POPULATION AND RECRUITMENT ESTIMATES FOR THE LORILLARD AND WAGER CARIBOU HERDS IN 1977

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ABSTRACT

From June to September 1977, I surveyed caribou herds ranging south and north of Wager Bay, District of Keewatin, N.W.T. These herds are referred to as the Lorillard and Wager herds respectively. Population estimates were 1,400 ± 390 in the Lorillard and 2,900 ± 500 caribou one year and older in the Wager herd. These estimates are significantly lower than the 1976 Lorillard and Wager estimates and higher than the 1974 Wager estimates. The herds may have shifted their distributions between years, or the 1974 and 1977 surveys may have incompletely covered the calving grounds. Recruitment in the Lorillard herd was not determined. In the Wager herd in late summer, calves represented 20.2 ± 1.4% of the total population in 1976, and 20.3 ± 1.1% in 1977. In August-September 1977, 12.5% of the adult population were yearlings. This level of recruitment is indicative of a stable or increasing population.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The Lorillard and Wager caribou (Rangifer tarandus groenlandicus) herds are located in the northeastern portion of the District of Keewatin, Northwest Territories. The Lorillard herd roams south of Brown Lake, Ford Lake, and Wager Bay; the Wager herd lies to the north (Fig. 1). Little was known of the distribution or size of these herds before impact assessment of the proposed Polar Gas pipeline began in 1976 (Heard et al. 1980). This study was undertaken to continue the assessment of caribou in the area associated with the proposed pipeline development. From June to September 1977, these caribou herds were surveyed in order to estimate population size, recruitment and summer distribution.

There was little documentation of the Lorillard herd before 1976. Bowden and Helmer (1974) referred to caribou on the Quoich River and north of Chesterfield Inlet but reported no calving ground. Heard et al. (1980) delineated a calving ground in the 600 m highlands south of Wager Bay and estimated the population at 14,000 ± 3,400 adult caribou in 1976.

The Wager herd was investigated by Pendergast and Bowden (1973) who reported calving in the vicinity of Stewart, Curtis, and Pearce Lakes north of Wager Bay. The following year, Bowden and Helmer (1974) surveyed that area and delineated a calving ground south of Pearce Lake. They estimated a population of 144 adults on the calving ground and 200 adults overall. In 1976, Heard et al. (1980) surveyed the area after calving and estimated a population of 9,400 ± 1,060 (S.E.).

2. METHODS

2.1 Estimation of Numbers

2.1.1 Survey Design

Calving ground surveys were conducted in two stages. First, we flew reconnaissance flights over the range of the herd as delineated in 1976 by Heard et al. (1980) (Fig. 1). The transects were 1.6 km wide and systematically spaced 19.3 km apart, giving 8.3% coverage. The area was then stratified on the basis of calf density. Areas in which calves were concentrated were re-surveyed with transects 0.8 km wide. This provided a range of coverage from 19 to 28% (Table 1). The reconnaissance transects that did not fall within a high coverage stratum were treated, without re-surveying, as a separate stratum (Lorillard Stratum 2 and Wager Stratum 4).

Transects on the high coverage strata were selected by one of three methods (Table 1).

(1) The transects of Lorillard Stratum 1 were of unequal length. Spaces 0.4 km wide were left between transects to reduce the possibility of caribou moving to adjacent transects. The transects were sampled using pairs of random co-ordinates that determined points in the stratum (Jolly 1969, method 3). Those transects on which points fell were selected. The probability of selection was, therefore, proportional to the size of the transect. Despite a minimum space of 1.2 km between transect centre lines, high snow cover and few topographic features sometimes caused flight lines to overlap. Consequently, three transects on this stratum were not surveyed and two subsequently surveyed strata were systematically sampled. Without the three unsurveyed transects, the number of transects was still proportional to the area in each of four sections of the trapezoid-shaped stratum.

(2) Strata 1 and 3 of the Wager herd were surveyed with transects systematically spaced 3.2 km apart.

(3) The transects of Stratum 2 of the Wager herd were sufficiently short and coverage was sufficiently low that random sampling again proved feasible. As on Lorrillard Stratum 1, a 0.4 km strirp separated all possible transects. The equal-length transects were selected using single random numbers.

2.1.2 Aerial Census

The reconnaissance transects and Stratum 1 of both herds were surveyed in a Cessna 185 aircraft. We used a twin-engine Cessna 337 to survey Strata 2 and 3 of the Wager herd. Transects were flown at 120 m above ground level (agl). The pilot attempted to maintain a speed of 160 km/hr but winds frequently increased ground speed. Two observers with cassette tape recorders noted the numbers of adults and calves. The right observer sat beside the pilot, the right observer in the rear passenger seat. Tape on the wing strut marked approximately 0.4 or 0.8 km on each side of the aircraft. Caribou numbers were rarely estimated; large groups were usually circled and counted precisely.

2.1.3 Analysis

The estimate of total numbers, $\hat{Y}_h$, for a given stratum is $\hat{Y}_h = N\bar{y}$ for transects of equal length and $\hat{Y} = Z\bar{d}$ for transects of unequal length, where N = total number of possible transects, $\bar{y}$ = mean number of caribou per surveyed transect, Z = area of the stratum, and $\bar{d}$ = mean density of caribou per transect ($\frac{1}{n}\sum\frac{Y_i}{z_i}$ where Y_i = number of caribou on transect i, z_i = area of transect i, n = number of transects surveyed). The population estimate, $\hat{Y}$, is the sum of the strata estimates.

The variance of the population estimate, Var $\hat{Y}$, is the sum of the variances of the strata estimates. The standard error of each population estimate, $s_{\bar{y}}$, is $\sqrt{\text{Var } \hat{Y}}$. The difference between population estimates was tested for departure from Ø using

$$t = \frac{\hat{Y}_1 - \hat{Y}_2}{\sqrt{\text{Var } \hat{Y}_1 + \text{Var } \hat{Y}_2}}$$

with $n_1 + n_2 - 2$ degrees of freedom where n = total number of transects surveyed.

Systematic sampling may yield a biased estimate of Var $\hat{Y}$ (Mendenhall et al. 1971, Cochran 1977). If the caribou were randomly distributed with respect to the transects, random and systematic sampling would have equivalent variances. However, the caribou were clumped (Table 2). Systematic sampling of clumped populations is more precise (i.e. $\hat{Y}$ has a lower variance) than random sampling. However, an estimate of the true variance of $\hat{Y}$ cannot be obtained from a single systematic sample. The variance of the four systematically sampled strata was estimated using formulae based on random sampling or random distribution. These overestimate the true variance so that tests based on these estimates should be conservative.

For transects of equal length and sampling without replacement (Wager Strata 1,2,3), Var $\hat{Y}$ was obtained as follows:

$$\begin{aligned}
\text{Var } \hat{Y} &= \text{Var } (N\bar{y}) \ \frac{(N-n)}{N} \\
&= N^2 \text{Var } \bar{y} \ \frac{(N-n)}{N} \\
&= N^2 \frac{S_y^2}{n} \ \frac{(N-n)}{N} \\
&= \frac{N(N-n)}{n} \ s_y^2
\end{aligned}$$

where Var $\bar{y}$ = variance of the mean number of caribou per transect and s_y^2 = variance in the number of caribou among transects (sample variance). $\frac{(N-n)}{N}$, the unsampled portion of the stratum or the finite population correction factor, adjusts the variance estimate for sampling without replacement. This correction causes Var $\hat{Y}$ to approach zero as n approaches N. The resulting equation is equivalent to Jolly's (1969) method 1.

For transects of unequal length and sampled with probability proportional to their length (Lorillard Stratum 1), Var $\hat{Y}$ was derived in an analogous manner:

$$\begin{aligned} \text{Var } \hat{Y} &= \text{Var } (Z\bar{d}) \left(\frac{Z - \bar{z}n}{Z}\right) \\ &= Z^2 \text{ Var } \bar{d} \left(\frac{Z - \bar{z}n}{Z}\right) \\ &= Z \frac{s_d^2}{n} (Z - \bar{z}n) \end{aligned}$$

The expression differs from that of Jolly's (1969) method 3, as that method assumed sampling with replacement (i.e. transects may be counted more than once), whereas this equation does not.

For transects of unequal length and sampled systematically (Lorillard Stratum 2 and Wager Stratum 4),

$$\text{Var } \hat{Y} = \frac{N(N-n)}{n} \quad (s_y^2 - 2\hat{R}s_{zy} + 2\hat{R}^2 s_z^2)$$

where $\hat{R} = \frac{y}{z}$ = ratio of caribou counted to area searched, $s_{zy} = \frac{1}{n-1} \frac{(\xi zy - (\xi z)\ (\xi y)}{n})$, = covariance between number of caribou and area of each transect, and s_z^2 = variance in area of transects (Jolly 1969, method 2).

2.2 Population Structure

Aerial surveys were flown in a Cessna 185 aircraft at 160 to 190 km/hr and 60 to 75 m agl. In the June aerial surveys, caribou were classified as adults or calves. Calves were distinguishable by their small size and reddish pelage. By late summer the calves had moulted to adult-like pelage, but were still obviously small. During the summer surveys of the Wager herd we recognized three classes: calves, mature bulls and "others". Bulls, 3 or 4 years and older, carried antlers longer than 70 cm. "Others" included cows, yearlings, 2 year and possibly 3 year old bulls.

To estimate yearling numbers, we segregated caribou from the ground between 25 July and 7 August and from 26 August to 3 September. On that survey we recognized six classes: mature bulls, young bulls (2 and possibly 3 years old), yearling males, yearling females, cows, and calves. Young bulls, yearlings and cows were similar in body and antler size. First, we determined the sex of the caribou and then classified them as yearlings or adults based on body size, antler length and antler development. Sex was determined by checking for the vulva when the tail was slightly raised (Bergerud 1961, Skoog 1968). Inability to detect a penis or udder was not considered a reliable criterion for sexing. Those classified as yearling females typically had antlers about 18 cm long with one or two points per antler. Yearling males had antlers 20 to 30 cm long, usually with both bez and terminal tines.

The standard error of the proportions is estimated by $\sqrt{\frac{p(1-p)}{n-1}}$ (Cochran 1977) where p = the proportion a specific age class represents and n = sample size. This formula is based on a binomial distribution. It assumes not only that sampling is random but also that group composition is random (Cochran 1977). Since mature bulls do not associate with other age-sex classes (see 3.3.2 Associations among the age-sex classes), the probability that an individual belongs to a specific age-sex class depends on the classes of other group members. As this correlation increases the variance of the estimated proportion, the binomial formula may underestimate its actual variance.

3. RESULTS AND DISCUSSION

3.1 Distribution

The calving ground of the Lorillard herd was found on the high rolling hills south of Wager Bay and Ford Lake (Fig. 2). It was considerably smaller than the area delineated in 1976 and lay completely within the 1976 calving ground. The areas indicated in Fig. 2 contained 92% of the calves observed on the reconnaissance transects (n=40 caribou) and 94% of the calves observed on Stratum 1 (n=81). In both 1976 and 1977, the area immediately south of Brown Lake and Wager Bay was also surveyed in late August. In both years few caribou were seen. Possibly they had moved south to Chesterfield Inlet and to Roes Welcome Sound where caribou traditionally winter (Rippin and Bowden 1972).

Calving in the Wager herd was concentrated in two areas (Fig. 2). The larger area, south of Pearce Lake, enclosed two calving areas mentioned by Bowden and Helmer (1974). A smaller, denser concentration of cows and calves occupied the hilly terrain south of a string of large unnamed lakes draining Stewart Lake. This calving ground is adjacent to what Bowden and Helmer (1974) suggested might be a smaller calving area. The two calving areas contained 86% of the calves observed on reconnaissance flights (n=36) and 96% of the calves observed on Strata 1 to 3 (n=218).

The Wager calving grounds, like those of the Lorillard herd to the south and Melville herd to the northwest, are on a height of land. All calves were found above 300 m elevation, most above 450 m. During late June, the cows and calves move south to join the bulls along the north shores of Brown and Ford Lakes and Wager Bay (Heard et al. 1980). They remain there until at least early September and possibly all winter. The caribou wintering on the west coast of Roes Welcome Sound north of Wager Bay (Rippin and Bowden 1972) may be from the Wager herd.

3.2 Population Size

The estimated size of the Lorillard herd in 1977 was 1,400 $\pm$ 390 caribou 1 year of age and older (Table 3). This is one-tenth the 1976 estimate (Table 4, Heard et al. 1980). Although the estimated size of the Wager herd in 1977 was 2,900 $\pm$ 500 (Table 3), it was less than one third of the 9,400 caribou estimated in 1976 (Table 4).

Three explanations for the difference in estimates between years are possible. First, unusually high mortality affecting all age classes equally may have caused a decline from 1976 to 1977. However, this is unlikely. Hunting is not an important mortality factor in these herds. Mortality due to severe weather can also be discounted because the Kaminuriak herd wintering near Baker Lake was not affected. Its estimated size did not differ between 1976 to 1977 (Heard 1980). Disease is rare in barren-ground caribou and has caused no widespread mortality since studies began in 1948 (Kelsall 1968).

Second, the populations may have changed little in numbers; the 1977 surveys may simply have found only a fraction of the actual numbers by missing concentrations of cows and calves. At first this appears unlikely for the following reasons: (1) the observers were equally experienced, hence there is little chance that observer bias could account for the order of magnitude differences in population estimates; (2) without knowledge of the 1974 Wager survey, I found concentrations of cows and calves in approximately the same areas as Bowden and Helmer had in 1974, and only in those areas, which suggests calving grounds were not overlooked in either year; (3) The 1977 reconnaissance flights of the Wager herd (Fig. 1) covered the entire area in which caribou were found in 1976. The 1977 Lorillard survey included all the 1976 calving ground and much of the area where bulls were found (Heard et al. 1980). However, the 1976 Wager survey began 17 days later than the first reconnaissance flights in 1977, and 24 days later than in 1974. The 1976 Lorillard survey started 11 days later than the 1977 survey. By late June, when the 1976 surveys were conducted, the cows and calves may have already been converging from dispersed calving areas into a more dense concentration.

Third, the different estimates of population size may reflect changes in distribution rather than numbers. Immigration may explain the estimated increase in the Wager herd between 1974 and 1976. (Recruitment is inadequate to account for this increase.) A similar increase occurred in the Melville herd on the Melville Peninsula northwest of Wager Bay at the same time. During calving surveys

from 1972 to 1974, Rippin and Bowden (1972), Pendergast and Bowden (1973) and Bowden and Helmer (1974) estimated 1,300 to 6,000 caribou on the Melville Peninsula. In 1976, Calef and Helmer (1980) found a population of 42,000 ± 7,200. Although population shifts to new calving grounds are infrequent, they are far from unprecedented. Skoog (1968) and Kelsall (1968) have both documented several cases in which groups of caribou as large as 25,000 and 30,000 calved up to 880 km away from their previous year's calving ground.

Where could an influx of caribou to Wager Bay and the Melville Peninsula come from? The Kaminuriak herd to the southwest has been declining. However, this decline appears to result from overhunting (Heard 1980). Boothia Peninsula to the northwest has supported only a sparse population in recent times (Anon. 1960, Fisher et al. 1977). Caribou occasionally cross Fury and Hecla Strait from north Baffin Island to the Melville Peninsula (R. Redhead, N.W.T. Wildlife Service, pers. comm.). Although little is known of north Baffin caribou, the migration of 60,000 would likely have been detected. The Beverly herd calves west of Aberdeen Lake and typically winters south of the treeline in Saskatchewan and in the District of Mackenzie, N.W.T. It was last estimated at 124,000 in 1974 (Moshenko 1974). Hunters occasionally shoot caribou tagged from this population north of Baker Lake and Chesterfield Inlet east to Daly Bay (Parker 1972a). The Beverly herd seems a likely source of the Wager-Melville caribou. Possibly a segment wintered on the tundra, as the Kaminuriak herd has since 1975. Their winter movements or a spring migration could have carried them to appropriate habitat for calving near Wager Bay and on the Melville Peninsula.

Similarly, a change in calving grounds could explain the apparent decline in numbers between 1976 and 1977. Selection for calving-ground fidelity in tundra-wintering caribou should be weaker than in caribou wintering in forests that are far from calving areas. The spring migration of forest-wintering herds brings them to the calving ground immediately prior to calving. The cost of calving away from traditional sites must be great, for the drive to reach the calving ground may supercede even that to tend the calf itself. When

the migration is slowed by snow conditions, calves born en route may be deserted as their dams continue toward the calving grounds (Bergerud 1974). Caribou wintering on the tundra are considerably closer to their traditional calving grounds. Their winter movements may lead them close to several areas appropriate for calving. If one of these areas is nearby in spring, pressure to return to the previous year's calving site may not be strong. In 1977 the Wager Bay caribou herds may have dispersed to other areas for calving.

To conclude, changes in population estimates of the Wager and Lorillard herds from 1976 to 1977 cannot be accounted for in terms of recruitment or mortality. The herds may have shifted their entire distributions or may calve over a larger area than the surveys suggest. Whether or not the populations found near Wager Bay during the spring and summer of 1976 still occupy the area in the same numbers can be determined only by further surveys.

3.3 Group Size and Associations among the Age-Sex Classes

3.3.1 Group Size

During June, groups on the calving grounds were larger than those in the surrounding areas. The largest group on the calving ground was estimated at 150 to 200 caribou, whereas the largest group elsewhere was 12. In the Lorillard herd, mean group sizes including calves, on and off the calving ground, were 6.7 and 2.5 respectively (Table 5). In the Wager herd, group sizes showed the same trend, respectively 7.5 and 2.4 on and off the calving grounds. In June 1976, Heard et al. (1980) found similar sizes on the Lorillard calving ground, groups averaged 7.9; after calving in the Wager herd the average group size was 7.8.

By mid-summer (5 July - August) the Wager cows and calves had moved south to join the bulls on the north shore of Brown and Ford Lakes and Wager Bay. The June nursery groups had disbanded. Group size was similar to that outside the calving ground in June, averaging 2.5 and ranging up to 15 (n=96). This pattern persisted until at least 26 August to 2

September when group size still averaged 2.4 ± Ø.35 and ranged up to 11 (n=43).

3.3.2 Associations among the Age-Sex Classes

To examine associations among the age-sex classes, I combined the August ground classifications with those of the adjacent Melville caribou herd on the Melville Peninsula. The Melville herd, like the Wager, winters on the tundra, forms no large post-calving aggregations, and appears to undergo no long migrations. Mean group size for the Melville herd during 22 August to 25 August 1977 (2.3 ± Ø.18, n=88) did not differ from the Wager herd in late August.

Group composition was not random. Whether an individual was associated with a particular group depended on its age and sex. Nearly all calves (96%) were in the company of cows (Fig. 3). Most yearlings (81%) were also associated with cows and only 2 of 43 were seen with mature bulls. As caribou age from calves to 2 and 3 year olds, they spend less time with cows and more time alone (Fig. 3).

Male and female yearlings did not differ in the company they kept (Table 6). In particular, yearling males were no more likely to associate with 2 year and older bulls than were female yearlings (Table 7). Two year old bulls differed significantly from yearlings in their associations (Table 8); their behaviour resembled that of cows (Fig. 3). They spent more time alone and less time with cows than did yearlings. Thus, during the first 2.5 years of a caribou's life, only its age and not its sex determines the associations. Half of 3 year and older bulls were found with other mature bulls; most others were alone (45%) (Fig. 3). Similarly, 46% of cows were seen with other cows; most others were alone (13%) or with only calves and/or yearlings (35%).

That most yearlings were in the company of a cow suggests caribou in the Wager herd may stay with their mothers during their second summer. Selection should favor a strong cow-calf bond during the first winter when antlered cows can dig and defend feeding craters for their calves. After the first winter,

selection, and hence the bond, should weaken. Whether cows and yearlings remain together during the second summer may depend on herd behaviour. Forest-wintering herds undergo long spring migrations and form post-calving aggregations that may number in the tens of thousands. During these migrations or post-calving movements, cows may be separated from their offspring. However, tundra-wintering caribou, such as the Wager herd, apparently make no long migrations and remain in small groups throughout the year. Therefore a weak cow-yearling bond may be sufficient to keep cows and yearlings together in tundra-wintering caribou during their second summer.

3.4 Population Structure

3.4.1 June

Calves on the calving grounds comprised 33% of the Lorillard herd and 25% of the Wager herd (Table 9). This is lower than that of other caribou herds just after calving. The theoretical maximum percent calves on the calving grounds (if only parous cows and their young are present) is 50%. After the peak of calving in 1968, Parker (1972b) found 44.4% calves on the calving ground of the Kaminuriak herd. In 1977, Heard (1980) found 45% calves on the Kaminuriak calving ground.

Possibly the low calf proportion in the Wager Bay herds reflects a greater representation of other age classes on the calving grounds than in other herds. Alternatively our surveys may have begun after high neonatal mortality had reduced the calf proportion. On 4-5 June, when reconnaissance flights began on the Lorillard herd, we saw few calves (5/58 caribou). However, most transects were off Stratum 1, the calving area. Bad weather prevented further flights until 10 June, when we found 34% calves (n=123). From then until 21 June, the proportion of calves on the calving grounds (high coverage strata) declined (arcs in transformations or proportions, $r = -0.883$, $p<0.05$, Fig. 4.). Calving may have finished by 10 June in the Lorillard herd and by 14 June in the Wager herd. Percent calves in the Kaminuriak herd south of Baker Lake had not started declining by 16 June 1977. Calving in the Lorillard

and possibly the Wager herds may have been a week or more earlier than in the Kaminuriak herd.

3.4.2 July to September

In 1977, the northern edge of the Lorillard range was surveyed briefly on 28 August and 3 September. We saw only 58 caribou of which 18 (35 ± 6.8% of the adults) were mature bulls and seven (12 ± 4.3% of the total) were calves. Few caribou were seen in this area in 1976.

Aerial surveys of the Wager herd in late August 1976 found 20.2 ± 1.4% calves (Table 10). In 1977, the herd was surveyed several times between 21 July and 3 September from both the air and ground (Table 11). There was little change throughout the season. Calves represented 20.3 ± 1.1% of the combined samples. There was no significant difference between aerial and ground samples (X^2 = 0.742, 1 df, p>0.30). The percentage of calves was similar in both years.

Calf numbers declined from at most 23% of the population in mid-June (Table 9) to 20% in late July and early August. By late August and early September they still represented 20% of the population. If calves comprise 25 to 31% of the population at birth, then most of the mortality between birth and early September must have occurred in June. This is consistent with the observations of Bergerud (1971), Parker (1972b), and Cameron and Whitten (1977). Despite different summer weather, relative calf mortality did not vary between 1976 and 1977. In July and August 1976, there was a 6 week period at Wager Bay without rain. In 1977, it rained on at least 4 days at Repulse Bay between 17 June and 28 June. At Wager Bay it rained on at least 14 days between 16 July to 13 August. Summer rainfall appears to have a negligible effect on calf mortality.

Yearlings represented 13.4% of the adult sample (Table 12). Three year and older bulls represented 29.3 ± 1.8% of the adult sample in 1976 and 29.3 ± 1.4% in 1977. This proportion is typical of caribou herds that are not hunted for sport (Table 13). The similarity of estimates between years, between air and ground surveys, and to other herds suggests that

29% mature bulls is a reliable estimate. If the ground sample of mature bulls (Table 12) is adjusted to 29.3% then the percentage of yearlings is reduced to 12.5%.
In the Wager herd, the sex ratio did not differ from 1:1 among adults (31M:40F, X^2 = 1.49, p > Ø.2Ø) or yearlings (4M:6F).

3.5 Recruitment

Bergerud (1971), Parker (1972b), Walters, Hilborn and Peterman (1975) and Haber (1977) suggest that the demographic behaviour of caribou populations is determined by the mortality rate of calves. The fall calf crop is not a good index of a population's rate of increase. Declining populations may have 19% or more calves in late summer while populations may increase with as few as 13% calves (Table 14). If calf mortality remains higher than adult mortality through the first winter, then percent yearlings in the spring should vary more than percent calves in the previous summer or fall among populations with different rates of increase. Percent yearlings should be a better index of the population rate of increase than percent calves. In declining caribou populations, surveys find less than 11% yearlings in the spring (Table 14). Increasing populations have greater than 11% yearlings. Yearlings range from 1Ø or 11% to 15% in stable populations. The recruitment in the Wager herd, 13% yearlings, is indicative of a stable or increasing population.

A healthy recruitment level is also substantiated by another approach. Bergerud (1978) suggested that adult natural mortality is correlated with first year mortality and can be predicted from: $y = 13.8 - Ø.3865\ x$, where y = percent adult mortality and x = percent yearlings in the population. In an unhunted herd, recruitment should equal adult mortality when yearlings represent 9.95% of the population. In the Wager herd, the probability that the adjusted sample recruitment of 12.5% yearlings differs from this value is about 6Ø% (n = 88, X^2 = Ø.635, 1 df).

If Bergerud's model holds, this recruitment indicates the Wager herd is at least stable, if not increasing.

4. RECOMMENDATIONS

1. Greater knowledge of the movements and distributions of the Lorillard and Wager herds is needed to reduce the impact of potential pipeline development, to estimate numbers and hunter kill, and to assist in the delineation of the boundaries of Wager Bay National Park.

   The summer movements and distribution of the Lorillard herd are unknown. Information on the herd after it leaves the highlands south of Wager Bay is needed to control contact with exploration and development activities.

   Neither the Lorillard or Wager herds have been surveyed between September and June. Information on distribution at this time, and on areas hunted by the residents of Repulse Bay and Chesterfield Inlet is needed to estimate hunter kill. Three areas should be surveyed, the west coast of Roes Welcome Sound between Repulse Bay and Chesterfield Inlet, the north shore of Wager Bay inland to Brown Lake and the north shore of Chesterfield Inlet.

2. To minimize the impact of development and to increase the reliability of population estimates, it is necessary to determine the extent of the calving areas and variation between years. Caribou are most sensitive to disturbance during calving. Exploration activities should be controlled on calving grounds. When another census is conducted, reconnaissance flights should first cover the entire area above 300 m elevation to search for calves or cows. This includes the highlands south of Wager Bay and Brown Lake which swing to the northwest past Laughland Lake and the height of land extending from north of Wager Bay to north of 67° N.

3. To manage these herds for hunting, estimates of total number, recruitment and hunter kill are needed. Population estimates should be obtained every 2 to 3 years. In 1977, percent yearlings in August was used as a measure of recruitment; however, this estimate is best made in spring, when yearlings are smaller and recognizable from the air. Sample sizes are usually much larger from aerial segregations than from ground counts. Recruitment should be estimated at least every second year if the herds are hunted, less often if unhunted. Hunter kill should be obtained annually.

Table 1. Design of Lorillard and Wager herd censuses, June 1977.

Herd	Stratum	Date surveyed	Area (km^2)	No. of transects	Spacing of transects	Transect lengths	Percent coverage
Lorillard	1	June 14,15	3,339	14	random pps[1]	unequal	18.6
	2	June 4,5,12,13	20,668	10	systematic[2]	unequal	8.3
Wager	1	June 16	2,471	14	systematic	equal	26.4
	2	June 19	935	7	Simple random	equal	18.9
	3	June 21	586	8	systematic	equal	27.6
	4	June 12-15	2,085	10	systematic[2]	unequal	8.3

[1] Random with probability of selection proportional to the size of the transect.

[2] Reconnaissance transects.

Table 2. Spatial pattern of caribou on Wager herd strata with transects of equal area, June 1977.

Stratum	Mean caribou per transect ($\bar{y}$)	Variance among transects (s^2)	Co-efficient of dispersion[1]	p
Wager 1	17.4	540.6	31.0	<0.002
Wager 2	22.0	567.3	25.8	<0.002
Wager 3	17.2	239.1	13.9	<0.002

[1] The co-efficient of dispersion, $\frac{s^2}{\bar{y}^2}$ is compared with $F_{(n-1\ \infty)}$. If this co-efficient is greater than 1, the population has a contagious (clumped) distribution.

Table 3. Stratum and population estimates of the Lorillard and Wager herds, June 1977.

Herd: Stratum	Adult caribou observed	Estimated total $\hat{Y}$	Standard error (S.E.)	% Confidence limits[1]	Density caribou/km^2
Lorillard: 1	164	900	288	±69.1	0.27
Lorillard: 2	41	492	268	±123.0	0.02
Lorillard	205	1,392	393	±58.4	0.06
Wager: 1	244	924	283	±65.8	0.37
Wager: 2	154	814	300	±90.2	0.87
Wager: 3	138	500	135	±63.8	0.86
Wager: 4	54	648	258	±89.7	0.03
Wager	590	2,886	518	±34.6	0.12

[1] $\frac{\text{0.5 x 95\% confidence interval}}{\text{population estimate}} = \frac{(S.E._{\hat{Y}})\ (t_{0.05,n-1})}{\hat{Y}}$

Table 4. Population estimates of Lorillard and Wager herds in 1974, 1976 and 1977.

Herd	Year	Adult caribou observed	Population estimate ± standard error	Survey area (km^2)	Density (caribou/km^2)
Lorillard	1976[1]	1,378	14,000 ± 3,400	65,739	0.21
	1977	205	1,400 ± 390	24,007	0.06
Wager	1974[2]	36[3]	200	269[3]	0.75[3]
	1976[1]	1,876	9,400 ± 1,060	38,101	0.25
	1977	590	2,900 ± 500	24,841	0.12

[1]Heard et al. 1980.

[2]Bowden and Helmer 1974.

[3]Calving ground only.

Table 5. Group size in the Lorillard and Wager herds, June 1977.

Herd	Stratum	Dates	Mean group size excl.calves	Mean group size incl.calves	Range incl. calves	Number of groups
Lorillard	1	June 14,15	4.56	6.67	1-74[1]	36
	2	June 4-13	2.41	2.53	1-6[2]	17
Wager	1	June 16	5.95	8.27	1-72	41
	2	June 19	5.70	8.04	1-53	27
	3	June 21	5.11	5.85	1-32	27
	4	June 12-15	2.39	2.43	1-12	23
Lorillard 1 and Wager 1-3[3]			5.34	7.28	1-74[1]	131
Lorillard 2 and Wager 4			2.40	2.48	1-12[2]	40
Combined			4.65	6.16	1-74[1]	171

[1] Off transect 150 to 200 seen, on reconnaissance flight over Stratum 1, June 10.

[2] Off transect 13 seen.

[3] Calving grounds.

Table 6. Comparison of conspecifics with which yearling males and females associate[1]. Data from Wager and Melville herds, August 1977.

Others in group	Yearling females	Yearling males	Total
None	4[2]	1	5
Yearling and calves	0	2	2
Cows	7	4	11
Yearlings and cows	8	8	16
Yearlings, cows and bulls[3]	3	0	3
Cows and bulls[3]	2	1	3
Bulls[3]	0	1	1
Total	24	17	41

Test of independence: $G = 10.212$, 6 df, $p > 0.10$

[1] Excluded are two yearlings of unknown sex; one was with a cow, the other with a group of cows, calves, yearlings and a bull.

[2] The estimate of lone female yearlings may be biased. Yearling females and cows are the most difficult classes to separate. The difficulty is aggravated when they are alone.

[3] Bulls = males 2 years and older.

Table 7. Observed and expected numbers of yearling males and females with 2 year and older bulls (Wager and Melville herds).

	Yearling females	Yearling males
Observed number with bulls	5	2
Expected number with bulls	4.2[1]	2.8

Test of goodness of fit: $X^2 = 0.381$, 1 df, $p > 0.50$

[1] Percent yearling females x number of observations of a yearling of either sex in the company of a bull = 0.6 x 7 = 4.2.

Table 8. Comparison of frequency with which yearlings and 2 year old bulls associate with different age-sex classes. (Wager and Melville herds).

Others in group	Yearlings	2 year old bulls
None	5	8
Cows	13	1
Cows and yearlings and/or 2 year old bulls	22	6
Yearlings and calves	2	0
Mature bulls	1	1
Total	43	16

Test of independence: $G = 12.568$, 4 df, $p < 0.05$

Table 9. Percent calves on and off the Lorillard and Wager calving grounds in 1977.[1]

Herd	Location	Percent	Sample Size
Lorillard	Stratum 1 (calving ground)	33.3	393
	Stratum 2	11.4	158
	Total	27.0	551
Wager	Stratum 1 (calving ground)	26.0	504
	Stratum 2 (calving ground)	29.6	277
	Stratum 3 (calving ground)	12.9	163
	Stratum 4	5.3	75
	Sub-Total (calving grounds)	24.8	944
	Total	23.4	1,019

[1] Calving ground estimates include data from both reconnaissance and census flights.

Table 10. Aerial segregations of the Wager herd in August 1976.

Date	Calves (%)	Bulls(%of adults)	Others	Total Adults	Total Adults+calves
Aug. 20	106 (20.5)	118 (28.8)	292	410	516
Aug. 30	48 (19.2)	58 (28.7)	144	202	250
Aug. 31	8 (21.6)	12 (41.4)	17	29	37
Total	162 (20.2)	188 (29.3)	453	641	803

Table 11. Segregated counts of the Wager herd, July to September 1977.

Survey type	Date	Calves (%)	Mature (% of bulls adults)	Others	Total Adults	Total Adults+Calves
Aerial	July 21	38 (21.2)	23 (16.3)	118	141	179
	August 27	142 (21.3)	146 (27.8)	379	525	667
	August 28	37 (19.2)	61 (39.1)	95	156	193
	September 3	6 (20.0)	10 (41.7)	14	24	30
	Aug. + Sept.	185 (20.8)	217 (30.8)	488	705	890
	Total	223 (20.9)	240 (28.4)	606	846	1,069
Ground	July 25 - Aug. 7	44 (18.8)	68 (35.8)	122	190	234
	Aug. 26 - Sept.2	19 (18.4)	20 (23.8)	64	84	103
	Total	63 (18.7)	88 (32.1)	186	274	337
Aerial + ground	Total	286 (20.3)	328 (29.3)	792	1,120	1,406

Table 12. Ground segregations of the Wager herd, 26 August to 2 September, 1977.

Date	Mature bulls	Young bulls	Cows	Yearlings			Calves	Unknown	Total
				Male	Female	Unknown			
August 26	2	3	6				3		14
August 27			11				4		15
August 28	1								1
August 29	2		2	1			1		6
August 31	7	4	14	1	5	1	8	3[1]	40+3
September 1	5	3	4	2	1		1		16
September 2	3	1	3				2		9
Total	20	11	40	4	6	1	19	3	101+3
Percent of adults	23.8	13.4	48.8	13.4			-	-	

[1] One a female yearling or calf, the others likely yearlings or cows.

Table 13. Percent of mature bulls in different caribou herds.

Percent mature bulls[1]	Herd	Year	Sport hunted	Reference
36.1	Melville	1977	no	unpublished data
31.3	Bathurst	1977	no	Calef and Boxer 1977
27.8	Kaminuriak	1977	no	Heard 1980
29.3	Kaminuriak	1968	no	Parker 1972b
29.3	Fortymile	1954	yes	Skoog 1968
22.9	Nelchina	1956	yes	Skoog 1968
17.8	Nelchina	1962	yes	Skoog 1968
25-14[2]	Interior	1957-67	yes	Bergerud 1971

1 Bulls 3 years and older as percent of herd excluding calves.

2 Two year and older bulls declined from 29.6% to 18.9%. Two year old bulls assumed to be about 5% of the adults

Table 14. Comparison of recruitment and status of different caribou populations.

July - November			February - May					
% Calves	Years[1]	Range	% Calves	Years[1]	Range	Herd status	Location	Reference
			22.7	(1)		increasing	Southampton Island, NWT	Helmer 1977
20.6	(6)	19.0-22.3	20.1	(7)	18.2-22.4	increasing	Alaska	Skoog 1968
	-		15.3	(13)	6.9-26.6	stable?	Mackenzie and Saskatchewan	Kelsall 1968
	-		11.2	(7)	4-17	incr. and declining[2]	Labrador	Bergerud 1967
13.4&19.6[3]	(11)	5.5-24.0	11.0	(7)	5.3-27.4	increasing	Newfoundland	Bergerud 1967
	-		19.9[4]	(1)		stable?	Mackenzie and Saskatchewan	Thomas 1969
19.2	(4)	12.0-24.0	10.4	(3)	7.7-12.0	declining	Keewatin and Manitoba	Parker 1972b
14.8	(1)		10.1[5]	(1)		stable?	Yukon and	Calef and Lortie 1973
18.6	(2)	18.2-18.9	6.5[6]	(1)		unknown	Alaska	Cameron and Whitten 1977
6.1	(3)	0.0-17.1	0.0	(2)	0 - 0	declining	Arctic Islands	Miller, Russell and Gunn 1977

Note: (See next page for Notes 1-6)

Table 14 (Cont'd)

NOTE

1 Number of years on which unweighted mean based.
2 Based on two herds with the same recruitment.
3 Interior plus Humber and Avalon herds respectively. Short yearlings based on Interior herd only.
4 Weighted mean of three herds ranging from 9.2 to 14.1% calves.
5 $\frac{\text{long yearlings}}{\text{yearlings + adults}}$ in October
6 $\frac{\text{yearlings}}{\text{yearlings + adults}}$ in July

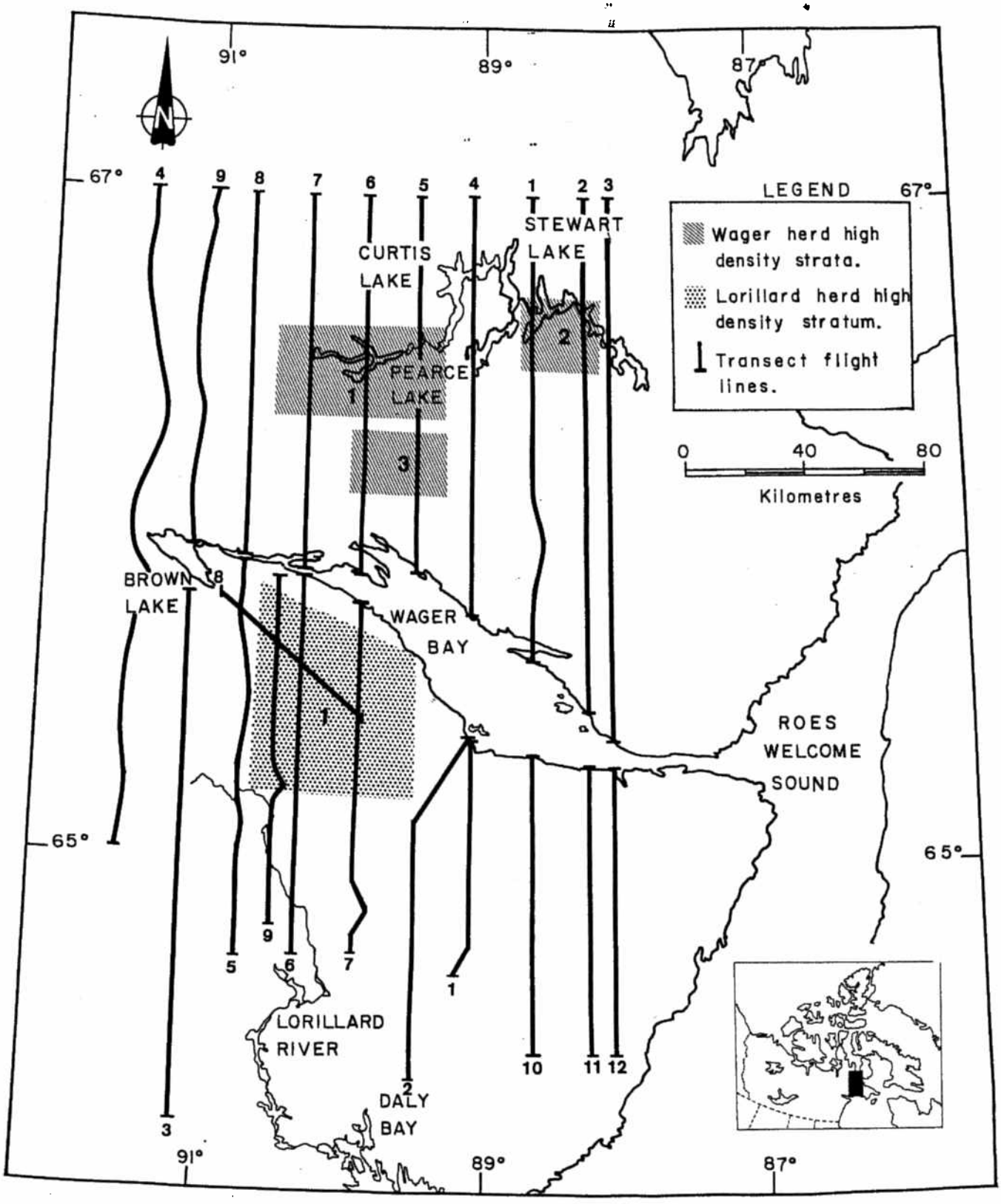

Figure 1. Location of reconnaissance transects and higher coverage strata, Lorillard and Wager caribou herds, June 1977.

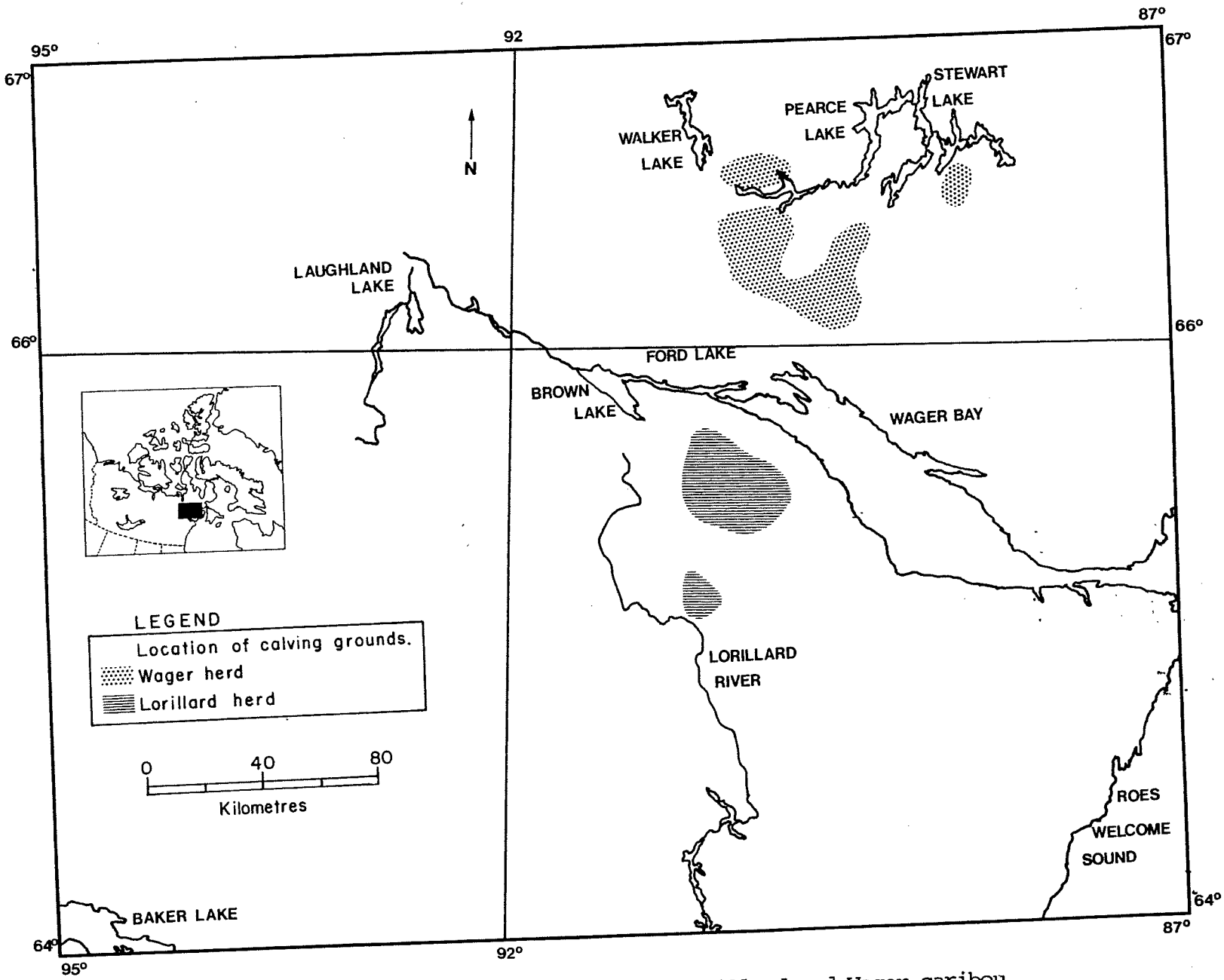

Figure 2. Location of calving grounds of Lorillard and Wager caribou herds, June 1977.

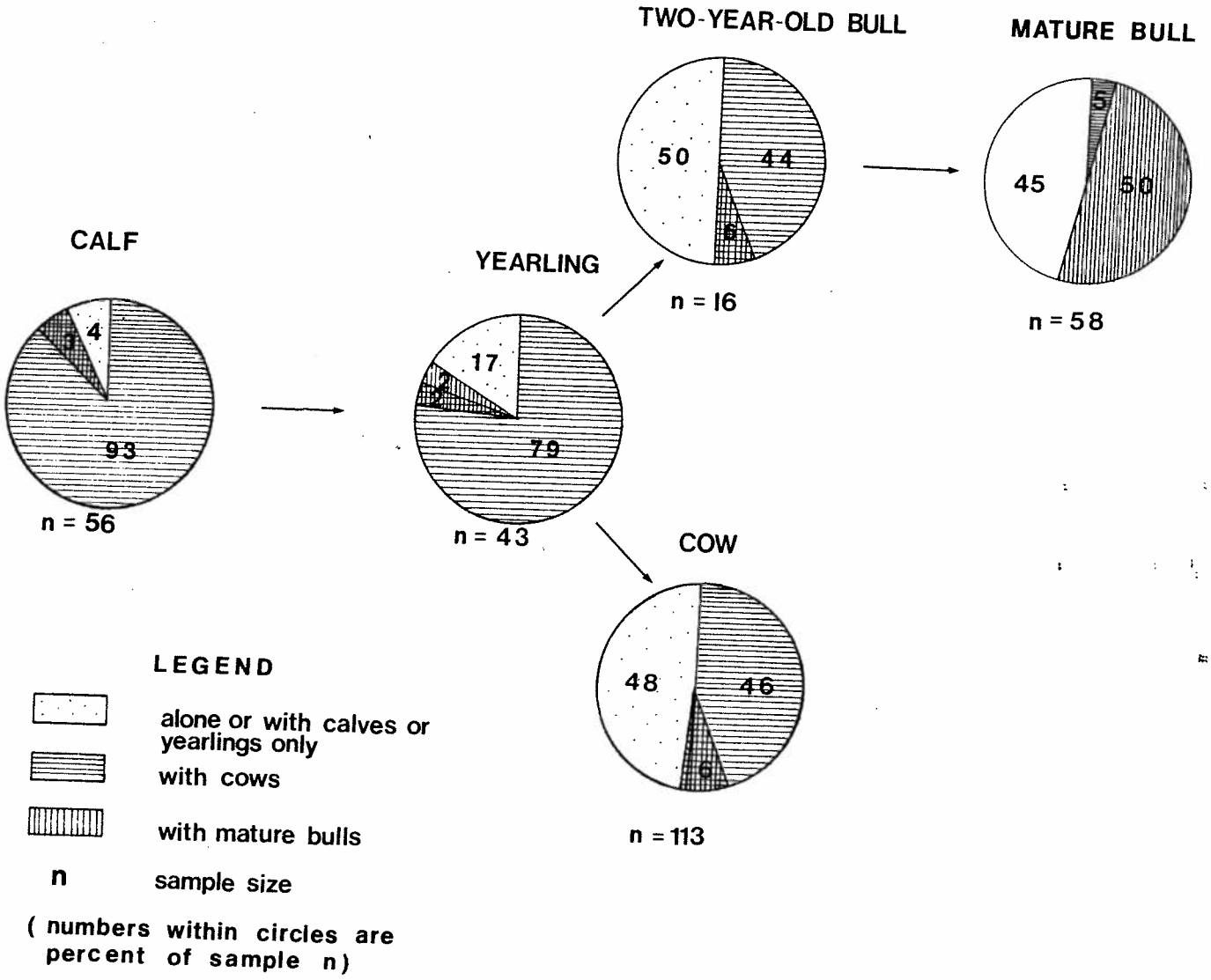

Figure 3. Associations among the age-sex classes, Wager and Melville herds, 22 August - 3 September, 1977.

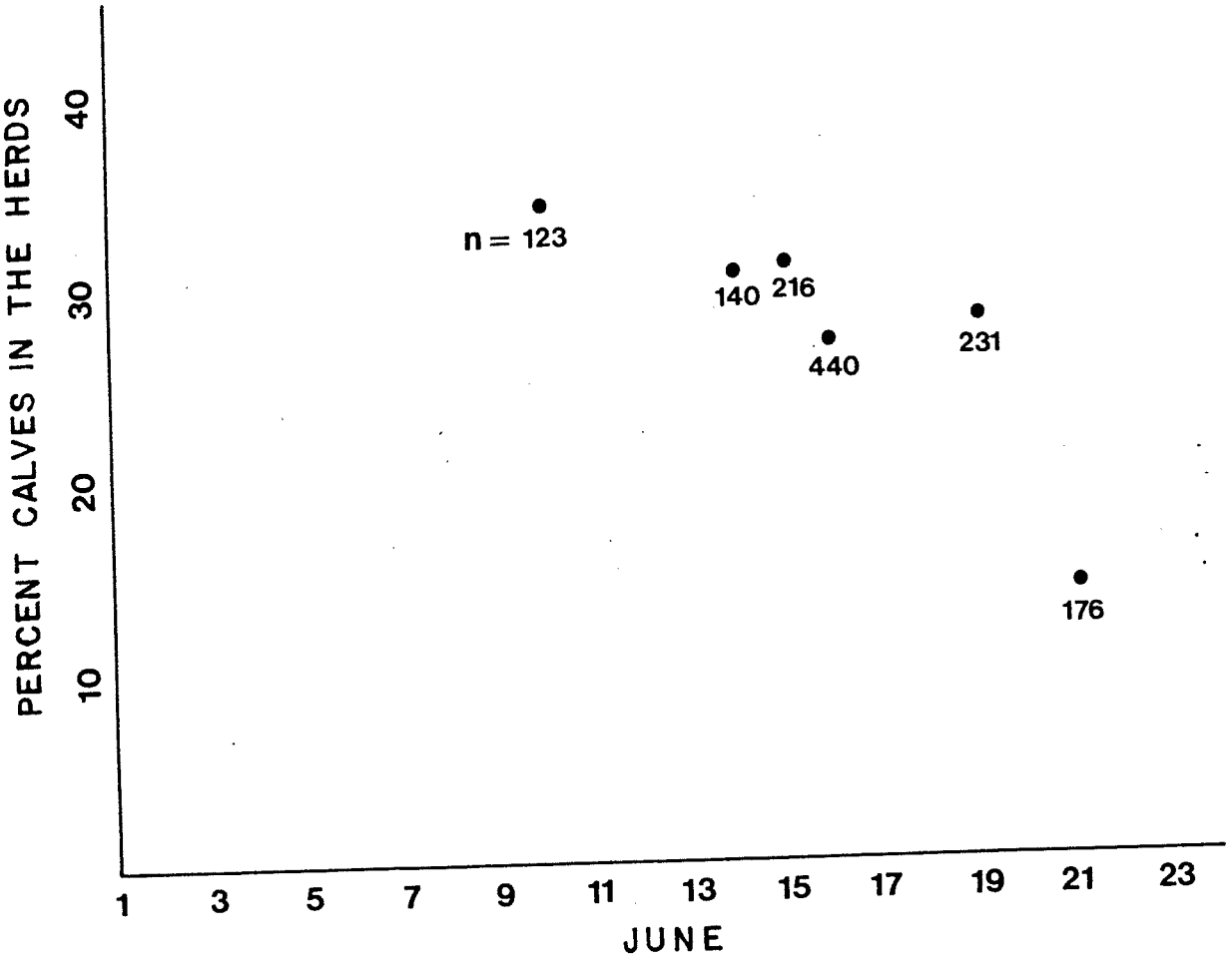

Figure 4. Decline in percent calves, 10-21 June, 1977, in Lorillard and Wager herds combined.

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Appendix A. Spring Break-up 1977

APPENDIX A. Spring Break-up 1977.

Snow cover from 4 June to 15 June averaged between 60 and 70% (Fig. A-1). High elevations had 85 to 100% snow cover and low areas had as little as 25 to 40%. The last snow fell about 11 June. Clear skies and warm weather between 14 June and 21 June increased melt, leaving about 30% snow cover on 21 June. By late July, a few snow patches remained on south facing slopes. In winter, snow accumulates on those slopes from the prevailing north wind. On calm July days, caribou stand on snow patches for relief from insects. By late August all remnants of snow had gone.

On 1 June, Ford Lake was still frozen, but there was too much overflow to land on the bay by the abandoned Hudson Bay post. A Cessna 185 aircraft could land on Brown Lake until at least 15 June, despite considerable overflow between 7-14 June. By my departure 28 June, Brown Lake was open around the shore. Ford Lake was still frozen except for the bay of the Hudson Bay Company post. On my return 16 July, Ford Lake was ice-free. On Brown Lake there was sufficient open water close to shore for a float plane to land.

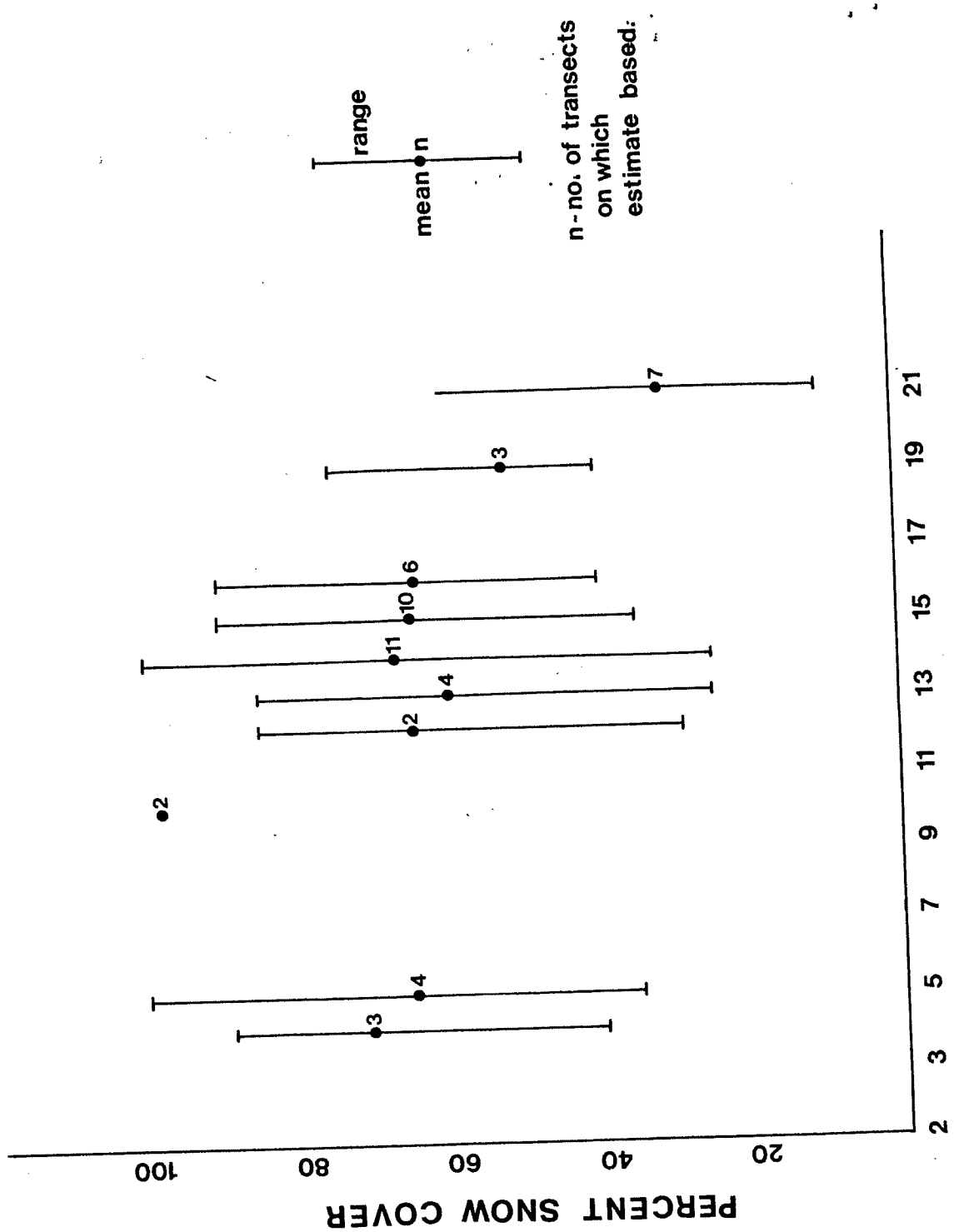

Figure A-1. Change in percent snow cover in June 1977, Wager Bay area.

APPENDIX B. Summary of Observations of the Lorillard Herd, June 1977.

B-1. Lorillard herd reconnaissance transects. Stratum 2[1].
Left observer: Tran. 1-7, M.L. Broderick, Tran. 8-12,
L. Ussak Right observer: J.L. Donaldson.

Transect	Date	Length (km)	Adult caribou	Calves	Groups	Percent snow cover
1	June 4	90	0	0	0	80
2	June 4	122	2	0	1	40 - 85
3	June 4	193	1	0	1	50 - 90
4	June 5	116	0	0	0	50 - 90
5	June 5	134	0	0	0	40 - 80
6	June 5	130	4	1	3	35 -100
7	June 5	122	5	3	4	h45 - 70
8	June 10	58	11	5	1	98
9	June 10	121	57	30	9	98
10	June 12	101	1	0	1	30 - 85
11	June 13	98	17	1	7	50 - 85
12	June 13	82	17	0	5	45 - 80
Total		1367	115	40	32	
Mean	June 7-8	113.9	9.6	3.3	2.7	70.9

1 The following were excluded from Stratum 2 because they overlapped Stratum 1:

Tran.6: 63.6 km and 1 adult

Tran.7: 55.5 km and all caribou sightings

Tran.8 and 9: total transect

Table B-2. Lorillard herd recconnaissance transects, Stratum 1[1]. Left observer: L. Ussak. Right observer: J. Donaldson.

Transect	Date	Length (km)	Adult caribou	Calves	Groups	Percent snow cover
1	June 14	71	3	Ø	2	3Ø - 8Ø
2	June 14	68	1Ø	4	2	35 - 6Ø
4	June 15	68	1Ø	2	5	5Ø
5	June 14	68	7	3	4	5Ø - 8Ø
6	June 15	66	16 - 19	4	3	5Ø
7	June 14	66	8	2	3	7Ø - 9Ø
8	June 15	64	68	39	9	7Ø
10[2]	June 15	64	1	Ø	1	85
12[2]	June 14	62	17	12	2	4Ø - 85
13[2]	June 14	6Ø	12	6	2	6Ø - 85
14[2]	June 14	55	Ø	Ø	Ø	55 -1ØØ
15	June 14	52	7	3	1	65
16	June 14	51	3	1	2	
17	June 14	47	Ø	Ø	Ø	6Ø - 95
Total	-	862	162 - 165	76	36	-
Mean	June 14-15	61.6	11.71	5.4	2.57	65.Ø

1 Transects 3, 9 and 11 were not flown because adjacent transects overlapped them.

2 No observations for left side of transect. Therefore, transect area is Ø.25 x length, not Ø.5 x length.

APPENDIX C. Summary of Observations of the Wager Herd, June 1977.

Table C-1. Wager herd reconnaissance transects, Stratum 4. Left Observer: L. Ussak. Right Observer: J.Donaldson.

		Reconnaissance				Stratum 4			
Transect	Date	Length (km)	Adult caribou	Calves	Groups	Length (km)	Adult caribou	Groups	Percent snow cover
1	June 12 and 14	152	11	Ø	3	121	3	1	65 - 80, 75
2	June 13	171	3	1	2	140	3	2	25 - 70
3	June 13	132	1	Ø	1	132	1	1	40 - 80
4	June 14	141	4	Ø	2	141	4	2	60 - 99
5	June 14	123	21	8	7	55	3	2	25 - 85
6	June 15	126	> 23[1]	> 3[1]	7[1]	58	4	2	40 - 65
7	June 15	123	55	6	12	80	23	7	80
8	June 15	120	5	Ø	3	120	5	3	35?- 70
9	June 15	117	7	Ø	2	117	7	2	60
10	June 15	115	1	Ø	1	115	1	1	60 - 90
Total		132.0	>131	>18	40	1079	54	23	
Mean	June 14	132.0	> 13.1	> 1.8	4.0	107.9	5.4	2.3	63.5

[1] Data lost on two groups.

Table C-2. Wager herd reconnaissance transects, Stratum 1: 42.6 x 57.9 km. Surveyed 16 June. Left observer: L. Ussak. Right observer: J. Donaldson.

Transect	Adults	Calves	Groups	Percent snow cover
1	2	2	1	50
2	11	5	2	40 - 65
3	4	0	2	65
4	11	0	2	60
5	2	0	1	-
6	4	2	2	-
7	8	7	1	-
8	6 + 6[1]	0 + ?	3[1]	90
9	70	>41	11	-
10	71	19	4	65
11	12	4	4	-
12	25	12	3	-
13	4	0	1	-
14	8	3	4	-
Total	244	>95	41	
Mean	17.43	> 6.79	2.9	63.75
Variance	540.571			

[1] Observation notes of the left side of the transect were destroyed. I assumed 6 caribou were there because (1) 6 caribou were seen on the right side and (2) only one group was present. The mean group size of 58 in the Stratum was 6.1 $\pm$ 1.27.

Table C-3. Wager herd reconnaissance transects, Stratum 2; 29.8 x 31.4 km. Surveyed 19 June. Left observer: J. Donaldson. Right observer: M.L. Broderick.

Transect	Adult	Calves	Groups	Percent snow cover
1	8	Ø	3	5Ø
2	1Ø	Ø	1	5Ø
3	4	Ø	1	–
4	7	Ø	1	–
5	43	27	8	–
6	15	> 6	4	–
7	67 (or 68)	3Ø	9	4Ø – 75
Total	154	> 63	27	
Mean	22	> 9.Ø	3.9	52.5

Table C-4. Wager herd reconnaissance transects, Stratum 3: 23.3 x 24.9 km. Surveyed 21 June. Left observer: J. Donaldson. Right observer: D. Heard.

Transect	Adults	Calves	Groups	Percent snow cover	
				L. Obs.	R. Obs.
1	1	1	1	60	
2	1	0	1	50 - 60	10 - 60
3	13	> 2	4	35	
4	23	9	1	20	
5	23	> 5	4	-	10 - 20
6	10	2	2	20	
7	18	0	7	15	5 - 15
8	49	1	7	35	
Total	138	>20	27		
Mean	17.25	> 2.5	3.4	34.3	20.6
Variance	239.07				