THE POPULATION STATUS OF CARIBOU IN THE NORTHWEST TERRITORIES

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ᓄᓇᑦᑎᐊᒥ ᑐᒃ ᑐᐃᑦ ᓯᑕᒪᐅᔪᑦ ᐊᐃᑉ ᑐᑦᓯᒪᓂᕆᑦᑎᒍᑦ, ᑕᒡ ᕙ ᐅᑯᐊᖑᔪᑦ: ᓇᐹᖅᑐᓕᕐ ᒦᑉ ᐸᒃ ᑐᑦᑐ, ᓇᐹᖅᑐᖅᑭᑦ ᑐᒦᑉ ᐸᒃ ᑐᑦᑐ, ᕿᑭᖅᑕᓃᑉ ᐸᒃ ᑐᑦᑐ ᐊᒻᒪᓗ ᐊᓕᒃ ᑲᐅᑦᑐ ᔭᑳᓂᐅᑦᑐ ᒥᒃ ᓵᓃᑉ ᐸᒃ ᑐᑦ, ᐊᒻᒪᓗ ᓄᓇᑦᑎᐊᒥ ᑕᒪᕐᒥᒃ ᐱᑕᖃᕈᓐᓇᖅᓯᑎᒃ. ᓇᐹᖅᑐᖅᑭᑦ ᑐᒦᑦ ᑐᑦ ᐊᒥᓲᕐᓂᖅᐹᖑᔪᑦ ᐱᒍᒪᔭᐅᓂᖅᐹᖑᔪᑦ ᓗᑎᒃ ᓗ ᐊᖑᓇᓱᒃ ᑎᓄᑦ. ᑲᑎᖅᓱᖅᓯᒪᕚᒃ ᑐᑦ 8, ᖑᑦ ᓗᑎᒃ ᐊᔾ ᔩᕆᑦ ᑐᑦ ᑐᒃ ᑐᐃᑦ ᑕᒪᕐᒥᒃ ᓇᐹᖅᑐᖅᑭᑦ ᑐᒥᐅᖑᑦ ᓗᑎᒃ ᓄᓇᑦᑎᐊᒥ ᐊᒥᓲᓂᕐᑦᓗ 600,000 ᐅᖓᑖᓂᐸᓗᒃ ᓱᑎᒃ. ᑕᒡ ᕙ ᐃᒪᓐᓇ ᑕᐃᔭᐅᕚᒃ ᐸᑦᓗ, ᐊᑎᖅᑎᑕᐅᔪᑦ ᓘᓐ ᓅᑦ ᐊᓕᒃ ᑲᐅᑦᓗ ᔭᑳᓂᐅᑦᓗ ᒥᒃ ᓴᓂᒥᐅᑦ (Porcupine), ᑐᒃ ᑐᔭᖅᑑᑦᓗ ᐃᓄᐃᕙᐅᑦᓗ ᒥᒃ ᓴᓂᒥᐅᑦ (Bluenose), ᖁᖅ ᓗᒃ ᑑᑦᓗ ᔭᓗᓇᐃᑉᓗ ᒥᒃ ᓴᓂᒥᐅᑦ (Bathurst), ᓄᓇᑦᑎᐊᑦᓗ ᕿᑎᓚᓕᖕᓂ (Beverly), ᖃᒪᓂᑦᑐᐊᑦᓗ ᐊᖅᕕᐊᑦᓗ ᒥᒃ ᓴᓂ (Kaminuriak) ᓇᐅᔾᔩᑦᓗ ᐃᓪᓗᓕᓖᖅᔭᑦᓗ ᒥᒃ ᓴᓂ (Wager Bay), ᐃᓪᓗᓕᐅᑦᓗ ᓴᓂᕋᔭᐅᑦᓗ ᒥᒃ ᓴᓂ (Meville Peninsula), ᐊᒻᒪᓗ ᕿᑭᖅᑖᓗᒻᒥ (Baffin). ᑕᒪᒃ ᑯᐊ ᓂᖅ ᔭᑎᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ ᓈᓴᐃᕚᒃ ᑐᑦ ᑐᒃ ᑐᓂᒃ ᖃᐅᔨᓴᖅᓯᒪᓕᖅᐸᑦ, ᖃᐅᔨᓯᒪᓕᖅᐸᑦᓗ ᑖᒃ ᑯᐊᒍᖅ ᐃᓪᓗᓕᐅᑦᓗ ᓴᓂᕋᔭᐅᑦᓗ ᒥᒃ ᓵᓃᑦ ᑐᑦᓗ, ᓇᐅᔾᔩᑦᓗ ᐃᓪᓗᓕᓖᔭᑦᓗ ᒥᒃ ᓴᓂᑦ ᑐᑦ ᐊᒻᒪᓗ ᑐᒃ ᑐᔭᖅᑑᑦᓗ ᐃᓄᐃᕙᐅᑦᓗ ᒥᒃ ᓵᓃᑦ ᑐᑦ ᐊᒥᓱᖑᖅᐸᑦ-ᓕᐊᔭᑎᔭᐅᕚᑦ; ᑕᒪᒃ ᑯᐊᓗ ᓱᖅ ᖁᒃ ᐸᑦᓕᐊᕐᕆᑎᑦᓗᕆᑦ ᖁᖅ ᓗᒃ ᑑᑦᓗ ᔭᓗᓇᐃᑦᓗ ᒥᒃ ᓵᓃᑦ ᑐᑦ, ᓄᓇᑦᑎᐊᖅ ᕿᑎᓚ-ᓕᖕᓂᒥᐅᑦᓗ, ᐊᓕᒃ ᑲᐅᑦᓗ ᔭᑳᓂᐅᑦᓗ ᒥᒃ ᓴᓂᒥᐅᑦᓗ . ᐊᒻᒪᓗ ᖃᒪᓂᑦᑐᐊᒥᓗ ᐊᖅᕕᐊᑦᓗ ᒥᒃ ᓵᓃᑦ ᑐᑦ ᐊᒻᒪᓗ ᕿᑭᖅᑖᓗᒻᒥ ᐊᒥᓲᕆᓕᖅᐸᑦᓕᐊᔭᑎᔭᐅᖅᒥᑦᓗᑎᒃ, ᑕᒪᒃ ᑯᐊ ᐊᖑᓇᓱᒃ ᑕᐅᖃᑦ ᑕᖅ ᓂᖅᐹᖑᔭᑦ ᐊᒥᓲᕆᓕᖅᐸᑦᓕᐊᑦᓗᑎᒃ, ᐊᒻᒪᓗ ᑕᒪᒃ ᑯᐊ ᐊᖑᓇᓱᒃ ᑕᐅᖃᑦ ᑕᕐᖓ ᓂᖅᓴᐅᔭᑦ ᐊᒥᓱᖑᖅᐸᑦᓕᐊᑦᓗᑎᒃ.

ᑕᐃᑦ ᓱᒪᓂᐅᓚᐅᖅᑐᖅ ᓈᓴᐃᔭᓐᓇᑦ ᓯᐊᖃᑦ ᑕᓚᐅᕆᐸᑦ ᑐᒃ ᑐᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ, ᒫᓐᓇᓕ ᓄᑖᓄᑦ ᐊᑲᐅᓂᖅᓴᐅᔪᓄᑦ ᓈᓴᐃᔭᓯᖃᑦ ᑎᐊᖅ ᓂᖅᓴᐅᓕᖅᐸᑦ, ᑭᓯᐊᓂᑦ ᑕᐅᖅ ᐃᓛᓐᓂᒃ ᑯ ᑕᒻ ᒪᖅᐸᒃ ᑲᓗᐊᖅᓱᑎᒃ. ᓈᓴᐃᔭᑎᓂᒃ ᓄᑖᓂᒃ ᐊᑐᖅᐸ-ᓕᐊᓕᖅᒪᑕ ᖃᐅᔨᓴᖅᑏᑦ ᑕᒻ ᒪᐅᑎᒥᔭᐅᖃᑦ ᑕᕐᖓ ᓂᖅᓴᐅᓂᐊᓕᖅᐳᖅ ᓈᓴᐃᓂᖅ ᑐᒃ ᑐᓂᒃ ᓯᕗᓂᑎᓂᐊᖅᑕᑦᑎᓐᓂ.

ᑕᒪᒃ ᑯᐊ ᑲᒪᒋᔭᐅᑦᑎᐊᖅ ᓂᐊᖅᐸᑕ ᑐᒃ ᑐᐃᑦ ᐊᔾ ᔩᕆᑦ ᑐᑦ ᓂᖅ ᔭᑎᓂᒃ ᖃᐅᔨᓴᖅᑏᑦ ᖃᐅᔨᓴᕆᐊᖃᖅᐸᑦ ᑐᒃ ᑐᐃᑦ ᓇᓂᖃᑦ ᑕᖅ ᓂᕐᖓ ᓄᑦ.

ABSTRACT

All four sub-species of North American caribou (Rangifer tarandus) occur in the Northwest Territories. Of these, only the barren-ground caribou (R.t. groenlandicus) are of major economic importance and have been intensively studied. Eight major herds of barren-ground caribou totalling over 600,000 animals range entirely or partly within the Northwest Territories. The most recent population estimates suggest that the Melville Peninsula, Wager Bay and Bluenose herds are increasing, the Bathurst, Beverly and Porcupine herds are stable in numbers, and the Kaminuriak and Baffin herds are declining. The most heavily hunted herds (by percentage) are declining and the most lightly hunted herds are increasing.

Population estimates of caribou herds in the Northwest Territories were carried out using various survey designs. However, these suffered from ineffective sampling procedures and observer bias, resulting in both high variances on the estimates and unmeasured inaccuracies. Improvements in survey design have reduced the 95% confidence intervals on estimates to 15-20% of the mean, but bias still remains unmeasured.

Remote sensing or new statistical analyses have the potential for reducing or eliminating bias in caribou surveys. Despite improvements in technique for censusing caribou, additional understanding of caribou ecology is required for successful management of the herds.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Caribou of one type or another range throughout most of the Northwest Territories. The purpose of this paper is to summarize the current population status of the Northwest Territories caribou herds, and to make some remarks concerning the problems of caribou management.

Caribou Sub-species and Their Distribution

In his revision of the genus Rangifer, Banfield (1961) recognized four sub-species of the caribou Rangifer Tarandus in North America. All four of these may be found in the Northwest Territories (Figure 1).

The range of the barren-ground caribou (R.t. groenlandicus), the most numerous and wide ranging of the sub-species, encompasses the tundra regions from Hudson Bay to the Mackenzie River, as well as Baffin Island. Many of these caribou migrate to the boreal forests to winter, but others spend the entire year within the tundra regions.

The woodland caribou (R.T. caribou) occupy the boreal forest regions on the southwest and northwest shores of Great Slave Lake, throughout the Mackenzie River drainage, and as far north as Colville Lake and the upper Anderson River. These caribou also range through the forests and alpine tundra of the Mackenzie Mountains.

Peary's caribou (R.t. pearyi) inhabit the Arctic Archipelago as far north as Ellesmere Island.

Banfield considered that the caribou of Alaska belonged to the sub-species (R.t. granti). If this is correct, then the migrations of the caribou of the Porcupine herd, which ranges in Alaska, the Yukon and the Northwest Territories would bring the granti sub-species into the Northwest Territories.

However, Banfield pointed out that inter-gradation occurs between the various sub-species where their ranges overlap. Thus inter-grades between groenlandicus and pearyi may be found on Banks Island and southern Victoria Island. The caribou of the lower Anderson River, Eskimo Lakes, and Travaillant Lake areas probably represent inter-grades between groenlandicus and caribou, and the inter-changes of animals which are known to have occurred across the Mackenzie Delta (Skoog 1968) suggest that the caribou of the Porcupine herd would be granti-groenlandicus inter-grades.

Within the ranges of the sub-species, populations vary in behaviour and appearance, depending on their habitat and degree of isolation from other populations. For example, the tundra-wintering caribou populations of Melville and Boothia Peninsulas morphologically belong to the sub-species groenlandicus, while in behaviour they may more closely resemble pearyi. Similarly, the woodland caribou in the alpine tundras of the Mackenzie Mountains may behave more like barren-ground caribou than like woodland caribou of the forest. Of the four sub-species, the barren-ground caribou are the most economically important, and only they have been intensively studied. Therefore, the remainder of my remarks will apply to this sub-species.

Herds and Ranges of Barren-ground Caribou

Caribou herds are currently defined as groups of animals which consistantly calve in a specific traditional location, distinct from calving areas used by other herds. By this criterion, we currently have eight major herds and several minor herds which spend all or part of their time in the Northwest Territories (Figure 2, Table I). Five of the herds range entirely within the Northwest Territories. The Porcupine herd ranges in Alaska and the Yukon, the Beverly and Kaminuriak herds roam into Saskatchewan and Manitoba.

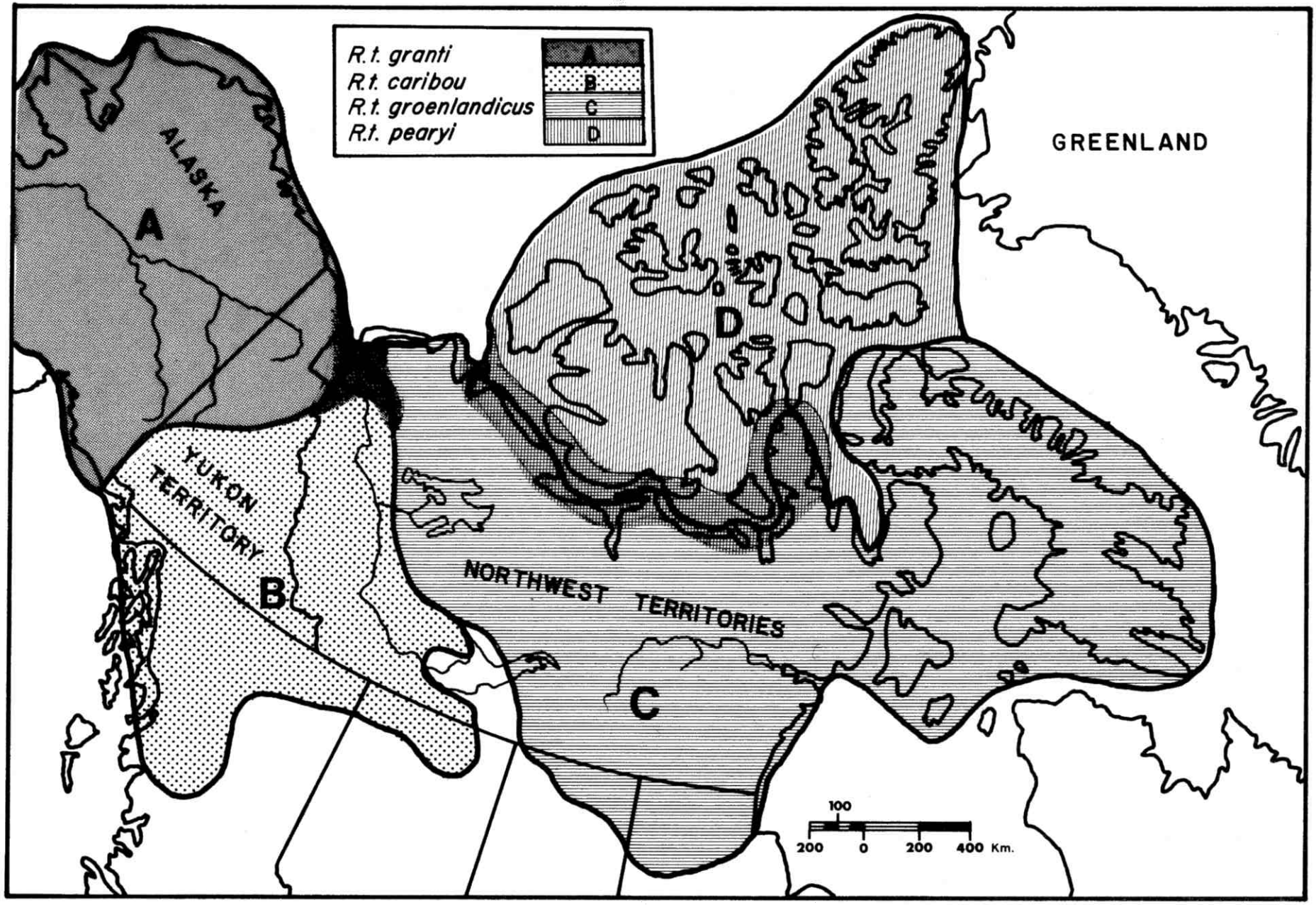

Figure 1. Distribution of caribou sub-species in the Northwest Territories.

Caribou have evidently occupied these areas throughout historical time (Skoog 1968, Banfield 1954), and Gordon (1975) has postulated that major ranges and migration routes of barren-ground caribou in central Canada have remained essentially unchanged since the retreat of the Keewatin Lobe of the Laurentide glaciation approximately 8,000 years ago.

CURRENT STATUS OF MAJOR CARIBOU HERDS IN THE NORTHWEST TERRITORIES

Table 1 summarizes the most recent population estimates for the Northwest Territories caribou herds and our best estimates of the population trend. All our major herds have been surveyed in the past 4 years, most within the past 2 years.

Porcupine Herd

The Porcupine herd was estimated at 93,000 - 103,000 animals by aerial photography of the post-calving aggregation in 1972 (LeResche 1972). Surrendi and DeBock (1976) estimated it at 117,000 in 1973, although their method of estimation was unspecified. Another photo census carried out this summer has not yet been completely analyzed, (D. Roseneau, pers. comm.).

Indications are that this herd is stable in numbers. Skoog (1962) estimated the herd at 117,000 (excluding calves), and Lentfer (1965) estimated the herd at 140,000. Within the normal confidence interval for this type of survey, these estimates are similar to the current estimate. Calves have represented 14-17% of the total autumn herd in recent years, a figure which should result in a more or less stable population (Skoog 1968, Kelsall 1968). Annual kill is 2,500 - 4,000, or 2-4% of the estimated population (Calef 1974).

Table 1. Estimated numbers and kill in the Northwest Territories caribou herds.

Herd	Population estimate		Suspected trend	Kill*	Kill as of % population	Industrial activity on calving ground
Porcupine	93,000-103,000	(1972)	Stable	1554	1.6	No
Bluenose	90,000	(1975)	Increasing	1124	1.2	Yes
Bathurst	150,000	(1977)	Stable or slightly decreasing	5896	4.4	Yes
Beverly	124,000	(1974)	Stable	4900+	4.0	Yes
Kaminuriak	44,000	(1977)	Decreasing	3890†	8.8	Yes
Melville Peninsula	52,000	(1976)	Increasing	518	1.2#	No
Wager Bay	29,000	(1976)	Increasing	0	0.0	No
Baffin	20,000	(1974)	Decreasing	2485	12.4	Little

* Average of 3 yrs. 1972-73 to 1974-75.

\+ Includes Saskatchewan kill.

† Does not include Manitoba-Saskatchewan kill.

\# 1970-71 to 72-73.

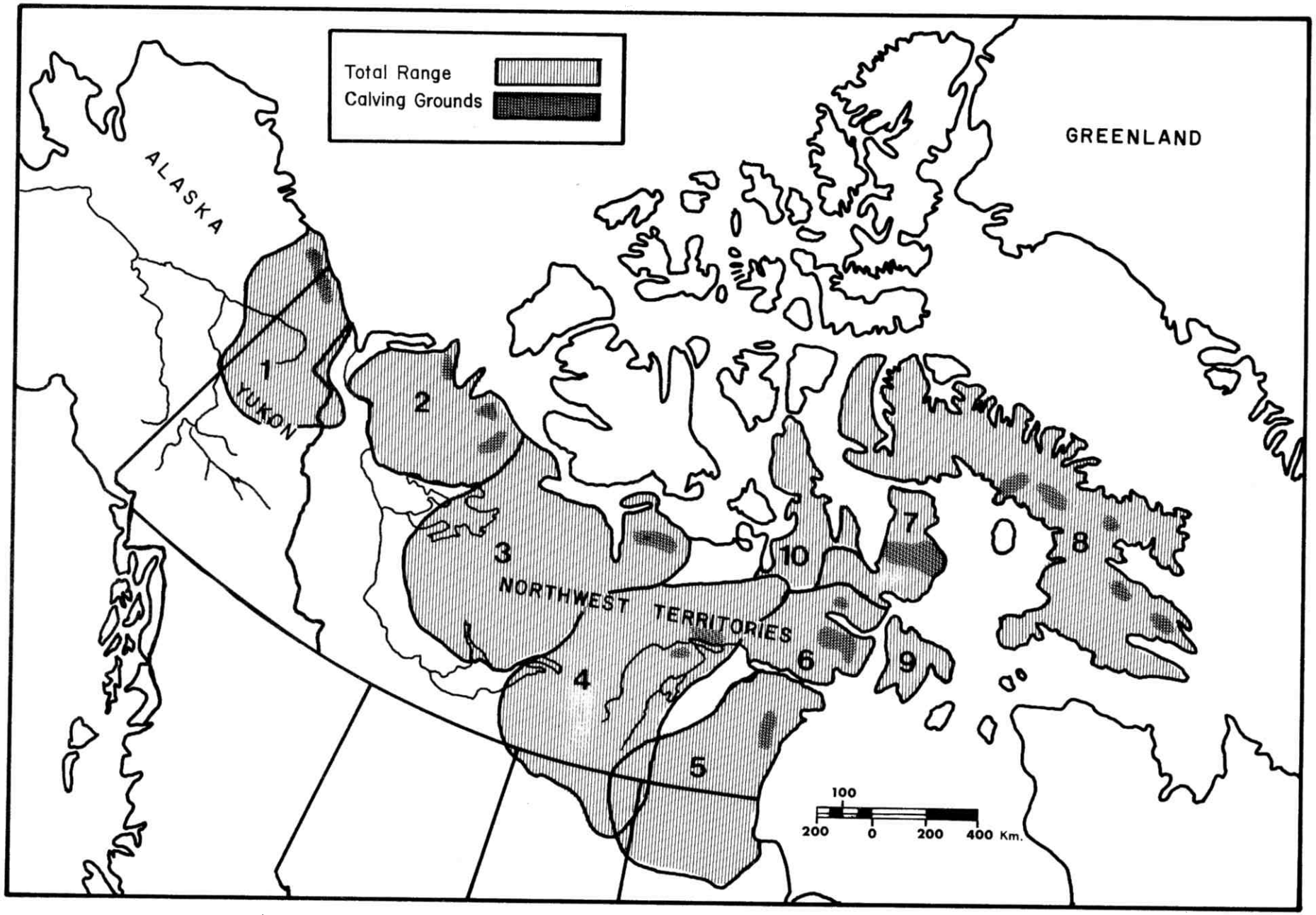

Figure 2. Ranges of barren-ground caribou herds in the Northwest Territories. Stippled areas indicate location of calving grounds.

Human industrial activity on the herd's range is limited to the Dempster Highway and the seismic activity in the Yukon and Northwest Territories. The Arctic Wildlife Range protects part of the calving grounds and the summer range.

Bluenose Herd

Thomas (1969) estimated the population of the Bluenose herd at 19,000 in 1967. The herd was not recensused until 1975 when Hawley et al. (1976) estimated 90,000 animals. Thomas probably missed a substantial part of the herd as his coverage of the range was "less than desired because of poor weather, the remoteness of the area, and limitation of time and funds". Nevertheless, the Bluenose herd has almost certainly been growing in recent years, as evidenced by their re-appearance on winter ranges from which they were absent for many years. The expansion of range areas is thought to accompany population growth in caribou (Skoog 1968).

This herd is one of the more lightly hunted in the Northwest Territories. Annual kill by residents of Colville Lake, Inuvik, Fort Good Hope and Paulatuk probably averages about 1-2% of the estimated population.

Industrial activity on the calving grounds of this herd has been restricted to some seismic activity, stratigraphic drilling, and airbourne gravimetric surveys.

Bathurst Herd

Calef and Boxer (in prep.) estimated the Bathurst herd at 150,000. This compares with previous estimates of 144,500 (Thomas 1969), 153,000 (Boxer 1970), 159,000 (Boxer 1971) and 174,000 (Boxer 1974). These figures suggest that the Bathurst herd increased from 1967 until 1974, and has since

declined. However, considering once again the inaccuracies of the surveys, a more conservative view might be that the herd has remained stable at about 150,000 animals.

The reported kill figures for this herd have recently averaged about 6,000 or 4-5% of the total herd. However, in 1974-75, a wasteful slaughter of several thousand animals from this herd took place from Coppermine, and in 1976-77, Jacobson (pers. comm.) estimated that the residents of Rae-Edzo alone might have killed over 10,000 caribou from this herd. Thus, a decline is possible.

Reproduction of this herd is excellent. Twenty-three percent of total animals classified in September 1977 were calves, but a high first year mortality is suggested by the low percentage of yearlings in the fall (7.4%).

There have been airborne geodetic surveys, some diamond drilling and some mineral exploration on the calving ground of this herd in the past 5 years.

Beverly Herd

The Beverly herd was last censused in 1974, when Moshenko (1974) estimated it to number 124,000. Previously the herd had been estimated at 159,000 in 1967 (Thomas 1969), and 164,000 in 1971 (Rippin 1971). Despite the apparent decline indicated by the 1974 survey, the herd is assumed to be stable in numbers.

Hunting by residents of the Northwest Territories and Saskatchewan accounts for about 4,900 animals per year.

Some uranium exploration and geodetic surveys have been carried out on the calving grounds of this herd since 1975.

Kaminuriak Herd

The Kaminuriak herd is the most intensively studied in the Northwest Territories, and censuses have been carried out in 6 of the last 7 years. These censuses have yielded quite variable and inconsistent estimates of the population size (see section on problems in population estimation). However, the last two estimates (44,000±34%; Hawkins and Calef in prep., and 45,000±23%; Heard in prep.) were similar, and the confidence interval suggests that they were more precise than previous surveys. The population has probably declined since the late 1960's when it was estimated to number 63,000 (Parker 1972), and has almost certainly declined since the 1950's when estimates of 120,000 (Banfield 1954) and 149,000 (Loughery 1955) were obtained.

In the past 3 years this herd has altered long established migration patterns. The herd formerly wintered in the forests of northern Manitoba and Saskatchewan, but since 1974-75 has wintered on the tundra near the communities of Baker Lake, Chesterfield Inlet, and Rankin Inlet. In 1975-76, the Kaminuriak caribou wintered north of Chesterfield Inlet for the first known time. The reason for this change in wintering behaviour is unknown. Despite changes in winter ranges, the Kaminuriak caribou herd has continued to use the same calving grounds each year.

The new wintering behaviour has made the already heavily hunted Kaminuriak herd even more vulnerable. Reported kill from the Northwest Territories alone has averaged in recent years, 3,900 or 8% of a population of 50,000 animals, making the Kaminuriak the most heavily hunted herd in terms of percentage kill. Wildlife Officers in Keewatin are unanimous in

their opinion that this herd is being hunted in excess of its recruitment rate and is declining. In the past 2 years calf production and summer survival have been good (calves comprised about 21% of the autumn herd), but yearlings represented only 6.4% of a small sample of caribou classified in autumn 1977.

Mineral exploration, diamond drilling, and airbourne geodetic surveys have been carried out on the Kaminuriak calving grounds in the past 5 years. A study of the effects of mineral exploration on caribou and other animals is currently being conducted for the Department of Indian Affairs and Northern Development in the Kaminuriak area.

Northeastern Keewatin Herds

Northeastern Keewatin is the least explored and most poorly known area of mainland Canada. Thorough surveys of the caribou in this area had not been carried out prior to 1971. The calving grounds of three new herds have been located in the past 2 years. Population estimates for the area are: Melville Peninsula herd, 52,000 (Calef and Helmer 1976); Wager Bay herd, 12,000; Lorillard herd, 17,000 (Heard et al. 1977).

Three previous surveys had been flown on the Melville Peninsula calving grounds, and only a few hundred caribou were observed (Rippin and Bowden 1972; Pendergast and Bowden 1973; Bowden and Helmer 1974). Thus, it is possible that the Melville Peninsula herd has received a large influx of animals from the Beverly, Kaminuriak or Baffin Island herds since 1974.

The herds of northeastern Keewatin are lightly hunted and are thought to be increasing. No industrial activity currently exists on these calving grounds.

Baffin Island Herds

The herds of Baffin Island remain the most poorly documented in the Northwest Territories. Calving grounds on south Baffin have been located, but bad weather has twice prevented satisfactory surveys from being carried out. On north Baffin, even calving grounds are unknown, and it is not certain whether north Baffin caribou are a separate herd from those on south Baffin.

A tagging program has been initiated to try to determine the wintering areas of animals using the various south Baffin calving grounds, but results are still inconclusive. The kill of caribou on Baffin Island is high, and probably more than recruitment of the population can replace. It is feared that the Baffin population may be declining. Little industrial activity has taken place on the calving grounds of Baffin herds.

In summary: the Northwest Territories has three caribou herds which are apparently increasing, three which are apparently stable, and two which are probably decreasing.

PROBLEMS IN ESTIMATING CARIBOU POPULATIONS

The most accurate method of estimating numbers in a caribou population is to photograph the post-calving aggregations with high resolution aerial cameras, and then adjust the count obtained from the photographs for missing age and sex classes. This technique has been successfully used on the Arctic herd and the Porcupine herd in Alaska (Hemming and Glenn 1968, Le Resche 1972). The caribou herds in the Northwest Territories however, do not usually form into one or two huge post-calving herds suitable for photography. Instead, the rule is for herds to form many scattered groups

of a few thousand. Thus, to obtain population information we have had to rely on aerial surveys using transects or random blocks on the calving grounds.

Unfortunately surveys carried out to estimate caribou populations in the Northwest Territories have been neither sufficiently accurate or precise to allow for the detection of anything but very large changes in population (Cook and Jacobson 1976). These surveys have been unreliable for the following reasons:

1. Sampling procedures have not allowed for varying densities on the calving grounds.
2. Unmeasured bias has resulted from observers estimating rather than counting large groups of caribou.
3. Unmeasured bias has resulted from observers missing animals.
4. Corrections for missing age and sex classes applied to calving ground estimates have often been done without accurate classifications of animals on the calving ground or in the whole population.

These difficulties can be appreciated by considering the surveys carried out on the Kaminuriak caribou herd in 1968, and 1971-1974. These surveys employed random-block design recommended by Parker (1972). Table 2 shows the estimated number of caribou on the Kaminuriak calving grounds, and the 95% confidence interval about these estimates. The confidence intervals are so large (±33% to ±178% of the estimated population) that is impossible to say whether apparent population changes are real, or attributable to sampling error. For example, although the estimated calving ground populations for 1973 and 1974 were estimated at 9,914 and 20,072 respectively, these estimates do not differ significantly ($p>.05$). Cook and Jacobson (1976)

Table 2. Summary of Kaminuriak calving ground population estimates for the period 1968 and 1971-1974.

	1968	1971	1972	1973	1974
Number of 16-square mile blocks on calving ground	168	49	124	72	147
Sample Size	28	7	18	20	30
Average Average caribou/block	185.1	392.1	108.3	137.7	190.9
Standard deviation	.175	817	169	228	313
Estimated calving ground population size ($\hat{y}$)	31,098	19,215	13,495	9,914	28,072
Half width of a 95% confidence interval on $\hat{y}$ as a per cent of $\hat{y}$.	33%	178%	71%	66%	53%

point out that "extreme variability of the results is due to the occurrence of a few blocks with very high densities of caribou and a number of blocks with very low densities". A similar variability in density was observed during the 1977 survey of the Bathurst herd where densities varying from over 100 caribou/mi^2 were estimated (Calef and Boxer in prep.). Highly variable density on the calving grounds appears to characterize most of the barren-ground caribou populations in the Northwest Territories, although it may be less pronounced in tundra-wintering populations. Thus, unless sampling is stratified, high variances on population estimates result.

The occurrence of high density areas also accounts for one of the two types of bias mentioned above. For example, during the 1971 Kaminuriak survey, three of the 28 blocks sampled contributed 89% of the total animals observed during the survey. Since the caribou in these blocks occurred mostly in large groups, the number of caribou was estimated rather than counted accurately. As Cook and Jacobson (1976) comment, "the fact that only 11 percent of the total survey count was based on 'accurate' counting of caribou within sample blocks is very disturbing and severely limits the researcher's ability to statistically estimate the population total and variance. The 1974 survey appears to suffer from the same problem, although perhaps not to the same degree."

The problem of groups too large to count is a recurrent one in caribou censuses in the Northwest Territories. Calef and Helmer (1976) reported that 30% of the total caribou observed during the Melville Peninsula caribou survey was estimated, and 31% of the total caribou observed in the 1977 Bathurst survey was based on estimated groups (Calef and Boxer in prep.). Data presented by Thomas (1969) suggest that estimates are approximately 20% inaccurate.

The other bias results from the observers missing animals completely. Parker (1972) arbitrarily suggested that 20% of the animals were missed during aerial calving ground surveys and subsequently raised his estimates by this factor. As Parker's techniques have since formed the basis for all surveys subsequently conducted by the Northwest Territories Fish and Wildlife Service, all survey results have been adjusted by this arbitrary 20%. No attempts have been made to experimentally determine this bias, but experienced observers are all aware that calving ground surveys in the Northwest Territories are conducted at the time when snow conditions make the pale-colored spring animals most difficult to see. Semi-controlled experiments designed to measure bias in aerial surveys of other ungulates indicate that 25-75% of the animals are missed (Caughley 1974).

Finally, when corrections for missing age and sex classes are applied to the calving ground estimates to obtain a final population figure, the corrections are often based on inadequate samples or on past classifications. For example, Parker (1972) obtained a ground classification of only 654 animals on the calving grounds (approximately 1% of the estimated population), and his autumn classification employed only aerial surveys, which made it impossible to identify 1 and 2 year old animals. These he extrapolated from the spring classifications.

In many surveys, no classifications were carried out at all on the population at the time of the survey. In these cases, past survey results were used for corrections, and these were applied inconsistently. For example, Moshenko (1974) citing Dauphine (1971) assumed that adult females comprise 57% of the spring population, while Calef and Helmer (1976) and Calef and Boxer (in prep.) cited Parker (1972) who stated that breeding

females (i.e. pregnant females) comprised 43% of the spring population. These different assumptions are reflected in the final population estimates which are all that a casual reader may note.

POTENTIAL IMPROVEMENTS IN METHODS OF POPULATION ESTIMATION

Clearly, the inaccuracies and biases described above must be remedied before our caribou censuses are reliable enough for management purposes.

The problems of sampling procedure have been largely solved by switching from random blocks to strip surveys, by stratifying the sampling, and by developing statistical methods to deal with unequal transect lengths. The confidence intervals on the most recent surveys are approaching a level acceptable for management. For the Melville herd the confidence interval was ±16%, for the Kaminuriak ±23%, and for the Bathurst herd ±18%. However, these procedures have still not been standardized within the Fish and Wildlife Service. Consequently, as biologists and wildlife officers come and go, procedures for the conduct and analysis of calving ground surveys may still vary.

The problems of bias are more difficult to overcome. The first type of bias, that of inaccurately estimating large groups, can usually be overcome by photographing groups with a hand-held 35 mm camera, or by deviating from transect to count until an accurate count is obtained. But in some cases, where caribou are densely distributed almost continuously along some of the transects (as often occurs on the Bathurst calving ground), then there is no alternative to estimating, unless a high resolution aerial photography method can be developed.

Bias introduced by missed animals is the most difficult problem with aerial sampling. There are four promising approaches to measuring "visibility bias". The first is the approach of Caughley (1974) by which sightability of animals is regressed against aircraft speed, altitude, and strip-width to obtain corrections for bias.

The second method, exemplified by Cook and Martin (1974), attempts to discover the underlying statistical distribution of the animals, and then adjust the raw data to fit the underlying distribution.

A third promising method involves comparing the percentage of caribou seen in common by front seat and back seat observers. The final method involves the use of remote sensing in the form of photography, video tape, or infra-red line scanner to obtain absolute counts of animals. During the 1977 Kaminuriak survey, an experiment was carried out to evaluate the usefulness of various remote sensors in reducing visibility bias. The results of this experiment should be available early in 1978 (Poole and Heard in prep.). High priority is placed on testing the other approaches to estimating bias in aerial caribou surveys so that the accuracy as well as the precision of the surveys can be improved.

The final difficulty, that of obtaining accurate age-sex classifications, is largely a matter of just putting in the required time, effort and money to obtain an adequate sample size. However, perhaps the most important classification for management purposes, that of percent yearlings in the spring (Haber 1977), is made rather difficult by the segregation which exists among caribou at that time.

PROBLEMS IN CARIBOU MANAGEMENT

Even if the formidable problems in accurately estimating the numbers and productivity of caribou were overcome, we would still be a long way from successfully 'managing' our populations. I would like to offer a brief outline of some of the difficulties.

Population Dynamics

One remarkable feature of caribou ecology is that herds tend to maintain an almost constant population density. This density relationship seems to hold over ranges that vary widely in productivity (eg. northeastern Keewatin, central Canada, and Alaska: Figure 3). During periods of population growth or decline, ranges expand or contract so that approximately constant density is maintained (Skoog 1968, Parker 1972).

These characteristics hint that caribou may have an intrinsic form of population regulation. Some authors have also suggested that caribou populations might be cyclic (eg. Clarke 1940). If this were the case, then a simplistic approach to sustained yield such as "you may harvest 10% of the population each year" is inadequate.

We need to know why and how the density relationship is maintained, and why it sometimes or periodically breaks down. Haber (1977) has suggested a relationship between population density and calf survival during the first year. If this is true, is the mortality determined intrinsically or through predation or range condition? Pegau (1972) for example, has suggested that caribou of the Nelchina herd mechanically damaged lichen ranges during a population high, and that the range would require decades to recover.

Figure 3. Relationship between herd size and range area for barren-ground caribou.

A.	Porcupine herd	1972
B.	Arctic herd	1970
C.	Bluenose herd	1975
D.	Bathurst herd	1977
E.	Kaminuriak herd	1967
F.	Kaminuriak herd	1977
G.	Beverly herd	1974
H.	Melville Peninsula	1976
I.	Nelchina herd	1955
J.	Nelchina herd	1962
K.	Nelchina herd	1967
L.	Nelchina herd	1973
M.	Fortymile herd	1953
N.	Fortymile herd	1973

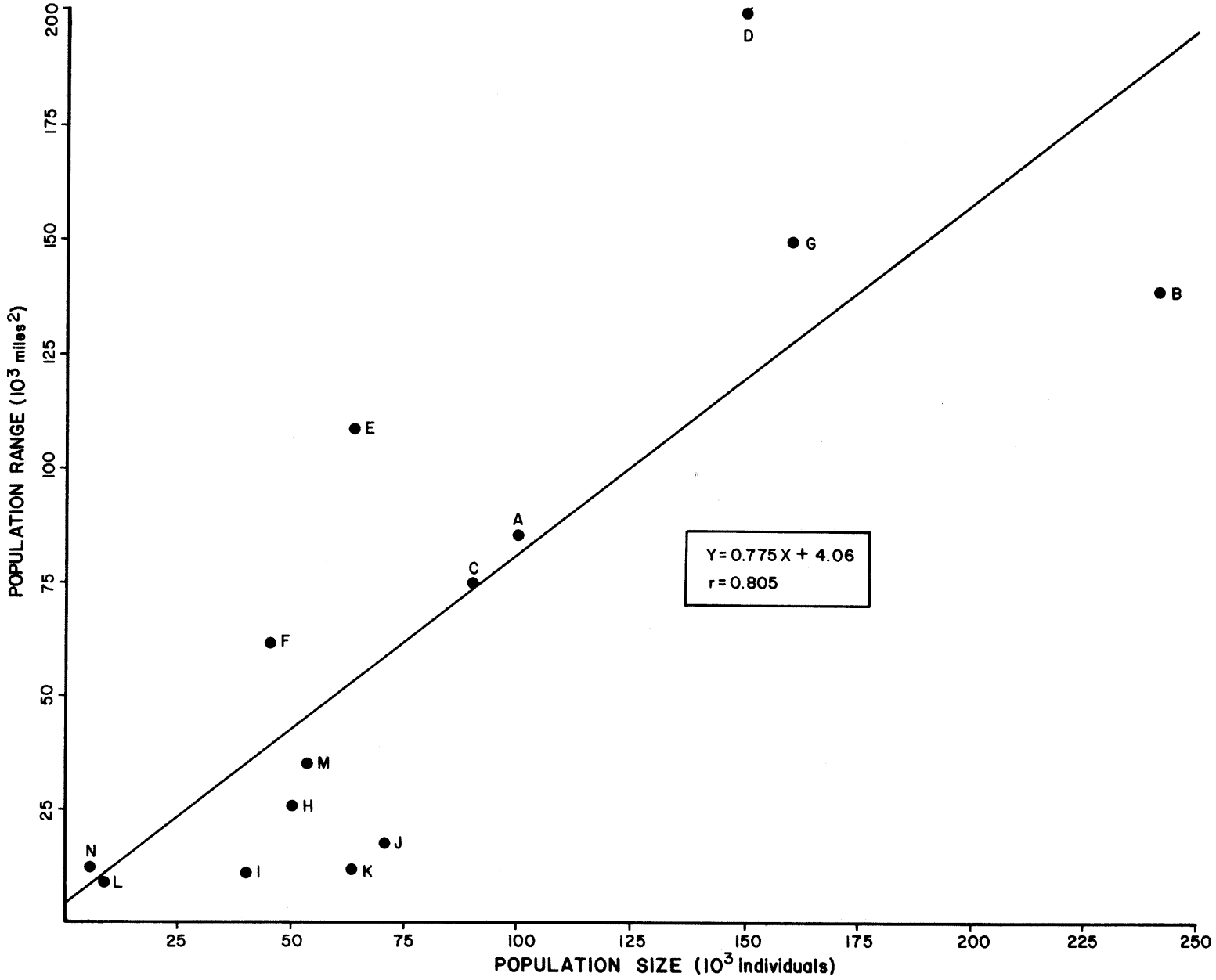

Figure 3. Relationship between herd size and range area for barren-ground caribou.

To carry speculation one step further, we can ask whether there are behavioural or physiological indicators which could tell us when a population might begin to grow or decline. Comparing descriptions of caribou behaviour in different populations, one is struck by reported differences in such parameters as group size and composition, length of time young remain with the female, duration of nursing, and response of females with new-born calves to disturbance. Are these differences a result of adaptations to different environments, or do they represent behaviour at different stages in a population cycle?

Even if management were as simple as just regulating the annual kill to the difference between recruitment and natural mortality, we would still be in trouble. With the exception of Miller's (1974) life table for the Kaminuriak herd, the mortality rates for the Northwest Territories caribou are unknown. With the exception of the work of Miller (1975), Parker (1973), and Kuyt (1972), very little is known about the wolves of the barren-lands and their effect on caribou.

Management of Sub-populations

Another poorly understood aspect of caribou biology, with important implications for management, is the existence of sub-populations within caribou herds. Groups consistently wintering in separate parts of the range have been reported from the Porcupine herd, Bathurst herd, Kaminuriak herd, and Baffin herd. It is unknown whether animals return to the same wintering group each year. If they do, then wintering groups might have to be managed separately, since the majority of caribou are killed on, or enroute to, the winter ranges.

Continued programs of marking animals with colored collars or radio transmitters seem to be called for to determine the fidelity of individuals to certain winter ranges. Such marking programs would also provide information such as that from the work of Miller et al (1975), on the social structure of the population.

Managing the Hunters

Caribou still provide food for a large proportion of the increasing native population of the Northwest Territories. Both Indians and Eskimos think of themselves as caribou hunters and believe that caribou hunting is one of the proper pursuits of man. Moreover, aircraft, snowmobiles, and rifles have provided them with the means to locate and kill caribou virtually at will. The potential exists, not only for overkill, but for harmful harrassment of the caribou during hunting.

Unfortunately, a formidable language barrier exists in most native communities. Several Indian languages, and several different Eskimo dialects make communication difficult. In addition, the concept of sustained yield, as we understand it, is foreign to native hunters. Often they are unaware that several communities are hunting the same herd. Kill statistics based on hunter returns (the current system in most of the Northwest Territories) are unreliable because the hunters either unintentionally or intentionally misrepresent their kill. Native people consider aerial surveys and other management practices at best pointless, at worst, harmful to the caribou.

The atmosphere is becoming polarized. Many native people see hunting laws as an infringement of their aboriginal rights. They see all white

man's activities, including our surveys and tagging programs, as harmful to the caribou, which of course, they potentially are. Before caribou management can proceed very far, regardless of our biological understanding of the caribou, ways must be found to foster greater understanding and co-operation between the people who hunt the caribou and those who manage them.

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