gathered into a few large calving herd aggregations and some small peripheral groups. This formation is completed towards the end of June or in early July (Davis, 1978; Le Resche, 1975;

Roseneau and Curatolo, 1976; Whitten and Cameron, 1980). During this period the animals are usually moving eastward but often head northward and even westward as well as towards the coast (LGL Ltd. 1983, Roseneau et al., 1974).

Meanwhile the bull segments that have been moving westward and/or northward encounter and amalgamate with the calving herd aggregations in early to mid July to form massive post-calving aggregations, some of which are very compact while others may be less densely organized (Whitten and Cameron, 1980; Calef, 1982). Animals that are not involved in the post-calving aggregations near the coast are most often distributed along the coastal plain or in the foothills of the Arctic Slope (Whitten and Cameron, 1980). In some years the post-calving aggregations do not completely form (Bente and Roseneau, 1978) but remain as scattered bands over a broad area (Yukon Wildlife Branch 1981d). Such variations are possibly related to reduced fly harrassment associated with inclement weather (Yukon Wildlife Branch 1981d).

During the remainder of July the post-calving aggregations tend to move southeastward or southwestward toward the Yukon side of the border, often reaching points anywhere from the upper Firth River to the N.W.T. border by late July (Roseneau et al., 1975; Surrendi and De Bock, 1976; Jakimchuk et al., 1974; Roseneau et al., 1974; Yukon Wildlife Branch, 1983c) (Fig. 5).

b) August dispersal

In late July and throughout much of August, the large aggregations progressively dissociate into smaller bands, most of which usually

travel quite rapidly into Alaska while the rest disperse in northern Yukon (Roseneau et al., 1975; Roseneau et al., 1974; Surrendi and De Bock,1976; Ealey, 1979). In the past 12 years the only exception has been in 1975 when the majority remained in western Yukon (Thompson 1979). By about the third week of August much of the herd is usually in Alaska and some of it may already be returning to Yukon (Roseneau et al., 1975; Surrendi and De Bock, 1976). Those which had remained in Yukon could be scattered in the British and Barn Mountains, the northern Richardson Mountains and probably the periphery of Old Crow Flats (Jakimchuk et al., 1974; Roseneau et al., 1975; Ealey, 1979). Although many or most caribou often return to Yukon in late August and early September, in some years substantial numbers remain on the Alaska side of the border and also above the continental divide in Alaska (Rosenau et al., 1974).

As with the other phases of the Porcupine herd's distribution, a very basic pattern exists upon which annual variations are superimposed. The general sequence of movements can be best summarized chronologically except for the least likely events which are mentioned last as follows:

a) Around mid to late June the calving herd aggregates on or near the Alaskan and/or Yukon arctic coast.

b) During the latter part of the calving period and onward into mid to late June the bull groups tend to coalesce and move towards the calving herd aggregations.

c) Around late June to early July the bull herds eventually encounter and mix in with the calving herd aggregations to form large and sometimes massive post-calving aggregations with the remaining caribou scattered about the coastal plain and the foothills.

d) During the remainder of July the post-calving aggregations in Alaska usually move southeastward into Yukon while the aggregations already in Yukon may move south or southwestwards.

e) Towards the end of July and during the first half of August the large aggregations split into smaller bands, most of which travel westwards into Alaska while the rest disperse in northeastern Yukon.

f) By late August a return to Yukon is underway while the Yukon contingent remains dispersed.

g) Caribou which did not leave Alaska become scattered in groups about the North Slope of the Brooks range.

h) Sometimes large post-calving aggregations do not completely form.

5. **Fall Migration**

As with the spring migration, the fall migration is a complex of movements that vary in timing, direction and duration, not only among years but among different herd segments in the same year. Most authors consider the eastward return of caribou from Alaska to Yukon in late August to early

September as part of the fall migration. At that time caribou may also be dispersed in northern Yukon and along the north slope of Alaska (Roseneau et al., 1975; Jakimchuk et al., 1974; Roseneau et al., 1974b).

Thereafter, the initiation, rapidity and progress of the fall migration is strongly influenced by weather patterns in northern Yukon (Surrendi and De Bock, 1976; Thompson, 1979; Ealey, 1980). As long as the fall weather remains clement, caribou tend to move leisurely, either towards Yukon from Alaska or, having reached there, southward in a widely dispersed pattern (Thompson 1979). Presumably other herd segments in northern and coastal Yukon and Alaska also move at a comparatively slow pace in many directions. A marked change in these types of movements usually occurs shortly after rapid temperature declines and substantial snowfalls which can occur anytime in September (Thompson 1979). Subsequent movements are generally rapid and more or less uniformly southward from wherever the caribou happen to be located when the weather conditions deteriorated (Thompson 1979). However, if the weather improves again (temperatures rise, low precipitation), the migration may slow down, or halt or reverse (Jakimchik et al., 1974; Ealey, 1980). At such times caribou may begin to drift northward sometimes recrossing the Porcupine River or the Dempster Highway until renewed snowfalls and temperature declines produce a resumption of the southward migrations sometime in October (Jakimchuk et al., 1974; Ealey, 1980; Yukon Wildlife Branch ,1983d). Occasionally however, weather improvements do not affect the southward migration which maintains its orientation and strength despite ameliorating conditions (Yukon Wildlife Branch 1980g).

The timing and progress of the fall migration may vary annually to the extent that caribou may reach a particular region in the southern extremity of their winter range (i.e. the lower Tatonduk River) anytime between late September and early November (or of course not at all), (Yukon Wildlife Branch 1983d, Roseneau and Curatolo 1976). Similarly, caribou may be crossing the Porcupine River throughout September and even up to mid October (Thompson and Roseneau 1979) and peak crossings can occur anytime between September 1 and October 4 (Ealey 1980). The fall migration is considered to have ended when steady movements have ceased and the migratory bands begin to disperse on the winter range. Such events have often been recorded between late October and late November (Thompson 1979, Russell and Martell 1980, Yukon Wildlife Branch 1983d) but sometimes migratory type movements can persist into December (Whitten and Cameron 1982).

An exceptional fall migration occurred in 1981 when caribou crossed the Yukon River in the vicinity of Eagle, Alaska. Such movements had not occurred since the 1950's when presumably the Porcupine herd performed similar manoeuvers which at the time were confused with those of then large 40-Mile herd (Whitten and Cameron 1982).

Documented fall migration routes are if anything more diverse than the spring ones, primarily because snow conditions are seldom a limiting factor (Thompson 1979). Still the fall routes can be generally grouped into the spring corridors (Fig. 6) which are described in reverse as follows:

a) Old Crow Route:

Originating primarily in the British and Barn Mountains, the paths of this corridor cross the Porcupine River in numerous locations but

principally between Bell River and Lard Creek and also west of Old Crow (Thompson 1979). Beyond the Porcupine River the broad corridor leads south generally within the Keele Range and mostly west of Eagle Plains. Upon reaching the Ogilvie Mountains, routes either continue south to the Tatonduk region winter range or branch westward towards the same area. Other routes diverge eastward to winter ranges in the Hart and Blackstone winter ranges.

b) Richardson Route:

The major Richardson Route penetrates the Richardson Mountains north of McDougall Pass and extends south along the long axis of this mountain chain to the Peel River while minor routes reach the Peel River by crossing the Bell, Rock or Eagle Rivers and travelling along the western flanks of the Richardsons (Thompson 1979). The majority of caribou appear to cross the Peel River between the Bonnet Plume and Wind rivers but crossings may occur as far west as north of Hungry Lake (Thompson 1979). After crossing the Peel River migration routes proceed to winter ranges in the Swake, Hart, Blackstone, Bonnet Plume and Wind River draninages (Thompson 1979).

c) Western Route:

Originally identifed as a distinct Spring Migration Route (Surrendi and De Bock 1976), this corridor has always been included as an extreme western component of the Old Crow Route. It has however, appeared as a principal route in the 1974, 1977 and 1981 fall migrations (Roseneau et al. 1975, Bente and Roseneau 1978, Yukon Wildlife Branch 1983d) and should perhaps receive separate recognition on those accounts. The

route essentially parallels the Alaska - Yukon border from the Upper Salmon Fork River to the Tatonduk River. Caribou using this route have reached winter ranges as far east as the Hart River (Bente and Roseneau 1978) and as far west as Delta Junction and Central Alaska (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983d).

d) Chandalar Route:

This route consists of a major component that extends westward from Old Crow Flats across the Alaska-Yukon border to the Chandalar River drainage (Fig. 6) essentially covering the same territory involved in the August dispersal movements. The minor component comprises trails through passes in the Brooks Range that are used by caribou migrating southward from the Arctic Slope. These caribou are usually the "residuals" (Roseneau and Stearn, 1974a) that did not join the large post-calving aggregations nor participate in the basic summer movements of the majority of the herd.

A noteworthy variation of the Chandalar Route occurred in 1972 when many fall migrants crossed the Porcupine River in Yukon but shortly thereafter swung northwestward, recrossing the Porcupine River in Alaska and merging with the Chandalar Route in the Coleen River region (McCourt et al., 1974).

It must be emphasized that the preceding corridor descriptions are gross simplifications of an extremely complex process. Not only do migration trails vary considerably within the corridors but additional albeit minor trails exist between them - particularly the Old Crow and

Richardson routes. Also caribou may begin the migration in one corridor but later switch to another (Jakimchuk, 1974; Ealey, 1980). Thus it is not possible to state unequivocally that the late summer distribution of the herd will indicate which migration routes the majority will take. The migration corridors and their constituent routes are best perceived as a complex road map in which turns may be made at any junction but in which certain combinations are used more frequently than others. An additional feature of the fall migrations that should be kept in mind is that all caribou seldom if ever follow the entire routes described but may winter at intermediate locations such that the winter distribution most often consists of a number of disjunctive winter ranges located at various points along the routes. Judging from winter distribution records, some caribou may not migrate at all but remain from one summer to the next and perhaps for a few consecutive years on the North Slope or north of the Porcupine River in Yukon.

In view of the preceding considerations, a summary of the basic fall migration pattern for the Porcupine Herd should contain the following highly generalized elements:

a) Each fall most caribou move southward from late summer locations.
b) In all but one year in the past 12, caribou have moved eastward from Alaska into Yukon prior to turning south.
c) The fall migration often begins in late August to early September with the beginning of the eastward return from Alaska to Yukon.

d) The fall migration is eventually accelerated by inclement weather (temperature declines, substantial snowfalls), occurring sometime in September, which often produces a southward movement in Yukon segments that have not already turned south.

e) Subsequent improvements in weather conditions sometimes slow, halt or reverse the Yukon migrations but not always.

f) The fall migration may end anytime between late October and early December. In the same year it may also end at different times for different herd segments.

g) Each fall migration pattern is unique. Although parts of many known routes are utilized each year, new routes are continually being recorded as well.

POPULATION RANGE

The range of the Porcupine caribou herd incorporates all accurate records of its occurrence. With respect to delineation, pertinent data is restricted to the past 13 years since prior accounts cannot be reliably distinguished from those of adjacent migratory herds and resident herds of mountain caribou. However, historical records dating from the early 1800's to the early 1960's indicate that caribou have at times wintered in all the regions presently utilized by the Porcupine Herd (Thompson and Roseneau, 1978). Two noteworthy historical locations are Herschel Island (Franklin, 1828, cited by Surrendi and De Bock, 1976), where caribou have not been reported in the past 13 years and the MacKenzie Delta (Simpson, 1843, and Pullen, 1850, cited by Surrendi and De Bock, 1976), where few Porcupine caribou have recently been observed and then only at the extreme western perimeter (Thompson, 1979). Additional confirmation of long term use of present summer and fall migration routes exists in the remnant of Kutchin caribou fences in northeastern Alaska and northern Yukon which date to the late 1800's (Warbelow et al., 1975). Traditional crossing points on the Porcupine River near the Old Crow River are believed to be at least 30,000 years old and archaeological evidence indicates that natives have killed caribou at such points and others along the Porcupine River for centuries (Irving and Harrington, 1973; Morlan, 1973).

The documented range of the Porcupine Herd, based on distribution studies since 1970, covers virtually the entire Yukon Territory north of Dawson, some bordering sections of the N.W.T. particularly west of Aklavik and Ft. MacPherson and a substantial portion of northeastern Alaska from the Arctic Coast almost to the Alaska Highway (Fig. 7).

Most of this vast area has been used regularly or intermittently in the past 13 years with the exceptions of the extreme southeastern portion in the N.W.T. which was reached twice (1971-72, 1976-77) and the extreme southwestern portion west of Fairbanks which was occupied only once (1981-82), Thompson and Roseneau 1978; Whitten and Cameron, 1982). Prolonged range shifts or abandonment have so far not been detected within this region. The 1981-82 southwestern winter distribution may be either a range extension or merely a reoccupation after a 40+ year absence (Whitten and Cameron, 1982).

The range of the Porcupine Herd overlaps with those of the Central Arctic Herd and the 40-Mile Herd north and south of the Yukon River respectively (Fig. 6), (Roseneau and Stern, 1974; Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983a). Elsewhere, the Porcupine range is distinct from other migratory barren-ground herds, however, it does cover the territories of some mountain caribou herds such as the Hart River herd (Farnell, 1984).

Since reliable distribution records span such a short period in the history of the herd, the boundary delineations merely signify the general range of the herd, which likely includes most but not all of the traditional range - an area that will never be completely known but which may become better identified as distribution data accumulates and is judged in relation to historical and archaeological information.

REPRODUCTION

The rutting period coincides with the fall migration but apparently has little or no influence on the timing or progress of such movements. Prerutting behaviour among Porcupine bulls usually begins around mid-September and continues to increase in intensity to mid-October (Yukon Wildlife Branch, 1980g; Russell and Martell, 1980; Calef, 1981). Rutting activity peaks about the middle to third week of October and matings occur (Russell and Martell, 1980; Calef, 1981) in those couple of weeks (Calef, 1974; Bergerud, 1978). Bull caribou are polygamous and the dominant ones mate with the receptive females in their band (Banfield, 1974). Cows can have several estrus cycles until mating occurs (Skoog, 1968; Bergerud, 1978). Age specific pregnancy rates of the Porcupine Herd have never been determined however, in other populations most females do not mature until between the ages of 29 and 41 months, although a small proportion may bear young as yearlings (Bergerud, 1978). For the Porcupine Herd it has been assumed that the pregnancy rate is 86% for 2+ year old females (Hoffman, 1975). The rut wanes rapidly in early November and the larger bulls begin to shed their antlers shortly thereafter (Calef, 1981). Although the chronology of the rut varies among barren-ground herds (Bergerud, 1978), the preceding sequence described for the Porcupine Herd closely approximates the average of others in North America (Banfield, 1974; Kelsall, 1968).,

The gestation period for caribou hs been variously given as about 227 - 229 days (Bergerud, 1978) and 210 days (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982. In the Porcupine Herd, calving may begin as early as May 22, but more often commences about the 27th of that month (Table 1). In all recorded years, the peak of calving has occurred between June 4-8 except in 1980 when several peaks were recorded between June 2-13 for different parts of

Table 1 Documented calving periods of the Porcupine Herd 1971 - 1981

Year	Start	Peak	End	Reference
1971	June 2	June 8	June 17-19	Roseneau & Curatolo, 1976
1972**	May 28-27	June 5-7	June 13	Roseneau & Curatolo, 1976
1973*	May 27	June 7	June 15	Doll et al., 1974
1974**	May 27-31	June 6-8	June 14-19	Roseneau & Curatolo, 1976
1975	-	June 4-5	June 14-15	Roseneau & Curatolo, 1976
1980	***	June 2-13		Yukon Wildlife Branch, 1980f
1981	May 22	June 4		Yukon Wildlife Branch, 1981c
*1973	June 3	June 12	June 18	Surrendi and De Bock 1976
**1972-	28 = Yukon 27 = Alaska	1974-	27 = Yukon 37 = Alaska	

***Suggested possible progression of peaks from west to east on calving grounds.

the calving ground (Table 1). Calving is essentially completed by about the third week of June. Normally a single calf is born to each female although twinning has been reported but is believed to be rare (Banfield, 1974; Kelsall, 1968; Bergerud, 1978). Caribou calves are extremely precocious, being able to stand and suckle within a few hours of birth (Banfield, 1974; Kelsall, 1968) and to graze within their first day or so (Kelsall, 1968). Weaning probably is completed for most calves by early September, although instances of suckling extending into winter have been recorded (Kelsall, 1968; Banfield, 1974). Such observations pertain to barren-ground herds of the N.W.T., but a similar development sequence is likely for Porcupine caribou calves as well.

Further considerations of reproduction such as productivity, sex ratios, etc. are discussed in the following section.

MORTALITY

Prior to European contact, all mortality factors affecting the Porcupine Herd could have been classed as natural. Now, however, it is necessary to separate natural mortality factors from those involving human activities none of which any longer bear a purely survival relationship to caribou. These two categories are discussed separately as follows.

Natural Mortality

1. Predation

Porcupine caribou share their range with predators common to most caribou herds. This aspect of mortality, however, has seldom been seriously investigated and existing data is mostly incidental observations of predators and occasionally predation recorded during other studies.

a) Wolf

The wolf population of the Porcupine range has never been properly assessed. In 499 hours of surveying the Yukon portion of the Porcupine range in 1971, 159 wolves were observed in 69 sightings - the largest pack containing 14 members (Jakimchuk et al., 1974). Of 133 wolf kills examined at that time, 131 were caribou and two were moose. Wolf predation on caribou was observed throughout the study period, and it appeared that wolves not involved with denning followed caribou (Jakimchuk et al., 1974). A subjective estimate of the northern Yukon population was 300-400 wolves between the Peel River drainage route and the Beaufort Sea (Jakimchuk, et al., 1974). A total of 154 wolf sightings were made during 1972 and 1973 caribou surveys, and like those of 1971 their distribution was quite broad and "sporadic"

throughout northern Yukon (Doll et al., 1974b). Wolves were often associated with caribou; of the 154 sightings 31 were either at caribou kills or of wolves hunting caribou, while in 1972 of the 122 sightings that year only two were at moose kills (Doll et al., 1974b). Wolves were reported to be numerous in the Richardson Range in the winters of 1972/73 at 1974/75 and to kill calves and old bulls most frequently in a diet that consisted exclusively of caribou (Hoffman, 1975).

In March 1980, nine wolves were observed in the Keele Range and one was sighted on the Ogilvie Plains. Since wolves were not sighted during many hours of winter range surveys, it was suggested that wolf populations were concentrated in the Keele Range and Porcupine River area but do not follow the caribou south into the winter ranges (Yukon Wildlife Branch, 198 b).

Active wolf dens have been recorded in the mountainous terrain of the Hulahula, Canning and Kongakut drainages, however, none have so far been found on the coastal plain of the Arctic National Wildlife Refuge (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). This has been attributed partly to the preference by wolves for the foothills of the Arctic Slope and the mountains of the Brooks Range where prey such as Dall sheep and moose reside (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). Furthermore when caribou are abundant on the coastal plain (May and June), most wolves are probably confined to these mountains where denning activities restrict their hunting radius at about 32 km (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). Aerial hunting up to the early

1970's and some continued aerial poaching have received credit for the existence of low wolf numbers on the Alaskan Arctic Slope (Roseneau and Curatolo, 1976). In Yukon no wolf dens have so far been reported within the calving grounds (D. Russell and R. Farnell, pers. comm.).

Despite numerous aerial surveys of the calving grounds since 1971, the number of wolf sightings each year has always been very low (Table 2).

In view of the conflicting evidence concerning wolf numbers on the Porcupine winter ranges, it is difficult to establish the potential significance of wolf predation on the herd. Certainly the level of predation must be lower than for adjacent N.W.T. herds, where wolves are commonly sighted during winter range surveys; on the other hand it is unlikely that wolf predation is insignificant as a mortality factor.

b) Grizzly Bear

Grizzly bears are by contrast quite common on the Porcupine calving grounds (Table 2) and at times appear to be gathered where calving activity is most concentrated (Yukon Wildlife Branch, 1979b). Of 25 bear observations made on the calving grounds in 1975, two single bears were at fresh caribou kills and two other attempts by bears to kill caribou were observed (Roseneau and Curatolo, 1976). In 1974, four out of nine observations made on the calving grounds involved bears at caribou kills (Roseneau and Curatolo, 1976). Of 45 sightings on the calving ground in 1979, two lone grizzlies were observed chasing caribou and three lone grizzlies were at kills two of which were

calves (Yukon Wildlife Branch, 1979b). On two occasions in 1981, grizzlies were observed feeding on calf carcasses on the calving grounds and one sow was seen chasing caribou (Yukon Wildlife Branch, 1981c). In 1982 only one instance of grizzly predation was noted in a calf mortality study on the calving grounds (Mauer et al., 1983), but on six other occasions grizzlies were observed at caribou kills in a separate study which captured 50 bears on the coastal plains and adjacent foothills of the Arctic National Wildlife Refuge in 1982 (Garner and Reynolds, 1983).

Of 93 sightings in 1971 throughout northern Yukon, 52 involved grizzlies associated with caribou either as kills or in proximity to live animals (Jakimchuk et al., 1974). Between March and November 1973, 144 grizzly bears were observed in northern Yukon, apparently somewhat segregated in distribution according to family units and solitary animals (Doll et al., 1974b). An apparent southward shift in distribution away from the coast in September was also noted (Doll et al., 1974b). Recorded denning sites in Yukon are all well south of the coast (Jakimchuk et al., 1974). It has been suggested that as calving and post-calving progresses, large mammalian predators become more numerous as individuals are attracted to these concentrations, however, it has also been noted that in northeastern Alaska, at least, both wolves and girzzlies are relatively scarce north of the Brooks Range (Roseneau and Curatolo, 1976). Of 38 den locations made in 1982 in the Arctic National Wildlife Refuge, only one was on the coastal plain and the remainder were in the foothills and mountains of the Brooks Range (Garner and Reynolds, 1983).

c) Golden Eagle

Between 1972 and 1975 reports of Golden Eagle numbers and calf predation on the calving grounds indicated that this species, particularly the non-nesting sub-adults, was the most important predator on the calving and post-calving grounds (Roseneau and Curatolo, 1976). The sub-adults being neither confined to nesting territories nor involved in the reproductive cycle, are highly mobile and the majority appear to maintain almost constant contact with the calving and post-calving herds (Roseneau and Curatolo, 1976). In a 1982 study of calf mortality, Golden Eagles were involved in 50% of the total mortality either as the probable predator or a predator/scavenger (Garner and Reynolds, 1983).

From the preceding information it is not possible to determine the relative importance of these three species as predators of the caribou herd nor can the relative contribution of predation to overall mortality of the herd be determined. While in order of importance the major calving ground predators are eagles, grizzlies and wolves respectively, neither eagles nor grizzlies are likely to be very significant predators of adult caribou whereas wolves are. The apparent scarcity of wolves on the major winter ranges in recent years suggests that wolf predation is probably low during the winter season, however, the amount of predation in this season or spring and fall cannot, at this time, even be estimated. Still, in comparison to many other North American herds, wolf predation seems to be quite low, while eagle predation (pactically unheard of in the N.W.T.) is quite high.

2. Accidents

Porcupine caribou are prone to accidents throughout the year, but they may sustain more injuries in certain periods such as during migrations and post-calving movements. A common cause of mortality is river crossings, where animals are either drowned or injured. In the 1971 spring migration, 28 caribou were killed while trying to cross the Porcupine River which was carrying moving ice pans which, when too many trapped animals tried to climb onto, overturned causing death by crushing and drowning (Jakimchuk et al., 1974). In 1975 a cow with a ruptured abdominal cavity was found near the Kongakut River bank from which it was inferred that the animal had impaled itself on a rock or limb while crossing (Roseneau and Curatolo, 1976). In 1982 a collared calf apparently died by drowning, while attempting to cross the Firth River with a nursery band on June 30 (Mauer et al., 1983).

Another likely source of injury and sometimes eventual mortality is running from predators or from insect harrassment. Post-calving aggregations in particular seem prone to such accidents perhaps partially because insect harrassment peaks at this period and partially because the aggregations appear susceptible to panic stampeding (Roseneau and Curatolo, 1976). These aggregations also at times move extensively and rapidly crossing many rivers in a relatively short interval (Roseneau and Curatolo, 1976). In July 1972, of 32,784 caribou which had been moving rapidly across the coastal plain for some time and reacting violently as well to insect harrassment, limping individuals were conspicuous among the last 1,000-2,000 animals to pass, and an estimated 200 or so were seriously injured and seemed unlikely to travel much farther (Roseneau and Stearn,

1974). Such post-calving movements have also been credited with contributing significantly to calf mortality (Calef and Lortie, 1973). Not only would calves be exhausted by hard travelling at such an early age and thus vulnerable to accidents and predation, but other factors such as calf abandonment would likely be increased by numerous river crossings and erratic stampeding.

3. Sickness, Disease and Parasitism

Information concerning diseases and parasitism of adult Porcupine caribou is very limited. The only noteworthy disease which has so far received comment is "lumpy jaw", a deformity caused by .

Calves may die from exposure or starvation during their first few weeks of life (Mauer et al., 1983). Starvation usually results from abandonment which may have a number of causes such as predator disturbance, neglect by inexperienced young females and physiological disorders such as mastitis that interfere with suckling (Mauer et al., 1976), as well as other factors such as cow mortality or accidental separation, especially at water crossings. In 1982, one radio-collared calf died of exposure following high winds (x=42.6 kph) and "mild temperatures" (x=3.8^{o}C), (Mauer et al., 1983).

4. Neonatal Mortality

Since calf mortality has been discussed in the previous three sections, it is only necessary to state that as an age class, calves have the highest mortality rate owing to their vulnerability to predation, accidents, exposure and starvation. That the Porcupine caribou population has remained relatively stable over the past decade despite apparently low

hunting and predation pressures, may signify that neonatal mortality rates in this herd are exceptionally high. A further discussion of mortality rates in relation to population dynamics is presented in the following section.

Human Related Mortality

1. Hunting

Humans have apparently hunted caribou on the Porcupine Range for at least 27,000 years (Irving and Harrington, 1973) employing, no doubt, the typical strategies of ambush, spearing at water crossings etc., but also erecting long driftwood fences and corrals such as those used by the Kutchin tribes (Warbelow et al., 1975). Aboriginal dependence upon Porcupine caribou likely fluctuated with the availability of other food sources such as fish, muskoxen and marine mammals for the Inuit and fish, moose, Dall sheep and woodland caribou for the inland Athapaskans. At times the failure of Porcupine caribou to arrive at a critical period resulted in starvation among both Inuit and Athapaskan communities as recently as the early 1900's (Stefansson, 1914).

The nature of the caribou harvest began to change significantly with the advent of the whalers in the early 1800's followed by the fur traders, prospectors, trappers and miners. At the height of the arctic whaling industry in the 1890's up to 5,000 caribou may have been taken annually for provisioning (Calef, 1974). Professional meat hunting was a common occupation in the period 1890-1910, and as late as the 1930's thousands of caribou were used as dog food by trappers and miners (USFWS, 1980). Other factors influencing the caribou harvest were a shift from subsistence

lifestyles to a greater dependence on imported food and clothing, centralization of human settlements, adoption of snowmachines in preference to dog teams (USFWS, 1980), as well as the population status of native and white groups plus of course the increasingly widespread use of rifles and the availability of ammunition.

The influence of such factors, in conjunction with the variability of caribou distribution, have determined the size of the caribou harvests over the past century, but since none of the factors can be quantified, and since some are synergistic while others are oppositional the net effect on the harvest is difficult to judge for any given period. For example, although it has been suggested that the harvest peaked during the height of the whaling era, and that "use by whites was practically non-existent by the 1930's" (LeResche, 1975), another opinion is that hunting pressures were also extreme in the 1930's (USFWS, 1980).

A similar analysis for the Bathurst Herd in the N.W.T. which was subjected to most of the same factors concluded that the greatest hunting pressure in the 20th century may have occurred between the two World Wars (1918-1945) (Urquhart, 1981).

Harvest data for the Porcupine Herd was probably first recorded from 1932 to 1948, when Game Return forms were distributed to R.C.M.P. detachments in the N.W.T. and Yukon, (Banfield and Jakimchuk, 1980). Beginning in 1953, hunters in the N.W.T. reported their harvest on their General Hunting License, and analyses of these returns for the period 1964 to 1972 yielded an average of 1,345 as a reported harvest from the settlements of Aklavik,

Ft. MacPherson and Inuvik (Hoffman, 1975), (Table 3). A separate analysis of returns from Aklavik and Ft. MacPherson plus reports for Old Crow and the Dempster Highway produced an average annual harvest of 1,183 for the same period (Surrendi and De Bock, 1976). Such analyses, however, are fraught with errors since the returns are incomplete, individually inaccurate in many cases and ignore a significant segment of the hunting community altogether (Table 3). Other harvest data for the Porcupine Herd has been acquired mainly by hunter interviews and field observations. Since 1976-77 hunters in Alaska have been required to submit a harvest report to transport caribou south of the Yukon River (Davis, 1978). These reports, however, account for a very small portion of the total harvest from Game Management units 25 and 26c which cover the Porcupine Range in Alaska. Otherwise, as in Canada, Alaskan harvest figures are based on a combination of interview, observation and conjecture.

Such methods vary greatly in reliability, but the types of errors involved tend to reduce harvest figures and thus the annual harvest totals (Table 3) are minimal, and since most totals are incomplete due to unreported regions, the figures are further reduced. It is also impossible to meaningfully compare harvests among years because the annual values in addition to their inherent errors, have been compiled by a variety of methods each with its own biases. Also, no two sets of data represent all the same settlements and regions.

Interpretations of harvest data are thus severely constrained by the data quality and about all that can be determined with some confidence is that

the annual harvests of the Porcupine Herd fluctuate between a low of around a couple of thousand and a high in the neighbourhood of 5,000. Not withstanding these limitations, one version is that the total mortality of the Porcupine population is 8,500 annually consisting of 3,000-5,000 animals from hunting, and the remainder being made up by natural factors (McCourt, 1980). This seems to imply that a) mortality is a constant, and b) that natural mortality somehow compensates harvest fluctuations. If this is so, then it is a unique and highly fortuitous relationship.

Annual harvests vary considerably not only in total, but also for particular communities depending upon the specific migration routes and winter ranges chosen by the majority of the herd. In particular, the communities in the N.W.T. on the eastern periphery of the range exhibit the highest variability among annual harvests (USFWS, 1980), but others such as those in the Chandalar winter range also experience years of extreme scarcity and abundance (Le Resche, 1975; Whitten and Cameron, 1980; Whitten and Cameron, 1982). In general, however, more caribou are harvested annually in Canada than in the U.S. perhaps within the suggested range of 50+% to 75% (USFWS, 1980) but probably by more than that, such as in 1980 when the reported Canadian harvest was 83% of the reported total which did not include the N.W.T. component (Table 3).

To properly assess the significance of hunting as a mortaity factor, the effect of crippling loss must also be considered. Accounts of "flock shooting" and poor marksmanship exist in hunting accounts from the Porcupine Herd from which a crippling loss of 10% was suggested (Hoffman, 1975). Another suggestion put the crippling loss as high as 33%

(Jakimchuk et al., 1974). A popular figure employed arbitrarily in many such harvest analyses for other herds is 25% which if applied to the Porcupine caribou harvest would increase the approximate range of the annual caribou kill to between about 2,500 and around 6,000+.

2. Non Hunting Factors

Apart from hunting, other human activities may directly or indirectly be involved in caribou mortalities. An obvious danger is from traffic on the Dempster Highway, and although few road kills have so far occurred (D. Russell, pers. comm.), increased traffic levels might eventually result in significant mortality levels.

On some caribou ranges, such as that of the Tuktoyaktuk Reindeer Herd, animals occasionally become entangled in blasting wire and die from such injuries (A. Martell, pers. comm.).

Caribou are vulnerable to harrassment either by snowmachines (Hoffman, 1975) or aircraft (Surrendi and De Bock, 1976) which stress animals and could conceivably contribute to mortality at certain times of the year.

So far none of the preceding possibilities constitute significant mortality for the Porcupine Herd, a few basic conclusions are possible from existing data. These are summarized as follows:

a) In order of significance, the major caribou predators on the Porcupine calving grounds are golden eagles, grizzly bears and wolves respectively.

b) In order of significance the major caribou predators on the rest of the Porcupine range probably are wolves, grizzly bears and golden eagles.

c) In recent years wolf predation has apparently been quite low.

d) Accidents contribute to mortality in the Porcupine population chiefly through mishaps at river crossings, but also from injuries sustained in stampedes either from predators or insect harrassment.

e) Some caribou succumb to starvation and exposure and probably also disease, although the latter has never been documented as a mortality factor.

f) Neonatal mortality results from a variety of factors including predation, starvation, exposure and accident.

g) Porcupine caribou have been hunted by humans for millenium.

h) European contact and succeeding stages of human history on the Porcupine range drastically altered hunting methods and harvest levels of Porcupine caribou.

i) Peak harvest periods may have occurred in the late 1800's and perhaps again around the 1930's.

j) Harvest data for the Porcupine Herd are generally incomplete and inaccurate to the extent that little substantive information can be obtained from them.

k) Annual harvests fluctuate considerably for most communities on the Porcupine range, primarily due to the variability in migration routes and winter ranges selected by the herd.

l) Total animal harvests probably fluctuate between around 2,000 animals and around 5,000.

m) The total mortality resulting from hunting is substantially higher than the actual harvest due to crippling losses which may account for an additional 10-33% of the actual harvest.

n) Generally more caribou are harvested annually in Canada than in the U.S., with the Canadian portion sometimes exceeding 80% of the reported total.

o) So far human activities other than hunting have caused negligible mortality in the Porcupine population, but some of these could become significant if the levels of activity (i.e. traffic) were substantially increased.

POPULATION DYNAMICS

The Porcupine Herd is a population of interbreeding caribou that is continually (but not constantly) losing individuals throughout the year (mortality), and once each year receives a quantity of new members (productivity). These two contending functions produce a dynamic that determines the characteristics of the Porcupine population such as its size and composition. Information concerning various aspects of the Porcupine population dynamics are discussed under the following topics:

Composition

The discussion in this and the following subsection are based upon composition data obtained from the Porcupine Herd at various seasons. Typically these data are acquired by trained observers using spotting scopes and hand tally counters. The observers are moved by aircraft to various locations in order to obtain a reliable sample distribution. Occasionally caribou are classified by helicopter or from aerial photographs.

Since the composition of the Porcupine Herd is never homogeneous, it is imperative that the total sample size be around 10% of the entire population or in the range of about 10,000 animals, and that this total be composed of several well dispersed samples. Applying these criteria to the data summarized in Table 4, it is apparent that some of the estimates are of doubtful reliability due to inadequate sample sizes. In addition all of the July samples are taken from the post-calving aggregrations, and therefore it does not represent the entire population since bull and yearling components are highly variable at that time. Thus the only value of the July data is the calf:cow ratio since it is likely that all but a few cows are comprised in the

aggregations. Even then, however, errors may arise such as in 1977 when the calf:cow ratio in July was 19% smaller than the October - November figure. This was attributed to calves being missed in oblique photographs (Dan's, 1978).

Productivity and Survival

The productivity of the Porcupine population is the number of calves born in June each year. The best measure of the calf crop is the proportion of calves per 100 cows. Ideally this calf:cow ratio should be obtained immediately after calving, but this is not possible since the calving herd is still widely dispersed and cannot be sampled accurately. Also a significant number of non-breeding cows may not have reached the calving grounds and thus cannot be accounted for. Consequently calf:cow ratios are determined from early to mid-July post-calving aggregations, but as such represent only the proportion of calves that have survived the first 2-4 weeks of life. These ratios vary annually within the range of 47 to 66 calves:100 cows (Table 4) for reliable samples. If about 87% of the females are pregnant each year as they were in 1974 (Hoffman, 1975), then about 54% to 76% of the calves survive until mid-July.

Calves continue to die throughout the summer and fall. The 1980 composition counts indicate that about 82% of the early July calf population survived to mid-October (Table 4). If the 1972 October ratio is accurate, then only 66% of the calves survived that year between July and October (Table 4).

Recruitment

Since the mortality rate of calves is so high, their contribution to the population cannot be gauged until the following spring at the earliest - after the winter has taken its toll. Spring segregations are rarely attempted for the Porcupine Herd, because of the extreme difficulty of obtaining reliable samples. For example, the March 1980 calf:cow ratio of 55:100 was higher than the July 1979 ratio fo 54:100 indicating that the March data is inaccurate.

The July composition counts are also unreliable due to the previously mentioned variability of bull and yearling mixing in the post-calving aggregations (Whitten and Cameron, 1980). The only remaining data therefore are the fall composition counts which range between 8% and 12% of the herd (Table 4) and actually represent 15 months old animals or "long yearlings". Unfortunately, only the 1977 figure of 12% can be used, since the 1972 sample size is too small and the 1980 sample was incomplete for yearling segregations (Yukon Wildlife Branch, 1980g). Thus the recruitment rate for the Porcupine Herd can be considered to be in the neighbourhood of 12%, but must fluctuate somewhat according to the previous years' calf crop and its mortality rate over the succeeding 15 months.

The documented recruitment rate of 12% for the Porcupine Herd is somewhat lower than average spring recruitment rates of 15-16% reported for Canadian Arctic caribou populations (Kelsall, 1968) and similar figures for the Western Arctic Herd in Alaska (Lent, 1966). This may indicate higher calf mortality rates for the Porcupine Herd than for the other herds mentioned and may be related to the levels of golden eagle and grizzly predation on the calving grounds as well as significant calf losses during the period of rapid movement often undertaken

by the post-calving aggregations. On the other hand, the 12% figure may not be typical. A 15% estimate was obtained for short yearlings in March 1980 which, if accurate, is within the range of the other herds.

Another recruitment parameter is the yearling to cow ratio which can only be reliably taken from the fall segregations. For the Porcupine Herd the only reliable estimate is 31:100 for 1977 as the 1972 and 1980 samples are unreliable. Since the 1976 July calf:cow ratio was 59:100, then 53% of the 1976 July calves survived the following 14 months of life that year.

Mortality Rates

There is only one complete analysis of differential mortality rates for the Porcupine caribou population (Martell and Russell, 1981). This was based on the age and sex of jaws from hunter kills on the Dempster Highway in the falls of 1972, 1973, 1977 and the winter of 1973-74 harvest by Ft. MacPherson residents. When only the jaws of known sex were used, the mortality rate for females greater than three years of age (3+ females) was 0.20, while for the 3+ males it was 0.41 (i.e. each year 20% of each 3+ females cohort and 41% of each 3+ male cohort die). For combined sexes over three years of age the rate was 0.25. The estimates for females and combined sexes are consistent with those for other herds, where the same analytical method was employed. The male mortality rate (0.41) is intermediate between the lightly sport-hunted Kaminuriak Herd (0.34), (Miller, 1974) and the heavily sport-hunted Nelchina Herd(0.51), (Bos, 1973) where the same analytical method was employed (Martell and Russell, 1981).

When unsexed jaws were included in the data, the mortality rate for all age classes was estimated to be .27, for 3+ animals the rate was 0.28, employing a somewhat different analytical method than for the sex jaws data only. In this version the estimates are slightly higher than the Kaminuriak Herd (0.24 and 0.24 respectively), Miller, 1974) and for Northern Canada (0.21 and 0.22), (Banfield, 1955).

Using census, recruitment and hunting parameters for the Porcupine Herd, the total mortality rate for the population was calculated to be 0.07 comprised of hunting 0.03 and natural mortality 0.04. The total rate (0.07) is extremely low and likely inaccurate, since it depends on two parameters - yearling recruitment and harvest levels that are not reliable for this population.

About all that can be concluded from the preceding analyses is that the Porcupine population does not exhibit drastically different mortality rates from those of other herds when the same analytical methods are employed. The estimates therefore should be considered as indices of comparison with other herds, but not as actual mortality rates for the Porcupine Herd alone.

Herd Structure

The sex and age composition of the Porcupine Herd is known from the segregation counts conducted in various seasons (Table 4). As mentioned previously in subsection "Composition data", however, most of these data are inadmissable due to the unreliability of the samples. The best available data is contained in the fall segregation of 1972, 1977 and 1980, but each of these is flawed as well. However, it appears from these that in the fall, adult cows constitute slightly less than half of the herd and adult bulls about a quarter of the

herd with the remainder divided between calves and long yearlings. As the year progresses, the calf proportion in particular drops substantially with the effect of elevating all the other proportions. Thus, by spring the percentage of adult females and adult males in the herd would be significantly greater. Also, it is likely that the proportion of adult bulls to adult cows will vary throughout the year as each sex experiences greater or lesser mortality in different seasons. However, the total mortality rates for bulls and cows may not vary much from year to year as the factors determining their mortality rates (weather, predation, hunting, etc.) might be fairly consistent. Thus the bull to cow ratio at any given season should, barring exceptional circumstances, be similar each year.

Three of the four bull:cow ratios from fall segregations range between 58:100 and 78:100 (Table 4), the fourth ratio of 33:100 is likely biased (Bente and Roseneau, 1978). These figures concur with those for lightly hunted herds in Alaska and Canada (Pegau and Hemming, 1972; Skoog, 1968; Kelsall, 1968), whereas for heavily hunted herds the bull:cow ratios are much lower (Bergerud, 1971; Bos, 1974). This effect of course only pertains to populations with bull only hunting restrictions or no sex hunting restrictions in which latter case there is usually some selection for bulls.

The age distribution of the Porcupine Herd based on hunter kill data from 1972 to 1977 indicated that 77% of the population is younger than six years old, but that Porcupine caribou can reach the age of 13 years (Martell and Russell, 1981).

Population Size

As with other caribou herds, attempts to enumerate the Porcupine population were made long before a reliable method had been developed. Thus early accounts of Porcupine caribou numbers (Table 5) incorporated unreliable data with rampant speculations bolstered by largely unfounded convictions. These opinions are not to be compared with those produced after 1971, when aerial photographic techniques were adopted. A fine example is the observation that, based on 1972 spring migration counts, the Porcupine population was judged to be 35,000 - 40,000, whereas 93,000 animals were counted in the 1972 July post-calving aggregations. Yet spring migration counts were the basis of the 1953 estimates (30,000 - Munro, 1953 - to 55,000 - Skoog, 1963a), apparently corroborating a "drastic" decline in the late 1940's which was attributed to migration to adjacent Alaskan and/or Canadian herds (Skoog, 1968). Concurrent declines were reported for Canadian herds (Banfield, 1954, 1980), but were based on cumulative reports from northern residents and conceivably may have arisen from shifts to rarely used and unpopulated winter ranges that were misinterpreted as population decreases rather than unusual (but not unique) distribution changes (Urquhart, 1981). It is possible, therefore, that data from the 1940's for Alaskan herds were similarly misinterpreted and that the Porcupine caribou population neither plunged in the 1940's nor rebounded in the 1950's to 110,000 in 19612; Skoog, 1963b, 1968). The 1961 figure was based on an entirely different technique which was the first to sample the calving ground population and extrapolate it to a total herd census. It stands, therefore, as an unique value since this method has never been repeated for the Porcupine Herd. Subsequent estimates for 1963 and 1964 are pure speculation based on the 1961 figure, the presumed 1962 recruitment and the presumed 1964 addition of 20,000 Forty-mile caribou (Skoog, 1963b, Lentfer, 1965). In 1957

and 1964, it was reported that many Forty-mile caribou migrated northward in the spring with the Porcupine Herd and were not known to have returned to their own range (Olson, 1958; Skoog, 1964). These accounts plus the proposed emigration of Porcupine caribou to adjacent herds in the late 1940's (Skoog, 1968) are without foundation and should no longer be treated as factual. Such explanations were popular in that era of caribou biology (Kelsall, 1968), but subsequent mark/recapture and monitorng studies indicate that herds essentially maintain their integrity despite overlapping winter ranges (Whitten and Cameron, 1982; Parker, 1972). When Porcupine caribou occupied Forty-mile winter range in the winter of 1981-82, marked Forty-mile caribou did not depart with the Porcupine animals in the spring (Whitten and Cameron, 1982).

The two 1971 population estimates of 60,000 (Table 5) employed visual estimates of wintering herds (Renewable Resources, 1972, cited by LeResche, 1975) and a crude extrapolation of general photo samples from post-calving aggregations (Calef and Lortie, 1972, cited by LeResche, 1975), neither of which methods can be considered reliable as executed.

Since 1972 population estimates for the Porcupine Herd have employed aerial photographs in a technique termed aerial photo direct count extrapolation (APDCE), (Hemming, 1971; LeResche, 1975). Basically this method attempts to photograph all post-calving aggregations to determine the number of cows (C) in the Porcupine population. The proportion of cows in the herd (.xy) is also calculated from the photos in conjunction with fall composition counts made by ground crews. These two figures are then combined (C/.xy) to produce a total population estimate. For example, if 50,000 cows were counted from aerial

photos and cows represented .50 of the entire herd, then the population would be 50,000/.50=100,000 animals. Although the APDCE eliminates many errors inherent in other methods, it still relies on several components that may be inaccurate (LeResche, 1975). Without providing a lengthy discussion of errors, it is sufficient to note that each APDCE estimate contains some potential fallability, the weakest part being the segregation of cows followed by missed herd segments or unsatisfactory photos. Also, modifications of the method in different years tends to produce unique results that cannot be compared with other estimates unless they are recalculated (Davis, 1978). Finally, the confidence intervals accompanying some estimates are too large to permit much meaningful comparison with others (Bente and Roseneau, 1978; Whitten and Cameron, 1980).

Undoubtedly the best estimate of the Porcupine population is the 1982 figure of 125,000, since it is based entirely on animals counted on photographs and does not require a cow composition ratio nor estimates of missed peripheral animals (D. Russell, pers. comm.). Sources of error are therefore limited to hidden animals in the photos and to fatigue on the part of the enumerators, both of which would produce underestimates. It is interesting to note that while the total population is larger than previous APDCE estimates, the adult estimate is lower than both the 1977 and 1979 values. This could be partly due to the misidentification of some yearlings as calves and does not detract from the total 1982 figure. The problem of inaccurate segregations and the consequent depreciation of the adult population figure is unfortunate, however, since it limits the comparative value of the estimate.

If future censuses are of the 1982 calibre and are further enhanced by accurate composition data, a valid population monitoring system might be realized. In this regard, it should be emphasized that while the Porcupine caribou population is often cited as the total July population, a better measure is the adult population alone, since it is more liable to reflect the status of the herd rather than the annual productivity and survival of calves to early July which tends to mask the long term population trends.

It can be concluded from the preceding information giving each type of data its due ments, that there is no evidence to suggest that the Porcupine caribou population has done anything other than remain relatively stable over the past decade. The reported increase in the herd's population to the early 1940's followed by a rapid decline to the early 1950's and a subsequent recovery to 1968 may or may not have occurred. Curiously, many analysts accept this version of the herd's history without reservation, while they quibble tirelessly over the unreliability of vastly superior data. Certainly if such data would be rejected by modern standards, it should at least be viewed objectively in retrospect.

In summary, the population dynamics of the Porcupine Herd, despite considerable data for some aspects is not well known. The chief problem is the acquisition of accurate data which for population parameters seems to be a very difficult task. Consequently, the following statements are considerably constrained by the reliability of available data.

a) The productivity of the Porcupine caribou population has varied between 44 and 66:100 cows in early July over the past 10 years.

b) If the pregnancy rate of Porcupine caribou is relatively constant then the early July productivity varies in relation to neonatal.

c) Survival rates of calves from July to October seem to vary substantially from year to year.

d) Recruitment rates for the Porcupine herd are virtually unknown due to unreliable data. The October 1977 figure of 12% long yearlings in the population is the only confident estimate and this gives no indication of this parameter's range among years.

e) If the 12% recruitment figure is average then it suggets a somewhat higher calf mortality rate than in other Alaskan and northern Canadian herds.

f) Differential mortality rates are essentially unknown for the Porcupine population since they do not appear to diverge significantly from those of other barren-ground herds.

g) The age and sex structure of the Porcupine herd changes over the period of a given year according to the survival rates of the various age and sex classes but particularly those of the calves.

h) The age and sex structure of the Porcupine herd varies among years for any particular season, however, in the falls of the last 10 years adult cows have comprised slightly less than half of the herd and adult bulls about a quarter of the herd with the remainder divided between calves and long yearlings.

i) Semi-reliable bull:cow ratios for the Porcupine herd range between 58:100 and 78:100 indicating a lightly harvested population.

J) The Porcupine caribou population is probably young with the majority of animals being less than 6 years of age and with potential longevity of about 13 years.

k) Circumstantial evidence of doubtful reliability has been commonly interpreted to indicate an increase in the Porcupine caribou population from 1900 to the early 1940's followed by a decline to the early 1950's and a recovery by 1968. All or part of this cycle may have occurred but the number duration and magnitude of fluctuations can never be determined from existing data.

l) Proposed emigrations of Porcupine caribou to adjacent herds and immigrations of Forty-mile caribou to the Porcupine herd likely did not occur.

m) The population history of the Porcupine herd should be considered as unknown prior to 1972 with the best evidence indicating a likely low around 1900, but probably additional fluctuations in the ensuing decades.

n) The Porcupine herd appears to have remained relatively stable over the past decade since prevailing census methods would probably have detected any change greater than 25% or so.

o) The current Porcupine caribou population is about 80,000+ adults and in early July could number more than 135,000.

UTILIZATION

Subsistence hunting constitutes the bulk of the Porcupine caribou harvest, most of which is taken by native peoples in Alaska, Yukon and the Northwest Territories. Non-native residents also hunt caribou for subsistence and perhaps a few hunt for trophies. Non-resident hunters are considered to account for an average of 1-2% of the annual harvest (U.S. Fish and Wildlife Service 1980).

Commercial sport hunting enterprises operate in Alaska and Yukon parts of the Porcupine range but constitute a very minor portion of the total harvest.

Hunting regulations are different for each jurisdiction managing the Porcupine herd. In Alaska, hunting restrictions concerning Porcupine caribou did not exist prior to 1975 and commercial hunting was permitted on part of the range until that year. Beginning in 1976 a 10 caribou limit per hunter was instituted (U.S. Fish and Wildlife Service 1980). Also no more than two caribou per hunter could be removed from the Game Management Units covering the Porcupine range. In Yukon non-natives are limited to an annual limit of one caribou which must possess antlers with one or more forks. Registered trappers may take two caribou per year and native people have no limit but no one may hunt females in the spring. Hunting along the Dempster corridor is the subject of an ongiong regulatory controversy. Non-native people were prohibited from hunting within a five mile limit of the highway until 1985. Native people including a significant number from the N.W.T. do use the Dempster Highway for access to Porcupine caribou. Since caribou may be lawfully transported across the Yukon-N.W.T. border, native hunters from N.W.T. may take Porcupine caribou

from Yukon and sell them in settlements of the N.W.T. (U.S. Fish and Wildlife Service 1980). In the N.W.T. there is no bag limit for native people but non-natives are restricted to a maximum of two animals per year, reduced in 1979 from a maximum of 5 (U.S. Fish and Wildlife Service 1980).

Tourism within the Porcupine range is relatively undeveloped. Some companies offer river-rafting trips in Alaska and as the Dempster Highway in Yukon becomes the focus of greater tourism promotion by the territory, the presence of Porcupine caribou is being recognized as a valuable asset.

Research interest in the Porcupine herd burgeoned in the early 1970's with the proposed MacKenzie Valley Pipeline and attendant environmental impact studies. Since then the herd has been subjected to numerous ecological studies in the past decade. As industrial proposals for the Porcupine range multiply, it is likely that research will increase as well.

CONFLICTS

Within the context of this plan, the following description of conflicts is restricted to aspects of Porcupine caribou management involving contending viewpoints or needs either among humans themselves or among humans and caribou. These matters are categorized as follows:

a) Conservation: The value of the Porcupine herd and its environment is perceived somewhat differently among the jurisdictions responsible for its management, whereas the Alaskan government has created the International Wildlife Range which so far protects the herd and its habitats, the Canadian government to date have not guaranteed similar protection.

So far, there has been little accord among jurisdictions concerning wildlife regulations pertaining to the herd. At present each jurisdiction formulates regulations independently so that the herd is subject to substantially different management regimes depending upon its seasonal location.

At times, conflicts arise among various public factions with respect to conservation measures undertaken for the Porcupine herd. In general, remoter groups support exclusive protection, whereas territorial and Alaskan groups plus their respective federal representatives may promote multiple use of the herd and its environment to accommodate both harvesting and industrialization. Such disparities of opinion often engender conflicts with the management agencies which must ultimately choose a conservation system which naturally cannot satisfy everybody.

b) Utilization: Conflicts exist among user groups with respect to harvest levels and rights. Yukon non-native big game hunters object to potentially unregulated hunting by Yukon native groups and both object to unregulated hunting in Yukon by N.W.T. native people. Increased access to the Porcupine range has resulted in disputes between hunters and ecologists concerning the proper use of such developments, particularly the Dempster Highway. The crux of this issue is that increased access results in greater harvest levels which may endanger the Porcupine population, either directly or through association of the road with hunting and consequent range abandonment. A related conflict concerns harvest demands for Porcupine caribou and the maximum harvestable surplus which, being contingent upon the status of herd, is independent of human needs. This also involves conflicts concerning harvest allocation among user groups and special harvest projects such as commercial meat hunting.

Although exploitation of the Porcupine herd by tourism is embryonic, future conflicts may arise between those wishing to photograph or view caribou and those wishing to hunt them.

c) Industrialization: At times, Porcupine caribou and industry compete for space. The major conflict thus far, has been road construction through Porcupine range. So far, such conflicts have been resolved in favour of industry and impacts on the caribou are being determined after the fact.

Various segments of society also strongly disagree upon the relative value of industry and wildlife in northern Yukon. The extreme polarization arising from this conflict has accentuated the need for the development of a proper regional plan for this area.

PROBLEMS

Apart from resolving the aforementioned conflicts, other problems associated with Porcupine caribou management are covered in this section. Of these, perhaps the most crucial is the difficulty of monitoring population characteristics of the herd. Such data are essential to a responsive management programme but existing methods present formidable technical problems in addition to the vicissitudes of weather and herd behaviour which can frustrate even the best of preparations. Reliable methods are also a drain on the manpower, time and resources of all management agencies making them even more difficult to justify since success is by no means assured.

A deceptively simple looking problem but one that has defied solution throughout northern Canada and Alaska is the accurate monitoring of caribou harvests. A major defect in this regard is the unrestricted hunting by native groups from both territories and to some extent in Alaska.

Industrial encroachment on Porcupine range has spawned a host of problems for caribou management chiefly related to disturbance and habitat alterations, the impacts of which are poorly understood for this species.

Insufficient knowledge in this realm substantially reduces the capacity of managers to mitigate negative effects of existing developments and limits their contribution to future proposals. This problem is aggravated by the difficulties of conducting behavioral and ecological studies and the fact that industry can develop swiftly often leaving the wildlife sciences years behind in providing answers to industrial demands.

For a system that is ultimately dependent upon law enforcement for effectiveness, a basic problem for wildlife management is the successful prosecution of offenders. This requires a substantial investment in manpower and funds for patrol duties plus additional time and costs for case hearings. And notwithstanding such efforts, convictions are rare concerning game law infractions and even then the penalties are seldom severe. Even then, most wildlife regulations only pertain to a small fraction of users.

Although caribou management is the responsibility of government agencies whose actions should be based upon public response to recommendations from wildlife managers, yet a satisfactory system of establishing a majority concensus among all concerned, particularly about controversial topics does not exist. Consequently, the media has become the principle public forum for negotation and one that has a number of serious drawbacks. Under such conditions management programmes are sometimes difficult to conduct and may be terminated at inopportune times. A related problem is that user groups in general do not appreciate that an international herd cannot be managed unilaterally nor at times do some groups fully understand the ecological relationships of the herd to its environment which necessarily influence the scope of management proposals.

IMPACTS

With existing knowledge of the status and requirements of the Porcupine herd, it is possible to predict the consequences of major changes in some basic factors influencing this population. It is also important to consider the impacts of the herd on people.

a) Hunting: If harvest levels do not exceed those of the past decade, it is unlikely that the herd would decline from overhunting, since the population is believed to have been fairly stable since about 1970. This implies that existing harvest levels have seldom exceeded the maximum allowable for the population under the prevailing conditions of the past ten ears or so. It follows therefore, that if harvests increased, such as would result from a relaxed policy towards the Dempster Highway or the introduction of market hunting, a population decline would be expected. Given existing monitoring techniques, the herd might be reduced by as much as 20,000 or more before the difference could be detected and unconditionally proven to everyone's satisfaction. Recovery might then require decades and could only be achieved by stringent hunting restrictions.

In so far as caribou hunting affects people, it is possible that more Yukon residents will become involved in such pursuits as access to the Porcupine range increases. Sport hunting also may increase due to greater public exposure of this area through tourism and industrial development. As well with a growing cultural awareness, native groups will desire more control over the herd and its management.

Since effective management of the Porcupine herd is impossible as long as each jurisdiction operates independently, either an agreement must be acceeded to by all user groups or the herd will suffer in the long run.

b) Industry and Tourism: Although the grossly detectable effects of the Dempster Highway on the seasonal distribution of the herd appear to be minimal so far, changes in traffic levels on the highway might significantly disrupt normal movements. If, as a result caribou failed to utilize the eastern winter range a high mortality could be expected in years of unfavourable snow conditions. Similarly linear developments on the North Slope which intersected major migration routes might disrupt periodic or cyclic events such as the occupation of particular calving grounds or the formation of post-calving aggregations. These effects might in turn be manifested as a population decline or aberrant range shifts.

Industrial complexes located anywhere but on the major calving grounds would likely have little direct impact on the herd since such developments never occupy much space in relation to the available range and their influence with respect to noise and odour pollution is similarly confined. Coastal developments restricted to sea and air access would have the least impact of all. Road access to hunters provided by industry, however, would have a major impact on the herd.

Tourism on the Porcupine range may increase significantly in the future but negative impacts from such activities should be slight as long as harrassment and unregulated hunting are minimized.

To some extent industrial activities may be thwarted by Porcupine caribou where such developments conflict with the herd's requirements and where public support exists to mitigate industrial impacts. Thus some projects may be delayed or abandoned while others will be more costly to undertake due to special measures required by the wildlife managers.

c) Environment: As with all migrating barren-ground herds, the Porcupine population is strongly affected by environmental conditions on its range. Weather, in particular, plays a major role in the timing and location of all seasonal movements and distributions. It may also be an important factor in population dynamics. Undoubtedly, the herd will maintain its reputation for unpredictability as it continues to respond to prevailing environmental conditions. Thus it will never be possible for managers to know other than generally where the various segments of the herd might be located. Where conflicts with industrial developments are involved this will necessitate annual monitoring of parts of the herd during the critical periods.

The effects of these relationships on the management agencies will be a need for special funds to conduct periodic surveillance and enforcement programmes. It will result also in an ever increasing data base concerning herd movements and behaviour at certain times of the year.

This information will likely be used in a variety of media productions for the enjoyment and enlightment of the public in general.

POLICY

The Porcupine herd will be managed on the principles of both conservation and sustained use but also as an integral part of the arctic ecosystem. As the only large international caribou herd in North America, a major emphasis of its management must be on cooperation with other jurisdictions responsible for its welfare.

Although public interests in and attitudes towards the Porcupine herd vary greatly with the economic status of the regions involved, an objective position must be maintained to guarantee the future conservation of the herd regardless of fluctuating economic conditions. Until recently the Porcupine herd required relatively little management attention by virtue of its remoteness and inaccessibility in an unpopulated region that attracted little industrial interest. But lately the north has been undergoing rapid changes, none of which are beneficial to Porcupine caribou and all of which require increasing management attention. In recognition of this trend, the efforts will be concentrated on aspects of caribou management that will be of greatest service to the continued conservation of the Porcupine herd. Among these, some of the most important are better harvest controls, greater input to industrial developments and more public education.

At the heart of any wildlife management system is accurate information concerning the species. This is not only necessary to conduct management programs but it is also essential to convince various public groups such as hunters and industrialists as to consequences of their actions. Only through the provision of incontrovertable evidence backed by sound research projects can managers hope to guide development on the Porcupine range in ways which

will be least disruptive to the Porcupine herd. Thus special attention will be devoted to the design and support of studies that best address present and future management problems concerning the herd. Chief among these are behavioral and habitat studies related to industrial development, mortality studies related to harvest levels and natural factors, and population monitoring.

At present, over a hundred thousand Porcupine caribou are thriving in their natural environment as they have done for longer than man can remember. If its current status is preserved over the next few decades, the management agencies will have accomplished their mission and the herd's future will be assured. This aim will remain foremost in all policies related to caribou management that are proposed and undertaken by managers of the Porcupine herd.

GOALS

The goals of the Porcupine herd management plan are consistent with the overall goals for wildlife management on its range. Goals are concise definitions for general purpose which collectively form the rationale for caribou management. A distinction between primary and secondary goals is provided to initiate the logical progression from theory to practice which forms the framework of this plan.

Primary Goals

Primary goals denote the ultimate and ideal aims of caribou management towards which all subsequent stages must contribute. Since without Porcupine caribou, this management plan would not exist, it is most appropriate that the herd be recognized first as a separate entity in nature and second in relation to mankind. Thus two primary goals have been developed as follows:

TO ENSURE THAT THE PORCUPINE CARIBOU HERD CONTINUES TO THRIVE IN ITS NATURAL HABITAT AND REMAIN ABUNDANT ON ITS TRADITIONAL RANGE

This goal established the most fundamental relationship between the management agencies and Porcupine caribou. It recognized the intrinsic value of the herd, its rights to co-exist with other species including man and the responsibility of managers to conserve it in its natural environment. Since wildlife populations normally fluctuate in size and distribution, it is consistent with the goal that the herd exhibits such trends although only within broadly defined limits. Inustrial developments on the herd's range can be accommodated by this goal, even where local displacement of animals occurs, so long as the overall welfare of the herd is not compromised. Since portions of the herd's

range incorporate both Alaska and the Northwest Territories, interjurisdictional cooperation is implicit in this goal.

TO DERIVE THE MAXIMUM BENEFIT FROM PORCUPINE CARIBOU FOR THE ENJOYMENT OF ALL PEOPLE

This goal defines the role of the management group as one which assists the public in the wisest and most rewarding uses of the resource. In this respect, the managers will strive to provide optimum levels of fulfillment for each use category and to provide an optimum opportunity for all users to participate within public guidelines for allocation priorities.

Secondary Goals

Secondary goals amplify primary goals to express specific aspirations for proper management of the Porcupine herd. As such, they provide the impetus for all management efforts which are chosen for and judged by their contribution towards the achievement of these goals. Five secondary goals have been developed for this plan. Their numerical order indicates management priorities only to the extent that the goals are arranged in a logical sequence.

1. **TO MAINTAIN THE PORCUPINE HERD NEAR OPTIMUM LEVELS OF DENSITY AND DISTRIBUTION FOR THE CAPACITY OF ITS TRADITIONAL RANGE**

This goal describes the principle function of the management group as the custodian of all wildlife and whose responsibility is to conserve Porcupine caribou according to the dictates of society. To do so, managers must first understand what characterizes the normal functions of the herd including

natural fluctuations in productivity and distribution. Secondly, they must determine what factors adversely affect the herd and which of these can be effectively managed for the herd's protection.

This goal establishes criteria for management response with respect to the basic parameters of abundance and distribution for the Porcupine herd in relation to the carrying capacity of its traditional range. Such a scale would enable better monitoring of programme effectiveness and establish levels for management action. Thus an unprecedented and sustained expansion, contraction or shift of the herd's range would, by contravention of the goal, elicit an investigative response followed by remedial action where possible. The same situation would pertain to exceptional changes in abundance.

2. TO MAINTAIN THE SIZE AND COMPOSITION OF THE PORCUPINE HERD WITHIN HABITAT LIMITATIONS AT PARAMETERS WHICH PROVIDE OPTIMUM SUSTAINED USE BUT NEITHER THREATEN ECOSYSTEM BALANCE NOR CONTRADICT SOCIETY'S PRIORITIES FOR WILDLIFE

This goal addresses the most demanding task of wildlife management which is to provide optimum use of a constantly fluctuating population that is influenced by factors, many of which are unmanageable or unknown. Under such circumstances, it is essential to determine which factors are of major significance to population dynamics and thereafter to monitor them as well as regulating those which are within management control to adjust the herd's population to the desired level. Although this goal acknowledges that society ultimately determines priorities for wildlife management, it has been assumed that such intentions would not alter the status of the herd to the extent that Goal 1 would be compromised.

3. TO ENSURE THAT HUMAN ACTIVITIES WITHIN THE PORCUPINE HERD'S RANGE DO NOT REDUCE THE POPULATION OR ITS DISTRIBUTION BELOW AN ACCEPTABLE LEVEL.

This goal addresses the only element of caribou management that is entirely within man's capacity to manipulate. In the past, hunting has been the only significant human factor affecting the Porcupine herd but recent industrial encroachments upon the herd's range are not only exaggerating hunting pressures but are also introducing a number of other human activities with which the caribou must interact. The Wildlife Branch must therefore not only regulate all forms of hunting, but also identify all aspects of industrial development which are potentially harmful to Porcupine caribou and restrict or prohibit them until their effects have been vindicated. Included in this category are related human activities such as tourism and research which may accompany industrial projects.

4. TO ENCOURAGE WISE UTILIZATION OF PORCUPINE CARIBOU FOR THE BENEFIT OF ALL USERS

This goal emphasizes respect for wildlife which deplores wasteful killing, needless harrassment and careless treatment of harvested animals. Support will be given to programmes which attempt to extract additional gains at no risk to the Porcupine herd. Where trophy hunting or tourism are involved, high quality experiences should be provided. Wise use of caribou however, will not be judged purely by economic standards since some aspects of utilization are of equal merit but cannot be translated into material profits.

5. TO INCREASE GENERAL KNOWLEDGE AND APPRECIATION OF THE PORCUPINE HERD AND ITS MANAGEMENT

This goal recognizes that our relationship to Porcupine caribou can be continually enhanced through the acquisition and disseminaton of information concerning the herd and its environment. The majority of people interested in the Porcupine herd may never see it in the wild but are dependent upon publications, films and other presentations produced directly by management agencies or with their guidance. In particular, persons or agencies directly affected by management policies should understand how and why they were developed. A sincere public regard for this herd and its habitats, achieved and reinforced through increased knowledge and appreciation, will also be helpful in reducing harrassment, careless hunting and unnecessary exposure to industry.

OBJECTIVES

The objectives of this plan are derived from the goals for Porcupine caribou management and are consistent with the overall objectives of wildlife management on the Porcupine range. Objectives describe general tasks which require continued effort and achievement to fulfill the goals. As such, they form the transition stage from specific theory to general practice which is essential to a logically designed management system. These objectives are based on universal management principles which have been adapted to suit the special requirements of the Porcupine herd in the Yukon. Seven objectives have been developed for this plan, and while most serve more than one goal, each is numerically identified with the major one that influenced its formation.

1.1 MONITOR THE STATUS OF THE PORCUPINE HERD AND ITS ENVIRONMENT

Proper management of any wildlife population depends primarily on thorough and up-to-date analyses of its status and trends in relation to its environment. Such information is essential for all subsequent decisions and actions, such as establishing harvest levels, delineating critical areas, defining acceptable limits of abundance and distribution, designing research programs and minimizing industrial impacts. A sophisticated monitoring program has already been developed which will continue to be refined in the future and modified according to needs for specific information. In recognition that this work requires continual data sharing with Alaskan and N.W.T. agencies, contacts must be maintained to foster such relations and to participate in coopoerative studies. Encouragement will also be given to other groups to undertake research projects, particularly in areas related to the most urgent management requirements.

In addition to monitoring the herd itself, managers should investigate and monitor aspects of the physical and biological environment which have a major influence on the herd in order to refine management responses to fluctuations in these factors or modifications of them by industrial developments.

Monitoring of both the herd itself and its environment must incorporate a factor of relative acceptability with respect to maintaining the herd's status in accordance with the goals for its management. Thus, levels of distribution and abundance must be established which function as a means of assessing the current status of the herd and the effectiveness of management programs.

2.2 MONITOR AND REGULATE PORCUPINE CARIBOU UTILIZATION

The greatest direct influence that man can exercise on Porcupine caribou is through his own use of them. Characteristics of the population can, to some extent, be manipulated by restricting harvests according to age, sex, number, season and location. Other uses such as tourism and research should also be regulated to permit broader control and to increase the manipulative capacity available to managers. Regulations must be designed in consultation with the public but be based on sound ecological principles and retain enough flexibility to permit necessary adjustments in response to population dynamics. It is also essential to any regulatory system that its effectiveness be monitored and that the results be of such quality that they can be judged in relation to the status of the herd.

3.3 MANAGE HUMAN ACTIVITIES THAT MAY HAVE ADVERSE IMPACTS ON THE PORCUPINE HERD

Since voluntary restraints with respect to wildlife conservation rarely receive sustained or conscientious compliance, activities which are considered harmful to the Porcupine herd must be restricted by law. The degree of impact resulting from a particular activity depends partly on its nature, level, timing and duration which are within management control and partly on behavioural characteristics and physical status of caribou, plus prevailing environmental conditions, all of which are largely independent of management. Regulations must therefore concentrate aspects of disturbances but also be responsive to ungovernable factors which influence the herd's vulnerability. In situations where human activities are beyond the purview of wildlife regulations, managers must make every effort to exert their influence upon the appropriate regulatory bodies to ensure that the herd's welfare is not compromised.

4.3 INCREASE PUBLIC AWARENESS OF ACTIVITIES WHICH MAY ADVERSELY AFFECT PORCUPINE CARIBOU

Considering the vast range of the Porcupine herd and the multitude of human interactions with caribou that occur annually therein, enforcement of wildlife regulations can never be thoroughly accomplished by existing manpower and resources. In addition, numerous incidents involving potentially negative consequences to caribou could not be properly covered by wildlife legislation. It is therefore important to employ other means for the public to respect

Porcupine caribou and their environment. Management agencies will investigate and utilize effective means of contacting the public and impressing upon them the value and vulnerability of this wildlife resource.

4.5 RECOGNIZE AND ACCOMMODATE DIVERSE INTERESTS IN PORCUPINE CARIBOU

Apart from subsistence hunting, other interests in Porcupine caribou have arisen over the past decade as the northern Yukon has become a focus for transportation, tourism, research and hydrocarbon exploration. To the extent that Porcupine caribou are not unduly stressed by such interests, managers must assist the public in their caribou related endeavors as well as attempting to ensure that each type of endeavor has an optimum opportunity for fulfillment. To do so effectively, it is imperative that all interests in Porcupine caribou be reitered with management agencies so that each may be scrutinized with respect to feasibility, conflicts with other interests and impacts on the herd.

5.6 PROMOTE AESTHETIC VALUES OF PORCUPINE CARIBOU AND THEIR ENVIRONMENT

Aesthetic values, as opposed to utilitarian values, are those qualities of the Porcupine herd and its members which are appealing and stimulating but which do not contribute directly to our physical well being. It is believed that this perception of the herd is very important and presents a desirable aspect of man's relationship to it. Thus, managers will endeavor to accentuate and promulgate such values for public enjoyment and enlightenment.

5.7 SHARE INFORMATION ABOUT THE PORCUPINE HERD WITH ANY INTERESTED PARTY

Management agencies function as principal repositories of information concerning the Porcupine herd, much of which is unavailable elsewhere. As a public service, they will share such material with whoever desires it and also prepare accurate, interesting and informative presentations for both general and specific audiences.

STRATEGIES

Strategies are derived from the objectives for Porcupine caribou management and indicate specific methods by which the objectives will be met. As such, they constitute the final stage of this plan as they are within the capacity of staff members or sections to undertake. For the sake of brevity, only the major strategies emloyed by managers are presented here. A host of minor tasks are also performed in the regular course of caribou management but a description of each would create a massive volume.

Twenty-two strategies have been developed for this plan. While many have been selected from the array of techniques common to wildlife management, others have been formulated especially for the management of the Porcupine herd in the Yukon. In all cases, both the choice and design of these strategies have been based on a candid appraisal of manpower and resources available to all agencies involved and their affiliates.

Strategies consist of both routine duties requiring continual attention by managers of their staff and finite projects, often in the form of research, but also involving other phases of management such as law enforcement, education and publicity. Both existing and proposed strategies are included in this plan to permit an evaluation of their relative importance, state of perfection and feasibility to determine priorities for future attention that forms the implementation schedule in this plan (Appendix A).

Since strategies are considered to be almost self-explanatory, elaborations are intentionally concise. Definitions of special terms and biological jargon are provided in the glossary. Although most strategies contribute to a number of

objectives, they have been numerically identified withthe principle objective which they serve. Thus, the numbers illustrate how a strategy was derived but do not indicate management priorities which are dealt with separately.

1.1.1 CENSUS THE POPULATON AT 2-YEAR INTERVALS

Censusing must be scheduled on a periodic basis to permit adequate resource and manpower planning. Accurate methods of obtaining and analyzing such data are costly and time consuming but it is preferable to acquire reliable information intermittently, rather than poor data annually. The financial burden of such programs may be alleviated somewhat by cooperative efforts. Of paramount importance to population estimations is a standardized technique that will permit realistic comparison of census results to enable managers to monitor population trends in the herd. Therefore, since an existing method has been agreed upon, managers should critically assess the merits of further refinements that might compromise the comparability of results.

1.1.2 ESTIMATE ANNUAL PRODUCTIVITY AND RECRUITMENT

Annual composition counts should be conducted in appropriate seasons. Although spring and fall counts may be the most valuable, such data can be scheduled for other periods, if necessary to conform with other field studies. Experienced observers are essential for such work and whenever staff changes are being contemplated, replacements should be given either prior exposure in the field or at least the opportunity for preparation with some visual aids. Productivity and recruitment figures may function as indices of population status particularly in the intervals between censuses.

1.1.3 INVESTIGATE MORTALITY FACTORS

Apart from hunting, the causes of mortality in the Porcupine caribou population are poorly understood. This strategy should constitute one or a series of research projects to be either conducted or supervised by management agencies.

1.1.4 DEFINE ACCEPTABLE LIMITS OF ABUNDANCE AND DISTRIBUTION FOR THE HERD

Such figures should be based on existing knowledge of the traditional size and range of the Porcupine herd. These values will indicate the extremes between which the herd may fluctuate without contravening the goals for its management. If one or both parameters are exceeded, managers would respond with special investigation and remedial actions where possible. Although there may be some resistance to a commitment to such values, the fact is that management operates within unstated and often nebulous versions of them all the time. A more concrete perception of the herd's relative status to such limits may clarify management actions both among the managers themselves and also the public.

1.1.5 INVESTIGATE ENVIRONMENTAL FACTORS OF MAJOR SIGNIFICANCE TO THE HERD

This strategy should involve a number of research projects designed to identify aspects of climate and habitat which significantly affect seasonal distribution, productivity and related aspects of the herd's survival. Such information may not only eventually permit some predictive capacity about the herd, but will also enable both the delineation of critical areas and industrial design that will have minimal impact on caribou.

2.2.6 ADOPT METHODS FOR THE COLLECTION AND ANALYSIS OF HARVEST DATA

In northern Canada and Alaska, experimentation with various harvest monitoring methods for big game has shown that particularly where the majority of hunters are unrestricted by quotas or seasons, the best means of obtaining complete and consistent harvest statistics is by a thorough canvassing of the settlements involved periodically throughout the year. This method should be uniformly adopted by all management agencies. In addition, major access routes should be patrolled during the hunting season to compute the harvest by non-residents of the areas.

2.2.7 REGULATE CARIBOU HUNTING

Hunting is the major mortality factor for this species that is within management control. Regulations therefore must be comprehensive, precise and flexible to enable complete manipulation of the kill. Harvest levels should be apportioned by quotas based on:

a) seasonal restrictions,

b) age, sex, cow/calf units,

c) population size and trend,

d) hunting zones (see),

e) hunting methods, and

f) use priorities for specific areas.

Regulations should be developed in consultation with appropriate communities and jurisdictions utilizing the herd. Interjurisdictional workshops and conferences concerning this subject may be beneficial towards an eventual management agreement among all parties.

2.2.8 PROMOTE NEGOTIATIONS TO ESTABLISH QUOTAS FOR HUNTERS OF PORCUPINE CARIBOU

A major obstacle to effective management of this herd is that the majority of hunters are not subject to existing or proposed hunting regulations. This situation persists in both territories and to some extent in Alaska. The management groups should therefore initiate negotiations that will ultimately rectify this situation.

2.2.9 MONITOR AND REGULATE SPORT-HUNTING TOURISM

Organized recreational use of the Porcupine herd must be conducted with due regard to the detrimental effects of careless hunting and harrassment on caribou. Managers will monitor such activities and restrict them or their methods in the best interests of both people and caribou. High quality experiences should be emphasized in all such undertakings, and manager will encourage recreational companies in this regard as well as ensuring compliance with other aspects of their operations which are covered by wildlife regulations.

2.2.10 REGULATE RESEARCH PROJECTS CONCERNING THE HERD AND ITS HABITATS

All research concerning the Porcupine herd must be approved by both governmental agencies and public organizations to ensure that such studies are publically sanctioned, that the methods are scientifically sound, and that any disturbance is both unavoidable and justified in terms of the need for data. This system may be administered through a Caribou Management Committee and the

issuance of Wildlife Research Permits by appropriate agencies subject to approval and recommendations from the committee or its contacts.

3.3.11 ESTABLISH CRITICAL WILDLIFE AREAS FOR THE PORCUPINE HERD

Given the essentially unpredictable nature of this herd's seasonal distribution and movements, it is difficult to establish critical areas with reasonable and meaningful boundaries. However, certain regions or topographical features, such as traditional water crossings and particularly favoured Dempster Highway crossing zones could be identified with some accuracy. Other areas such as the calving grounds, should receive the status of a critical area but be defined as the area where the majority of parturient cows are located in any particular year. Enforcement of pertinent regulations would thus be contingent upon annual calving ground surveys to further delineate the core area each year.

3.3.12 LEGISLATE HABITAT PROTECTION REGULATIONS

Apart from critical areas which are restricted sites with specific characteristics, other important elements of the herd's environment that cannot be precisely defined by location or extent should also be protected. These may be included as habitat stipulations conditional to the granting of Land Use Permits.

3.3.13 INCREASE INPUT TO INDUSTRIAL PROPOSALS

Wildlife managers must be involved in the initial planning phases of any industrial development within the range of the Porcupine herd. Also, they

must contribute substantially to EARP hearings and other enquiries concerning Porcupine caribou and their environment. Comments should cover every conceivable aspect of caribou ecology and utilization with statements by managers being reinforced wherever possible by wildlife regulations concerning proven hazards to the species.

3.4.14 INFORM THE PUBLIC OF ACTIVITIES WHICH ADVERSELY AFFECT PORCUPINE CARIBOU

Since regulations cannot always be adequately enforced with the limited manpower available, other means also must be employed to enlist public cooperation in minimizing harrassment and other needless disturbances of caribou or their habitats. Managers will explore all forms of media communication and concentrate on those which most effectively reach particular audiences and impress them with its concerns.

4.5.15 MANAGE SPECIFIC PORTIONS OF THE HERD'S RANGE FOR EXCLUSIVE OR MULTIPLE USES OF CARIBOU

This strategy combines the use potential of Porcupine caribou with the principles of wise husbandry. Uses which serve basic needs may take precedence in certain areas according to priorities established by public consensus. Other uses such as research, photography, viewing and sports hunting may be compatible with primary uses in certain areas or may require exclusive areas conforming to specific requirements. Uses must be categorized with respect to compatibility and applicability for certain areas. As well, managers must assess the effects of each use type on the herd in order to protect caribou

from negative impacts resulting either from the use itself or specific methods employed. Following such preliminaries, the herd's range must be partitioned according to the results plus public approval of such divisions.

4.5.16 ESTABLISH AND MAINTAIN SPECIAL LINES OF COMMUNICATIONS WITH OTHER INVOLVED IN USES, CONSERVATION AND RESEARCH CONCERNING PORCUPINE CARIBOU

Proper wildlife management is based upon accurate and continuous communication between the public and the management agency. Managers will improve existing modes of communication and develop new ones to increase its awareness of public expectations, to ensure public involvement in management decisions and to avail itself of expertise in all matters relating to the study and appreciation of the species.

5.6.17 COLLABORATE WITH THE YTG DEPARTMENT OF EDUCATION TO PROVIDE INFORMATION CONCERNING THE PORCUPINE HERD IN SPECIFIC COURSES

Modern concepts of wildlife management can be most effectively instilled in students, many of whom will eventually become hunters, legislators and voters in the Yukon. This relationship is recognized as being of paramount influence to the future of wildlife conservation and its importance will be emphasized by full cooperation with the education departments in the design of courses where the Porcupine herd is a major topic. It will also encourage its staff to provide interesting and informative accounts of the herd to other student bodies in Yukon and elsewhere as well as providing information for other educational endeavors such as the production of textbooks.

5.6.18 PRODUCE AUDI-VISUAL MATERIAL FOR USE IN EDUCATIONAL AND ENTERTAINMENT MEDIA

Management agencies should produce film and video programs emphasizing the aesthetic qualities of the Porcupine herd's natural history for use as short and full length programs by television stations and in educational courses. Public awareness and enjoyment of this herd can only be maintained through repeated exposure to a variety of such presentations which serve the triple purpose of entertainment, education and empathy with the herd's status in relation to the encroachment of humans on its range.

5.7.19 RESPOND TO ENQUIRIES FROM ANY SOURCE

Individuals frequently write to the Wildlife Branch requesting information about the Porcupine herd. Such requests and similar enquiries will be handled, where appropriate, on a personal level with the provision of some relevant information and guidance for the acquisition of additional material. As well, information packets will be supplied to requests of a more general nature.

5.7.20 COOPERATE WITH MEDIA AGENCIES

Documentary films, television and radio programs, newspaper and magazine articles will all receive input and assistance from the management agencies upon request. As well, many of these outlets will be used to publicize matters concerning the Porcupine herd.

5.7.21 DISTRIBUTE PUBLISHED INFORMATION CONCERNING THE PORCUPINE HERD TO SPECIFIC AND GENERAL AUDIENCES

Six major types of publications should be produced by management agencies being:

a) Posters and pamphlets explaining the natural history of the Porcupine herd emphasizing aesthetic qualities of the species and its habitats.

b) In-service reports describing the purpose, methods and results of specific projects undertaken by the Wildlife Branch.

c) Environmental impact assessments and similar reports related to industrial development proposals.

d) Reports to private companies detailing results of studies undertaken or supervised by the Wildlife Branch but funded by non-Government sources.

e) Research papers published in scientific journals.

f) Special reports to committees, conventions or agencies concerned with caribou conservation and research.

1.1.2B MONITOR THE SEASONAL DISTRIBUTION AND MOVEMENTS OF THE HERD

This strategy has been employed for the past 13 years with the result that a basic understanding of the seasonal distribution cycle already exists. Further refinements of this knowledge therefore should be specifically directed towards problem areas such as the North Slope and the Dempster corridor.

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LIST OF TITLES

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

A great deal has been written about the Porcupine Herd in the past 30 years but this material has never been completely summarized under one cover. This report is designed as a readable encyclopedia of Porcupine caribou information to be used primarily as a reference for particular topics but also as a detailed account for those involved with research and management. For others who wish merely to obtain a rapid overview of the herd, the summaries at the end of each section are recommended.

As with other caribou herds, much of the early work on this one was attended by considerable theorizing and speculation some of which, along the way, became converted to dogma. This report attempts a fresh summary of the original observations unencumbered by the conjecture of their time, and also provides concluding statements that hopefully do not exceed the capacity of the data to support them. This serves to pare down the mountain of information to what is truly known about the herd.

Originally written in 1983, this report has recently been redrafted and the population section updated. Otherwise the background information is only current to 1983.

TAXONOMY

All existing caribou belong to the tarandus species and separate Rangifer genus of the deer family (Cervidae) in the order of even-toed ruminants (Artiodactyla). Porcupine caribou together with the migratory barren-ground caribou of Alaska compose the subspecies granti.

The other four current subspecies in the genus refer to the arctic mainland in the Northwest Territories (groenlandicus), the arctic island (pearyi), woodland and mountain (caribou), and reindeer (tarandus) types.

The classification of caribou has a complex history of alternating subdivision and amalgamation with attendant controversies over proper nomenclature. The most thorough analysis was produced in 1961 by A.W.F. Banfield and has since been considered by the majority as the definitive version.

The earliest fossil evidence of caribou comes from Germany and has been dated to about 440,000 years ago (Banfield, 1961). It has been suggested that caribou reached Alaska before the next to last glaciation (Illinois) and persisted in North America throughout both the Illinois and Wisconsin Glaciations in the Alaska-Yukon refugium as well as in a tundra belt at the south edge of the ice sheet during the latter glaciation.

The extinct species Rangifer muscatinensis has been linked to various fossil forms from the Wisconsin age and is tentatively considered to be the progenitor of both the modern groenlandicus and granti subspecies (Banfield, 1961).

DESCRIPTION

Caribou are deer which have become highly adapted to survival in regions of prolonged snow coverage and low temperatures. Unlike the feet of most other deer, theirs have blunt toes, crescent-shaped sharp-edged hooves and functional dew claws (Russell and Martell, 1983). Also the toes bend almost horizontally and in winter, the feet are covered by a dense growth of coarse

hair so that caribou can virtually "float" over the snow on little "bear paw" snowshoes, (Russell and Martell, 1983). Other distinctive adaptations to cold and snow are a blunt, fully furred muzzle; valvular nostrils; short, heavily furred ears; a short well furred tail and a compact body covered with a thick coat of hollow guard hairs and fine crinkly underfur (Banfield, 1974).

Porcupine caribou are among the smaller of the North American subspecies. Mature males average 113 cm to the shoulder and 125 kg in weight, while mature females are substantially smaller at 103 cm and 89 kg respectively (Yukon Wildlife Branch, 1983). By comparison males of the larger subspecies in central Alaska, northern British Columbia, Ungava and Quebec weigh 181 - 272 kg and females are usually 91 - 136 kg (Bergerud, 1978).

The coat colour of Porcupine caribou varies seasonally and individually but generally these animals are considerably darker than those in the High Arctic and somewhat lighter than the woodland subspecies. The most typical colour pattern in winter consists of a dark face, back, flanks and dorsal tail surface; a light neck, belly, rump, under surface of the tail and hindquarters; and dark legs with white "socks" just above the hooves.

Caribou are the only deer that produce antlers in both sexes. The proportion of antlered females varies greatly among North American herds (Bergerud, 1978) with the Porcupine Herd belonging to the upper extreme having about 95-97% of females with antlers (A. Martell, pers. comm.). Bulls begin to develop antlers around March and employ them during rutting contests in October when the antlers are full size and out of velvet (Banfield, 1974). Older males begin to shed their antlers by early November while younger ones

may keep them until February (Banfield, 1974). Cow antlers do not commence growth until the summer months and are retained throughout the winter when they may be used in the defence of feeding craters from larger but antlerless bulls (Banfield, 1974).

BEHAVIOUR

Porcupine caribou, like the rest of their genus, are highly gregarious, pursuing daily and seasonal activities (except parturition) either in small groups, large bands or massive aggregations. Consequently, they exhibit both individual and group responses to varying situations often with the latter evolving from the former, such as the selection of migration trails, the initiation of river crossings and the response toward predators.

Prerutting and rutting behaviour is similar to that of other deer in which bulls vocalize, execute threat displays and spar among each other with their antlers (Banfield, 1974; Kelsall, 1968). Such engagements can result in injuries and even fatalities at times (Calef, 1981; Bergerud, 1978), although most contests terminate with little or no apparent damage (Kelsall, 1968). Dominant bulls pursue and mate with cows in the large mixed bands comprising all age and sex classes which are usually migrating southward during the rut (Calef, 1981; Kelsall, 1968). Subdominant males present in such bands are prevented from mating with cows by the constant vigilance of the dominant bulls (Calef, 1981; Kelsall, 1968). Energy demands upon rutting bulls are extreme and a dramatic loss of condition is associated with this period (Calef, 1981).

Calving is probably the only major solitary activity that Porcupine caribou regularly engage in. Although pregnant cows reach the calving grounds in

large groups, parturient females isolate themselves for the period required to give birth and attend the calf until it is mobile (Calef, 1981; Kelsall, 1968; Banfield, 1974). Thereafter, most cows, calves and many yearlings usually coalesce into large post-calving aggregations (Bente and Roseneau, 1978; Yukon Wildlife Branch, 1979; Whitten and Cameron, 1980).

Migratory behaviour of Porcupine caribou has been extensively documented mainly as an aspect of distribution and movement studies. Such observations may be summarized as follows:

a) Initial migratory movements often coincide with major environmental changes such as rapid temperature declines plus snowstorms in the fall (Thompson, 1979; Surrendi and De Bock, 1976) and early thaws with consequent snow loss in the spring (Thompson and Roseneau, 1978).
b) The direction, duration and speed of migrations are strongly influenced by travelling conditions which in turn are related to weather patterns (Surrendi and De Bock, 1976; Thompson, 1979; Whitten, 1982).
c) Caribou follow contours in hilly terrain, traversing side hills rather than travelling perpendicularly (Le Resche, 1975).
d) Caribou tend to travel in narrower lanes in steep terrain and to spread out on a broader front in flatter areas (Le Resche, 1975).
e) Caribou tend to course natural features such as rivers, steep slopes and cut banks for some distance before crossing them, regardless of the relative ease of crossing at the point of first encounter (Le Resche, 1975).
f) Caribou tend to follow previous caribou trails, their inclination to do so being in direct relation to the age of the trails (Le Resche, 1975).

g) During winter, caribou frequent frozen lakes and water courses for travelling and resting (Surrendi and De Bock, 1976).

h) Traditional water crossings are used by the Porcupine Herd.

i) Porcupine caribou movement rates peak during the spring migration, the post-calving period and the fall migration. Movement rates are lowest during the calving period, August dispersal and winter. Average movement rates are greater during the post-calving period than during either seasonal migration (Russell, H.J. and Farnell, 1981).

j) In conjunction with movement behaviour, other activity patterns such as feeding and resting vary considerably during the year. In October and November, about 35% of the non-bedded time is spent in walking and trotting while for other months, from December through March, these activities decrease from 14% to 4% of the non-bedded time. Feeding intensity on the other hand is higher during the same four months than in either October - November or April. Such behavioural variations constitute energy budgeting strategies by Porcupine caribou to adjust costly activities such as walking and trotting in relation to food supply (Russell and Martell, 1980).

Behaviour toward industrial facilities and disturbances by Porcupine caribou can only be described so far as obvious short-term reactions to some elements of industrial developments and activities. These may be summarized as follows:*

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*See also Dempster Highway Section.

a) Escape responses to aircraft disturbance increased dramatically when exposure was below approximately 75 m (Surrendi and De Bock, 1976).

b) Seasonal variations in response to aircraft disturbance was evident among Porcupine caribou. Peaks of sensitivity occurred in spring and early winter with the most sensitive period being June. By contrast, the greatest tolerance of overflights occurred in July (Surrendi and De Bock, 1976).

c) Caribou in open habitats (arctic tundra, alpine areas, frozen lakes) reacted less to overflights than did animals in heavily forested areas (Surrendi and De Bock, 1976).

d) Porcupine caribou have little difficulty crossing the Dempster Highway under light to moderate snow conditions. Caribou use the highway for travel as they would a frozen river (Russell, 1982).

e) Avoidance of the Dempster Highway will occur if the road is associated with significant wolf predation (Russell, 1982).

f) At 1982 levels of traffic, the Dempster Highway is perceived by Porcupine caribou as a slightly negative element (Russell, 1982).

g) Caribou react more negatively to vehicles approaching at high speeds (Horejsi, 1981).

h) Disturbed caribou frequently crossed the Dempster Highway at night after traffic ceased (Surrendi and De Bock, 1976).

i) Caribou approaching the Dempster Highway in forested areas seemed more apprehensive than those doing so in open areas (Surrendi and De Bock, 1976).

j) Caribou quickly associate the Dempster Highway with hunting and consequently avoid sections where hunting has occurred (Russell, 1982).

SEASONAL DISTRIBUTIONS AND MIGRATIONS

It may be said of the Porcupine Herd that it is in continual motion. It is also true that the herd seldom exhibits uniformity in the timing and direction of its movements but functions rather as a composite of individuals and groups which choose from a variety of movement options throughout the year. Still, with rare exceptions, a basic pattern of annual distribution does occur that by convention has been subdivided into the seasonal categories of spring migration, calving ground distribution, post-calving movements, August dispersal, fall migration, and winter distribution.

Each phase, however, being subject to considerable variation, cannot be described in full detail but only according to its major features. It must be stressed that such descriptions do not represent the "norm", an attribute which caribou movements unfortunately do not possess, and that major deviations, while anomalous to the theoretical standard cannot be interpreted as abnormal, particularly since reliable documentation covers only the past 13 years of the herd's history.

Given the above considerations and constraints, the distribution of the Porcupine herd is presented as follows:

1. **Winter Range**

The winter distribution of the Porcupine Herd may be considered as the area occupied between the fall and spring migrations. The duration of winter range occupancy therefore varies in length depending upon the end of the preceeding fall migration (mid-November to mid-December)* and the beginning of the following spring migration (mid-January to mid-May)*. Although some historical records of wintering caribou in the Yukon do exist (Thompson and Roseneau, 1978), their relevance is compromised by the lack of distinction made prior to 1970 between Porcupine caribou and those of adjacent migratory herds. Such sitings are included in this summary, however, since the majority likely pertain to the Porcupine Herd and thus expand the history of the herd's winter range. Historical records of caribou wintering in northern Yukon are as follows:

a) Along the Arctic Coast in the vicinity of Herschel Island (Franklin, 1828; Jackson, 1892-1908; Russell, 1898; Harrison 1908; Olson, 1959).
b) Richardson Mountains (Isbister, 1845; Porsild, 1945; McEwen, 1956).
c) North of the Porcupine River (Soper, 1951; McEwen, 1952a, 1952b).
d) Along the Porcupine River from Old Rampart House to LaPierre House and to its headwaters (Murie, 1935).
e) Upper Porcupine drainage (McEwen, 1956).

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*See spring and fall migration sections.

f) "Well south" of the Porcupine River (Munro, 1953).

g) In the northern Ogilvie Mountains (Olsen, 1958; Keele, 1910; Clarke, 1944).

h) In the Black River drainage of Alaska and Yukon (Hemming and Pegau, 1970).

i) Old Crow Flats (Kevan, 1970).

j) Whitefish Lakes area (Kevan, 1970).

k) Northern Richardson Mountains west of Aklavik (Hemming, 1971).

Winter range surveys have been flown annually since 1970-71 either for general distribution data or in conjunction with radio-tracking studies. The compiled results from all these investigations produce a total winter range for the Porcupine Herd encompassing borderline areas of the N.W.T., most of the Yukon north of Dawson and a substantial portion of north-eastern Alaska from east of Fairbanks to the Arctic Coast (Fig. 1) (Thompson and Roseneau, 1978; Yukon Wildlife Branch, 1980c; Yukon Wildlife Branch, 1981d; Whitten, 1982; Yukon Wildlife Branch, 1983). Within this vast area, Porcupine caribou may winter in a number of regions, with concentrations over the past 13 years being most common in a) the Ogilvie Mountains, b) the Chandalar region and c) the Richardson Mountains (Thompson and Roseneau, 1978; Whitten, 1982; Yukon Wildlife Branch, 1983). Sometimes most of the herd will be located in one region while at other times a few large separate concentrations may exist, or alternatively, caribou may be broadly dispersed in varying concentrations throughout the winter range (Thompson and Roseneau, 1978; Yukon Wildlife Branch, 1983). A further complexity is that "new", i.e. previously undocumented distributions, may arise such as in 1982 when part of the herd wintered southwest of the Yukon River in what was

previously considered to be the exclusive winter range of the Forty-mile Herd (Whitten, 1982).

Winter distributions also vary greatly in the amount of local movement that occurs within the general wintering region occupied. Winter range selection is stongly associated with prevailing snow conditions, which when they deteriorate, induce caribou to seek better feeding areas (Russell and Martell, 1983). Thus some winters entail considerable local movements due to extensive unfavourable snow conditions, while in other winters with generally favourable conditions, local movements are small (Whitten 1982, Surrendi and De Bock, 1976). Similarly, dispersal over the winter range is greater when snow conditions are generally favourable but can be very limited when conditions are generally unfavourable (Surrendi and De Bock, 1976). Extensive winter range shifts may also occur.

Another factor influencing winter range occupancy may be the particular fall migration route taken which lead caribou to certain traditional winter ranges (Whitten 1982).

Considering the variation in winter range occupation and movements that are possible, it is very risky to attempt delineations of major winter range areas (Thompson and Roseneau, 1978) based on accumulated survey data which seldom depicts the total range used for the entire winter season in any year. Consequently such ranges are best referred to by name alone lest such calculations become misleading.

Since the aforegoing winter range description is of necessity complex and apt to be confusing, it is perhaps easier to perceive winter range use by this herd as a sequence of decreasing probabilities as follows:

1) Most Porcupine caribou will winter south of the Arctic coast and within their known range.

2) The majority of the herd will winter in or near the Ogilvie mountains with lesser numbers wintering in both or either the Chandalar and Richardson regions and scattered groups elsewhere up to the Arctic coast.

3) The majority of the herd will winter in either the Chandalar or Richardson region with lesser numbers in the Ogilvie region and one or other of the former regions and scattered groups elsewhere up to the Arctic coast.

4) Almost the entire herd will be located in one of the major winter ranges with few animals elsewhere.

5) The herd will be widely dispersed in scattered groups of varying size throughout most of its winter range.

6) In addition to any of the above, a significant number of caribou will winter in a previously undocumented area.

2. <u>Spring Migration</u>

Among barren-ground caribou, the spring migration has been differentiated from winter movements by appearing "direct and

purposeful" as well as "goal oriented" (Kelsall 1968). This migration is initiated by the pregnant cows which are destined for the calving grounds. Bulls and many juveniles may start later than the cows (Russell, H. J. and Farnell, 1981) and use different routes which generally take them to "staging areas" on the periphery of the calving grounds (Farnell 1979b). All such movements are usually most apparent in April and May but they have been recorded as early as February and March (Thompson 1978, Whitten and Cameron, 1982). With the advantage of radio-tracking it has been shown that cows may begin to drift northward as early as January (Russell, H. and Farnell, 1981). Steady travelling however seldom precedes significant snow loss which usually occurs in April or May but may vary as much as a month or more among years (Thompson and Roseneau, 1978). In springs with extremely late snowmelt, the migration may be delayed to the extent that some cows calve enroute to the calving grounds.

The spring migration is considered to have ended when the last cows reach the calving grounds which is usually in early June, (or later when the migration has been delayed). Thus the spring migration covers an entire potential period of about five months from mid-January to mid-June during which the greater movements are undertaken in April and May. Even after calving is underway many bulls and yearlings may still be moving northward or drifting towards the calving grounds (Yukon Wildlife Branch 1980f, Yukon Wildlife Branch 1981b).

Spring migration trails used by Porcupine caribou are numerous and also highly variable among years. They may however be grouped into three or four major routes or corridors which seem to be widest at the southern

end and more constricted towards the north (Thompson 1978). Within each corridor the paths chosen in any given year are largely determined by prevailing snow conditions (McCourt et al., 1974). The major corridors may be described as follows:

a) The Old Crow Route:

Originally designated in 1974, (Jakimchuk et al., 1974) this route has been consistently used by most or part of the herd since 1971 when accurate monitoring began (Thompson and Roseneau, 1978; Farnell 1979b; Russell and Farnell, 1980; Yukon Wildlife Branch, 1981b; Whitten and Cameron, 1982). The Old Crow Route gathers trails from widely dispersed winter ranges in the Ogilvie Mountains from north of Dawson eastward to the Hart River (Fig. 2) and funnels them through the Keele range across the Porcupine River east and west of Old Crow, and onward through Old Crow Flats to eventually join the Richardson Route in the vicinity of the Western Barn Mountains (Thompson 1978).

b) The Western Route:

First described as a separate route in 1976 (Surrendi and De Bock, 1976), this small route has since been included in the Old Crow Route (Thompson and Roseneau, 1978) but may deserve special attention in view of the 1979 and 1982 spring migrations in which caribou wintering in the Tatonduk River drainage traversed the same route described in 1976 until it converged with the Old Crow Route near the upper Salmon Fork River (Fig. 2), (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983b).

c) Richardson Route:

Also designated first in 1974 (Jakimchuk et al., 1974) this route has apparently been used by the majority of Yukon wintering caribou four times in the past twelve years (Thompson 1978, Yukon Wildlife Branch 1983b). In the remaining years, the proportion of Yukon wintering animals following the Richardson Route has ranged from a few thousand animals (Thompson 1978) to nearly half of the Yukon wintering herd (Roseneau et al., 1975). Originating in the Wind, Bonnet Plume, Snake and Arctic Red river areas this route crosses the Peel River and follows the long axis of the Richardson Mountains to the Fish Creek - Rapid Creek - Blow River area where it turns northwest along the Barn and British Mountains to the Alaska border (Fig. 2) (Thompson 1978).

The migration along the Richardson Route typically occurs in two waves, the first representing animals that wintered north of the Peel River and the second being composed of those wintering south of the Peel River which are often delayed by more severe snow conditions (Thompson 1978).

d) The Chandalar Route:

Sometimes also referred to as the Arctic Village - South Brooks Range Route (U.S. Dept. Interior and U.S. Fish and Wildlife Serv. 1982, U.S. Fish and Wildlife Serv. 1983), this route had been used only by Porcupine caribou wintering in the Arctic Village region until 1982 when a substantial portion of the herd moved northwards through previously undocumented spring migration territory to link up with the Chandalar Route and the Old Crow Route in the general vicinity of Bear Mountain (Fig. 2).

The longer Chandalar Route leads northeast from Chandalar Lake across the East Fork of the Chandalar River towards the British Mountains in the vicinity of the Firth River (Fig. 2) (U.S. Fish and Wildlife Serv. 1983, Yukon Wildlife Branch 1983). Alternatively, caribou may travel northwards from the Chandalar region to reach the Arctic Coast of Alaska via a number of mountain passes in the Brooks range, the most heavily used pass being at the head of the East Fork of the Chandalar River (U.S. Dept. of State 1980, Whitten et al 1982, Roseneau et al 1974).

It should not be misconstrued from the preceding route descriptions that all Porcupine caribou traverse these entire routes every spring. Rather, the length of each route travelled depends upon the late winter distribution of various herd segments such that some animals, for example those wintering in the northern Richardson Mountains, travel only a small portion of the route compared to those wintering in the Peel River region. As for caribou which winter on or near the Arctic Coast there may be little or no distance remaining between them and the calving grounds. The migratory behaviour of such animals remains undocumented but it is conceivable that they remain virtually stationary throughout the spring migration period.

A major obstacle to migrating caribou is hazardous watercrossings where injuries, drownings and hunting may occur. For the Porcupine herd on its spring migration the principal rivers to be crossed are the Porcupine, Blow, Babbage and Firth rivers (Thompson 1978, Yukon Wildlife Branch 1983). Caribou often cross at traditional sites on these rivers

where topographical features seem to foster such efforts (D. Russell, R. Farnell, pers. comm.).

Another important aspect of the spring migration is that many other trails exist between the major migration corridors although such routes appear to be "only sporadic and rather inconsistent with regard to the general routes that are followed" (Thompson 1978). Also the major routes depicted in Figure 2 should be considered as a map of potential pathways in which an endless variety of combinations is possible. For example in 1982, most animals wintering in the Ogilvie Mountains moved up the main trunk of the Ogilvie route but turned westward south of Old Crow and met up with the latter part of the Chandalar Route (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983).

A graphic perception of the spring migration could be to imagine the herd as a giant amoeba gradually shifting its mass northward by a process that entails the rapid streaming of cytoplasm (caribou) in some sections while elsewhere the cytoplasm is hardly moving at all or is slowly flowing in different directions. Yet the overall effect is one of a coordinated reorganization that eventually transfers the cell (Porcupine herd) to a position along the coastal regions of Yukon and northeast Alaska. Each spring this shift occurs in a unique combination of cytoplasmic withdrawals and amalgamations but always produces a similar distribution by early June.

3. Calving Ground Location

Since 1971 annual calving ground surveys of the Porcupine herd indicate that calving has occurred throughout the Arctic Slope from the Canning

River, Alaska to Shallow Bay, N.W.T. and as far south as the northern drainages of Old Crow Flats (Fig. 3) (LGL Ltd. 1982, Yukon Wildlife Branch 1979b, Yukon Wildlife Branch 1982, U.S. Dept. of Interior and U.S. Fish and Wildlife Service 1982). Within this general area, the calving ground boundaries have shifted annually, often excluding areas east of the Babbage River, but always including a central portion between the upper Jago River and the Firth River. Also, each year the calving herd has been concentrated in one or more high density areas and distributed in varying but lesser densities in the remainder of the calving ground. Over the last 12 years three core areas have been located between the Katakuvuk River, Alaska and some distance east of the Firth River, Yukon (Fig. 3) (LGL Ltd. 1983, Yukon Wildlife Branch 1982). The composition of the calving herd also varies from sections where bands are almost exclusively adult females to other parts where bands contain more juveniles and some bulls (Yukon Wildlife Branch 1981c, Yukon Wildlife Branch 1979b). It should also be noted that the calving ground is never completely occupied by calving caribou at any time but that it represents the total area in which calving caribou move during the calving period (U.S. Fish and Wildlife 1980).

Although most calving usually takes place in the foothills of the Brooks Range and the British Mountains (U.S. Dept. of State 1980, LGL Ltd. 1982) it may sometimes occur across the coastal plain to the shoreline of the Arctic Ocean (Yukon Wildlife Branch 1981c, LGL Ltd. 1982). It has been suggested that factors influencing annual calving ground locations may include winter range distributions of the previous winter, the timing of spring migration and routes taken, as well as the progress of the snowmelt (Yukon Wildlife Branch 1979b). Such considerations have

prompted the prediction that early spring migrations will result in most calving occurring in Alaska whereas late spring migrations would shift the calving grounds into the Yukon (Surrendi and De Bock, 1976; U.S. Dept. of Interior, 1983). Within the general North Slope region, the choice of specific calving areas may be related to snowmelt conditions which, when late, may make the comparatively snow free uplands of the Arctic Slope initially preferable for calving but, when early, may expose the coastal plain sufficiently for calving or at times may produce a shift from the foothills to the plains as the snowmelt progresses (Yukon Wildlife Branch 1979b, 1980f, 1981c). It has also been observed that the earlier arriving cows may not occupy the calving ground's remotest areas and that some cows coming later may actually penetrate further into the calving grounds.

During the calving period most of the bulls, many juveniles and some dry cows*, become located on the southern and eastern peripheries of the calving ground and/or some distance south of it (Fig. 4) (Martell 1982, Yukon Wildlife Branch 1979b, 1982). Two commonly mentioned "staging areas" for the bull segments are the Firth and Babbage River regions (Farnell 1979b, LGL Ltd. 1982).

Based on past documentation it appears that consistent features of the calving ground distribution are:

a) that a portion of the calving ground will be located between the upper Jago and Firth Rivers;

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* cows that do not have calves

b) that the composition of the calving herd will vary from nearly exclusive adult female bands to mixed groups including cows, juveniles and some bulls;

c) that most of remaining Porcupine caribou will be located on the southern or eastern peripheries of the calving herd or some distance south of it;

d) that the timing, origination and progress of the spring migration likely determines the particular location of the calving grounds;

e) that relative snow conditions on the North Slope may influence the choice between the foothills and the coastal plain as the major calving area.

4. **Summer Movements**

During the summer, the movements and behaviour of the Porcupine herd usually involves two phases referred to as post-calving aggregation and August dispersal. These are described separately as follows:

a) Post-calving aggregation:

Immediately following calving, the Porcupine herd is arranged with the majority of non-calving groups situated east and south of the calving herd. This relative positioning occurs annually regardless of the particular location of the calving ground. In some years when the calving herd is located across the Alaska-Yukon border, the non-calving segments will be generally further east and south in Yukon. If the calving ground is mainly in Alaska, the non-calving segments may be concentrated on the Alaska-Yukon border, still east of the calving herd but much further westward

than in the previous example (Yukon Wildlife Branch 1983c). By mid June, cows and calves have begun to form "nursing bands" that continue to grow in size until practically all the females and their young are gathered into a few large calving herd aggregations and some small peripheral groups. This formation is completed towards the end of June or in early July (Davis, 1978; Le Resche, 1975; Roseneau and Curatolo, 1976; Whitten and Cameron, 1980). During this period the animals are usually moving eastward but often head northward and even westward as well as towards the coast (LGL Ltd. 1983, Roseneau et al., 1974).

Meanwhile the bull segments that have been moving westward and/or northward encounter and amalgamate with the calving herd aggregations in early to mid July to form massive post-calving aggregations, some of which are very compact while others may be less densely organized (Whitten and Cameron, 1980; Calef, 1981). Animals that are not involved in the post-calving aggregations near the coast are most often distributed along the coastal plain or in the foothills of the Arctic Slope (Whitten and Cameron, 1980). In some years the post-calving aggregations do not completely form (Bente and Roseneau, 1978) but remain as scattered bands over a broad area (Yukon Wildlife Branch 1981d). Such variations are possibly related to reduced fly harrassment associated with inclement weather (Yukon Wildlife Branch 1981d).

During the remainder of July the post-calving aggregations tend to move southeastward or southwestward toward the Yukon side of the border, often reaching points anywhere from the upper Firth River

to the N.W.T. border by late July (Roseneau et al., 1975; Surrendi and De Bock, 1976; Jakimchuk et al., 1974; Roseneau et al., 1974; Yukon Wildlife Branch, 1983c) (Fig. 5).

b) August dispersal:

In late July and throughout much of August, the large aggregations progressively dissociate into smaller bands, most of which usually travel quite rapidly into Alaska while the rest disperse in the northern Yukon (Roseneau et al., 1975; Roseneau et al., 1974; Surrendi and De Bock,1976; Ealey, 1979). In the past 12 years the only exception has been in 1975 when the majority remained in the western Yukon (Thompson 1979). By about the third week of August much of the herd is usually in Alaska and some of it may already be returning to the Yukon (Roseneau et al., 1975; Surrendi and De Bock, 1976). Those which had remained in the Yukon could be scattered in the British and Barn Mountains, the northern Richardson Mountains and probably the periphery of Old Crow Flats (Jakimchuk et al., 1974; Roseneau et al., 1975; Ealey, 1979). Although many or most caribou often return to the Yukon in late August and early September, in some years substantial numbers remain on the Alaska side of the border and also above the continental divide in Alaska (Rosenau et al., 1974).

As with the other phases of the Porcupine herd's distribution, a very basic pattern exists upon which annual variations are superimposed. The general sequence of movements can be best summarized chronologically except for the least likely events which are mentioned last as follows:

a) Around mid to late June the calving herd aggregates on or near the Alaskan and/or Yukon arctic coast.

b) During the latter part of the calving period and onward into mid to late June the bull groups tend to coalesce and move towards the calving herd aggregations.

c) Around late June to early July the bull herds eventually encounter and mix in with the calving herd aggregations to form large and sometimes massive post-calving aggregations with the remaining caribou scattered about the coastal plain and the foothills.

d) During the remainder of July the post-calving aggregations in Alaska usually move southeastward into Yukon while the aggregations already in Yukon may move south or southwestwards.

e) Towards the end of July and during the first half of August the large aggregations split into smaller bands, most of which travel westwards into Alaska while the rest disperse in the northeastern Yukon.

f) By late August a return from Alaska to Yukon is underway while the Yukon contingent remains dispersed.

g) Caribou which did not leave Alaska become scattered in groups about the North Slope of the Brooks range.

h) Sometimes large post-calving aggregations do not completely form.

5. Fall Migration

As with the spring migration, the fall migration is a complex of movements that vary in timing, direction and duration, not only among years but among different herd segments in the same year. Most authors consider the eastward return of caribou from Alaska to Yukon in late August to early September as part of the fall migration. At that time caribou may also be dispersed in northern Yukon and along the north slope of Alaska (Roseneau et al., 1975; Jakimchuk et al., 1974; Roseneau et al., 1974b).

Thereafter, the initiation, rapidity and progress of the fall migration is strongly influenced by weather patterns in northern Yukon (Surrendi and De Bock, 1976; Thompson, 1979; Ealey, 1980). As long as the fall weather remains clement, caribou tend to move leisurely, either towards Yukon from Alaska or, having reached there, southward in a widely dispersed pattern (Thompson 1979). Presumably other herd segments in northern and coastal Yukon and Alaska also move at a comparatively slow pace in many directions. A marked change in these types of movements usually occurs shortly after rapid temperature declines and substantial snowfalls which can occur anytime in September (Thompson 1979). Subsequent movements are generally rapid and more or less uniformly southward from wherever the caribou happen to be located when the weather conditions deteriorate (Thompson 1979). However, if the weather improves again (temperatures rise, low precipitation), the migration may slow down, or halt or reverse (Jakimchik et al., 1974; Ealey, 1980). At such times caribou may begin to drift northward sometimes recrossing the Porcupine River or the Dempster Highway until renewed snowfalls and temperature declines produce a resumption of the southward migrations

sometime in October (Jakimchuk et al., 1974; Ealey, 1980; Yukon Wildlife Branch, 1983d). Occasionally however, weather improvements do not affect the southward migration which maintains its orientation and strength despite ameliorating conditions (Yukon Wildlife Branch 1980g).

The timing and progress of the fall migration may vary annually to the extent that caribou may reach a particular region in the southern extremity of their winter range (i.e. the lower Tatonduk River) anytime between late September and early November (or of course not at all), (Yukon Wildlife Branch 1983d, Roseneau and Curatolo 1976). Similarly, caribou may be crossing the Porcupine River throughout September and even up to mid October (Thompson and Roseneau 1979) and peak crossings can occur anytime between September 1 and October 4 (Ealey 1980).

The fall migration is considered to have ended when steady movements have ceased and the migratory bands begin to disperse on the winter range. Such events have often been recorded between late October and late November (Thompson 1979, Russell and Martell 1980, Yukon Wildlife Branch 1983d) but sometimes migratory type movements can persist into December (Whitten and Cameron 1982). An 'exceptional' fall migration occurred in 1981 when caribou crossed the Yukon River in the vicinity of Eagle, Alaska. Such movements had not occurred since the 1950's when presumably the Porcupine herd performed similar manoeuvers, which at the time were confused with those of then large 40-Mile herd (Whitten and Cameron 1982).

Documented fall migration routes are if anything more diverse than the spring ones, primarily because snow conditions are seldom a limiting factor (Thompson 1979). Still the fall routes can be generally grouped into the spring corridors (Fig. 6) which are described in reverse as follows:

a) Old Crow Route:

Originating primarily in the British and Barn Mountains, the paths of this corridor cross the Porcupine River in numerous locations but principally between Bell River and Lard Creek and also west of Old Crow (Thompson 1979). Beyond the Porcupine River this broad corridor leads south generally within the Keele Range and mostly west of Eagle Plains. Upon reaching the Ogilvie Mountains, routes either continue south to the Tatonduk region winter range or branch westward towards the same area. Other routes diverge eastward to winter ranges in the Hart and Blackstone winter ranges.

b) Richardson Route:

The major Richardson Route penetrates the Richardson Mountains north of McDougall Pass and extends south along the long axis of this mountain chain to the Peel River while minor routes reach the Peel River by crossing the Bell, Rock or Eagle Rivers and travelling along the western flanks of the Richardsons (Thompson 1979). The majority of caribou appear to cross the Peel River between the Bonnet Plume and Wind rivers but crossings may occur as far west as north of Hungry Lake (Thompson 1979). After crossing the Peel River migration routes proceed to winter ranges in the

Swake, Hart, Blackstone, Bonnet Plume and Wind River drainages (Thompson 1979).

c) Western Route:

Originally identifed as a distinct Spring Migration Route (Surrendi and De Bock 1976), this corridor has always been included as an extreme western component of the Old Crow Route. It has however, appeared as a principal route in the 1974, 1977 and 1981 fall migrations (Roseneau et al. 1975, Bente and Roseneau 1978, Yukon Wildlife Branch 1983d) and should perhaps receive separate recognition on those accounts. The route essentially parallels the Alaska - Yukon border from the Upper Salmon Fork River to the Tatonduk River. Caribou using this route have reached winter ranges as far east as the Hart River (Bente and Roseneau 1978) and as far west as Delta Junction and Central Alaska (Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983d).

d) Chandalar Route:

This route consists of a major component that extends westward from Old Crow Flats across the Alaska-Yukon border to the Chandalar River drainage (Fig. 6) essentially covering the same territory involved in the August dispersal movements. The minor component comprises trails through passes in the Brooks Range that are used by caribou migrating southward from the Arctic Slope. These caribou are usually the "residuals" (Roseneau and Stearn, 1974a) that did not join the large post-calving aggregations nor participate in the basic summer movements of the majority of the herd.

A noteworthy variation of the Chandalar Route occurred in 1972 when many fall migrants crossed the Porcupine River in Yukon but shortly thereafter swung northwestward, recrossing the Porcupine River in Alaska and merging with the Chandalar Route in the Coleen River region (McCourt et al., 1974).

It must be emphasized that the preceding corridor descriptions are gross simplifications of an extremely complex process. Not only do migration trails vary considerably within the corridors but additional albeit minor trails exist between them - particularly the Old Crow and Richardson routes. Also caribou may begin the migration in one corridor but later switch to another (Jakimchuk, 1974; Ealey, 1980). Thus it is not possible to state unequivocally that the late summer distribution of the herd will indicate which migration routes the majority will take. The migration corridors and their constituent routes are best perceived as a complex road map in which turns may be made at any junction but in which certain combinations are used more frequently than others. An additional feature of the fall migrations that should be kept in mind is that all caribou seldom if ever follow the entire routes described but may winter at intermediate locations such that the winter distribution most often consists of a number of disjunctive winter ranges located at various points along the routes. Judging from winter distribution records, some caribou may not migrate at all but remain from one summer to the next and perhaps for a few consecutive years on the North Slope or north of the Porcupine River in Yukon.

In view of the preceding considerations, a summary of the basic fall migration pattern for the Porcupine Herd should contain the following highly generalized elements:

a) Each fall most caribou move southward from late summer locations.

b) In all but one year in the past 12, caribou have moved eastward from Alaska into Yukon prior to turning south.

c) The fall migration often begins in late August to early September with the beginning of the eastward return from Alaska to Yukon.

d) The fall migration is eventually accelerated by inclement weather (temperature declines, substantial snowfalls), occurring sometime in September, which often produces a southward movement in Yukon segments that have not already turned south.

e) Subsequent improvements in weather conditions sometimes slow, halt or reverse the Yukon migrations but not always.

f) The fall migration may end anytime between late October and early December. In the same year it may also end at different times for different herd segments.

g) Each fall migration pattern is unique. Although parts of many known routes are utilized each year, new routes are continually being recorded as well.

POPULATION RANGE

The range of the Porcupine caribou herd incorporates all accurate records of its occurrence. With respect to delineation, pertinent data is restricted to the past 13 years since prior accounts cannot be reliably distinguished from those of adjacent migratory herds and resident herds of mountain caribou. However, historical records dating from the early 1800's to the early 1960's indicate that caribou have at times wintered in all the regions presently utilized by the Porcupine Herd (Thompson and Roseneau, 1978). Two noteworthy historical locations are Herschel Island (Franklin, 1828, cited by Surrendi and De Bock, 1976), where caribou have not been reported in the past 13 years and the MacKenzie Delta (Simpson, 1843, and Pullen, 1850, cited by Surrendi and De Bock, 1976), where few Porcupine caribou have recently been observed and then only at the extreme western perimeter (Thompson, 1979). Additional confirmation of long term use of present summer and fall migration routes exists in the remnant of Kutchin caribou fences in northeastern Alaska and northern Yukon which date to the late 1800's (Warbelow et al., 1975). Traditional crossing points on the Porcupine River near the Old Crow River are believed to be at least 30,000 years old and archaeological evidence indicates that natives have killed caribou at such points and others along the Porcupine River for centuries (Irving and Harrington, 1973; Morlan, 1973).

The documented range of the Porcupine Herd, based on distribution studies since 1970, covers virtually the entire Yukon Territory north of Dawson, some bordering sections of the N.W.T. particularly west of Aklavik and Ft. MacPherson and a substantial portion of northeastern Alaska from the Arctic Coast almost to the Alaska Highway (Fig. 7).

Most of this vast area has been used regularly or intermittently in the past 13 years with the exceptions of the extreme southeastern portion in the N.W.T. which was reached twice (1971-72, 1976-77) and the extreme southwestern portion west of Fairbanks which was occupied only once (1981-82), (Thompson and Roseneau 1978; Whitten and Cameron, 1982). Prolonged range shifts or abandonments have so far not been detected within this region. The 1981-82 southwestern winter distribution may be either a range extension or merely a reoccupation after a 40+ year absence (Whitten and Cameron, 1982).

The range of the Porcupine Herd overlaps with those of the Central Arctic Herd and the 40-Mile Herd north and south of the Yukon River respectively (Fig. 6), (Roseneau and Stern, 1974; Whitten and Cameron, 1982; Yukon Wildlife Branch, 1983a). Elsewhere, the Porcupine range is distinct from other migratory barren-ground herds, however, it does cover the territories of some mountain caribou in the Hart River and Bonnet Plume herds (Farnell, 1984).

Since reliable distribution records span such a short period in the history of the herd, the boundary delineations merely signify the general range of the herd, which likely includes most but not all of the traditional range - an area that will never be completely known but which may become better identified as distribution data accumulates and is judged in relation to historical and archaeological information.

REPRODUCTION

The rutting period coincides with the fall migration but apparently has little or no influence on the timing or progress of such movements. Prerutting behaviour among Porcupine bulls usually begins around mid-September and continues to increase in intensity to mid-October (Yukon Wildlife Branch, 1980g; Russell and Martell, 1980; Calef, 1981). Rutting activity peaks about the middle to third week of October and matings occur (Russell and Martell, 1980; Calef, 1981) in those couple of weeks (Calef, 1974; Bergerud, 1978). Bull caribou are polygamous and the dominant ones mate with the receptive females in their band (Banfield, 1974). Cows can have several estrus cycles until mating occurs (Skoog, 1968; Bergerud, 1978). Age specific pregnancy rates of the Porcupine Herd have never been determined, however in other populations most females do not mature until between the ages of 29 and 41 months, although a small proportion may bear young as yearlings (Bergerud, 1978). For the Porcupine Herd it has been assumed that the pregnancy rate is 86% for 2+ year old females (Hoffman, 1975). The rut wanes rapidly in early November and the larger bulls begin to shed their antlers shortly thereafter (Calef, 1981). Although the chronology of the rut varies among barren-ground herds (Bergerud, 1978), the preceding sequence described for the Porcupine Herd closely approximates the average of others in North America (Banfield, 1974; Kelsall, 1968).,

The gestation period for caribou has been variously given as about 227 - 229 days (Bergerud, 1978) and 210 days (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). In the Porcupine Herd, calving may begin as early as May 22, but more often commences about the 27th of that month (Table 1). In all recorded years, the peak of calving has occurred between June 4-8 except in 1980 when several peaks were recorded between June 2-13 for

different parts of the calving ground (Table 1). Calving is essentially completed by about the third week of June. Normally a single calf is born to each female although twinning has been reported but is believed to be rare (Banfield, 1974; Kelsall, 1968; Bergerud, 1978). Caribou calves are extremely precocious, being able to stand and suckle within a few hours of birth (Banfield, 1974; Kelsall, 1968) and to graze within their first day or so (Kelsall, 1968). Weaning probably is completed for most calves by early September, although instances of suckling extending into winter have been recorded (Kelsall, 1968; Banfield, 1974). Such observations pertain to barren-ground herds of the N.W.T., but a similar developmental sequence is likely for Porcupine caribou calves as well.

Further considerations of reproduction such as productivity, sex ratios, etc. are discussed in the following section.

Table 1. Documented calving periods of the Porcupine Herd 1971 - 1981

Year	Start	Peak	End	Reference
1971	June 2	June 8	June 17-19	Roseneau & Curatolo, 1976
1972**	May 28-27	June 5-7	June 13	Roseneau & Curatolo, 1976
1973*	May 27	June 7	June 15	Doll et al., 1974
1974**	May 27-31	June 6-8	June 14-19	Roseneau & Curatolo, 1976
1975	-	June 4-5	June 14-15	Roseneau & Curatolo, 1976
1980***		June 2-13		Yukon Wildlife Branch, 1980f
1981	May 22	June 4		Yukon Wildlife Branch, 1981c
*1973	June 3	June 12	June 18	Surrendi and De Bock 1976
**1972-	28 = Yukon	1974-	27 = Yukon	
	27 = Alaska		31 = Alaska	

***Suggested possible progression of peaks from west to east on calving grounds.

MORTALITY

Prior to European contact, all mortality factors affecting the Porcupine Herd could have been classed as natural. Now, however, it is necessary to separate natural mortality factors from those involving human activities which no longer bear a purely survival relationship to caribou. These two categories are discussed separately as follows.

Natural Mortality

1. Predation

Porcupine caribou share their range with predators common to most caribou herds. This aspect of mortality, however, has seldom been seriously investigated and existing data is mostly incidental observations of predators and occasionally predation recorded during other studies.

a) Wolf:

The wolf population of the Porcupine range has never been properly assessed. In 499 hours of surveying the Yukon portion of the Porcupine range in 1971, 159 wolves were observed in 69 sightings - the largest pack containing 14 members (Jakimchuk et al., 1974). Of 133 wolf kills examined at that time, 131 were caribou and two were moose. Wolf predation on caribou was observed throughout the study period, and it appeared that wolves not involved with denning followed caribou (Jakimchuk et al., 1974). A subjective estimate of the northern Yukon population was 300-400 wolves between the Peel River drainage route and the Beaufort Sea (Jakimchuk, et al., 1974). A total of 154 wolf sightings were made during 1972 and 1973 caribou surveys, and like those of 1971 their distribution was

quite broad and "sporadic" throughout the northern Yukon (Doll et al., 1974b). Wolves were often associated with caribou; of the 154 sightings 31 were either at caribou kills or of wolves hunting caribou, while in 1972 of the 122 sightings that year only two were at moose kills (Doll et al., 1974b). Wolves were reported to be numerous in the Richardson Range in the winters of 1972/73 and 1974/75 and to kill calves and old bulls most frequently in a diet that consisted exclusively of caribou (Hoffman, 1975).

In March 1980, nine wolves were observed in the Keele Range and one was sighted on the Ogilvie Plains. Since wolves were not sighted during many hours of winter range surveys, it was suggested that wolf populations were concentrated in the Keele Range and Porcupine River area and that caribou were not followed further south into the winter ranges (Yukon Wildlife Branch, 1980b).

Active wolf dens have been recorded in the mountainous terrain of the Hulahula, Canning and Kongakut drainages, however, none have so far been found on the coastal plain of the Arctic National Wildlife Refuge (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). This has been attributed partly to the preference of wolves for the foothills of the Arctic Slope and the mountains of the Brooks Range where prey such as Dall sheep and moose are found (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982). Furthermore when caribou are abundant on the coastal plain (May and June), most wolves are probably confined to the mountains where denning activities restrict their hunting radius to about 32 km (U.S. Dept. of Interior and U.S. Fish and Wildlife Service, 1982).

Aerial hunting up to the early 1970's and some continued aerial poaching have received credit for the existence of low wolf numbers on the Alaskan Arctic Slope (Roseneau and Curatolo, 1976). In Yukon no wolf dens have so far been reported within the calving grounds (D. Russell and R. Farnell, pers. comm.). Also, despite numerous aerial surveys of the calving grounds since 1971, the number of wolf sightings each year has always been very low (Table 2).

In view of the conflicting evidence concerning wolf numbers on the Porcupine winter ranges, it is difficult to establish the potential significance of wolf predation on the herd. Certainly the level of predation must be lower than for adjacent N.W.T. herds, where wolves are commonly sighted during winter range surveys; on the other hand it is unlikely that wolf predation is insignificant as a mortality factor.

b) Grizzly Bear:

Grizzly bears are by contrast quite common on the Porcupine calving grounds (Table 2) and at times appear to be gathered where calving activity is most concentrated (Yukon Wildlife Branch, 1979b). Of 25 bear sightings made on the calving grounds in 1975, two single bears were at fresh caribou kills and two other attempts by bears to kill caribou were observed (Roseneau and Curatolo, 1976). In 1974, four out of nine grizzly observations made on the calving grounds involved bears at caribou kills (Roseneau and Curatolo, 1976). Of 45 sightings on the calving ground in 1979, two lone grizzlies were observed chasing caribou and three lone grizzlies

were at kills - two of which were calves (Yukon Wildlife Branch, 1979b). On two occasions in 1981, grizzlies were observed feeding on calf carcasses on the calving grounds and one sow was seen chasing caribou (Yukon Wildlife Branch, 1981c). In 1982 only one instance of grizzly predation was noted in a calf mortality study on the calving grounds (Mauer et al., 1983), but on six other occasions grizzlies were observed at caribou kills in a separate study which captured 50 bears on the coastal plains and adjacent foothills of the Arctic National Wildlife Refuge in 1982 (Garner and Reynolds, 1983).

Of 93 sightings in 1971 throughout northern Yukon, 52 involved grizzlies associated with caribou either as kills or in proximity to live animals (Jakimchuk et al., 1974). Between March and November 1973, 144 grizzly bears were observed in northern Yukon, apparently somewhat segregated in distribution according to family units and solitary animals (Doll et al., 1974b). An apparent southward shift in distribution away from the coast in September was also noted (Doll et al., 1974b). Recorded denning sites in Yukon are all well south of the coast (Jakimchuk et al., 1974). It has been suggested that as calving and post-calving progresses, large mammalian predators become more numerous as individuals are attracted to these concentrations, however, it has also been noted that in northeastern Alaska at least, both wolves and grizzlies are relatively scarce north of the Brooks Range (Roseneau and Curatolo, 1976). Of 38 den locations made in 1982 in the Arctic National Wildlife Refuge, only one was on the coastal plain and the

remainder were in the foothills and mountains of the Brooks Range (Garner and Reynolds, 1983).

c) Golden Eagle:

Between 1972 and 1975 reports of Golden Eagle numbers and calf predation on the calving grounds indicated that this species, particularly the non-nesting sub-adults, was the most important predator on the calving and post-calving grounds (Roseneau and Curatolo, 1976). The sub-adults being neither confined to nesting territories nor involved in the reproductive cycle, are highly mobile and the majority appear to maintain almost constant contact with the calving and post-calving herds (Roseneau and Curatolo, 1976). In a 1982 study of calf mortality, Golden Eagles were involved in 50% of the total mortality either as the probable predator or a predator/scavenger (Garner and Reynolds, 1983).

From the preceding information it is not possible to determine the relative importance of these three species as predators of the caribou herd nor can the relative contribution of predation to overall mortality of the herd be determined. While in order of importance the major calving ground predators are eagles, grizzlies and wolves respectively, neither eagles nor grizzlies are likely to be very significant predators of adult caribou whereas wolves are. The apparent scarcity of wolves on the major winter ranges in recent years suggests that wolf predation is probably low during the winter season, however, the amount of predation in winter, spring or fall cannot, at this time, even be estimated. Still, in comparison to many other North American herds, wolf predation seems to be relatively low, while eagle predation is relatively high.

2. Accidents

Porcupine caribou are prone to accidents throughout the year, but they may sustain more injuries in certain periods such as during migrations and post-calving movements. A common cause of mortality is river crossings where animals are either drowned or injured. In the 1971 spring migration, 28 caribou were killed while trying to cross the Porcupine River which was carrying moving ice pans which, when too many trapped animals tried to climb on them, overturned causing death by crushing and drowning (Jakimchuk et al., 1974). In 1975 a cow with a ruptured abdominal cavity was found near the Kongakut River bank from which it was inferred that the animal had impaled itself on a rock or limb while crossing (Roseneau and Curatolo, 1976). In 1982 a collared calf apparently drowned while attempting to cross the Firth River with a nursery band on June 30 (Mauer et al., 1983).

Another likely source of injury and sometimes eventual mortality is running from predators or from insect harrassment. Post-calving aggregations in particular seem prone to such accidents perhaps partially because insect harrassment peaks at this period and partially because the aggregations appear susceptible to panic stampeding (Roseneau and Curatolo, 1976). These aggregations also at times move extensively and rapidly, crossing many rivers in a relatively short interval (Roseneau and Curatolo, 1976). In July 1972, of 32,784 caribou which had been moving rapidly across the coastal plain for some time and reacting violently as well to insect harrassment, limping individuals were conspicuous among the last 1,000-2,000 animals to pass, and an estimated 200 or so were seriously injured and seemed unlikely to travel much farther (Roseneau and Stearn, 1974). Such post-calving movements

have also been credited with contributing significantly to calf mortality (Calef and Lortie, 1973). Not only would calves be exhausted by hard travelling at such an early age and thus vulnerable to accidents and predation, but other factors such as calf abandonment would likely be increased by numerous river crossings and erratic stampeding.

3. Sickness, Disease and Parasitism

Information concerning diseases and parasitism of adult Porcupine caribou is very limited. The only noteworthy disease which has so far received comment is "lumpy jaw". Calves may die from exposure or starvation during their first few weeks of life (Mauer et al., 1983). Starvation usually results from abandonment which may have a number of causes such as predator disturbance, neglect by inexperienced young females, and physiological disorders such as mastitis that interfere with suckling (Mauer et al., 1976); as well as other factors such as cow mortality or accidental separation, especially at water crossings. In 1982, one radio-collared calf died of exposure following high winds (42.6 kph) and 'mild temperatures' (3.8^{o}C), (Mauer et al., 1983).

4. Neonatal Mortality

Since calf mortality has been discussed in the previous three sections, it is only necessary to state that as an age class, calves have the highest mortality rate owing to their vulnerability to predation, accidents, exposure and starvation. That the Porcupine caribou population has apparently increased slowly over the past decade despite apparently low hunting and predation pressures, may signify that neonatal mortality rates in this herd are quite high. A further discussion of mortality rates in relation to population dynamics is presented in the following section.

Human Related Mortality

1. Hunting

Humans have apparently hunted caribou on the Porcupine Range for at least 27,000 years (Irving and Harrington, 1973) employing, no doubt, the typical strategies of ambush, spearing at water crossings etc., but also erecting long driftwood fences and corrals such as those used by the Kutchin tribes (Warbelow et al., 1975). Aboriginal dependence upon Porcupine caribou likely fluctuated with the availability of other food sources such as fish, muskoxen and marine mammals for the Inuit and fish, moose, Dall sheep and woodland caribou for the inland Athapaskans. At times the failure of Porcupine caribou to arrive at a critical period resulted in starvation among both Inuit and Athapaskan communities as recently as the early 1900's (Stefansson, 1914).

The nature of the caribou harvest began to change significantly with the advent of the whalers in the early 1800's followed by the fur traders, prospectors, trappers and miners. At the height of the arctic whaling industry in the 1890's up to 5,000 caribou may have been taken annually for provisioning (Calef, 1974). Professional meat hunting was a common occupation in the period 1890-1910, and as late as the 1930's thousands of caribou were used as dog food by trappers and miners (U.S. Department of State, 1980). Other factors influencing the caribou harvest were a shift from subsistence lifestyles to a greater dependence on imported food and clothing, centralization of human settlements, adoption of snowmachines in preference to dog teams (U.S. Department of State, 1980), as well as the population status of native and white groups plus of course the increasingly widespread use of rifles and the availability of ammunition.

The influence of such factors, in conjunction with the variability of caribou distribution, have determined the size of the caribou harvests over the past century, but since none of the factors can be quantified, the net effect on the harvest is difficult to judge for any given period. For example, although it has been suggested that the harvest peaked during the height of the whaling era, and that "use by whites was practically non-existent by the 1930's" (Le Resche, 1975), another opinion is that hunting pressures were also extreme in the 1930's (USFWS, 1980).

A similar analysis for the Bathurst Herd in the N.W.T. which was subjected to most of the same factors concluded that the greatest hunting pressure in the 20th century may have occurred between the two World Wars (1918-1940) (Urquhart, 1981).

Harvest data for the Porcupine Herd was probably first recorded from 1932 to 1948, when Game Return forms were distributed to R.C.M.P. detachments in the N.W.T. and Yukon, (Banfield and Jakimchuk, 1980). Beginning in 1953, hunters in the N.W.T. reported their harvest on their General Hunting License, and analyses of these returns for the period 1964 to 1972 yielded an average of 1,345 as a reported harvest from the settlements of Aklavik, Ft. MacPherson and Inuvik (Hoffman, 1975), (Table 3). A separate analysis of returns from Aklavik and Ft. MacPherson plus reports for Old Crow and the Dempster Highway produced an average annual harvest of 1,183 for the same period (Surrendi and De Bock, 1976). Such analyses, however, are fraught with errors since the returns are incomplete, individually inaccurate in many cases, and

ignore a significant segment of the hunting community altogether (Table 3). Other harvest data for the Porcupine Herd have been acquired mainly by hunter interviews and field observations. Since 1976-77 hunters in Alaska have been required to submit a harvest report to transport caribou south of the Yukon River (Davis, 1978). These reports, however, account for a very small portion of the total harvest from Game Management units 25 and 26c which cover the Porcupine Range in Alaska. Otherwise, as in Canada, Alaskan harvest figures are based on a combination of interview, observation and conjecture.

Such methods vary greatly in reliability, but the types of errors involved tend to reduce harvest figures and thus the annual harvest totals (Table 3) are minimal, and since most totals are incomplete due to unreported regions, the figures are further reduced. It is also impossible to meaningfully compare harvests among years because the annual values in addition to their inherent errors, have been compiled by a variety of methods each with its own biases. Also, no two sets of data represent all the same settlements and regions.

Interpretations of harvest data are thus severely constrained by the data quality and about all that can be determined with some confidence is that the annual reported harvests of the Porcupine Herd fluctuate between a low of around a couple of thousand and a high in the neighbourhood of 5,000. Not withstanding these limitations, one version is that the total mortality of the Porcupine population is 8,500 annually consisting of 3,000-5,000 animals from hunting, and the remainder being made up by natural factors (McCourt, 1980). This seems to imply that a) mortality is a constant, and b) that natural mortality

somehow compensates for harvest fluctuations. If this is so, then it is a unique and highly fortuitous relationship.

Annual harvests vary considerably not only in total, but also for particular communities depending upon the specific migration routes and winter ranges chosen by the majority of the herd. In particular, the communities in the N.W.T. on the eastern periphery of the range exhibit the highest variability among annual harvests (U.S. Department of State, 1980), but others such as those in the Chandalar winter range also experience years of extreme scarcity and abundance (Le Resche, 1975; Whitten and Cameron, 1980; Whitten and Cameron, 1982). In general, however, more caribou are harvested annually in Canada than in the U.S. perhaps within the suggested range of 50+% to 75% (U.S. Department of State, 1980) but probably by more than that, such as in 1980 when the reported Canadian harvest was 83% of the reported total which did not include the N.W.T. component (Table 3).

To properly assess the significance of hunting as a mortality factor, the effect of crippling loss must also be considered. Accounts of "flock shooting" and poor marksmanship exist in hunting reports for the Porcupine Herd from which a crippling loss of 10% was suggested (Hoffman, 1975). Another suggestion put the crippling loss as high as 33% (Jakimchuk et al., 1974). A popular figure employed arbitrarily in many such harvest analyses for other herds is 25% which if applied to the Porcupine caribou harvest would increase the approximate range of the annual caribou kill to between about 2,500 and around 6,000+.

2. Non Hunting Factors

Apart from hunting, other human activities may directly or indirectly be involved in caribou mortalities. An obvious danger is from traffic on the Dempster Highway, and although few road kills have so far occurred (D. Russell, pers. comm.), increased traffic levels might eventually result in significant mortality levels.

On some caribou ranges, such as that of the Tuktoyaktuk Reindeer Herd, animals occasionally become entangled in blasting wire and die from such injuries (A. Martell, pers. comm.).

Caribou are vulnerable to harrassment either by snowmachines (Hoffman, 1975) or aircraft (Surrendi and De Bock, 1976) which stress animals and could conceivably contribute to mortality at certain times of the year.

So far none of the preceding possibilities constitute significant mortality for the Porcupine population but they might pose a threat if industrialization and other activities increase on the herd's range.

Although mortality factors have so far received little research attention and most data are incidental to other studies, a few tentative conclusions are provided as follows:

a) In order of significance, the major caribou predators on the Porcupine calving grounds are golden eagles, grizzly bears and wolves respectively.
b) In order of significance the major caribou predators on the rest of the Porcupine range probably are wolves and grizzly bears.

c) In recent years wolf predation has apparently been quite low.

d) Accidents contribute to mortality in the Porcupine population chiefly through mishaps at river crossings, but also from injuries sustained in stampedes either from predators or insect harrassment.

e) Some caribou succumb to starvation and exposure and probably also disease, although the latter has never been documented as a mortality factor.

f) Neonatal mortality results from a variety of factors including predation, starvation, exposure and accident.

g) Porcupine caribou have been hunted by humans for millenia.

h) European contact and succeeding stages of human history on the Porcupine range drastically altered hunting methods and harvest levels of Porcupine caribou.

i) Peak harvest periods may have occurred in the late 1800's and perhaps again around the 1930's.

j) Harvest data for the Porcupine Herd are generally incomplete and inaccurate to the extent that little substantive information can be obtained from them.

k) Annual harvests fluctuate considerably for most communities on the Porcupine range, primarily due to the variability in migration routes and winter ranges selected by the herd.

l) Total reported harvests fluctuate between around 400 animals and around 5,000, but totals rarely include all communities.

m) The total mortality resulting from hunting is substantially higher than the actual harvest due to crippling losses which may account for an additional 10-33% of the actual harvest.

n) Generally more caribou are harvested annually in Canada than in the U.S., with the Canadian portion sometimes exceeding 80% of the reported total.

o) So far human activities other than hunting have caused negligible mortality in the Porcupine population, but some of these could become significant if the levels of activity (i.e. traffic) were substantially increased.

POPULATION DYNAMICS

The Porcupine Herd is a population of interbreeding caribou that is continually (but not constantly) losing individuals throughout the year (mortality), and once each year receives a quantity of new members (productivity). These contending events produce a dynamic that determines the characteristics of the Porcupine population such as its size and composition. Information concerning various aspects of the Porcupine population dynamics are discussed under the following topics:

Composition

The discussion in this and the following subsection are based upon composition data obtained from the Porcupine Herd at various seasons. Typically these data are acquired by trained observers using spotting scopes and hand tally counters. The observers are moved by aircraft to various locations in order to obtain a reliable sample distribution. Occasionally caribou are classified by helicopter or from aerial photographs.

Since the composition of the Porcupine Herd is never homogeneous, it is imperative that the total sample size be around 10% of the entire population or in the range of about 10,000 animals, and that this total be composed of

several well dispersed samples. Applying these criteria to the data summarized in Table 4, it is apparent that some of the estimates are of doubtful reliability due to inadequate sample sizes. In addition all of the July samples are taken from the post-calving aggregrations, and therefore do not represent the entire population since bull and yearling components are highly variable at that time. Thus the only value of the July data is the calf:cow ratio since it is likely that all but a few cows are comprised by the aggregations. Even then, however, errors may arise such as in 1977 when the calf:cow ratio in July was 11% smaller than the October - November figure. This was attributed to calves being missed in oblique photographs (Davis, 1978).

Productivity and Survival

The productivity of the Porcupine population is the number of calves born in June each year. The best measure of the calf crop is the proportion of calves per 100 cows. Ideally this calf:cow ratio should be obtained immediately after calving, but this is not possible since the calving herd is still widely dispersed and cannot be sampled accurately. Also a significant number of non-breeding cows may not have reached the calving grounds and thus cannot be accounted for. Consequently calf:cow ratios are determined from the early to mid-July post-calving aggregations, but as such represent only the proportion of calves that have survived the first 2-4 weeks of life. These ratios vary annually within the range of 47 to 66 calves:100 cows (Table 4) for reliable samples. If about 86% of the females are pregnant each year as they were in 1974 (Hoffman, 1975), then about 54% to 76% of the calves survive until mid-July.

Calves continue to die throughout the summer and fall. The 1980 composition counts indicate that about 82% of the early July calf population survived to mid-October (Table 4). If the 1972 October ratio is accurate, then only 66% of the calves survived that year between July and October (Table 4).

Recruitment

Since the mortality rate of calves is so high, their contribution to the population cannot be gauged until the following spring at the earliest - after the winter has taken its toll. Spring segregations are rarely attempted for the Porcupine Herd, because of the extreme difficulty of obtaining reliable samples. For example, the March 1980 calf:cow ratio of 55:100 was higher than the July 1979 ratio of 54:100 indicating that the March data is inaccurate.

The July composition counts are also unreliable due to the previously mentioned variability of bull and yearling mixes in the post-calving aggregations (Whitten and Cameron, 1980). The only remaining data therefore are the fall composition counts which range between 8% and 12% of the herd (Table 4) that actually represent 15 month old animals or "long yearlings". Unfortunately, only the 1977 figure of 12% can be used, since the 1972 sample size is too small and the 1980 sample was incomplete for yearling segregations (Yukon Wildlife Branch, 1980g). Thus the recruitment rate for the Porcupine Herd might be considered to be in the neighbourhood of 12%, but must fluctuate according to the previous years' calf crop and its mortality rate over the succeeding 15 months.

The documented recruitment rate of 12% for the Porcupine Herd is somewhat lower than average spring recruitment rates of 15-16% reported for Canadian

Arctic caribou populations (Kelsall, 1968) and similar figures for the Western Arctic Herd in Alaska (Lent, 1966). This may indicate higher calf mortality rates for the Porcupine Herd than for the other herds mentioned and may be related to the levels of golden eagle and grizzly predation on the calving grounds as well as significant calf losses during the period of rapid movement often undertaken by the post-calving aggregations. On the other hand, the 12% figure is a fall estimate and may be lower on that account alone compared to spring figures for younger animals.

Another recruitment parameter is the yearling to cow ratio which can only be reliably taken from the fall segregations. For the Porcupine Herd the only reliable estimate is 31:100 for 1977 as the 1972 and 1980 samples are unreliable. Since the 1976 July calf:cow ratio was 59:100, then 53% of the 1976 July calves survived the following 14 months of life that year.

Mortality Rates

There is only one complete analysis of differential mortality rates for the Porcupine caribou population (Martell and Russell, 1981). This was based on the age and sex of jaws from hunter kills on the Dempster Highway in the falls of 1972, 1973, 1977 and the winter of 1973-74 harvest by Ft. MacPherson residents. When only the jaws of known sex were used, the mortality rate for females greater than three years of age (3+ females) was 0.20, while for the 3+ males it was 0.41 (i.e. each year 20% of the 3+ females and 41% of the 3+ male die). For combined sexes over three years of age the rate was 0.25. The estimates for females and combined sexes are consistent with those for other herds, where the same analytical method was employed. The male mortality rate (0.41) is intermediate between the lightly sport-hunted Kaminuriak Herd (0.34), (Miller, 1974) and the heavily sport-hunted Nelchina

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Herd (0.51), (Bos, 1973) where the same analytical method was employed (Martell and Russell, 1983).

When unsexed jaws were included in the data, the mortality rate for all age classes was estimated to be .27, and for 3+ animals the rate was 0.28, employing a somewhat different analytical method than for the sexed jaws data only. In this version the estimates are slightly higher than the Kaminuriak Herd (0.24 and 0.24 respectively), (Miller, 1974) and for Northern Canada (0.21 and 0.22), (Banfield, 1955).

Using census, recruitment and hunting parameters for the Porcupine Herd, the total mortality rate for the population was calculated to be 0.07 comprised of hunting 0.03 and natural mortality 0.04. The total rate (0.07) is extremely low and likely inaccurate, since it depends on two parameters - yearling recruitment and harvest levels that are not reliable for this population.

About all that can be concluded from the preceding analyses is that the Porcupine population does not exhibit drastically different mortality rates from those of other herds when the same analytical methods are employed. The estimates therefore should be considered as indices of comparison with other herds, but not as actual mortality rates for the Porcupine Herd alone.

Herd Structure

The sex and age composition of the Porcupine Herd is known from the segregation counts conducted in various seasons (Table 4). As mentioned previously in subsection "Composition data", however, most of these data are inadmissable due to the unreliability of the samples. The best available

data is contained in the fall segregation of 1972, 1977 and 1980, but each of these is flawed as well. However, it appears from these that in the fall, adult cows constitute slightly less than half of the herd and adult bulls about a quarter of the herd with the remainder divided between calves and long yearlings. As the year progresses, the calf proportion in particular, drops substantially with the effect of elevating all the other proportions. Thus, by spring the percentage of adult females and adult males in the herd will be much greater. Also, it is likely that the proportion of adult bulls to adult cows will vary throughout the year as each sex experiences greater or lesser mortality in different seasons.

Three of the four bull:cow ratios from fall segregations range between 58:100 and 78:100 (Table 4), the fourth ratio of 33:100 is likely biased (Bente and Roseneau, 1978). These figures concur with those for lightly hunted herds in Alaska and Canada (Pegau and Hemming, 1972; Skoog, 1968; Kelsall, 1968), whereas for heavily hunted herds the bull:cow ratios are much lower (Bergerud, 1971; Bos, 1974). This effect of course only pertains to populations with bull only hunting restrictions or no sex hunting restrictions in which latter case there is usually some selection for bulls.

The age distribution of the Porcupine Herd based on hunter kill data from 1972 to 1977 indicated that 77% of the population is younger than six years old, but that Porcupine caribou can reach the age of 13 years (Martell and Russell, 1981).

Population Size

As with other herds, attempts to estimate the Porcupine population were made long before a reliable method had been developed. Without going into the numerous details of how and why population estimates are unreliable, suffice

it to say that the cumulative errors in each estimate contrive to make it a virtually unique figure that cannot be compared with any others to provide a trend except by the grossest standards (Table 5). This pertains particularly to estimates made prior to 1972 which by modern standards are highly questionable (even when they agree). In the 1950's and 1960's the theory of population shifts among adjacent caribou herds became quite popular and was used to help explain changes in the Porcupine population estimates from that period. Results from subsequent tagging and radio-collaring studies however, have shown that exchanges of animals among caribou herds is very slight, (Parker 1972, Whitten and Cameron 1982).

Since 1972, population estimates have been based on a technique termed Aerial-Photo-Direct-Count-Extrapolation (APDCE). Basically this method relies on aerial photographs of the large post-calving aggregations which in "good" years comprise essentially the entire herd. These photographs can be analysed in several ways to generate a total population figure. The chief advantage of this technique is that the total number of animals counted in the photographs represents a relatively solid figure although subsequent analyses are always subject to interpretation. Nevertheless in 1979, 105,683 caribou were counted from the photos, in 1982 about 125,339 were counted and in 1983 135,284 were counted.

Traditionally, the population estimates of the Porcupine Herd have usually included calves. This may suit biologists but it can become confusing for managers and the public since calf crops can vary substantially among years. Thus a poor calf crop, although significant to the herd, will have an exagerated influence on the population estimate and apparent trend. From a management standpoint, it seems better to consider only the adult population

Table 5. Population Estimates of the Porcupine Herd, 1953 - 1983

Year	Estimate		Reference
	Adults	Total	
1953		30,000 (spring)	Munro 1953
1953		55,000 (spring)	Skoog 1963a
1961	110,000 (summer)		Skoog 1963b
1962	unavailable		
1964	140,000 (summer)		Skoog 1968
1971		60,000 (spring)	Renewable Resources 1972
1971		21-30,000 (spring)	Calef & Lortie 1972
1971		60,000 (summer)	Calef & Lortie 1972
1972	84,965* (fall) (±11,640)	99,959 (fall) (±13,711)	LeResche 1975
1977	85,685* (fall) (±22,792)	105,126 (fall) (±28,009)	Bente & Roseneau 1978
1979	84,700* (fall)	110,000 (summer)	Whitten & Cameron 1980
1982	123,000** (summer)	137,000 (summer)	Whitten 1986
1983	104,168*** (fall)	135,284 (summer)	Whitten 1986

* calculated for this report from data in references.

** author assumed only 10.6% calves, adults would = 105,490 if 23% calves (see Note).

*** assuming 23% calves (see Note).

Note: The 23% calves was derived from 19% calves in October 1977 and a calf survival rate of 82% from July to October (1979 data). Therefore the percent of calves in July might be 19 divided by .82 = 23%.

(i.e. over one year old), which is more stable and is the most hunted segment of the herd. Accordingly I recalculated the estimates from 1972 to 1983 to provide this figure which during that period may have shifted from the 80,000's to the 100,000's except for the figure of 123,000 which may be anomalous due to the method of analysis which attempted to count calves on the photos but only tallied 2.1%. The possibility that other calves were either counted as adults or missed makes subsequent analyses very risky. This emphasizes the value of the actual photo count of 125,339 which shows that there were at least 125,000 caribou of some kind or other out there. It should also be noted that the confidence intervals of the 1972 and 1977 estimates overlap the estimates for the early 1980's (for which confidence intervals were not calculated). This reduces support for the assertion that the herd has been increasing in the past 10 years.

Considering the accuracy of the data and analyses from the APDCE method together with other population parameters suggest that the Porcupine Herd may have increased slowly[1] from the 1970's to the 1980's and presently numbers around 100,000 adults. It also can be stated that there is no reliable evidence to suggest that the herd has been anything other than relatively stable since 1953 when the first census was attempted. The reported fluctuations between the early 1940's and the late 1960's may or may not have occurred. Curiously, many analysts accept the herd's early population history without reservation but quibble endlessly over the unreliability of vastly superior estimates since 1972. The apparent increase from 1972 to

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[1] A change from 80,000 to 100,000 in 10 years represents an increase of only 2% per year.

1983 may be, in fact, only a moderate fluctuation in a relatively stable system that has prevailed for a number of decades.

From a management standpoint, there is no need to become excited over the results of any "latest" survey unless it indicates a drastic change in the herd's status. Current methods are quite capable of detecting such changes, and with periodic monitoring should alert managers in time to take action.

In summary, the population dynamics of the Porcupine Herd are incompletely known. Some aspects have been quite well documented while others remain poorly understood. Given the constraints of existing information, the following statements can be made.

a) The productivity (as of July) of the Porcupine Herd has varied between 44 and 66 calves per 100 cows.
b) If the pregnancy rate in the Porcupine Herd is fairly constant, then variations in July calf:cow ratios would be due primarily to neonatal mortality.
c) The age and sex structure of the Porcupine Herd changes over the period of a given year according to the survival rates of the various age and sex classes but particularly calves.
d) In the falls of the last 10 years (from 1983) adult cows probably comprised slightly less than half of the herd and adult bulls about a quarter of the herd.
e) Semi-reliable fall bull:cow ratios for the Porcupine herd range between 57:100 and 78:100 indicating a lightly harvested population.

f) The Porcupine caribou population is probably young with the majority of animals being less than 6 years of age with a potential longevity of about 13 years.

g) There is no reliable evidence to support any of the reported population changes between 1900 and 1972 actually ocurred.

h) Proposed emigrations of Porcupine caribou to adjacent herds and immigrations of Forty-mile caribou to the Porcupine Herd likely did not occur.

i) The Porcupine caribou population presently numbers around 100,000 adults.

j) The herd has either remained relatively stable since 1972 or increased slightly.

UTILIZATION

Subsistence hunting constitutes the bulk of the Porcupine caribou harvest, most of which is taken by native peoples in Alaska, Yukon and the Northwest Territories. Non-native residents also hunt caribou for subsistence and perhaps a few hunt for trophies. Non-resident hunters are considered to account for an average of 1-2% of the annual harvest (U.S. Fish and Wildlife Service 1980).

Commercial sport hunting enterprises operate in Alaska and Yukon parts of the Porcupine range but constitute a very minor portion of the total harvest.

Hunting regulations are different for each jurisdiction managing the Porcupine herd. Also, such regulations are modified so often that any account of them is almost immediately obsolete. This history therefore summarizes regulations up to the summer of 1983 and should not be considered

as accurate after that date. In Alaska, hunting restrictions concerning Porcupine caribou did not exist prior to 1975 and commercial hunting was permitted on part of the range until that year. Beginning in 1976, a 10 caribou limit per hunter was instituted (U.S. Fish and Wildlife Service 1980). Also no more than two caribou per hunter could be removed from the Game Management Units covering the Porcupine range. In the Yukon, non-natives are limited to an annual limit of one caribou which must possess antlers with one or more forks. Registered trappers may take two caribou per year and native people have no limit but no one may hunt females in the spring. Hunting along the Dempster corridor is the subject of an ongoing regulatory controversy. Non-native people were prohibited from hunting within a five mile limit of the highway until 1985. Native people including a significant number from the N.W.T. do use the Dempster Highway for access to Porcupine caribou. Since caribou may be lawfully transported across the Yukon-N.W.T. border, native hunters from N.W.T. may take Porcupine caribou from Yukon and sell them in settlements of the N.W.T. (U.S. Fish and Wildlife Service, 1980). In the N.W.T. there is no bag limit for native people but non-natives are restricted to a maximum of two animals per year, reduced in 1979 from a maximum of 5 (U.S. Fish and Wildlife Service, 1980).

Tourism within the Porcupine range is relatively undeveloped. Some companies offer river-rafting trips in Alaska and as the Dempster Highway in Yukon becomes the focus of greater tourism promotion by the territory, the presence of Porcupine caribou is being recognized as a valuable asset.

Research interest in the Porcupine herd burgeoned in the early 1970's with the proposed MacKenzie Valley Pipeline and attendant environmental impact studies. Since then the herd has been subjected to numerous ecological

studies in the past decade. As industrial proposals for the Porcupine range multiply, it is likely that research will increase as well.

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