CARIBOU BEHAVIOUR, RANGE USE PATTERNS AND SHORT TERM RESPONSES TO HELICOPTER LANDINGS ON THE BEVERLY CALVING GROUND, N.W.T., 1982

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ABSTRACT

The exploration for minerals on the tundra ranges of migratory barren-ground caribou (_Rangifer tarandus groenlandicus_) raised concerns about the potential effects of these activities on the well-being of caribou, especially on cows and calves. As a result, the Department of Indian Affairs and Northern Development implemented the Caribou Protection Measures which limit land-use activities just before and during the calving and post-calving periods of the Beverly and Kaminuriak herds (15 May - 31 July). As an initial step to evaluating the Caribou Protection Measures and to develop appropriate methodology for measuring some behavioural responses to man's activities, we field-tested a sampling design for recording undisturbed behaviour of cow-calf pairs on the Beverly calving ground in 1981 and 1982. Additionally, we recorded the responses of cow-calf pairs to 16 helicopter landings. We landed 950 ± 650 m, SD from the caribou, and shut down the helicopter for about 20 min before flying away. Observations of the same caribou after the helicopter landings indicated greater proportions of cows and calves were walking, trotting or galloping during post-disturbance than pre-disturbance. The frequency and duration of nursing was slightly less during the landing than before and after, but sample sizes were small as seven groups were totally and six groups were partially out of sight during the landing. We cannot evaluate the consequences of displacing all or some of the caribou during 13 of the 16 landings. Any measurement of the short-term consequences to the population exposed to human activities is beyond the objectives and scope of this study.

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INTRODUCTION

Traditional calving grounds of migratory barren-ground caribou (*Rangifer tarandus groenlandicus*) are of paramount importance to each herd as every year, the parturient cows return to their traditional calving grounds to give birth. There, during the first days of the newborn calf's life, the cow and calf form a strong attachment to each other that is critical to the survival of the calf (Gunn 1983). Calving and post-calving are also the times when lactating cows face their highest energy output and nutrient intake demands, and when critical early growth of calves occurs, which will subsequently influence their chances of survival. Responses to human activities that could reduce foraging and disrupt the continuing formation and strengthening of the mother-young bond during the sensitive calving and post-calving periods are potentially detrimental to calf survival and to the long-term well-being of the caribou population. The definition of "disturbance" is a contentious and complex issue. In this report we are defining disturbance as the introduction of man-induced, novel stimuli in the animal's environment. Further discussion and justification of use of the term "disturbance" are described elsewhere (Gunn 1983).

Concerns have been raised about the consequences of human activities on cows and calves on their traditional calving grounds. In 1978, the Federal Department of Indian Affairs and Northern Development (DIAND), with the advice from the N.W.T. Wildlife Service, developed and implemented the "Caribou

Protection Measures" that were designed to restrict land-use operations in the areas used during calving and post-calving by the cows of the Beverly and Kaminuriak herds (Clement 1983). DIAND also recognized the need for research into the potential effects of human activities on caribou and, in 1980, funded the N.W.T. Wildlife Service to "conduct disturbance studies".

In 1980, during the first phase of the research, Fleck and Gunn (1982) described the environmental characteristics of the calving grounds used by migratory barren-ground caribou of the Beverly, Bathurst and Kaminuriak herds. Their results suggested that there were no unique characteristics that clearly identified each calving ground, except the traditional use by the caribou cows.

The second phase of the research was to document how the caribou use the calving grounds and to begin to describe how caribou might respond to human activities on the calving ground. In 1981, we developed a sampling technique for quantitatively describing behaviours and range use patterns of cow-calf pairs under "natural" or undisturbed conditions (Jingfors et al. 1982). By developing a sampling technique based on relatively unbiased descriptions of undisturbed behaviour and that is repeatable under experimental conditions, we would be able to recognize changes in behaviour and some of the short-term effects of human activities. This recognition and description of behavioural responses to human activities has applications elsewhere in studies of the effects of man's activities on caribou, as well as a beginning for an evaluation of the Caribou Protection Measures.

In the third year of our study of caribou on the Beverly calving grounds, we continued the baseline approach initiated in 1982 (Jingfors et al. 1982). We expanded our objectives to include an experimental approach to describing the behavioural changes after exposure to a controlled disturbance.

Practical and logistical considerations led us to use a helicopter landing as our experimental disturbance. We required a mobile source of disturbance so we could move to caribou that were already under observation. The unpredictability of the day to day movements of caribou and our requirement to compare behaviour before and after a controlled disturbance prevented us from describing the responses of caribou to a diamond drill or other such stationary structure. A helicopter is almost invariably associated with exploration and development activities and thus descriptions of caribou responses to a helicopter are both relevant and applicable elsewhere.

STUDY AREA

Our study area was a segment of the northern portion of the Beverly Caribou Protection Area (Fig. 1). Based on 11 years of data between 1957 and 1980, Fleck and Gunn (1982) showed considerable overlap between successive years in the use of this area for calving by Beverly cows. In comparison, use of the southern portion (south of the Thelon River) has been less regular and occurred primarily in years when the spring migration of pregnant cows was delayed by deep snow (Fleck and Gunn 1982). We used Fleck and Gunn's (1982:2) definition, where a "calving ground" is an area where parturient cows concentrate during calving in any one year, and "calving grounds" are all areas where parturient cows of a herd have been known to concentrate. Thus, the 1981 calving ground was located on the northern portion of the Beverly calving grounds.

The northern portion of the Beverly calving grounds lies on sedimentary deposits within the Canadian Shield. The flat-lying sandstones form a smooth surface that is overlain by various glacial landforms, such as eskers and drumlins. Drainage patterns are poorly developed in the rolling topography resulting in numerous lakes. Snow melt on the northern calving grounds is characteristically late and often over 70% of the area is still covered with snow at the initiation of calving in early June (Fleck and Gunn 1982).

On the northern portion of the calving grounds shrubs taller than 30 cm are absent. Lichen communities dominate the xeric and mesic ridge areas where prostrate shrubs, such as *Vaccinium*

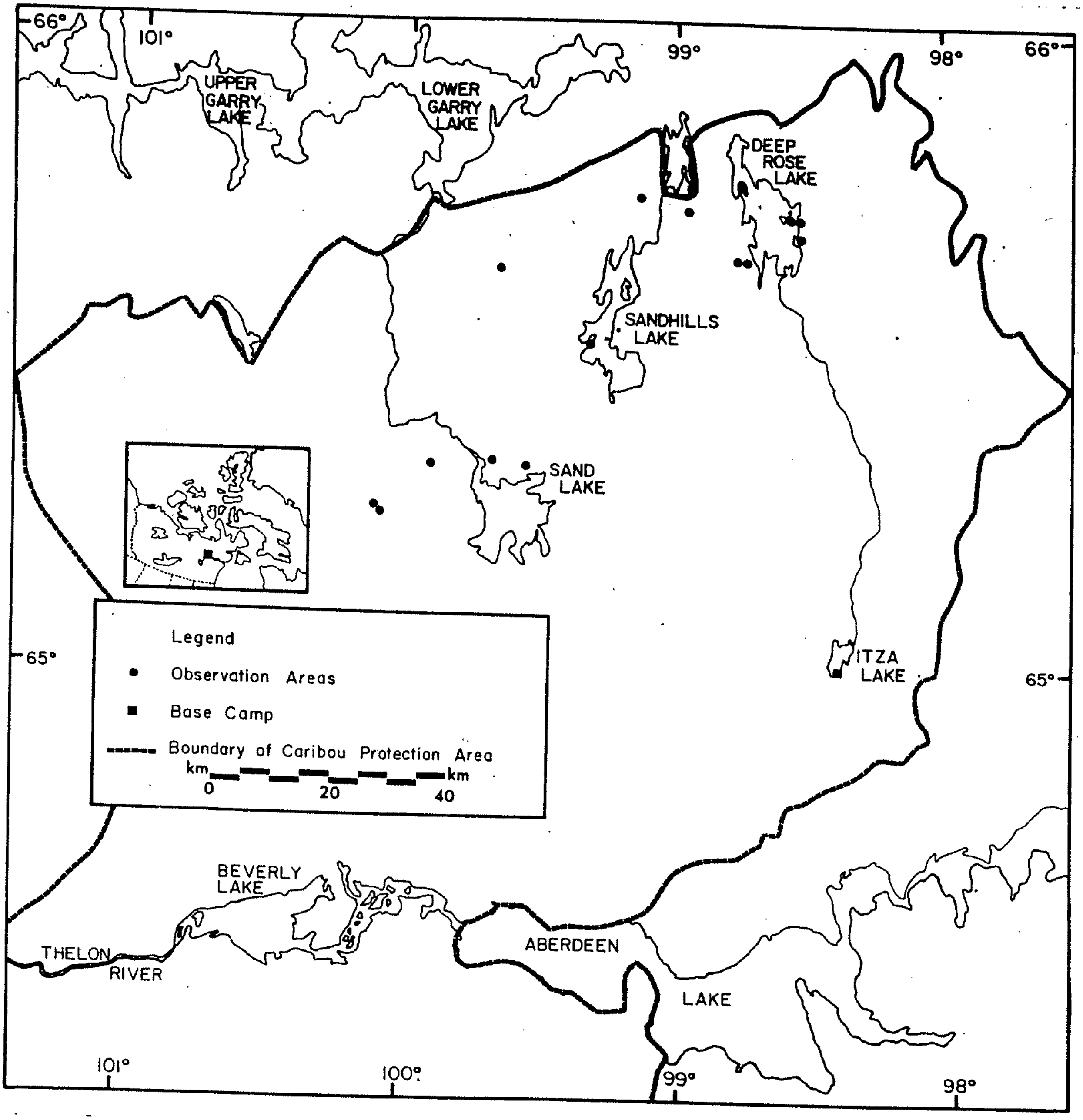

Figure 1. Locations of sampling areas for behavioural observations of caribou within the Protection Area of the Beverly caribou herd, 1982.

vitis-idaea and Ledum decumbens, are also found. Mosses and various graminoids (primarily Carex spp.) dominate the more hydric lowlands.

The parturient cows usually arrive on the Beverly calving grounds at the end of May (Darby 1978, 1980, Cooper 1981). Most cows give birth during a 5-7 day period; calving often extends from about 31 May to 15 June, with a peak between 4-10 June (Fleck and Gunn 1982). In 1980, Gunn and Decker (1982) estimated that about 47,000 caribou (1-yr and older) were within an area of 5,300 km^2. The post-calving aggregations usually leave the calving grounds during July (Darby 1978, 1980, Cooper 1981, Clement 1982).

Caribou cows had reached the calving ground by 19 May (Clement 1983) and by 3 June when we started flying and ground observations, calving had already started. The stabilization of our counts of calf:cow ratios suggested that calving peaked in the centre of the calving ground (high density stratum, Stephenson et al. 1983) between 9-10 June, and on the eastern calving ground (medium density stratum) between 11-12 June. We termed the period 3-13 June as calving, and the period after the peak of calving as post-calving (14-29 June). Some calves were born during the early part of what we defined as post-calving but as the calf:cow ratio was 85:100 on 13 June, the number of calves born after 13 June would have been relatively few. The last date we observed a newborn calf was 23 June.

The cows remained isolated or scattered in small groups until 15 June when groups of hundreds were starting to form and by 18 June, several aggregations of at least a thousand cows and calves were observed in the central calving ground. Large aggregations of caribou were moving west and southwest streaming along the north end of Sand Lake (Fig. 1) by 23 June. Caribou cows and calves were still on the islands of eastern Deep Rose Lake on 29 June but most all other cows and calves had left the calving ground and were west of Sand Lake. On 12 July, the caribou monitor observed no caribou in the Sand Lake and Upper Garry Lake areas (Clement 1983).

METHODS

Study Design

We applied the same research design and field observation techniques as were developed and used in 1981 for collection of data on activity budgets and frequency of behavioural events (Jingfors et al. 1982). In both years we used two-person stationary observer teams. As in 1981, we focused on describing behavioural parameters of cow-calf pairs which could be easily and uniformly recognized with consistency by all observers. We selected distinct behavioural events that may be influenced by man-induced disturbance and that reflect characteristics of the cow-calf bond, fear or aggression (eg. nursings, alarm postures and aggressive acts). We also recorded activity budgets (states) which reflect energy balance and may indicate the general well-being of cow-calf pairs. Both activity budgets and behavioural events represent potentially measurable changes in on-going maintenance activities and behavioural responses of caribou to man-induced disturbance. Those maintenance behaviours and behavioural responses were described by stationary ground observers during a controlled experiment that included a disturbance situation.

We rigorously defined the different behavioural categories so that our design was repeatable. Descriptions of behaviour and range use patterns were quantified during predetermined, systematic sampling periods to avoid subjective interpretations and to facilitate data analysis. We collected data by a design that allowed us to use an analysis of variance to describe between - observer team variations and to provide estimates of expected frequencies of behavioural events and activity budgets during undisturbed and disturbed situations.

We again used area sampling (having observers at fixed points) rather than having observers following caribou, to reduce the possibility of observers causing changes in the behaviour of caribou. As we were interested in describing undisturbed behaviour and potential disturbance behaviour in the absence of observer team effects, it was imperative that observers remained inconspicuous throughout the sampling period.

Unfortunately we were not able to use identical observer teams between years, nor were we able to use exactly the same observation areas due to between-year changes in caribou distribution on the calving grounds. We were, however, able to ensure that at least one member of each observer team in 1982 had been on an observer team in our 1981 study, and we used films of caribou behaviour to illustrate the different behavioural patterns that we defined. By virtue of this, and the fact that we used a standardized technique, we should have reduced the potential for technical bias in between-year comparisons.

Activity Budgets

We described activity budgets as the proportion of animals engaged in different maintenance activities or physical states that are usually behaviours of relatively long duration (states). We recognize and define the following categories:

Bedded - a caribou is considered bedded when it is in a resting or ruminating position either upright on its brisket or lying on its side. Bedded caribou could and would exhibit alertness (head-high, head-low, or head-tracking alert positions) to undiscernible or observer-detected stimuli.

Foraging - a caribou is considered foraging when it is feeding while standing in place or walking with muzzle touching or nearly touching (head below knees) ground, and showing no apparent signs of alertness to changes in its environment. Foraging includes nursing (suckling) and feeding-related activities such as visual or olfactory search for forage and cratering in snow for forage. A caribou is not considered foraging if it assumes the head-high alert position; however, it is considered foraging if it assumes a head-low or head-tracking alert position in the absence of observer-detected stimuli. A caribou is not considered foraging if it assumes an alarm stance.

Standing - a caribou is considered standing when it remains stationary with head elevated above the knees. A standing caribou could also exhibit alertness (head-high, head-low or head-tracking alert positions) to changes in its environment. A standing caribou could and would assume an alarm stance in the presence of undiscernible or observer-detected disturbing or harassing stimuli, but it could not perform alarm locomotor movements.

Walking - a caribou is considered walking when it is moving in a relatively slow gait with head elevated above the knees. The "walk" is the slowest and most usual gait employed during feeding activities and unharassed movements. The "walk", usually at a faster or more deliberate tempo, is also the slowest gait during periods of restrained flight behaviour.

Trotting - a caribou is considered trotting when it employs a two-timed symmetrical gait of medium speed. Trotting occurs during periods when no discernible alarm stimuli are present or during periods of apparently restrained flight behaviour to observer-detected stimuli.

Galloping - a caribou is considered galloping when it employs a rapid asymmetrical gait during periods when no discernible alarm stimuli are present or during periods of unrestrained flight behaviour to observer-detected stimuli.

We used scan sampling to record activity budgets (Altmann 1974). At regular intervals, the observers scanned a group of caribou and recorded the activity and age/sex class (cow, calf, yearling, other) of each individual animal. We also recorded various environmental parameters during each activity scan (see Field Observation Techniques) as well as general comments concerning observed caribou behaviour in the area, eg., herd movements, presence of wolves, trends in the weather, changes in visibility, and ground cover.

Events

Events, or behavioural reactions, are typically of short duration that usually cannot be timed but are recorded simply as having occurred. We recognize and define the following events:

Nursing - an event lasting more than 5 s from the first observed bunting (striking at the udder) by the calf until the calf removes its head from the nursing position; if bunting is not observed, especially in the case of newborn calves, initiation is defined as the moment when the calf reaches the nursing position. We are aware that some nursing occurs when both animals (or the cow alone) are lying down; however, we do not believe that we are confident enough to attempt to quantify observations of this kind. Repeated nursings are recorded as separate events if more than 30 s lapses between the termination of the first nursing and the initiation of the second.

Attempted nursing - an event lasting less than 5 s from the initiation of the first bunting of the udder by the calf to the active rejection of the calf by the cow e.g., by stepping away or by head swings.

Head bobbing - at least two consecutive lowerings of the head in the vertical plane with a straight or slightly curved neck of the cow directed towards the calf to induce the calf to follow (Pruitt 1960); once the calf responds by coming toward the cow, any further head bobbing is not tallied, unless other behaviour patterns are interposed.

Alarm stance - a deliberate placing of one hindleg set out from the body while the caribou with an elevated head faces the alarm stimulus (Pruitt 1960, Lent 1966) or, additionally, with head raised up and down; to avoid confusing an alarm stance with a caribou trying to change its footing, the stance has to persist for a 3-s count, to be recorded as an event.

Head swing - sudden movement of the head in the lateral plane by an antlered or unantlered caribou towards another caribou that overtly responds to the movement; this is a modification of the "antler threat" and "hooking" described by Lent (1966).

Kick - downward strike with the hoof of either foreleg directed at another caribou.

Rush - rapid advance (at a fast walk or trot) by a caribou with ears back, muzzle extended and antlers (if present) laid back along the neck; this is a modification of the "threat pose" (Pruitt 1960).

The head swing, kick and rush are aggressive acts. We used the all-occurrence sampling technique (Altmann 1974) to estimate the rate of occurrence of these behavioural events. This method of sampling was useful provided observational conditions were adequate; the behaviours had been carefully defined, so that they were easily and consistently recognized; and the behaviours did not occur more often (or more rapidly) than the observers could record them (Lehner 1979). Included in the "Remarks" section of the all-occurrence form (Appendix A) were additional observations concerning the response of cow-calf pairs or other nearby caribou to other species of animals, e.g., gulls, arctic fox, wolves, and jaegers.

Range Delineation and Use

The same classifications of range type were used in 1982 as were derived and used in the 1981 study (Jingfors et al. 1982). These are in order of overall relative occurrence on the northern calving grounds: 1) Lichen Uplands, 2) Dwarf Shrub, 3) Meadow and 4) Rock/Sand Barrens (Appendix B). These range types, if snow free, could usually be distinguished by observers on the ground. Prior to the first observation sequence at an observation site, each observer team would agree upon the distribution of range types over the site area. This factor served to minimize individual observer bias within observer teams. All formal observations were terminated when visibility became impaired due to weather or when caribou became too distant for an accurate determination. By having determined the distribution of range types over the calving ground, patterns of caribou range use could be evaluated in relation to the proportional occurrence of the range types. Comparing caribou range use relative to proportional occurrence provides a measure of "preference" or "selection" (Petrides 1975).

Selection of feeding sites by caribou on the calving grounds is at a finer level than the community or range type level, and is influenced by microclimate, topography, phenology and other factors. We could not, however, consistently and accurately identify any finer components of the generalized range types from the distances at which we observed caribou. We recorded caribou use of range types by the scan sampling technique described earlier for activity budgets. We related observed range use by caribou to the relative occurrence of the range types on the northern portion of the Beverly calving grounds. Relative occurrence was estimated from the coverage of range types as determined from aerial photography (Jingfors et al. 1982).

Phenology

Patterns of plant phenology and snow melt were quantitatively measured and described in 1981 (Jingfors et al. 1982). Those measurements were not carried out in 1982, but some subjective evaluations were made.

Field Observational Techniques

We were on the Beverly calving ground from 25 May to 29 June, 1982. A base camp was established at Itza Lake (65°02' N, 98°27' W) in the southeastern part of the study area (Fig. 1). This was the same base camp site as was used in the 1981 study (Jingfors et al. 1982). We used a Bell 206B turbo-helicopter to move the observer teams between sampling areas as well as to conduct studies of herd composition and calf mortality.

Each of the three two-person observer teams was equipped to remain at a sampling area for 4-5 days. We attempted to select areas that had clear natural boundaries and that provided good visibility. Sampling areas varied in size but were generally kept to about 1 km^2. Distances between observers and caribou varied depending on the topography of the sampling area; during most observations the observers were sitting concealed on high ground about 0.8-1.0 km from the caribou.

Each observer team communicated over a SBX-11 two-way radio with the base camp and the crew in the helicopter. If the caribou moved out of the sampling area and no others were in sight, the helicopter was called in to move the observer team to a different location (Fig. 1). Following relocation of observers, behavioural observations were not started until at least 60 min after the helicopter had left the area. During observations of undisturbed behaviour the helicopter did not operate in the vicinity of the sampling area.

Activity Budgets

We recorded the number of caribou engaged in different activities at regular 20-min intervals. Scans lasted for a maximum of 5 min or until all caribou in the scan area had been covered, which ever came first. While one observer scanned a group of caribou in the sampling area with the aid of a zoom spotting scope (15-60x), the other observer recorded the following information on data forms for every scan:

(1) Date.

(2) Observer team.

(3) Time - at beginning of scan.

(4) Wind speed - measure with a Dwyer anemometer hand-held at about 1.5 m above ground.

(5) Wind direction - wind direction is recorded relative to caribou and observers as: (1) wind from caribou to observers, (2) from observers to caribou, (3) crosswind or, (4) calm.

(6) Temperature - measure in the shade.

(7) Cloud cover - record as overcast (100% cover), broken (50-99%), scattered (1-49%) or clear.

(8) Location - each sampling area receives an unique identification number.

(9) Activity - record as bedded, foraging, standing, walking, trotting or galloping.

(10) Age/sex class - record as cow, calf, yearling or "other". The latter includes juvenile animals (2-yr-old and older) and bulls. We make no attempt to separate parous cows from barren cows.

We recorded data on range use on a combined scan and all-occurrence sampling form (Appendix A) for each caribou during the scan.

We limited the time spent on each individual caribou during a scan to a maximum of 5 s which was adequate for the observers to record activity, age class and range use. To allow scan sampling at regular time intervals and to use the time in between scans for all-occurrence sampling of behavioural events, we limited the scans to a maximum of 100 caribou per scan. When more caribou were in a sampling area, we started each scan on the left side of the area to standardize scan sampling between observer teams and to reduce biases from the distribution of caribou or range types on a particular sampling area.

Events

We recorded all occurrences of behavioural events during continuous 10-min observation periods that were scheduled at regular 20-min intervals either preceding or immediately following scan samples. One observer continuously watched a cow-calf pair through a spotting scope while the second observer recorded the following information on the combined scan/all-occurrence form:

(1) Date.

(2) Observer.

(3) Time - at beginning of sampling period; time is also noted when an event occurs and when an animal beds or disappears from view.

(4) Number - the total number of cows and calves under observation during the 10-min observation period.

(5) Duration - the duration of time (min) cows and calves under observation are active (non-bedded) and in view; this represents the time base used for calculating rates (number of events/unit active time).

(6) Group size - the number of caribou within 5 body lengths (approximately 7.5 m) of observed cow or calf recorded as: (0) 0, (1) 1-5, (2) 6-10, (3) 11-15, (4) 16-20, or (5) 20+.

(7) Group composition - the age and sex category of caribou within 5 body lengths of observed cow or calf are recorded in the "Remarks" section. Both group size and composition are recorded at the start of an observation period; if group characteristics changed during the 10-min period, the time and nature of the change were noted.

(8) Wind direction - measure relative to observers and caribou at the beginning of the

10-min observation period as in the scan sampling procedure.

(9) Nursing - when a nursing is observed, the initiator and terminator are recorded -- if the observer misses the initiator of the nursing, only the terminator is recorded; complete nursings are timed and the duration noted under "Remarks". Position of nursing is recorded as whether the calf is nursing from the cow's left or right side (reverse parallel position), from the rear while standing between the cow's hindlegs or from the front with the calf standing underneath the cow's body. We also record whether or not the calf had been active, e.g., foraging, walking, or bedded prior to nursing and whether or not maternal licking occurred.

(10) Nursing attempt - record occurrence of event.

(11) Head bobbing - record occurrence of event.

(12) Alarm stance - record occurrence of event.

(13) Aggressive acts - record occurrence of head swing, kick or rush; if the acts occur together, the sequence is recorded. The initiator and recipient of the act(s) are noted as: (1) observed cow, (2) observed calf, (3) other cow, (4) other calf, (5) yearling, (6) other, to separate between pairs under observation and others.

We selected focal pairs (cow-calf pairs under observation) that were readily visible to the observers. We always started with an active pair, but made no effort to repeat later observation periods with the same pair. If either pair member bedded or moved out of the field of view of the observers, we focused on the cow and terminated the calf's observational time. If both pair members bedded or moved out of view, we would continue observations on another pair for the remainder of the 10-min observation period and note the switch-over under "Remarks".

If several active cow-calf pairs were within the same field of view, we attempted to include them in our observations to increase sample size and thereby the "active time" base used when calculating the rates of occurrence of the different events. When observing more than one focal pair, we recorded group size and composition based on all pairs, e.g. if two cow-calf pairs were under observation and no other caribou were present within 5 body lengths of either pair, group size was recorded as "1" and the composition noted under "Remarks".

Scan and all-occurrence sampling periods were done at regular pre-determined times; each hour we took three, 10-minute all-occurrence samples each of which was followed by a scan of 5-min maximum and then a 5-min break. During the break we would organize forms and locate a cow-calf pair for the next all-occurrence sample. Provided animals were present, we usually obtained three sets of data by each method during 1 h of observation. We made daily observations between 1000 and 1700 h, weather permitting.

Range Use

Delineation of four major range types (Lichen Upland, Dwarf Shrub, Meadow and Rock/Sand Barrens) on the northern portion of the Beverly calving grounds was done in 1981. From this work we were able to determine the relative proportion or availability of each range type.

We recorded range use by caribou during each scan as the number of caribou (irrespective of age/sex class) bedded or foraging on the different range types (Appendix B). We characterized ground cover as either snow or bare. When caribou were bedded on snow or cratering through the snow cover, we did not attempt to guess the underlying range type but recorded ground cover as snow.

We did not attempt to record use of individual forage species by caribou. The long observation distances (usually 0.8-1.0 km) that we used to minimize observer effects on caribou behaviour, prevented detailed observations of forage use.

Weather Recording

The observer teams recorded daily weather at their observation sites. Air temperature was recorded at ground level using a shielded max-min thermometer. Wind speed was recorded with the aid of a hand-held Dwyer anemometer.

Disturbance Experiment

As part of the 1982 study design, we included an experimental disturbance phase to the methodology. Caribou behaviour was described before and after a helicopter landing using our standardized scan and all-occurrence sampling. The period in which the helicopter was first and last audible to the ground observers was referred to as the disturbance phase. The periods before and after this phase were referred to as pre-disturbance and post-disturbance, respectively. Post-disturbance observations were never extended beyond 4 h, usually attributable to the observed animals having moved out of range or the end of the day's observation period. Animals viewed the following day were considered pre-disturbance until the next helicopter approach became audible. All landings were arranged and coordinated via radio communication with the base camp and the helicopter.

The disturbance phase (Appendix A) had eight phases associated with it:

(1) Approach - time when helicopter is first audible to ground observers until the time when it passes over the observers. The approach is at about 300 m above ground level (agl) and cruising speed.

(2) Turn - from passing over observers to turning and passing over caribou.

(3) Descent - from beginning of descent (as told on radio) to touchdown.

(4) Wind-down - from landing to shutdown (power off).

(5) Shutdown and ground activity - from emergence of crew (blades may still be turning) until people are back in the helicopter and power is on. This phase would last for about 20 min.

(6) Wind-up - from power-on to take-off.

(7) Take-off - from leaving ground until helicopter has climbed to about 300 m agl (as told on radio).

(8) Last audible - from 300 m agl altitude to when last audible.

Radio communication was used to direct the helicopter to come in at approximately 300 m, pass over the observers, the observed caribou, and then to swing back for a landing near the ground observers. A rectangular orange tarp, spread out beside each observer team, served as a locator and directional signal. An individual left the helicopter during wind-down and walked around the helicopter to expose caribou to human activity on the ground. On take-off, the helicopter flew away from both the observers and the observed caribou. Caribou behaviour during the disturbance was recorded using a modified scan form and a modified all-occurrence form (Appendix A).

For the scan phase, a more or less discrete group of animals was identified and monitored. The proportion of the group involved in different activities (bedded, foraging, standing, walking, trotting, galloping), was monitored at 2-min intervals over the entire disturbance phase. Punctuality was facilitated by using a 2-min electronic beeper. An estimate was made of the distance between the ground observer and the group's core. The direction of group movement was taken in relation to the helicopter. The all-occurrence observations included the same type of observation as was taken during pre- and post-disturbance as well as four new variables. These variables recorded whether the cow and calf trotted or galloped, the direction they moved (i.e. toward each other, toward other caribou or obvious focal points, or toward an unknown), and the duration either animal was engaged in trotting or galloping. The all-occurrence sampling was for the duration of the disturbance phase. Range finders were used to estimate distances within 1200 m; however, they presented technical difficulties and were not effective under field conditions.

Ice conditions and poor weather delayed the establishment of our camp at Itza Lake (Fig. 1) from 20 to 26 May. Poor weather prevented the helicopter ferrying from Resolute Bay from 20 May until 4 June; then it became weatherbound at Shepherd Bay until 12 June. We were, however, able to arrange for brief use of a helicopter based in Baker Lake and another one at a mining camp. The three observer teams were flown out to observation sites on 3 June; the last day of observations was 29 June and on 2 and 3 July, we returned to Yellowknife.

In 1981, the observer teams were usually watching caribou cow-calf pairs on sites well within the core of the calving ground in the area of highest density of breeding cows. Thus, the occurrence of yearlings, juveniles, and non-breeding females was low and sex-age classification of most caribou under observation exceeded 90% or often approached 100% cow-calf pairs. In 1982 most of the observation sites were located on or beyond the eastern edge of the core of the calving ground in an area of only medium density of breeding cows. Thus, yearlings, juveniles and non-breeding females generally occurred more frequently in the groups and aggregations under observation in 1982 than in 1981. Therefore, the relative lack of yearlings, juveniles and non-breeding females in 1981 compared with 1982 can be explained by the apparent westward shift of the core of the Beverly calving ground in 1982.

Data Analysis

We coded and transcribed behavioural observations directly on the data forms (Appendix A). While in the field we checked the forms to ensure that observers were using the correct procedures. We also edited the data files for any spurious values after the information was entered on the computer. Data processing and analyses were done on a HP3000 and the University of Calgary, Honeywell System, using SPSS (Statistical Package for the Social Sciences) (Nie et al. 1975).

Activity Budgets

We summed the number of caribou observed during 5-min scans in each activity for each day and observer team. This procedure gave a measure of total frequency which is equal to the number of occurrences per aggregated sample unit. We weighed the sum for each activity over all other activities and calculated the mean proportion (expressed as a percentage) of caribou engaged in that activity. We then calculated the mean of those proportions by summing those proportions and dividing by the total number of observer team days for the period (calving, post-calving, post-disturbance).

Statistical analysis of scan samples, beyond simple frequency descriptions, is usually limited by the lack of independence between consecutive scans especially for activity patterns of ruminant herbivores that are characterized by regular alternations between two main activities (bedding and foraging). By using different observer teams in different areas on different days to record caribou activity, we assumed independence between samples from each team and day of observations. Prior to further data analysis, we tested the data for independence using runs tests for randomness (Sokal and Rohlf 1969). Normality was tested using the Kolmogorov-Smirnov test (Sokal and Rohlf 1969).

We tested seasonal differences in activity budgets between the calving and post-calving periods using standard t-tests or a Mann-Whitney U-test (where data were non-normally distributed) (Sokal and Rohlf 1969). After testing for normality and independence and then using a F_{max}-test (Sokal and Rohlf 1969) to confirm equality of treatment variances, we examined differences between observer teams in a standard analysis of variance (ANOVA) or a Kruskal-Wallis 1-way ANOVA procedure when data were non-normally distributed.

To test the assumption that we in fact were recording undisturbed caribou behaviour, we compared activity budgets during scans for bedded, foraging and walking behaviour, when the wind was from the observers to the caribou (i.e. caribou were downwind and potentially aware of the observers) with activity budgets recorded when caribou were not down wind. We tested significance between the two conditions with standard t-tests.

Data analyses of post-disturbance versus pre-disturbance animals looked at all post-disturbance animals and compared these with all post-calving/pre-disturbance phase animals. Ideally, tests would have been performed on the same animals, pre- and post-disturbance. However, there were insufficient data for this purpose and only data summaries are provided.

Events

We calculated rates of behavioural events as the frequency of occurrence per unit active cow or calf time and selected 100 min as our basic time unit, i.e., number of events per 100 cow-min. For infrequently occurring events we pooled samples on a per day, per observer, basis to avoid zero values. The three aggressive acts (head swing, kick and rush) were also combined to form one variable for analysis.

We analyzed rates of nursing and attempted nursing on a seasonal basis where the calving and post-calving periods were further divided into 4-day phases. We used season rather than age as our independent variable because we could not accurately estimate the age of the calves. We examined seasonal differences using a 1-way ANOVA; significant effects were further analyzed by the Student-Newman-Keuls procedure (Sokal and Rohlf 1969). We analyzed the duration of nursing events on a seasonal basis using a 1-way ANOVA. We used SPSS cross tabulations (Nie et al. 1975) and the chi-square test statistic to examine the effects of season on the initiator and terminator of nursing events.

We only used acts initiated by the observed cow to calculate rates (i.e. number of aggressive acts per 100 active cow-min) although all aggressive acts involving the focal pair(s) were recorded. We analyzed the distribution of nursings, attempted nursings, and aggressive acts by group size, wind direction and observers using the non-parametric median test (Zar 1974) to calculate chi-square statistics. The procedure is to determine the median for all data in the different groups or categories of the independent parameter (group size, wind direction or observer). The distribution of events is analyzed in a 2xk contingency table where k is the number of categories and where the two rows correspond to the number of observations above or below the median. We did not include Yate's correction for continuity as it results in an unduly conservative test even with low sample sizes such as N=20 (Sokal and Rohlf 1969).

RESULTS

Activity Budgets

We obtained 500 scan samples with 24,271 "point-in-time" observations of activities of individual caribou during 166.7 h of observation between 3-29 June, (Appendix C). As in 1981, we made the majority of our observations on cows (64.5%) and calves (29.9%), while yearlings and "others" represented 5.3% and 0.3% respectively. A larger percentage of the observations involved yearlings in 1982 than in 1981 (0.5%). Our analysis is restricted to cows and calves, because of the low proportion of yearlings and "others".

The proportion of time cows spent bedded, foraging and standing was normally distributed during calving and post-calving (Appendix D). Post-calving unless otherwise specified only includes pre-disturbance (or no disturbance) data. The proportion of time cows spent walking during post-calving, and trotting and galloping during calving and post-calving was not normally distributed ($P < 0.05$). For calves, the proportion of time spent galloping during calving and post-calving was not normally distributed ($P < 0.05$) nor was the proportion of time calves spent trotting during post-calving. Those activities were not normally distributed probably because they occurred at a low frequency. All observations were found to be independent (Appendix D).

In 1982, there were significant differences ($P < 0.05$) in activity budgets between calving and post-calving. Cows bedded less, foraged and stood more during calving than post-calving

(Table 1). Calves also bedded less and stood more during calving than post-calving, but the proportion of time spent foraging was similar between the two periods.

In 1981, there was less of a difference in the activity budgets between calving and post-calving. The only significant ($P < 0.05$) differences were that cows walked less and calves trotted more during post-calving than calving. The proportions of time spent bedded did suggest that cows also bedded less during calving (32.8%) than post-calving (40.2%) - a similar finding to 1982. The same trend of less time bedded during calving than post-calving also held for the calves (58.5% vs 66.0%) (Table 2).

When the activity budgets are combined over the calving and post-calving periods (Table 1), calves spent a significantly ($P < 0.05$) greater proportion of their time bedded than cows (58.7% vs 40.9%, $t=-4.1128$, 96 df). Cows spent a significantly ($P < 0.05$) greater proportion of their time foraging than calves (44.6% vs 12.7%, $t=11.7350$, 96 df).

When calving is combined with post-calving there were no differences between years in the proportion of time spent by cows or calves in the different activities (Table 2). During 1982 calving period, however, calves spent more time trotting (1.9%) than in 1981 (0.6%) (Table 2). During the 1982 post-calving, there was significantly ($P < 0.05$) less time spent by cows foraging (37.8% vs 47.5%) and standing 2.7% vs 4.3%) than in 1981; calves also spent a significantly ($P < 0.05$) smaller proportion of their time foraging in 1982 (11.2%) than in 1981 (16.0%).

Table 1. Seasonal activity budgets of caribou expressed as the mean proportion of time spent in each activity, Beverly calving ground, 1982.

			Proportion of time (%)				
Season	Class	Activity	$\bar{x}$	SD	n^{a}	t statistic^{b}	F ratio^{c}
Calving (3-13 June)	Cow	Bedded	34.8	15.9	28	-	36.198*
		Foraging	50.3	14.5	28	-	35.628*
		Standing	5.0	2.4	28	-	1.242
		Walking	9.6	7.0	28	-	1.693
		Trotting	0.2	0.5	28	-	1.493^{c}
		Galloping	0.0	0.1	28	-	1.006^{c}
	Calf	Bedded	50.4	21.2	27	-	4.410
		Foraging	14.0	9.9	27	-	13.862*
		Standing	18.3	18.6	27	-	4.104
		Walking	21.6	13.2	27	-	3.005
		Trotting	1.9	2.5	27	-	1.375
		Galloping	0.6	1.3	27	-	0.178^{c}
Post-calving (14-29 June)	Cow	Bedded	48.3	21.7	23	-	0.234
		Foraging	37.8	17.1	23	-	4.777*
		Standing	2.7	2.7	23	-	0.182
		Walking	10.6	16.8	23	-	0.518^{c}
		Trotting	0.5	1.4	23	-	3.248^{c}
		Galloping	0.1	0.5	23	-	4.480^{c}
	Calf	Bedded	69.0	21.3	22	-	1.961
		Foraging	11.2	6.8	22	-	1.159
		Standing	4.9	4.6	22	-	1.009
		Walking	12.0	14.5	22	-	3.876*
		Trotting	1.9	3.3	22	-	3.248^{c}
		Galloping	0.9	1.9	22	-	4.480^{c}

Table 1 continued

Season	Class	Activity	Proportion of time (%) $\bar{x}$	SD	n[a]	t statistic[b]	F ratio[c]
Combined (3-29 June)	Cow	Bedded	40.9	19.8	50	-2.48*	3.289*
		Foraging	44.6	16.8	50	2.80*	12.25*
		Standing	3.9	2.8	50	3.19*	1.140
		Walking	10.1	12.3	50	-1.203[d]	0.771
		Trotting	0.4	1.0	50	-0.3949[d]	0.018[e]
		Galloping	0.1	0.3	50	-0.3713[d]	2.341[e]
	Calf	Bedded	58.7	23.0	48	-3.06*	0.6070
		Foraging	12.7	8.7	48	1.11	3.560*
		Standing	12.3	15.6	48	-1.426[d]	3.261[e]
		Walking	13.6	13.7	48	0.73	0.541
		Trotting	1.9	2.8	48	0.1657[d]	2.269[e]
		Galloping	0.7	1.6	48	-0.9481[d]	2.241[e]

[a] Number of observer team days.

[b] H_o: There is no difference between seasonal means.

[c] H_o: There are no differences between observer teams.

[d] Mann-Whitney-U test statistic.

[e] Kruskal-Wallis 1-way ANOVA, chi-square statistic.

* Significant difference ($P < 0.05$).

Table 2. Comparison of the mean proportion of time spent by caribou in different activities, Beverly calving ground, 1981 and 1982.

			% Time 1981			% Time 1982			
Season	Class	Activity	$\bar{x}$	SD	n[a]	$\bar{x}$	SD	n	t-statistic[b]
Calving	Cow	Bedded	32.8	12.1	20	34.8	16.0	28	-0.4720
		Foraging	49.4	11.9	20	50.3	14.5	28	-0.2231
		Standing	4.8	2.6	20	5.0	2.4	28	-0.2763
		Walking	12.4	6.8	20	9.6	7.0	28	1.3551
		Trotting	0.5	0.9	20	0.2	0.5	28	-
		Galloping	0.6	0.3	20	0.0	0.1	28	-
	Calf	Bedded	58.5	21.0	20	50.4	21.2	27	1.3010
		Foraging	16.3	13.1	20	14.0	9.9	27	0.6729
		Standing	13.5	21.1	20	18.3	18.6	27	-0.8326
		Walking	11.0	7.8	20	14.9	13.2	27	-1.1883
		Trotting	0.6	0.8	20	1.9	2.5	27	-
		Galloping	0.3	0.5	20	0.6	1.3	27	-
Post-calving	Cow	Bedded	39.7	15.7	26	48.3	21.7	23	-1.6151
		Foraging	47.5	13.7	26	37.8	17.1	23	2.2171*
		Standing	4.3	2.1	26	2.7	2.7	23	2.3153*
		Walking	7.8	4.6	26	10.6	16.8	23	-0.8363
		Trotting	0.6	1.0	26	0.5	1.4	23	-
		Galloping	0.2	0.9	26	0.1	0.5	23	-
	Calf	Bedded	66.0	11.7	26	69.1	21.3	22	-0.6291
		Foraging	16.0	6.0	26	11.2	6.9	22	2.5635*
		Standing	5.2	3.3	26	4.9	4.6	22	0.1919
		Walking	10.3	5.8	26	12.0	14.5	22	-0.5360
		Trotting	1.8	2.0	26	1.9	3.3	22	-
		Galloping	0.8	1.3	26	0.9	1.9	22	-
Combined	Cow	Bedded	36.9	14.6	45	40.9	19.8	50	1.1103
		Foraging	48.1	12.9	45	44.6	16.8	50	-1.1294
		Standing	4.4	2.3	45	3.9	2.8	50	-0.9448
		Walking	9.9	6.1	45	10.1	12.3	50	-0.0987
		Trotting	0.6	1.0	45	0.4	1.0	50	-
		Galloping	0.2	0.7	45	0.1	0.3	50	-

Table 2 continued.

Season	Class	Activity	% Time 1981 $\bar{x}$	SD	n[a]	% Time 1982 $\bar{x}$	SD	n	t-statistic[b]
	Calf	Bedded	62.7	16.8	45	58.7	23.0	48	0.9524
		Foraging	16.1	9.7	45	12.7	8.7	48	-1.7816
		Standing	8.7	14.7	45	12.3	15.6	48	-1.1436
		Walking	10.7	6.7	45	13.6	13.7	48	-1.2831
		Trotting	1.3	1.7	45	1.9	2.8	48	-1.2390
		Galloping	0.6	1.1	45	0.7	1.6	48	-

a Number of observer team days.

b T-statistic calculation based on assumption of unknown but assumed equal population variance (Dunn and Clark 1974:58).

* Significant difference ($P < 0.05$).

Examination of variability in activity budgets on the basis of observer teams (Appendix C) using a 1-way ANOVA revealed significant ($P < 0.05$) differences between observer teams in the observed proportion of time cows spent bedded and foraging, and calves spent foraging, during the calving season. During post-calving there were significant ($P < 0.05$) differences between observer teams in the observed proportion of time cows spent foraging and calves spent walking (Table 1). When both seasons were combined there was a significant ($P < 0.05$) difference between observer teams in the proportion of time spent by cows bedded and foraging and by calves foraging. During 1981 the only observer team differences were in the observed proportion of time cows were observed bedded during post-calving.

We tested for differences in the proportions of time spent bedded, foraging or walking relative to wind direction. If the caribou were responding to the observers when the wind was from the caribou to the observers, a difference in activity patterns could be expected. Wind direction relative to the observer teams did not significantly ($P > 0.05$) influence the proportion of time spent by cows or calves bedded, foraging or walking (Table 3). Cows and calves did, however, spend proportionately more time walking when down wind of the observers which was similar to the result in the 1981 study.

Events

We observed 559 cows for a total of 4,754 active cow-min (79.2 h), 498 calves for 3,201 active calf-min (53.4 h) (Table 4). Out

Table 3. Influence of wind direction on caribou activity budgets, Beverly calving ground, 1982.

		Wind direction						
		From observers to caribou			Other[a]			
Class	Activity	$\bar{x}$[b]	SD	n[c]	$\bar{x}$	SD	n	t statistic[d]
Cow	Bedded	39.6	6.6	4	37.1	15.0	14	-0.31
	Foraging	45.6	11.8	4	52.7	13.4	14	0.96
	Walking	14.9	11.3	4	10.2	7.0	14	-1.04
Calf	Bedded	49.6	23.4	4	65.4	15.6	14	1.59
	Foraging	11.7	9.9	4	18.4	6.9	14	1.54
	Walking	38.6	32.2	4	16.2	13.8	14	-2.07

[a] Includes observations when wind was recorded as calm, crosswind or from caribou to observers.

[b] Mean proportion of caribou (expressed as a percentage) observed in each activity.

[c] Number of observer team days when wind direction was recorded.

[d] No significant difference (P>0.05).

Table 4. Summary of cow-calf pair observation periods by season, Beverly calving ground, 1982.

	Season	
	Calving	Post-calving
Observation periods	357	125
Total cows	393	166
Duration cows (min)	3,495	1,259
Total calves	335	163
Duration calves (min)	2,220	981
Single pairs	291	89
Multiple pairs	34	35
Single animals	31	1
Observations < 10 min[a]	223	65

[a] Single pair observations.

of 498 continual 10-min observation periods, single cow-calf pairs were observed during 78.3% (418) of the sampling periods. Of these single pair observations, 57.9% (309) were less than 10 min as a result of the pair bedding or going out of sight. We observed more than one cow-calf pair during 15.7% (84) of the sampling periods, but never more than four pairs at any one time.

Nursing Behaviour

The mean rate of nursing was normally distributed during calving and post-calving when analyzed on a per day, per observer team basis (K-S Z=1.163 and 0.925 respectively; $P > 0.05$). The mean rate of attempted nursing was normally distributed only during post-calving (K-S Z=1.504; $P > 0.05$). When calving and post-calving were combined both the rate of nursing and the rate of attempted nursing were not normally distributed (K-S Z=2.292 and 2.265 respectively; $P > 0.05$). Log transformations of the combined season rates were also not normally distributed. In 1981 both the mean rate of nursing and the mean rate of attempted nursing were normally distributed over the combined seasons. When the observation period was broken down into six 4-day periods and one 3-day period (27-29 June) and analyzed using a Kruskal-Wallis 1-way ANOVA there were significant differences ($P < 0.05$) between periods for the mean rate of nursing and attempted nursing (Chi-square = 13.1 and 15.2, respectively).

The mean rate of nursing generally declined with the progression of the calving season (Table 5). However, this trend was broken by a small sample of high rate observations during

Table 5. Seasonal variation in the rates of nursing and attempted nursing by caribou calves, Beverly calving ground, 1982.

Period[a]	Nursing rate (events/100 calf-min)			Attempted nursing rate (events/100 calf-min)	
	n[b]	$\bar{x}$	SD	$\bar{x}$	SD
3-6 June	18	13.9	14.1	10.7	11.0
7-10 June	19	12.0	7.6	6.8	6.4
11-14 June	21	10.2	5.3	10.2	10.2
15-18 June	10	6.5	4.9	5.0	8.2
19-22 June	3	24.3	12.3	0.8	1.5
23-26 June	12	7.2	5.8	3.6	6.1
27-29 June	10	6.3	5.0	4.8	5.4
Calving	56	12.0	9.6	9.4	9.6
Post-calving	37	8.3	7.4	4.2	6.1
Combined	93	10.6[b]	9.0	7.3[c]	8.7

[a] Significant difference ($P < 0.05$) between 4-day periods.

[b] Number of observer team days.

[c] Significant difference ($P < 0.05$) between 1982 calving and post-calving periods and between years 1981 and 1982.

19-22 June. A more clearly defined trend to decreasing mean nursing rate was observed in 1981. There was a significant difference between calving and post-calving mean nursing rates (Mann-Whitney U statistic = 757.5; $P < 0.05$). The mean rate during calving was 12.0/100 calf-min while during post-calving it was 8.3/100 calf-min. There was also a significant difference ($P < 0.05$) in 1981 between calving and post-calving nursing rates, with higher rates being observed during calving than post-calving. The mean rate of nursing for the combined seasons in 1982 was 10.6/100 calf-min, which was significantly ($P < 0.05$) greater than the 1981 rate of 7.3/100 calf-min.

The rate of attempted nursing also significantly decreased from calving to post-calving (Mann-Whitney U statistic = 607.5; $P < 0.05$). During calving the mean rate was 9.4/100 calf-min, and it decreased to 4.2/100 calf-min during post-calving. The mean rate for the combined seasons was 7.3/100 calf-min, significantly ($P < 0.05$) higher than the 1981 rate of 4.7/100 calf-min.

As in 1981, the 1982 distribution of nursings and attempted nursings did not seem to vary significantly ($P > 0.05$) under different wind conditions (Table 6), suggesting that the occurrence of these events was unaffected by wind direction relative to the observers and caribou. Similarly, there were no significant ($P > 0.05$) differences between observer teams in either year for nursing rate and attempted nursing rate.

We timed the duration of 261 (pre-disturbance) nursing events (Table 7). Logarithmic transformations were used in both 1981 and 1982 to normalize data. The mean duration of nursing was 46.4 s.

Table 6. Distribution of nursing and nursing attempts by cow-calf pairs of caribou by wind direction, Beverly calving ground, 1982.

	Wind direction		
Event	From observer to caribou	Other	X^2
Nursing			
Above median[a]	60	182	1.855^b
Below median	47	197	
Attempted nursing			
Above median[a]	32	111	0.000^b
Below median	75	268	

[a] Median = 0, i.e. values "above median" represent the number of all-occurrences in which at least one nursing bout was observed.

[b] No significant difference ($P > 0.05$).

Table 7. Durations of nursing events by caribou calves during calving and post-calving, Beverly calving ground, 1982.

Period	Durations of nursing events			
	n[a]	$\bar{x}$	SD	range
3-6 June	59	51.7	46.7	6-232
7-10 June	74	44.0	32.7	6-123
11-14 June	81	37.7	31.7	6-127
15-18 June	19	67.3	60.5	14-290
19-22 June	5	64.6	8.5	55-75
23-26 June	13	58.9	36.5	5-143
27-29 June	10	38.2	20.9	8-72
Calving	204	43.6	37.0	6-232
Post-calving	57	52.1	44.2	5-290
Combined[b]	261	46.4	38.8	5-290

[a] Number of nursings recorded where duration was known.

[b] Significantly different ($P < 0.05$) from 1981 combined season mean duration.

Though there were no obvious trends in nursing duration when the season was broken down into 4-day periods, duration was significantly ($P < 0.05$) less during calving compared to post-calving for the log transformed data. In 1981 there were no significant ($P > 0.05$) differences between 4-day periods or between calving and post-calving. The 1981 mean duration for the combined seasons (50.2 s) was not significantly ($P > 0.05$) different than the 1982 rate.

In 1982, most nursings (47.9%) occurred on the right side of the cow; 46.5% occurred on the left. This was the reverse of the situation in 1981 where 52.8% occurred on the left side and 39.1% on the right. We observed 16 nursings (4.7%) from the rear, all but three of which occurred during calving, and three nursings (0.9%) from the front. A similar trend was observed in 1981 with 7.7% from the rear and 0.4% from the front. In both years the side chosen for nursing appears independent of season ($P > 0.05$).

The initiator of nursing was determined for 277 of the 329 observed nursings. In 1982, calves initiated 89.5% (248) of the nursings where initiator was known while in 1981 they initiated 91.5% (248) of all nursings. The greatest proportion of cow initiated nursings occurred during 15-18 June when 21.1% (4) of all observed nursings for that period (19) were cow initiated. In 1981 the highest proportions observed occurred during the 2-5 June period when 16.0% (8) of all observed nursings for that period (50) were cow initiated. Cows terminated 67.9% of all nursings. Terminations by calves were more common during calving than post-calving (38.9% versus 15.7%; $P < 0.05$). In 1981 these figures were 29.0% and 17.4% and were also significantly different ($P < 0.05$).

Aggressive Acts

Head swings, kicks, and rushes were pooled together as aggressive acts on a per day basis. The mean rate of aggressive acts was 1.72/100 cow-min ($SD = 1.47$, $n = 21$). There was no significant difference ($P > 0.05$) between the rate of aggressive acts in 1982 and the rate in 1981 (2.0/100 cow-min).

The rate of aggressive acts in 1982 was dependent on group size which was also true in 1981. Lower than expected rates were recorded when no other caribou were within 5 body lengths of the observed cow (Table 8). Higher than expected rates were observed for all groups sizes greater than the 1-5 class size. As in 1981, when a change occurred in group size aggressive acts occurred more frequently than expected on the basis of a random occurrence (Table 9). In 1981, more aggressive acts were observed than expected when caribou were downwind of the observers, however, this was not observed in 1982 (Table 9). Aggressive acts appeared to be independent of the observer making the observations in 1982. In 1981, however, one observer was found to record a proportionately higher rate of aggressive acts than the other observers.

We recorded a total of 201 aggressive acts during 178 aggressive events: 45.7% (92) involved rushes 44.3% (89) involved head swings and 10.0% (20) involved kicks (Table 10). A single aggressive act (1-act event) was displayed during 88.8% (158) of the observed aggressive events but the remaining events involved

Table 8. Distribution of aggressive acts by caribou cows by group size, Beverly calving ground, 1982.

	Group size				
Rate of aggressive acts	0	1-5	6-10	11+	Total
Above median	13	32	8	4	57[a]
Below median	217	183	23	7	430
Chi-square contribution	8.2	2.11	6.0	5.7	22.01*

[a] Represents the number of observation periods when one or more aggressive acts occurred; i.e., when the rate was above 0 (median = 0).

* Significant difference ($P < 0.05$).

Table 9. Distribution of aggressive acts by caribou cows by change in group size (A) and by wind direction (B), Beverly calving ground, 1982.

A. Change in group size

Rate of aggressive acts	Change	No change	
Above median	46	10	$X^2 = 24.8415$*
Below median	125	149	

B. Wind direction

Rate of aggressive acts	Wind direction		
	From observers to caribou	Other	
Above median	10	47	$X^2 = 0.486$
Below median	97	332	

a Represents the numbers of observation periods when one or more aggressive acts occurred, i.e. when the rate was above 0 (median = 0).

* Significant difference ($P < 0.05$).

Table 10. Seasonal distribution of 201 aggressive acts exhibited by caribou during 178 aggressive events, Beverly calving ground, 1982.

Aggressive act	Calving[a]	Post-calving[b]
Rush	80	12
Head swing	63	26
Kick	14	6
Total	157	44

[a] Data based on 362 point-in-time observation periods (3,495 active cow-min).

[b] Data based on 125 point-in-time observation periods (1,259 active cow-min).

17 2-act events and 3 3-act events. Most aggressive acts were initiated by cows (observed cow and other cow) and were mostly directed towards calves (observed calf and other calf): 67.5% during calving, 95.4% during post-calving (Table 11). In 1981 these values were 74.6% and 77.5%, respectively. Observed cows directed about an equal proportion of aggressive acts toward their own calves (observed calf) as they did toward other calves during the calving period. But during post-calving observed cows directed proportionately more of their aggressive acts towards other calves (88.0%) than toward their own calves (0.0%). Similar trends were shown by observed cows during the calving and post-calving periods in 1981 for the initiator and recipient of aggressive acts (Jingfors et al. 1982).

Observed calves exhibited aggressive-like behaviour on three occasions that was recorded as aggression (Table 11). It is most likely, however, that those three events were actually exhibits of attention-getting behaviour or attempts at initiating play and not truly aggressive acts by those calves.

Other Events

We observed three sessions of head bobbing and 13 alarm stances during 4,754 active cow-min of observation. The overall rates were 0.06/100 and 0.25/100 cow-min, respectively. These low frequencies are comparable to 1981 values of 0.15/100 and 0.19/100, respectively). The three sessions of head bobbing were observed on 3 and 5 June. Two sessions took place while the cows

Table 11. Seasonal distribution of the initiator and recipient of aggressive acts between caribou, Beverly calving ground, 1982.

	Recipient								
	Calving[a]				Post-calving[b]				
Initiator	Observed cow	Observed calf	Other cow	Other calf	Observed cow	Observed calf	Other cow	Other calf	Total
Observed cow	-	4	27	26	-	0	3	22	82
Observed calf	1	-	1	0	0	-	0	1	3
Other cow	11	74	-	2	1	17	-	0	105
Other calf	0	0	0	-	0	0	0	-	0
Total	12	78	28	28	1	17	3	23	190[c]

[a] Data based on 362 point-in-time observation periods (3,495 active cow-min).

[b] Data based on 125 point-in-time observation periods (1,259 active cow-min).

[c] Eleven aggressive acts (9 events) involving yearlings or juveniles of unknown sex were excluded from this table; 10 by observed cows, 4 rushes, 2 head swings, and 2 antler-kicks; and 1 aggressive rush by a yearling or juvenile toward an observed calf.

and their calves were trotting on lake ice. One cow head-bobbed to encourage her calf to catch up after she had out-distanced it; the other cow stopped and head bobbed to encourage her calf to get up and continue on after the calf had fallen on the ice. The third session of head bobbing occurred as an interruption to a cow's foraging; when it stopped feeding and head bobbed at its calf, then licked the calf's face after it approached, before resuming foraging. We could not detect any reason for 6 of the 13 alarm stances. Alarm stances were exhibited on three occasions, seemingly, in response to the presence of the observers; on two occasions in response to an approaching Arctic fox (Alopex lagopus); once in response to an approaching wolf (Canis lupus); and once as several whistling swans (Olor columbianus) flew overhead.

Range Use

During 1981, aerial photography was used to establish the distribution of range types on the Beverly calving ground. "Lichen Uplands" covered approximately 38.8% of the area, "Dwarf Shrub"24.1%, "Meadow" 12.3% and "Rock/Sand Barrens" 4.0%. Lakes and other water bodies covered the remaining 20.8% (Jingfors et al. 1982).

From 500 scans of caribou in 1982, we recorded 18,483 "point-in-time" observations of caribou range use (Appendix E). The proportion of caribou observed bedded on Lichen Uplands was normally distributed during calving and post-calving (Appendix F). The proportion foraging on Lichen Uplands was normally distributed only during post-calving. The proportion of caribou observed bedded on Dwarf Shrub was normally distributed for all but calving and post-calving combined. During 1981, proportions observed on Dwarf Shrub for the combined seasons were also not normally distributed. Proportions of caribou observed bedded and foraging on Meadow were normally distributed during all parts of the season. Observations of caribou on Rock/Sand Barrens were not analyzed in detail due to the infrequent occurrence of caribou on that range type ($< 1.0\%$). Assumptions of independence were met for observations of caribou bedded and foraging on all range types during calving, post-calving and both seasons combined.

Most caribou were observed bedded (49.0%) or foraging (44.0%) on Lichen Uplands during calving; during post-calving most were observed bedded (44.0%) and foraging (50.9%) on Meadow (Table 12). In 1981, the apparent post-calving shift to Meadow, as observed in 1982, was not as marked though proportionately greater for Dwarf Shrub areas. Between season differences were not significant ($P > 0.05$) in either year. There were significantly ($P < 0.05$) fewer caribou observed foraging on Dwarf Shrub during 1982 post-calving (9.8%) compared with 1981 post-calving (26.9%). The proportion observed bedded on Dwarf Shrub was also significantly ($P < 0.05$) less during post-calving in 1982 (11.6%) when compared with post-calving in 1981 (33.7%). There were significantly ($P < 0.05$) more caribou observed bedded on Meadow during 1982 (44.4%) than during 1981 (18.0%). For the combined calving and post-calving there was a significantly ($P < 0.05$) higher proportion of caribou observed bedded (40.4%) and foraging (44.6%) in Meadow during 1982

Table 12. Comparison of seasonal range use by caribou calculated as the mean proportion of caribou observed bedded or foraging on each range type, Beverly calving ground, 1982 and 1981.

			Proportion of caribou (%)								
			1982				1981				
Season	Range type	Activity	$\bar{x}$	SD	n[a]	F ratio[b]	$\bar{x}$	SD	n[a]	F ratio	t statistic[c]
Calving											
	Lichen Uplands	Bedded	49.0	30.1	28	10.620*	50.4	29.4	20	0.263	-0.1559
		Foraging	44.0	25.3	28	--	52.5	27.8	20	1.758	-1.1075
	Dwarf Shrub	Bedded	13.9	12.5	28	1.086	17.3	26.9	20	--	-0.5878
		Foraging	16.9	15.9	28	5.662*	16.8	23.7	20	--	0.0190
	Meadow	Bedded	37.1	31.4	28	14.392*	27.3	18.3	20	0.676	1.2424
		Foraging	39.1	27.8	28	20.493*	30.7	20.1	20	0.068	1.1524
	Rock/Sand Barrens	Bedded					<1.0		20		
		Foraging					<1.0		20		
Post-calving											
	Lichen Uplands	Bedded	44.0	34.1	24	2.187	48.3	34.2	25	2.805	-0.4460
		Foraging	39.3	32.9	24	4.738*	37.7	31.5	25	2.013	0.2500
	Dwarf Shrub	Bedded	11.6	18.4	24	--	33.7	29.8	25	0.950	-3.1010*
		Foraging	9.8	14.5	24	1.964	26.9	22.8	25	1.313	3.1227*
	Meadow	Bedded	44.4	38.4	24	4.399*	18.0	17.2	25	2.401	3.1311*
		Foraging	50.9	33.9	24	10.001*	35.3	21.9	25	1.800	1.9262
	Rock/Sand Barrens	Bedded	<1.0		24		<1.0		20		
		Foraging	<1.0		24		<1.0		25		

Table 12 continued.

			Proportion of caribou (%)								
			1982				1981				
Season	Range type	Activity	$\bar{x}$	SD	n[a]	F ratio[b]	$\bar{x}$	SD	n[a]	F ratio	t statistic[c]
Combined											
	Lichen Uplands	Bedded	46.7	31.8	52	8.687*	49.2	31.8	45	1.337	-0.3880
		Foraging	41.8	28.8	52	--	44.3	30.5	45	2.071	-0.6930
	Dwarf Shrub	Bedded	12.9	15.4	52	--	26.4	29.4	45	--	2.8956*
		Foraging	13.6	15.6	52	--	22.4	23.5	45	--	-2.1947*
	Meadow	Bedded	40.5	34.7	52	12.753*	22.1	18.1	45	2.372	3.1939*
		Foraging	44.6	31.0	52	19.970*	33.3	21.0	45	1.567	2.0594*
	Rock/Sand Barrens	Bedded	<1.0		52		<1.0		45		
		Foraging	<1.0		52		<1.0		45		

a Number of observer team days.

b H_o: There are no differences between observer teams.

c H_o: There are no differences between years.

* Significant difference ($P < 0.05$).

than in 1981 (22.1% and 33.3%, respectively). The increased proportion of caribou observed on Meadow during 1982 was matched by a reduced number of animals observed bedded (12.9%) and foraging (13.6%) on Dwarf Shrub relative to 1981 (26.4% and 22.4%, respectively).

During calving, post-calving, both seasons combined and during post-calving/post-disturbance there were significant differences ($P < 0.05$) between observer teams in the proportion of caribou observed using the different range types. Due to the rigorous nature of the study design, this difference is more likely attributable to differences in the relative availability of the range types among sampling areas than to observer bias.

During the 1982 calving period, 93.5% of all caribou observed bedded and 78.0% of those foraging were on bare ground while the remaining 6.5% and 22.0%, respectively, occurred on snow covered ground (Table 13). For bedded animals, the proportions on snow and bare ground were similar between years. A larger percentage was observed foraging on snow covered areas during 1982 than 1981. During 1982 post-calving, the proportion of caribou bedded and foraging on bare ground increased to 99.5% and 98.0%, respectively; a similar trend occurred in 1981. However, there was still a slightly larger percentage of caribou observed foraging on snow covered ground in 1982 than in 1981 (24.0% vs 10.1%). This may be related either to differences in relative proportions of range covered by snow between years or to differences in caribou behaviour.

Table 13. Comparison of seasonal range use by caribou calculated as the mean proportion (expressed as a percentage) of caribou observed bedded or foraging on snow or bare ground, Beverly calving ground, 1982 and 1981.

			Proportion of caribou (%)					
			1982			1981		
Season	Ground cover	Activity	$\bar{x}$	SD	n[a]	$\bar{x}$	SD	n
Calving	Snow	Bedded	6.5	9.0	28	5.9	12.1	20
		Foraging	22.0	17.1	28	9.5	8.6	20
	Bare	Bedded	93.5	9.0	28	94.1	12.1	20
		Foraging	78.0	17.1	28	90.5	8.6	20
Post-calving	Snow	Bedded	0.5	1.8	24	0.5	1.1	25
		Foraging	2.0	4.0	24	0.6	1.3	25
	Bare	Bedded	99.5	1.8	24	99.5	1.1	25
		Foraging	98.0	4.0	24	99.4	1.3	25

a Number of observer team days.

When comparing caribou range use with availability of range types, we found a significant ($P < 0.05$) deviation from what would be expected if caribou were distributed randomly (Table 14). This condition was also observed in 1981. During 1982 calving and post-calving, foraging caribou used the Meadow range type most intensively (Selectivity index = +0.4 and +0.8, respectively); in 1981, a similar trend occurred (Selectivity index = +0.3 and +0.4, respectively).

During 1982 calving, bedded caribou were observed slightly more on Lichen Uplands and Meadow than expected (Selectivity index = +0.1 and +0.1, respectively); use of Dwarf Shrub areas by bedded caribou was less than expected (Selectivity index = -0.3). In the 1981 calving period, bedded caribou showed a similar though more intense selectivity for the above range types (Selectivity index = +0.2, +0.2 and -0.6, respectively). During 1982 post-calving, bedded caribou made greater use of Meadow than expected (Selectivity index = +0.5) and lower use of Dwarf Shrub (Selectivity index = -0.6). This was in marked contrast to 1981 where caribou appeared to bed on the different range types more closely to their proportional availability.

For the combined season most caribou were observed bedded on Lichen Uplands and foraging on Meadow. However, only Meadow was used for bedding or foraging proportionately more than would be expected (Selectivity index = +0.4 and +0.5, respectively). On the basis of the selectivity index, all other range types were used proportionately, as expected or less than expected (Table 14).

Table 14. Seasonal range use by caribou in relation to availability of range types, Beverly calving ground, 1982.

Season	Activity	Number of caribou observations in range type				Total	X^2*
		Rock/Sand Barrens (0.04)[a]	Lichen Upland (0.49)	Dwarf Shrub (0.31)	Meadow (0.16)		
Calving	Bedded						
	Observed	0(-1.0)	3467(+0.1)[b]	963(+0.1)	990(+0.1)	5420	788.1
	Expected	217	2656	1680	867		
	Foraging						
	Observed	0(0.1)	1921(0.0)	768(-0.3)	1547(+0.4)	4236	1520.6
	Expected	169	2076	1313	678		
Post-calving	Bedded						
	Observed	62(-0.6)	2303(-0.1)	398(-0.6)	2679(+0.5)	5442	4899.0
	Expected	218	2666	1687	871		
	Foraging						
	Observed	3(-0.1)	983(-0.3)	189(-0.7)	2210(+0.8)	3385	6242.2
	Expected	135	1658	1049	542		
Combined	Bedded						
	Observed	62(-0.8)	5770(0.0)	1361(-0.3)	3669(+0.4)	10862	3697.1
	Expected	434	5322	3367	1738		
	Foraging						
	Observed	3(-1.0)	2904(-0.1)	957(-0.4)	3757(+0.5)	7621	6603.5
	Expected	305	3734	2362	1219		

a Availability (expected value) expressed as the proportion of calving area covered by this range type. Proportional coverage was based on land area only.

b Selectivity index = $\frac{U-A}{U+A}$ where U = Use, and A = availability from Ivlev (1961).

Proportional use given in Table 13.

c Significant departure from use in relation to availability ($P < 0.05$).

Fundamental to comparisons of this kind is the assumption that during both seasons, observer teams were viewing caribou in areas which had a coverage by the different range types similar to that for the entire calving ground. As observers only chose sites where caribou occurred rather than choosing a typical area and waiting for caribou, the evaluation may have been somewhat biased if the above assumption was not met. If anything, the trends would have been more pronounced. Ideally, availability of range types at each site should have been accurately determined at each site using aerial photography or intensive ground work. Also, determination of range types under snow covered areas was not possible without disturbing the animals under observation. Observers were therefore forced to evaluate range type coverage from a distant and often oblique perspective.

Helicopter Landings

The late arrival of the helicopter, poor weather and the shared use of the helicopter all contrived to delay the start of the experimental landings to 18 June. We carried out 16 successful landings near post-calving groups of caribou between 18 and 28 June. The helicopter landed 300-550 m from the caribou under observation on nine occasions; 1000-2000 m on six occasions; and once at about 2200 m (Appendix G). On those 16 occasions distances from helicopter to observed caribou averaged about 950 m (± 650 m, SD). The initial group size, position of the sun and wind conditions, and time of day all varied between the landings and no patterns could be discerned within the small sample (Appendix G).

At the beginning of each landing, the caribou were foraging or bedded except at the beginning of landing No. 12-27L when the caribou were steadily walking in small groups of 20-50. During that landing, the caribou continued to walk through the sample area and the appearance of new groups seemed to stimulate caribou on the sample area to trot and gallop. The group of 30 caribou initially under observation moved out of sight during the Descent phase. On 25 June (Landing No. 8-25I) the helicopter landed about 1000 m from a group of 22 cows and calves which was foraging but also steadily moving in a southeast direction before the Approach phase. As the helicopter approached at 300 m agl, the caribou began to trot and continued to trot for 3 min until out of sight over a ridge during the beginning of the Shut-down/Ground activity phase. Meanwhile, groups of 25, 4 and 10 trotted onto the sample area and also trotted out of sight over the ridge while the helicopter was shut down. The observers switched to a group of 30 caribou about 3 km away for the last 4 min of Shut-down to Take-off. Those caribou continued to forage and remain bedded.

The first landing on 18 June (No. 1-18B) was inadvertently on the wrong area and the helicopter then landed a second time, compounding the problem by landing between the observers and caribou at a distance of only 300 m from the nearest caribou. Within 11 min, the 400-500 caribou had left the sample area: between 50% and 75% of the group walked but some trotted or galloped until out of sight about 2.3 km away.

The 50 caribou that were bedded or foraging in a clumped group mostly trotted as the helicopter approached and turned over them at the beginning of the second landing (2-18H) on 18 June. During the descent and for the first 6 min after Shutdown most of the caribou walked, but then less than 25% bedded and the rest foraged and drifted away from the helicopter. As the helicopter started up (Wind-up phase) caribou began to walk (50%) or trot (25%). Then during the Take-off phase they all began walking (75%) or trotting (25%) until they were out of sight, having moved 1 km since the helicopter landed.

The fourth landing that caused the caribou to move out of the observer's sight during the landing was on 23 June (No. 4-23E, Appendix G). The caribou had been bedded or foraging but as the helicopter wound down, most caribou (51-75%) were walking away, < 25% were standing, and < 25% were trotting. Six min after Shut-down a few caribou had started to forage but continued to drift away. By the time the helicopter started up the caribou had walked and foraged over about 1500 m and were out of sight.

The 50 caribou in a group stopped foraging and began to walk, or a few trotted, as the helicopter turned over them on 24 June (No. 7-24E, Appendix G). Within 6 min after Shut-down the caribou walked behind a ridge but were back in sight 14 min later. Less than 50% of the group were walking, the others were foraging. When the helicopter took off, almost all the group was foraging but they continued to drift away and were out of sight before the post-disturbance observations could begin. Similarly during the landing No. 3-23C on 23 June some caribou were foraging and drifting away and about half the group started to walk after the helicopter landed. That pattern of walking away and foraging continued until about 1500 m was covered and only five cow-calf pairs were still in sight as the helicopter took off. They had moved out of sight after a few minutes of post-disturbance observations.

Four other landings resulted in some of the caribou under observation moving out of sight (Appendix G). During the Shutdown phase of No. 6-23L and No. 11-27N, about 20% and 60% of the caribou, respectively, walked and foraged out of sight. The third and fourth cases when part of the group under observation moved out of sight were two of three landings near caribou on the small islands of Deep Rose Lake (Nos. 10-27G and 14-28G).

There were three landings near caribou, excluding one landing on the islands of Deep Rose Lake, which did not result in the caribou moving out of the observer's view (Nos. 5-23J, 9-25M, and 15-28O) even though the helicopter landed within 500 m of the caribou for two groups (Nos. 9-25M and 15-28O) and 2200 m for the third group (No. 5-23J, Appendix G). Within each group up to 25% responded to the descent and landing by walking and trotting and the foraging caribou tended to drift away from the helicopter (Appendix H).

We landed the helicopter three times on a small island (about 1 km long) off the east shoreline of Deep Rose Lake (Nos. 10-27G, 13-28G and 14-28G). This island was separated from a second island to the north by channels of open water along the shores and a large ice pan in the middle (about 400 m wide). There were 200-300 caribou on the north island and, although a few cows tried to lead their calves into the water, the reluctance of the calves to follow was apparently preventing the group from leaving the island. We landed once on 27 June and twice on 28 June on the southern island. On 27 June most of the caribou walked and milled away from the helicopter to the shoreline. About 15 caribou swam to the edge of the ice but could not or would not climb up the ice shelf and retreated to their point of entry. About 50% of the caribou walked or stood alerted and 25-50% foraged and drifted away and 90% of the caribou were out of sight by the time the helicopter took-off.

The following day, we made a similar approach and during the descent and landing 50% of the caribou on the northern island had walked out of sight, and all had walked and foraged out of sight within 15 min of Shut-down. At the end of the ground activity, about 80 cow-calf pairs walked back into view but were again out of sight as the helicopter took-off. Six hours later, we returned for a second landing, and during the helicopter turn over the northern island, half the caribou were alerted and started to walk together. As the ground activity phase started, calves started to bed and the cows foraged. When the helicopter started up the calves rose to move to their mothers and some caribou walked together. Less than 25% remained bedded or foraging while about 40% had walked away out of sight as the helicopter took-off.

On one occasion (No. 13-28G in Appendix H) the caribou group that had moved out of sight during the helicopter landing moved back in sight. Including one group that had not been observed during the landing but moved into sight within a few minutes of the helicopter's departure, we obtained post-disturbance data on

11 groups of caribou (Appendix H). We had pre-disturbance observations of 7 of those 11 groups (Appendix H). The comparison of activity patterns of the same groups of caribou during pre- and post-disturbance (Appendix I) was hampered by the small sample size. Additionally, the longer the post-disturbance observation period, the more likely that differences occurring during early post-disturbance will become masked when averages are taken over the entire post-disturbance period.

The standard deviations for the mean activity budgets of the cows and calves during post-disturbance were generally higher than during pre-disturbance suggesting greater variation in the activity patterns (Table 15). On the average more than twice the proportion of cows were walking, trotting or galloping during post-disturbance as during pre-disturbance. The difference was more marked for the calves which showed almost a three fold (2.7) increase on the average in the proportion walking, trotting and galloping during post-disturbance as during pre-disturbance (Table 15).

The proportions of caribou observed on the different range types were more variable during post-disturbance than pre-disturbance (Table 16, Appendix J). The largest proportion of bedded caribou was on Meadow during pre-disturbance but was on Lichen Upland during post-disturbance. The greatest proportion of caribou foraging was observed on the Meadow range type both before and after the helicopter landings. After the landings, however, a relatively larger proportion of caribou were foraging on Lichen Upland and Dwarf Shrub (Table 16).

Table 15. Pre- and post-disturbance activity budgets of caribou[a] calculated as mean proportions and expressed as percentages of time spent in each activity, Beverly calving ground, 1982.

		Pre-disturbance			Post-disturbance		
Class	Activity	$\bar{x}$[b]	SD	n	$\bar{x}$	SD	n
Cow	Bedded	44.3	8.1	7	46.6	18.1	7
	Foraging	47.2	7.8	7	39.7	10.2	7
	Standing	3.0	2.5	7	2.5	3.1	7
	Walking	5.3	3.7	7	11.1	13.7	7
	Trotting	0.1	0.2	7	0.1	0.2	7
	Galloping	0.0	0.0	7	0.0	0.0	7
Calf	Bedded	73.5	9.6	7	64.2	24.4	7
	Foraging	6.6	6.2	7	15.5	7.5	7
	Standing	3.3	2.3	7	2.5	2.0	7
	Walking	5.8	4.8	7	15.4	17.9	7
	Trotting	0.6	0.7	7	1.9	2.6	7
	Galloping	0.1	0.2	7	0.5	0.8	7

[a] Observations of the same caribou group during pre- and post-disturbance.

[b] Mean proportion of time (expressed as a percentage) spent in each activity.

Table 16. Range use by caribou[a] pre- and post-disturbance, calculated as mean proportions and expressed as percentages of caribou observed bedded or foraging on each range type, Beverly calving ground, 1982.

Range type	Activity	Pre-disturbance			Post-disturbance		
		$\bar{x}$	SD	n[b]	$\bar{x}$	SD	n
Lichen Upland							
	Bedded	32.0	30.5	7	46.5	39.1	7
	Foraging	24.9	24.6	7	37.9	40.5	7
Dwarf Shrub							
	Bedded	8.4	12.9	7	12.0	19.7	7
	Foraging	6.9	9.3	7	11.4	21.9	7
Meadow							
	Bedded	55.5	31.3	7	41.4	40.6	7
	Foraging	67.6	28.6	7	50.8	36.8	7

[a] Observations of the same caribou group during pre- and post-disturbance.

[b] Number of observer team days.

We observed a total of 46 different cow-calf pairs during 545 min of all-occurrence sampling during the 16 helicopter landings. We recorded 517 active cow-min and 476 active calf-min. Only one pair was observed at a time but because of the need for changing pairs during observation periods an average of 2.9 pairs (range 1-9) was observed during each landing. The all-occurrence sampling of the same caribou groups before and after the helicopter landing produced relatively small sample sizes as did the scan sampling of activity patterns. Pre-disturbance all-occurrence sampling totalled 287 active cow-min and 219 active calf-min; post-disturbance sampling totalled 341 active cow-min and 294 active calf-min.

The rates of nursing were slightly higher during pre-disturbance than post-disturbance being 8.2/100 calf min and 6.9/100 calf min, respectively (Table 17). The rates of nursing during both pre- and post-disturbance were higher than the rate observed during the 16 landings, which was 3.7/100 calf-min. The trend in the rates of attempted nursings varied from that shown for nursings (Table 17). The rates were all similar: 5.0/100 calf-min before the landings, 4.8/100 calf-min during the landings and 4.7/100 calf-min after the landings. The mean duration of the nursings was slightly less during the landings than before or after (Table 17).

The occurrences of other behavioural bouts (Table 17) were too infrequent to compare rates but the occurrence of alarm stances and antler threats (all by cows toward calves that were not their's) appeared to occur at higher rates during the landings than before or after.

Table 17. Distributions of events displayed by caribou[a] during pre-disturbance, disturbance and post-disturbance periods, Beverly calving ground, 1982.

Event	Number of occurrences		
	pre-disturbance[b]	disturbance[c]	post-disturbance[d]
Nursing			
Initiation[e]			
Cow	4	0	2
Calf	10	11	11
Termination			
Cow	15	10	18
Calf	3	1	1
Nursing duration mean, (SD) (sec)	39.8 (19.3)	34.8 (21.1)	49.1 (25.1)
Attempted nursing	11	14	13
Head bob	0	0	0
Alarm stance	0	4	1
Head swing	1	4	0
Kick	0	0	1
Rush	2	0	0

a Observations of the same caribou group during pre- and post-disturbance.

b Data based on 287 active cow-min and 219 active calf-min.

c Data based on 341 active cow-min and 294 active calf-min.

d Data based on 517 active cow-min and 276 active calf-min.

e Initiation of four nursings missed during pre-disturbance and six during post-disturbance (sample sizes for durations of nursings are equal to total initiation count: pre-disturbance, 14; disturbance, 11; and post-disturbance, 13).

Our analysis of the behavioural responses by caribou to the helicopter landings was handicapped by the small sample size; the variability in environmental factors; variation in group sizes sampled; changes in the actual groups being observed during different phases of the same landing, in some cases; and the range of distances from the helicopter to the caribou being observed. The distribution of maintenance activities (bedded or foraging), or behavioural responses during each phase of the helicopter landing, based on the proportions of the group observed in each maintenance activity or behavioural response category during every 2-min scan sampling period, varied markedly among the different phases of each landing (Appendix K). During the 16 helicopter landings we carried out 307 2-min scan sampling periods; 22.5% (69) of the sampling periods were during the time from when the helicopter was first audible (Approach phase) to the end of the Wind-down phase; 56.7% (174) of the sampling periods were during the Shut-down/ Ground activity phase; and 20.8% (64) were during the time from the beginning of the Wind-up phase to the end of the Last Audible phase. The overall time spent sampling in each of the eight phases of each helicopter landing varied in a descending order of time as follows: (1) Shut-down/Ground activity, 56.7%; (2) Approach, 8.8%; (3) Wind-up, 8.4%; (4) Take-off, 7.5%; (5) Wind-down, 6.2%; (6) Last Audible, 4.9%; (7) Descent, 4.6% and (8) Turn, 2.9%.

We can draw the following inferences from the proportional distribution of the number of times the different maintenance behaviours and behavioural responses to the helicopter disturbance were exhibited during 2-min scan samples that were taken in the eight phases of the disturbance sampling period (Table 18). The frequencies with which maintenance behaviours and behavioural responses were seen were analyzed by comparing with expected values calculated by the standard expression for contingency table analysis: expected = row total x column total/grand total.

There were relatively more occasions than expected when caribou exhibited maintenance behaviours or behavioural responses to the helicopter (disturbance stimuli) as follows: (1) when engaged in maintenance activities (bedded or foraging) during the Approach Phase; (2) when responding to the helicopter by galloping and trotting during the Turn Phase; (3) when responding to the helicopter by galloping, trotting, walking, and standing alerted during the Descent Phase; (4) when increasingly responding to the helicopter by galloping, trotting, walking, and standing alerted during the Wind-down Phase; (5) when returning to maintenance activities during the Ground Activity Phase; (6) when remaining engaged in maintenance activities into the Wind-up Phase; (7) when responding to the helicopter by galloping and trotting, but seemingly not responding by walking or standing alerted during the Take-off Phase; (8) when again returning to maintenance activities during the Last Audible Phase. These proportions follow a logical pattern of likely response to the helicopter (disturbing stimuli): (1) an initial switch from ongoing maintenance activities to mild to stronger responses to the on-coming helicopter during the Approach Phase; (2) followed by increasing participation in locomotory responses to the helicopter from the Turn Phase to the

Table 18. Percentage of frequency of occurrence of maintenance activities and behavioural responses by a proportion (25-100%) of caribou during each 2-min scan sampling period that occurred in each phase of each helicopter landing, Beverly calving ground, 1982.

Behaviour	Approach (n=58)[a]	Turn (n=25)	Descent (n=42)	Wind-down (n=54)	Shut-down/ ground activity (n=422)	Wind-up (n=72)	Take off (n=66)	Last audible (n=37)
Bedded	37.9	16.0	14.3	9.3	17.1	20.8	13.6	24.3
Foraging	43.1	28.0	16.7	14.8	35.8	33.3	22.7	35.1
Standing	3.4	8.0	16.7	22.2	10.9	13.9	12.1	10.8
Walking	12.1	32.0	30.9	31.5	28.7	22.2	28.8	24.3
Trotting	3.4	16.0	14.3	16.7	6.6	8.3	13.6	5.4
Galloping	0.0	0.0	7.1	5.5	0.9	1.4	9.1	0.0

[a] The number of 2-min scan sampling periods in which the behaviour was observed during each disturbance phase of each of the 16 helicopter landings (summed over days and observer teams).

Wind-down Phase; (3) then a waning of responses to the disturbing stimuli and a return to maintenance activities during the 20-min Ground Activitiy Phase into the Wind-up Phase; (4) then, a marked increase in responses to the disturbing stimuli during the Take-off Phase and (5) the termination of responses to the helicopter after the removal of the disturbing stimuli and a return to ongoing maintenance activities as the helicopter departed during the Last Audible Phase.

The increase in locomotory activities during the landings in response to the disturbing stimuli, and the resultant tendency for caribou that were foraging to actually also be moving away from the disturbing stimuli at the same time, resulted in the initially observed group being completely out of sight of the observers during seven landings and most caribou out of sight during an additional six landings (Appendix H). Therefore, we can conclude that most all caribou under observation in the initial phases of 81.2% (13/16) of the landings were displaced in excess of 1 km before the disturbance periods were completed. This condition is masked and further analysis is complicated by the fact that when observers lost sight of the initial groups under observation they continued their observations on different caribou during those landings, if possible.

To better evaluate both the relative intensity of the proportional contributions of the caribou group responses and the level of the responses, we weighted the observed values (Appendix K) by response level and by proportion. A numerical score was assigned to each behaviour: bed (1), forage (2), stand (3), walk

(4), trot (5), and gallop (6); and to each proportion; < 25% (1), 25-50% (2), 51-75% (3), 76-99% (4), and 100% (5). Thus, the maximum score would be achieved when 100% of a caribou group galloped (5 x 6 = 30) and the minimum score would be when < 25% of a group remained bedded (1 x 1 = 1). The individual disturbance phases were then grouped into three segments based on the interpretation of the data in Table 18. "Incoming segment" includes Approach, Turn, Descent, and Wind-down phases; "Ground activity segment" includes Shut-down/Ground activity phase; and "Out-going segment" includes Wind-up, Take-off, and Last Audible phases (Appendix L). We then took the sums of the observed values and the weighted scores in Appendix L and gave them as percentage distributions in Table 19. The following analysis of observed to expected values and its associated interpretation are drawn from comparisons of the observed values and the weighted scores given in Table 19.

Examination of the Observed/Expected (O/E) ratios for the observed values in Table 19 allows the same general conclusions derived from analysis of the data in Table 18. That is, contributions to maintenance activities were relatively greater than expected during the "Ground activity segment" (Shut-down/ Ground activity phase) and less than expected during both the "Incoming segment" (Approach - Wind-down phases) and "Outgoing segment" (Wind-up - Last Audible phases). While contributions of the behavioural responses to the disturbing stimuli (helicopter landings) were proportionately greater than expected during both the "Incoming" and "Outgoing" segments of the disturbance periods

Table 19. Percentage distributions of observed values and weighted scores for maintenance activities and behavioural responses during three different segments of the disturbance periods for the 16 helicopter landings, Beverly calving ground, 1982.

Behaviour and segment	Observed values (weighted scores)					
	Bedded	Foraging	Standing	Walking	Trotting	Galloping
% Behaviour[a]	26.1 (29.6)	18.9 (15.7)	25.6 (26.9)	21.4 (21.8)	31.8 (35.5)	35.3 (22.2)
% Incoming[b]	20.7 (7.5)	26.3 (20.4)	12.8 (9.2)	25.1 (38.2)	11.7 (20.8)	3.4 (3.9)
% Behaviour	50.7 (46.1)	60.6 (66.5)	51.1 (50.0)	57.6 (56.6)	42.4 (41.1)	23.5 (33.3)
% Ground	17.1 (4.8)	35.8 (35.3)	10.9 (7.0)	28.7 (40.6)	6.6 (9.9)	0.9 (2.4)
% Behaviour	23.2 (24.3)	20.5 (17.8)	23.3 (23.1)	21.0 (21.6)	25.8 (23.4)	41.2 (44.5)
% Outgoing	19.1 (6.4)	29.5 (23.9)	12.1 (8.2)	25.4 (39.1)	9.8 (14.2)	4.1 (8.2)
N[c] behaviour	142 (230)	249 (1182)	90 (312)	210 (1596)	66 (535)	17 (162)

[a] Equals percentage of column total for each behaviour.

[b] Equals percentage of row total for each of the three different segments of each disturbance period.

[c] N equals the number of 2-min scan samples in which the behaviour occurred for observed values and for the weighted scores N equals the summation of the weighting of the observed values (see text for further explanation). N values for "Incoming" segment equal 179 (912); for "Ground" segment equal 422, (2226); and for "Outgoing" segment equal 173, (879) respectively, for observed values and for (weighted scores). Total sample sizes equal 774 for observed values and (4017) for (weighted scores).

and slightly less than expected during the "Ground Activity" segment.

Observed values in Table 19 indicate that caribou groups were exhibiting locomotory responses to the disturbing stimuli during only 37.8% of the sampling periods throughout all disturbance phases. The weighted score for the same category, however, increases that proportion by 51.0% to 57.1%. When we compare the observed values to their respective weighted scores for locomotory responses, we find that galloping increases 86.4% from 2.2 to 4.1%; trotting increases 56.5% from 8.5 to 13.3%; and walking increases 46.5% from 27.1 to 39.7%.

The main effect of the weighted scores was in causing changes in relative values which increased percentage contributions for gallop, trot, and walk; and decreased contributions for bed, forage, and stand (Table 19). The overall percentage contributions to locomotory responses for both observed values and respective weighted scores also suggest that the levels and intensities of responses were similar during both the "Incoming" and the "Outgoing" segments of the disturbance periods: "Incoming, 40.2% vs 62.9% and "Outgoing" 39.2% vs 61.5%. This condition reveals that the contributions by all locomotory responses during all three segments of the disturbance periods, and especially for both the "Incoming" and "Outgoing" segments, are masked in any evaluation that does not offer some means of evaluating the proportion of each of the caribou groups involved (Table 18). The resultant difference seemingly reflects the relative weighting of the greater proportions of the caribou groups that were responding at any given behavioural level, especially at the higher levels of response (locomotory responses - gallop, trot, and walk).

Therefore, we can conclude that a greater proportion of the caribou were actually responding more actively by locomotion than was apparent. This condition most likely pertains because of the often abstruse displacement of the caribou from the areas under observation by a combination of foraging and at the same time slowly drifting away from the disturbing stimuli. The general conclusion that can be drawn from these analyses of data in both Table 15 and 16 is that caribou groups exposed to helicopter landings within 300-2200 m from them did respond mostly by deliberate but controlled movements (mainly walking) away from the source of the disturbing stimuli.

DISCUSSION

Study Design

One basic assumption in our study is that the caribou did not change their behaviour in response to the presence of the observers. The observer teams were at pains to make themselves as visibly inconspicuous as possible. Nevertheless, there were times when the caribou were downwind of the observers. In 1982, we documented that cows spent proportionately more time walking and less time foraging. Calves spent proportionately less time bedded or foraging and twice as much time walking when downwind of the observers (Table 3). In 1982 as in 1981, those differences in the activity patterns were not significant.

In 1981 there was an apparent increase in the frequency of aggressive acts when the caribou were downwind of the observers. However, a similar increase was not recorded in 1982, nor was there a change in the frequency of other behavioural events recorded, though small sample sizes confound any analysis. We are not suggesting that the caribou did not detect the observers on all occasions but that the detection was not frequent or extreme enough to change the ongoing behaviours. Had the sample size of observer team days, where observers were upwind of the caribou been large, a more definitive statement could be made.

The second basic assumption in our design was that the observers were identifying and recording the same behaviours in the same way (i.e. we minimized observer error and bias, Lehner 1979). Our rigorous definitions and procedures eliminated most subjectivity in the way observers recorded behavioural events while the continued checking of forms in the field ensured that procedures were correctly followed.

There were, however, significant differences in activity patterns of caribou recorded by the three observer teams in 1982, and those differences were not related to obvious differences in actual numbers of caribou observed by any one team or to sample size. Those differences during calving were between all three observer teams. Team 1 recorded a significantly greater proportion of cows and calves foraging than the other two teams, which may be related to the fact that Team 1's scan areas had greater proportions of Meadow than did those of the other two teams. Team 2 was off the east coast of Deep Rose Lake on the complex of small islands which were heavily used by caribou during calving in both 1981 and 1982. The greatest proportion of cows and calves bedded was recorded by Team 2.

Team 1 changed locations twice, Team 2, three times and Team 3, five times during post-calving; and those moves crossed from Deep Rose Lake west to Sand Lake. Team 1 again recorded a significantly greater proportion of cows foraging than the other two teams and also recorded greater proportions of Meadow in their scan areas. The only other significant difference in the activity patterns recorded by the three teams was that Team 1 had a lower proportion of calves walking than the other two teams, and a higher proportion of cows foraging.

It is suggested that caribou preferentially bed in Lichen Upland areas and forage in the lowland Meadows. Lichen Uplands are the first range type to be free of snow during calving and do provide good vantage points in an area typically of low relief. The best sites for foraging, however, tend to occur in the more hydric lowland areas which are characterized by relatively lush sedge (*Eriophorum vaginatum*) communities.

Our procedures for observing the caribou and recording the scan data left little need for subjective decisions and hence should have minimized individual differences between observer teams. We believe the differences between the observer teams are largely the result of the different proportions of range types in the scan areas. The observers tended to select scan areas that facilitated observation by choosing areas that they could overlook and that had relatively distinct landscape boundaries (i.e. sites were chosen to minimize errors of apprehending, Lehner 1979). It would be difficult to select scan areas on the basis of proportional distribution of range types because of the obvious requirement to select areas with caribou that can be observed. A second possible source of bias which could cause differences between teams in activity patterns recorded is the age and sex composition of caribou in the scan sample. A. Martell (pers. comm.) suggests that cows without calves have relatively different activity patterns from cows with calves. We cannot use the calf:cow ratios during our scan data to test that assumption because the calf:cow ratios are biased by the frequent difficulty of spotting bedded calves (Jingfors et al. 1982).

We are unable to find in the ungulate literature any solution or even acknowledgement of the problems we have identified with sampling activity patterns. Our use of and comparison between different observer teams identified the problems, and the other studies did not describe the use of different observation teams (Thomson 1973, Gaare et al. 1975, White et al. 1975, Roby 1978, Wright 1979, Boertje 1981).

We did not have the opportunity to carry out focal animal sampling (Lehner 1979) which would have given us continual observations and thus exact rates and durations of events necessary to select the most suitable durations and frequency of the all-occurrence sampling period. Altmann (1974) reported that the duration of the observation period is theoretically immaterial for measuring rates of events. With data on the frequency of behavioural events, a bout of appropriate frequency and duration can be objectively delimited (Slater and Lester 1982).

We arbitrarily chose to have an equal amount of time spent each hour in all-occurrence sampling as not (e.g., three 10-min samples per hour and alternating 10-min non-sampling periods per hour), thus supposedly equalizing the probability of detecting events regardless of their relative rates of occurrence.

The selection of a cow-calf pair for all-occurrence sampling can introduce biases into the observed rates of behavioural events. If there was even an unintentional tendency to select cow-calf pairs that "looked like they would be active" - e.g., the pair had just risen from being bedded, and if there is a likelihood of the behavioural event being influenced by a change in the activity state of the caribou, the rates will be biased. We believe that when calves, and especially when cows rose from being bedded, a nursing event was more likely to occur, and selection of "active" pairs could have increased the observed rate of nursing events.

We did not however, detect significant differences in the rates of behavioural events especially nursing frequency between observer teams, although the proportions of bedded and other activity states did vary. The lack of between observer team differences suggests that any bias from selection of cow-calf pairs was not reflected in the data.

Our methods of describing the group response of the caribou to the helicopter landings are a first step; further study will require refinement in experimental design and method of data collection. Our approach of attempting to describe many variables (group proportions by activity state by time and helicopter phase; distance and directions moved, etc.) was not practical as there were simply too many data to objectively record for one person (the second observer was recording the behaviour of a cow-calf pair). The largely subjective estimation of the proportions of the caribou group in each activity type (bedded, foraging, standing, walking, trotting, galloping) is difficult to analyze or interpret and the differences in responses according to sex/age classes are ignored. Although our approach of recording the activity states by sex/age class and phase of the helicopter had proved practical before (Miller and Gunn 1979), it was not suitable when group size exceeded 10-20 caribou. The observers were not practiced in estimating proportions and additionally, certain activities are likely to be over-emphasized as they are more conspicuous (e.g., galloping compared to bedding) and differential conspicuousness also varies by sex and age class (Hinde 1973). The descriptions of the distances covered and the direction of movements are also confounded by practical problems. The range finders were inadequate for the distances and time consuming to use. Whereas improved equipment or training in the estimation of distances could rectify that problem, there remains the problem of defining how far and in what direction the group (and not some conspicuous individuals) moved. Frequently the group was spread out over 200-300 m and moved together or in different directions which required observers to select which movement and starting-stopping point to use to estimate distance travelled. As Hinde (1973) and Lehner (1979) emphasize, the selection of appropriate behaviours depends on the precise aims of collecting the data. Hinde (1973) also noted that qualitative study is an essential preliminary to guard against the problems of the inappropriate selection of behaviours to be described.

Our problems in quantifying group responses suggest time lapse photography would have been a useful tool in subsequent determination of group responses together with mapping of the caribou movements on aerial photographs. The continuous observation of cow-calf pairs during the controlled disturbance by the second observer, however, is a satisfactory approach to describing the behavioural responses. The refinements that should be considered are to record the data in 10-min bouts to facilitate comparisons with pre- and post-disturbance observations. The behavioural events recorded during all three phases should be similar which means bouts of trotting and galloping would have to be added to the pre- and post-disturbance all-occurrence sampling.

We believe that our relatively large samples and the replicate sampling from the use of three teams have minimized sampling biases, and that we have designed a repeatable program to describe baseline behaviour of cows and calves on the calving grounds. Our descriptions of group responses to the helicopter landings were preliminary but allow us to suggest some refinements to the data collection.

Activity Budgets

Jingfors et al. (1982) describe activity patterns of caribou and reindeer (*R. t. tarandus*) and discuss methods and results of other studies in comparison with our approach. Our results in 1982 were relatively similar to those activity patterns recorded in 1981 (Table 2). The differences likely reflect differences in phenology and snow conditions. Subjectively, we believe that phenology and snow melt were several days later in 1982 when compared to 1981. It was unfortunate that we were unable to repeat the phenological sampling of 1981. The snow melt and phenological differences may also account for the observed differences in range use and the observed proportions of bedded and foraging caribou.

Events

We suggest that the body condition of the cows and phenological differences between 1981 and 1982 also contribute to the differences in the rates of nursing and attempted nursing recorded between 1981 and 1982. In 1982 we observed 10.6 nursings/100 calf-min and 7.3 attempted nursings/100 calf-min which are significantly greater ($P < 0.05$) than the rates of 7.3 nursings and 4.7 attempted nursings/100 calf min observed in 1981. The duration of the nursing, however, was not significantly different between the 2 years, though the mean duration in 1981 was 50.2 s compared to 46.4 s in 1982. The difference is not explained by nursing position: there was a slightly greater frequency of nursing from the rear in 1981 (7.0%) compared to 4.7% in 1982. Nursing bouts from the rear tend to be of shorter duration for calves older than 30 h (Espmark 1971, Lent 1966); 13 nursings from the rear averaged 25.1 s. The relatively higher frequencies of nursing and attempted nursing might suggest that the maternal cows were nutritionally stressed in 1982 compared to 1981, but the cows terminated more nursings (76.1%) in 1981 than 1982 (67.9%) which does not support the suggestion that the cows were undernourished. The calves of undernourished reindeer cows nursed more frequently but with shorter nursing durations due to a high frequency of maternal rejection (Espmark 1980).

The reduced rate of aggressive acts by the maternal cow toward her calf during calving in 1982 compared to 1981 was unexpected as the rate of attempted nursing was higher in 1982 than in 1981, and we have observed a cow aggressively swing her head at a calf that persisted in attempting to nurse. Espmark (1980) did not observe maternal cows directing aggressive acts towards their calves, nor did he observe any difference in the rates of aggressive acts towards other calves or cows between normally fed and undernourished captive reindeer cows. This sample size, although not stated, was small as the observations were of two groups of eight cows each with their calves for 3 days (Espmark 1980).

The frequencies of head bobbing and alarm stances were low in 1981 and 1982 as would be expected if the caribou were not being exposed to alarming or frightening stimuli. The head bobbing we did observe was by cows toward newborn calves. As Jingfors et al. (1982) note, there are no published comparative data to compare with ours for the rates of aggressive acts, alarm stances and head bobbing. There would be biases, however, in comparing rates and durations of specific behavioural events between our study and other studies as a result of our rigid definitions. An alarm stance, for example, had to be held for 3 s or longer and a head bob was at least two lowerings of the cow's head. Our definition of a nursing bout also complicates comparisons with other studies; if the duration was less than 5 s, the event was termed a nursing attempt. A second factor which could slightly increase the mean duration was that if the calf stopped nursing but then resumed nursing, and the break in a nursing bout was less than 30 s, the break was included in the duration. The duration of 19 interrupted nursings (excluding four untimed ones) was greater than the overall mean duration, 57.9 s and 46.4 s, respectively, but we have no measure of what the breaks contributed to the duration. Lent (1966) did not record a separate bout if "the calf momentarily removed its lips from the teat" (p. 716), and Espmark (1971, 1980) does not define how duration of nursing bouts was measured.

Our 1982 observations of calves support the suggestion from 1981 (Jingfors et al. 1982) that the calves on the Beverly calving ground nurse more frequently and for longer periods than in Alaska (Lent 1966, White et al. 1975) or Norway (Thomson in Gaare et al. 1975). There are no data to compare the rates of the other behavioural events that we recorded to determine whether they were comparable with other caribou or reindeer populations.

Helicopter Landings

The helicopter approached the caribou at a relatively high altitude (300 m agl) and turned at that altitude over the caribou, but some caribou were already responding by standing alerted, walking, or trotting on 9 of 16 occasions before the helicopter descended and landed. We do not know the consequences of those behavioural responses, if any, to the cow-calf pairs. But we suggest that these observations of more than half the groups of caribou responding to a helicopter at 300 m agl above them, supports the recommendation by Miller and Gunn (1979) that flights during calving and post-calving should be at a minimum altitude of 600 m agl, whenever possible.

We deliberately landed relatively far away from the caribou so as not to precipitate severe locomotory responses as we wanted to be able to observe activity patterns subsequent to the landing.

However, the caribou of seven groups and some caribou of six groups initially under observation during the 16 helicopter landings left the scan sample areas during the disturbance periods, which considerably diminished our sample size for comparison of the same groups before and after a helicopter landing.

We cannot evaluate the consequences of displacing all or some of the caribou during 13 of 16 landings, or of the variation in activity patterns and range use of the caribou after as compared to before the landings. We suggest that the critical consideration in evaluating those consequences would be how often such displacements and changes in behaviour were caused. Any descriptions of the consequences of behavioural responses to an individual or to the population are currently speculative and are discussed elsewhere (Gunn 1983).

The only other quantitative descriptions of caribou responses to helicopter landings are from 116 landings near Peary caribou (*R. t. pearyi*) in 1977 on Prince of Wales Island (Miller and Gunn 1979). The landings were within 500 m of the caribou which were in small groups (mean size of six individuals) of all sex/age classes including calves 2-8 weeks old. Those results are not strictly comparable due mainly to small groups sizes, and different but constant distances between the helicopter and caribou, (Miller and Gunn 1979).

In the same study, Miller and Gunn (1979) identified cow-calf pairs as the most responsive relative to other group types during helicopter harassment (disturbance). They noted that calves tended to alert more, respond sooner than their maternal cows and were more likely to rejoin their maternal cows than the mother was to seek her calf. Rejoining of the cow-calf pair and rejoining of the pair with a group accounted for 19.5% and 20.3%, respectively, of the locomotory responses to the helicopter overflights (Gunn and Miller 1980). Of the 57 bouts of trotting or galloping that we recorded for cow-calf pairs during the landings on the calving ground in 1982, 17.5% were rejoining of the pair and 19.3% were from the pair rejoining the group.

Our small sample size precluded us from demonstrating changes in the frequency of specific behavioural events. When compared to pre- and post-disturbance periods our data suggest that the rate of nursing declined but the rate of attempted nursing remained about the same during the disturbance periods. Nursing often occurs after an unfamiliar (novel) stimulus causes a calf to rejoin its mother (Lent 1974). However, we observed that the movement of the calf to the cow was immediately followed by the pair moving away on 10 of 11 occasions during the helicopter landings. This might explain why we did not see an increase in the rate of nursing but does not explain the apparent decrease.

Our results from the experimental landings, although a preliminary effort, showed that the cows and calves were readily displaced and their activity patterns interrupted even by landing at a distance of 300-2200 m away from them. We again emphasize that we do not know the consequences of that displacement and interruption of activity patterns to the cows and calves. We believe that the key as to how serious such human activities are to caribou could only be obtained if we could measure and evaluate the single and combined influences of the frequency, duration and intensity of the disturbance as well as the kind of disturbance experienced.

Any measurement of the long-term impact to the population or even the short-term consequences to the cow-calf pairs of caribou exposed to human activities during calving or early post-calving go far beyond the objectives and scope of this study. We have documented in a cursory manner that man-caused novel stimuli (helicopter landings) within several hundred meters of early post-calving groups or aggregations of caribou will (1) cause disruption of ongoing maintenance activities; and (2) elicit behavioural responses that lead to displacements from the immediate range to distances of, at least, 1-3 km.

A strong argument can be made for creating concern about possible future high levels of exploratory activities for non-renewable resources that could have significant impact on the well-being of cow-calf pairs of caribou exposed to such activities during calving and post-calving. This concern would validly persist on a biological basis throughout the summer period of dependency by the calf on its mother for sustenance, protection and acceptance into its mother's social group. The concern could even by extended on a biological basis into and possiby throughout the first winter of the calf's life. This is true because no one has demonstrated that a weaned caribou calf orphaned in the fall or early winter has the ability to psychologically adjust to life on its own. Thus, it could be supposed and convincingly argued that orphaned calves are less likely to survive the rigors of the first winter than calves in the company of their mothers.

A herd of migratory barren-ground caribou increases in size essentially by survival exceeding mortality in more years than not, especially in consecutive years. Thus, high recruitment of calves to 1 year of life is often the principal contribution to the population's growth. Therefore, any true concern for the well-being of the caribou resource must employ the maximizing of high rates of survival of each calf crop. This means that it is necessary to take conservative measures in the absence of biologically sound data to the contrary and provide the fullest measure of protection to the caribou herds that is possible.

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PERSONAL COMMUNICATIONS

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LITERATURE CITED

Altmann, J. 1974. Observational study of behaviour: sampling methods. Behaviour 49(3-4): 227-267.

Boertje, R.D. 1981. Nutritional ecology of the Denali caribou herd. M.Sc. Thesis, Univ. Alaska, Fairbanks. 294 pp.

Clement, H. 1982. Beverly and Kaminuriak caribou monitoring and land-use controls, 1981. N.W.T. Wildl. Serv. Prog. Rep. No. 6. 49 pp.

Clement, H. 1983. Beverly and Kaminuriak caribou monitoring and land-use controls, 1982. N.W.T. Wildl. Serv. Prog. Rep. No. 8. 39 pp.

Cooper, S. 1981. Beverly and Kaminuriak caribou monitoring and land use controls, 1980. N.W.T. Wildl. Serv. Prog. Rep. No. 4. 74 pp.

Darby, W.R. 1978. Beverly and Kaminuriak caribou monitoring and land use controls, 1978. N.W.T. Wildl. Serv. Compl. Rep. No. 1. 83 pp.

Darby, W.R. 1980. Beverly and Kaminuriak caribou monitoring and land use controls, 1979. N.W.T. Wildl. Serv. Prog. Rep. No. 3. 74 pp.

Dunn, J.O. and V.A. Clark. 1974. Applied statistics: analysis of variance and regression. John Wiley and Sons, Toronto. 387 pp.

Espmark, Y. 1971. Mother-young relationship and ontogeny of behaviour in reindeer (Rangifer tarandus L.) Z. Tierpsychol. 29: 42-81.

Espmark, Y. 1980. Effects of maternal pre-partum undernutrition on early mother-calf relationships in reindeer. Pages 485-496. In: Reimers, E., E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/ Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

Fleck, E. S. and A. Gunn. 1982. Characteristics of three barren-ground caribou calving grounds in the Northwest Territories. N.W.T. Wildl. Serv. Prog. Rep. No. 7. 158 pp.

Gaare, E., B.R. Thomson and O. Kjos-Hanssen. 1975. Reindeer activity on Hardangervidda. Pages 206-215. In: Wielgolsaki, F.E., (ed.), Fennoscandian tundra ecosystems. Springer Verlag, New York. 337 pp.

Gunn A. and F.L. Miller. 1980. Responses of Peary caribou cow-calf pairs to helicopter harassment in the Canadian High Arctic. Pages 497-507. In: Reimers, E., E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

Gunn, A. 1983. A review of research on the effects of human activities on barren-ground caribou of the Kaminuriak and Beverly herds, Northwest Territories. N.W.T. Wildl. Ser. Comp. Rep. No. pp.

Gunn, A. and R. Decker. 1982. Survey of the calving grounds of the Beverly caribou herd, 1980. N.W.T. Wildl. Serv. File Rep. No. 20. 27 pp.

Hinde, R.A. 1973. On the design of check-sheets. Primates 14(4): 393-403.

Ivlev, V.S. 1961. Experimental ecology of the feeding of fishes. Yale Univ. Press, New Haven.

Jingfors, K., A. Gunn and F.L. Miller. 1982. Behaviour and range use patterns of caribou on the Beverly calving ground, N.W.T. N.W.T. Wildl. Serv. File Rep. No. 22. 118 pp.

Lehner, P.H. 1979. Handbook of ethological methods. Garland STPM Press, New York. 403 pp.

Lent, P.C. 1966. Calving and related social behaviour in the barren-ground caribou. Z. Tierpsychol. 6: 701-756.

Lent, P.C. 1974. Mother-infant relationships in ungulates. Pages 14-55. In: Geist, V. and F. Walther (eds.), The behaviour of ungulates and its relation to management. IUCN Publ. New Series No. 24, Morges, Switzerland. 940 pp.

Miller, F.L. and A. Gunn. 1979. Responses of Peary caribou and muskoxen to helicopter harassment. Can. Wildl. Serv. Occas. Pap. No. 40. 90 pp.

Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrenner and D.H. Bent. 1975. SPSS: Statistical package for the social sciences. 2nd ed. McGraw-Hill, New York. 675 pp.

Petrides, G.A. 1975. Principal foods versus preferred foods and their relations to stocking rate and range condition. Biol. Conserv. 7: 161-169.

Pruitt, W.O. 1960. Behaviour of the barren-ground caribou. Biol. Papers Univ. Alaska. No. 3. 43 pp.

Roby, D.D. 1978. Behavioural patterns of barren-ground caribou of the Central Arctic herd adjacent to the Trans-Alaska oil pipeline. M.S. Thesis, Univ. Alaska, Fairbanks. 200 pp.

Slater, P.J.B. and N.P. Lester. 1982. Minimizing errors in splitting behaviour into bouts. Behaviour 79: 153-161.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman Co. San Francisco. 776 pp.

Stephenson, B., R. Decker and A. Gunn. 1983. Calving ground survey of the Beverly caribou herd, 1982. N.W.T. Wildl. Serv. File Report (in press).

Thomson, B.R. 1973. Wild reindeer activity, Hardangervidda, 1971. Prog. Rep. Norwegian IBP Committee. Direktoratet for vilt og Ferskvannsfisk, Trondheim. 83 pp.

White, R.G., R.B. Thomson, T. Skogland, S.J. Person, D.E. Russell, D.F. Holleman and J.R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. Pages 151-201. _In_: Brown, J., (ed.), Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. Biol. Pap. Univ. Alaska Spec. Rep. Ser. No. 2, Fairbanks. 215 pp.

Wright, J.M. 1979. Reindeer grazing in relation to bird nesting on the northern Seward Peninsula. M.S. Thesis, Univ. Alaska, Fairbanks. 109 pp.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall Inc. Englewood Cliffs, New Jersey. 620 pp.

Appendix A. Instructions for recording scan and all-occurrence sampling of caribou behaviour on Beverly calving ground, 1982.

RECORDING FORM FOR SCAN SAMPLING
(pre- and post-disturbance phases)

HEADING	COLUMNS	EXPLANATION
Date	1-6	Day, month and year (e.g. 290581).
Observer team	7	Each observer team has an identifying number.
Time	8-11	At beginning of 20-min interval scan, use 24 h clock.

NOTE: At each scan activity data are coded separately from range use data. However, columns 1-11 are similar for both types of data.

a) Activity Data

Wind speed and direction	13-15	Record speed from anemometer held about 1.5 m above ground. Note direction relative to observers and caribou - wind from caribou to observers (1); wind from observers to caribou (2); crosswind (3); calm (4).
Cow	17-28	Sum number of cows observed in each of the six possible activities (bedded, foraging, standing, walking, trotting, galloping); record as a 2-digit number (e.g. 4 cows foraging "04"). Activities are coded in the same order as the rows in the table (i.e. B, F, S, W, T, G). If a cow-calf pair is nursing, record: calf foraging and cow standing.
Calf	30-41	Same as above.
Yearling	43-45	Same as above.
Other	56-67	Same as above.
Phase	69	Disturbance phase - pre-disturbance or no disturbance (1); post-disturbance (3).

HEADING	COLUMNS	EXPLANATION
Lag	70	If in post-disturbance phase, record time lapsed since helicopter left area using 1 h intervals and code as: less than 1 h (1); 1-2 (2); 2-3 (3); 3-4 (4); 4-5 (5); 5-6 (6); etc. If still in pre-disturbance phase, code a "0" in column 70.
b) <u>Range Use Data</u>		
<u>Range Type</u>		
RB	13-16	Rock/Sand Barrens - sum number of caribou (irrespective of sex/age class) observed bedded (B) or foraging (F) on this range type. DO NOT record range use for other activities or when caribou are bedded or foraging on snow-covered ground.
LU	17-20	Lichen Upland - same as above.
DS	21-24	Dwarf Shrub - same as above.
M	25-28	Meadow - same as above.
<u>Ground Cover</u>		
Snow	30-33	Sum number of caribou observed bedded or foraging on snow-covered ground.
Bare	34-37	Same for bare ground.
<u>Stage</u>		
Phase	39	Disturbance phase - pre-disturbance (1); post-disturbance (3).
Lag	40	If in post-disturbance phase, record time lapse since helicopter left area using 1 h intervals and code as: less than 1 h (1); 1-2 (2); 2-3 (3); 3-4 (4); 4-5 (5); 5-6 (6); etc. If still in pre-disturbance phase, code a "0" in column 40.

NOTE: All range use data and the individual activities for the different age/sex categories are coded as 2-digit numbers; thus, a number below 10 should be preceded by a zero.

HEADING	COLUMNS	EXPLANATION
<u>Other Explanations</u>		
Location		A number (for observation team) followed by a letter (i.e. 1-A) indicates the particular study area used. Mark location as "1-A" on a map.
Cloud cover		Note as overcast, broken, scattered or clear.
Wind direction		Same as for All-occurrences.
Remarks		Note factors which may disrupt or otherwise influence activity or range use; predators, airplanes, changes in group size or composition, % snow cover. Additional information on forage use is useful.

RECORDING FORM FOR ALL-OCCURRENCE SAMPLING (pre- and post-disturbance phases)

HEADING	COLUMNS	EXPLANATION
Date	1-6	Day, month and year (e.g. 290581); also acts as observation number.
Observer	7	Each observer has an identifying number.
Time	8-11	At beginning of sampling period, use 24 h clock.
Number	13-14	Maximum number of cows or calves observed during a 10-min period (no more than five pairs).
Duration	15-18	Sum number of minutes by cows and calves under observation using the length of time that they are active (non-bedded) and in sight.
Group size and composition	19	Group is defined as caribou within 5 body lengths of observed cow or calf. In "Remarks" note group composition (cows, calves, yearlings or young bulls) and total numbers of caribou on the study area. Note the group size and composition at the beginning of the sampling period. Size: 0 (0); 1-5 (1); 6-10 (2); 11-15 (3); 16-20 (4); 20+ (5)
Change in Group Size	21	If group size around the focal pair(s) changes, note time and use a "+" to indicate increase or "-" for decrease in group size. When coding the data, indicate in column 21 whether there was a change in group size by: Change (1); No Change (2).
Wind	22	Wind direction relative to observers and caribou - note at beginning of 10-min period as - wind from caribou to observers (1); wind from observers to caribou (2); crosswind (3); calm (4).

HEADING	COLUMNS	EXPLANATION
Behavioural Events		
Nursing	23-26	Note the time of a nursing and whether the cow or calf initiates or terminates the nursing (with a "1"). Use a separate line for each nursing. If initiation missed, indicate the termination and sum for totals. Code total initiations by cow or calf in column 23-24 and total terminations in column 25-26. In "Remarks" note: a) whether calf is bedded (B) or active (A) immediately before nursing; b) side of nursing (LS, RS, rear); c) duration (in seconds). If nursing is briefly interrupted (< 30 s between bouts) record total duration and note with an "*". Record duration only when intiation observed. ML = maternal licking.
Attempted nursing	27	Code total number of attempts (lasting less than 5 s from the first observed bunting by the calf).
Head bobbing	28	If cow lowers head down and up (at least twice) towards calf, indicate with a "1" and code total numbers.
Alarm stance	29	Record for cow only.
Aggressive acts (head swing, kick and rush)	30-32	Record all aggressive acts that the focal pair is involved in (i.e. all acts where observed cow is initiator or recipient, and all acts where observed calf is recipient. Code only total number of aggressive acts where observed cow is initiator. Record (but do not code) the age/sex class of the initiator and recipient as: observed cow (1); observed calf (2); other cow (3); other calf (4); yearling (5); other (6), using the

HEADING	COLUMNS	EXPLANATION
Aggressive acts (continued)		code to distinguish between pairs under observation and others. If aggressive acts (head swing, kick, rush) occur together use numbers 1-3 to indicate a sequence. *Remember*: the occurrence of an event is recorded by using one line and a "1"; the numerical codes (1, 2, 3, etc.) represent a code for an individual or a sequence *not* the number of events.
Stage		
Phase	34	Disturbance phase: pre-disturbance (1); post-disturbance (3).
Lag	35	If post-disturbance phase, record time lapse since helicopter left area using 1 h intervals and code as: less than 1 h (1); 1-2 (2); 2-3 (3); 3-4 (4); 4-5 (5); 5-6 (6); etc. If pre-disturbance phase code a "0" in column 35.
Other Explanations		
Remarks		Record: - whether observed cow is antlered or unantlered; - when observed pair walks out of sight or beds down and you switch to a new pair; - when helicopter left area; - the occurrence and duration of trotting and galloping; - or unantlered; - when observed pair walks out of sight or beds down and you switch to a new pair; - when helicopter left area; - the occurrence and duration of trotting and galloping; - presence and behaviour of gulls or other birds.

RECORDING FORM FOR ALL-OCCURRENCE SAMPLING (disturbance phase)

Basically, the method of recording is similar to that used during the pre- and post-disturbance phases. Note, however, the following additions:

HEADING	COLUMNS	EXPLANATION
Helicopter Phase	N/A	Record the time at the beginning of each phase. If phase is in progress (e.g., ground activity) when you start the sample, note in "Remarks". The phases are:
1) Approach		Time when helicopter is first audible to ground observers until the time it passes over the observers.
2) Turn		From passing over observers to turning and passing over caribou.
3) Descent		From beginning of descent (as told on radio) to touchdown.
4) Wind-down		From landing to shutdown (power off).
5) Shutdown and ground activity		From emergence of crew (blades may still be turning) until people are back inside helicopter and power on. This phase will last for about 20 min.
6) Wind-up		From power-on to take-off.
7) Take-off		From leaving ground until helicopter has climbed to about 300 m agl (as told on radio).
8) Last audible		From 300 m agl altitude to when last audible.

HEADING	COLUMNS	EXPLANATION
Locomotory Response		
Trot/Gallop	36-39	Record occurrence of trotting and galloping for cow (C) or calf (Ca) and code total number of events for that sampling period.
Direction	N/A	Record direction of trot/gallop as: directed towards other pair member (1); directed towards other caribou (2); other (3); unknown (4).
Duration	N/A	Time start of trot/gallop and record the duration of the run(s) in seconds. If it is possible to keep both C and Ca in sight, note differences in duration.
Remarks		
Distance	41	Record distance from observer to focal pair at beginning and end of sampling period, code difference as: < 50 m (1); 50-150 m (2); 150-300 m (3); 300-500 m (4); 500-800 m (5); 800-1200 m (6); 1200+ m (7).
Direction	42	Record direction of movement of focal pair in relation to disturbance (i.e. helicopter) code direction as: away from helicopter (1); towards helicopter (2); parallel to helicopter (3); other (4).

NOTE: The ground observer (not the one with the helicopter) should make a simple drawing including location of helicopter in relation to observer team and the distance between them and the focal pair, i.e.:

If the observed pair moves out of sight or beds down before the 10-min observation period is over, record their final distance. When you switch to a new pair, record initial and final distances. When coding the data, sum the distances moved in Column 41. If both focal pairs move in the same direction, enter appropriate code in Column 42; if not, use a "4" to indicate "other" direction.

Use "Remarks" to record details of nursings (as before) and other comments useful to describe the response of the focal pair to the helicopter (e.g., excitation leaps, calf separations, etc.).

<u>Stage</u>

Phase	34	Disturbance phase code (2).
Lag	35	Code a "9".

RECORDING FORM FOR GROUP RESPONSE LEVELS
(disturbance phase)

This form is used only during the disturbance phase, i.e. from the time the helicopter is first audible until it is last audible. It is a descriptive account (not coded) of the responses of a group of caribou within the study area. Select, if possible, a distinct group and stay with it throughout the disturbance phase. The ground observer should note the following:

HEADING	EXPLANATION
Observer, Date	As before.
Group size and composition	As before.
Location	Same as for scan sampling.
Activity	Record the <u>predominant</u> activity of the group prior to disturbance.
Sun	During "Approach" and "Take-off", note the position of the sun relative to the helicopter and the caribou as: SHA - sun-helicopter-animals; SAH - sun-animals-helicopter; SNV - sun not visible.
Time	Record time when helicopter first audible and last audible.
Helicopter Phase	At <u>2-min intervals</u> note phase (approach, turn, descent, wind-down, shut-down, wind-up, take-off, last audible) and the following information:
Wind	Wind direction relative to helicopter and caribou as: wind from caribou to helicopter (1); wind from helicopter to caribou (2); crosswind (3); calm (4).
Response level	Record the proportion of the group engaged in different activities as: no individuals (0); less than 25% of group (1/4);

HEADING	EXPLANATION
Response level (continued)	26-50% (1/2); 51-75% (3/4); 76-99% (4/4); all individuals (1). If the group is small (< 10) animals) and individuals can be quickly counted, tally the number of caribou in each activity. The activities are the same as those used during scan sampling and are included under the following maintenance activities and response levels: Maintenance - bedded, foraging Moderate - standing, walking Extreme - trotting, galloping.
Distance	Distance between the ground observer and the core of the group (as with Response Level, distance is recorded during each 2-min interval scan).
Direction	Direction of group movement in relation to disturbance (i.e., helicopter): away from helicopter (1); towards helicopter (2); parallel to helicopter (3); other (4).

NOTE: The observer from the helicopter will start observations after the shutdown phase and record movements in direct relation to the helicopter.

Again, the ground observer should sketch the location of the helicopter (after landing) relative to the ground observer team (include distance) and to the caribou group under observation.

Remarks	Note whether levels are specific for only one or two age classes (e.g., 1/4 of the group that galloped were calves). If movements and directions become complicated, use bottom of paper for simple drawings. Again note the occurrence of excitation leaps, calf separations (include maternal behaviour), major movements out of the observation area, etc.

Northwest Territories

Behavioural Study Record I

Wind Speed	Direction	Temp.	Location	Cloud Cover	Time	Date	Obs. Team

	COW	CALF	YLG	OTHER	RB	LU	DS	M	SNOW	BARE
B										
F										
W					Remarks					
S										
T										
G										

1 12 16 29 42 55

Date Obs. Time Wind Dir Cow Calf Yearling

56 68

Other P L

1 12 29 38

Date Obs. Time RB DS LU M Snow Bare P L

8-11 Time	Nos.		19 Size	22 Wind	Nurse				27 ATP NUR	28 HD BOB	29 ALA ST	Aggressive					1-6 DATE 7 OBS
					Init		Term					Acts			Init	Rec	Remarks
	13 C	14 Ca			23 C	24 Ca	25 C	26 Ca				30 Ant	31 Kick	32 Rush			
TOTALS																	

1 12 20 33

Date Obs. Time C Ca Nos. Dur C Dur Ca Size Chg Wind C Ca Init C Ca Term A/N HB AL A K R P L

NWT135/REN

Northwest Territories

Behavioural Study Record II

Activity	Group Size	Comp.	Location	Date	OBS
Sun AP T-O					

Time	Hel. Phase	Wind	Response Level						Dist	DIR	Remarks
			Maint.		Mod.		Extreme				
			B	F	W	S	T	G			

NWT136/REN

Northwest Territories

Behavioural Study Record II

8-11 Time	Hel. Phase	No.		19 Size	22 Wind
		13 C	14 Ca		
TOTALS					

Nurse				27 ATP NUR	28 HD BOB	29 ALA ST	Aggressive					Trot		Gal		Dir		Dur Move
Init		Term					Acts			Init	Rec							
23 C	24 Ca	25 C	26 Ca				30 Ant	31 Kick	32 Rush			36 C	37 Ca	38 C	39 Ca	C	Ca	

Remarks	1-6 Date	7 OBS
Distance		
41 Distance	42 Direction	

1 Date OBS Time 12 C Ca Nos. Dur C Dur Ca Size 20 Chg Wind C Ca Init C Ca Term A/N HB AL A K R 33 P L C Ca Trot C Ca Gal 40 Dist Dir

Appendix B. Range types and their characteristics on the Beverly calving ground (Jingfors et al. 1982).

Range type	Moisture regime	Key features	Dominant plant species
Rock/Sand Barrens	xeric	-low cover of vegetation; -dominant % cover of exposed bedrock, coarse boulder, till or pure sand;	_Pogonatum dentatum_
Lichen Upland (I)[a]	xeric to dry-mesic	-dominant cover of fruticose lichens; -upland sites including slopes of eskers, drumlins and coarse well-drained till plateaus;	_Cornicularia divergens_ _Alectoria ochroleuca_ _Cetraria nivalis_ _C. cucullata_
Dwarf Shrub (II, IV)	mesic	-dominant shrub plant cover; sites include the base of slopes, draws and some gently sloping uplands;	_Betula glandulosa_ _Salix arctophila_ _S. planifolia_
Meadow	wet-mesic to hydric	-often pure stands of sedges, -sites adjacent to permanent water bodies following local drainage patterns.	_Carex aquatilis_ _C. rostrata_ _C. rariflora_ _Eriophorum_ spp.

[a] The Roman numerals refer to the closest physiognomic types described by Fleck and Gunn (1982: Table 11). Rock/Sand Barrens were not included in their description.

Appendix C. Distribution of "point-in-time" observations of caribou activity by season and observer team, Beverly calving ground, 1982.

Class	Activity	Calving			Post-calving		
		Team 1 (122)[a]	Team 2 (169)	Team 3 (79)	Team 1 (44)	Team 2 (33)	Team 3 (53)
Cow	Bedded	484	2842	602	948	295	1484
	Foraging	1555	1884	1150	749	347	1674
	Standing	123	326	97	54	38	81
	Walking	238	294	243	88	116	255
	Trotting	6	5	3	1	10	7
	Galloping	0	1	1	0	1	0
Calf	Bedded	291	1243	169	1136	333	284
	Foraging	109	294	46	124	100	241
	Standing	59	185	135	47	40	188
	Walking	64	136	147	74	93	249
	Trotting	9	21	16	10	21	24
	Galloping	2	14	4	4	6	13
Yearling	Bedded	80	260	105	38	14	10
	Foraging	403	131	117	38	11	57
	Standing	7	18	6	1	1	8
	Walking	45	37	43	4	11	3
	Trotting	0	1	2	3	1	0
	Galloping	0	0	0	0	0	0

[a] Number of scans by each observer team.

Appendix D. Tests for normality and independence of caribou activity data, Beverly calving ground, 1982.

		Calving			Post-calving			Calving and post-calving		
		Normality	Independence		Normality	Independence		Normality	Independence	
Class	Activity	K-S Z[a]	Z[b]	n	K-S Z	Z	n	K-S Z	Z	n
Cow	Bedded	0.734	1.6756	28	0.742	0.0000	23	0.759	0.0859	51
	Foraging	0.662	0.9957	28	1.315	0.5196	23	0.570	0.9933	51
	Standing	0.651	0.2213	28	1.129	0.9763	23	0.757	-1.2156	51
	Walking	0.833	-0.5711	28	1.446*	1.0742	23	1.532*	-0.3167	51
	Trotting	1.848*	0.0416	28	2.040*	0.0000	23	2.592*	0.2777	51
	Galloping	2.776*	0.0000	28	2.585*	0.0000	23	3.693*	0.4872	51
Calf	Bedded	1.005	1.1095	27	0.515	0.0000	22	0.974	-0.9490	49
	Foraging	0.549	0.0000	27	0.469	0.6554	22	0.503	0.0744	49
	Standing	1.101	1.1095	27	0.912	-0.5144	22	1.502*	-1.6628	49
	Walking	0.953	0.0000	27	1.080	0.1508	22	1.168	0.4138	49
	Trotting	1.172	-0.0391	27	1.652*	0.4911	22	1.763*	0.0000	49
	Galloping	1.780*	0.5886	27	1.489*	0.9892	22	2.252*	0.8934	49

a Kolmogorov - Smirnov Z statistic (Sokal and Rohlf 1969:573).

b Runs test above and below mean. All data conform to random sequence and are independent (P>0.05) (Nie and Hull 1977:25).

c No data.

* Significant departure from normality (P<0.05).

Appendix E. Distribution of "point-in-time" observations of caribou range use by season and observer team, Beverly calving ground, 1982.

Range type	Activity	Calving Team 1 (122)[a]	 Team 2 (169)	 Team 3 (79)	Post-calving Team 1 (44)	 Team 2 (33)	 Team 3 (53)
Rock/Sand	Bedded	0	0	0	0	0	62
Barrens	Foraging	0	0	0	0	0	3
Lichen	Bedded	218	2733	516	868	417	1018
Upland	Foraging	404	889	628	448	123	412
Dwarf	Bedded	137	722	104	174	162	62
Shrub	Foraging	200	437	131	52	88	49
Meadow	Bedded	429	333	228	1078	141	1460
	Foraging	866	183	498	611	114	1485

[a] Number of scans by each observer team.

Appendix F. Test for normality and independence of caribou range use data, Beverly calving ground, 1982.

		Calving			Post-calving			Calving and post-calving			Post-disturbance		
		Normality	Independence		Normality	Independence		Normality	Independence		Normality	Independence	
Range Type	Activity	K-S Z[a]	Z[b]	n	K-S Z	Z	n	K-S Z	Z	n	K-S Z	Z	n
Lichen Upland													
	Bedded	0.972	1.0148	28	0.705	-0.5957	24	0.835	0.2801	52	0.617	0.0000	12
	Foraging	1.383*	1.0148	28	0.761	0.7882	24	1.374*	1.6934	52	0.632	0.0000	12
Dwarf Shrub													
	Bedded	0.702	-1.1556	28	1.361*	0.8075	24	1.455*	-0.6398	52	0.932	-0.3028	12
	Foraging	0.950	-1.2648	28	1.230	0.8075	24	1.377*	-0.9715	52	1.194	-0.8357	12
Meadow													
	Bedded	0.905	0.2213	28	0.896	0.3150	24	1.002	1.0378	52	0.788	1.5138	12
	Foraging	0.909	1.2711	28	0.561	0.6261	24	0.738	1.4005	52	0.756	0.4164	12

[a] Kolmogorov - Smirnov Z statistic (Sokal and Rohlf 1969:573).

[b] Runs test above and below mean. All data conform to random sequence and are independent ($P>0.05$) (Nie and Hull 1977:25).

* Significant departure from normality ($P<0.05$).

Appendix G. Group size, distance from caribou to observers, wind direction and sun's position at the start of 16 experimental helicopter landings, Beverly calving ground, 1982.

Observer number	Time (C.D.S.)	Group size	Distance caribou to helicopter (m)	Wind direction[a]	Sun position[b]
1-18B	1529-1604	400-500	300	3-1	SHA
2-18H	1614-1649	50	1500	1	SNV
3-23C	1442-1525	75	2000	1-3	SHA
4-23E	1859-1935	25	1200	2-1	SHA
5-23J	1521-1555	20	2200	3	SHA
6-23L	1615-1651	230	1000	1	SAH
7-24E	2034-2112	50	2000	2	SHA
8-25I	1311-1325	20-30	1075	2	SNV
9-25M	1045-1126	150	500	3-2	SNV
10-27G[c]	1400-1446	275	500	1	SNV
11-27N	1458-1533	150-200	500[d]	1	SHA
12-27L	1629-1708	30	500	3	SNV
13-28G[c]	1019-1054	100	550	1	SHA
14-28G[c]	1732-1808	350	400	1-2-3	SHA
15-280	1410-1458	150	500	3	SHA
16-280	1556-1634	150	500	3-1	SHA

[a] 1, wind from caribou to observers; 2, wind from observers to caribou; 3, crosswind (3-1, wind change from 3-1).

[b] Sun-helicopter-animals, sun-animals-helicopter, sun not visible.

[c] Landings were on an island and by the same aggregation of caribou.

[d] Helicopter likely out of sight of the caribou.

Appendix H. Direction and distance travelled during helicopter landing, final group size and number of scans of activity patterns before and after experimental helicopter landing, Beverly calving ground, 1982.

Observer number	Final group size	Minimum distance travelled (m)	Direction travelled relative to the helicopter	Number of scans pre-	post-
1-18B	0[a]	2300	away	11	0
2-18H	0[a]	1000	away	7	0
3-23C	5[b]	1000	parellel	2	1[a]
4-23E	0[a]	1500	away	0	0
5-23J	20	250	away	5	3[d]
6-23L	190[b]	50	away	4	4[d]
7-24E	50[b]	400	away/parallel	0	0[a]
8-25I	0[a,c]	300	away	0	9[e]
9-25M	150	1050	away	3	3[d]
10-27G	30[b]	200	away/parallel	6	6[d]
11-27N	60[b]	400	away	5	2[d]
12-27L	0[a]	200	away	0	0
13-28G	0[a]	300	away/parallel	3	11[f]
14-28G	350[b]	250	away	0[f]	3[d]
15-280	150	350	away	2	2[f]
16-280	0[a,c]	50	away/parallel	0[f]	4[d]

a group moved out of sight.

b some of group moved out of sight.

c new groups observed during landing.

d end of daily observation period.

e new group not observed during landing.

f Second experimental landing by same group, so no pre-disturbance data.

Appendix I. Distribution of caribou[a] activity pre- and post-disturbance by observation, Beverly calving ground, 1982.

Date	Sex/age class	Activity	Pre-disturbance		Post-disturbance	
23 June 82			5-23J(5)[b]	6-23L(4)	5-23J(3)	6-23L(4)
	Cow	Bedded	78	107	31	116
		Foraging	108	89	11	99
		Standing	10	4	3	2
		Walking	14	11	1	1
		Trotting	0	1	0	0
		Galloping	0	0	0	0
	Calf	Bedded	143	105	21	154
		Foraging	20	25	3	19
		Standing	6	8	0	7
		Walking	11	9	1	1
		Trotting	3	1	0	0
		Galloping	1	0	0	2
25 June 82				9-25M(3)		9-25m(3)
	Cow	Bedded		118		44
		Foraging		78		107
		Standing		3		0
		Walking		1		35
		Trotting		0		1
		Galloping		0		0
	Calf	Bedded		99		32
		Foraging		9		2
		Standing		7		0
		Walking		2		31
		Trotting		0		6
		Galloping		0		0
27 June 82			11-27N(5)	10-27G(6)	11-27N(5)	10-27G(6)
	Cow	Bedded	140	77	223	47
		Foraging	139	73	138	31
		Standing	27	2	10	0
		Walking	25	19	4	2
		Trotting	1	0	0	0
		Galloping	0	0	0	0
	Calf	Bedded	178	85	265	28
		Foraging	66	27	13	10
		Standing	15	2	4	2
		Walking	24	20	2	3
		Trotting	0	2	0	2
		Galloping	1	0	1	0

Appendix I continued.

Date	Sex/age class	Activity	Pre-disturbance		Post-disturbance	
28 June 82			13-28G(3)	15-280(2)	13-28G(3)	15-280(2)
	Cow	Bedded	96	35	270	17
		Foraging	131	57	222	32
		Standing	4	2	45	0
		Walking	13	1	99	29
		Trotting	0	0	2	0
		Galloping	0	0	0	0
	Calf	Bedded	136	56	297	18
		Foraging	47	9	69	10
		Standing	3	0	23	0
		Walking	7	0	85	25
		Trotting	1	0	15	0
		Galloping	0	0	11	0

a Observations of the same caribou group, when both pre- and post-disturbance data were collected.

b Observation number and number of scan samples obtained during pre- or post-disturbance periods.

Appendix J. Distribution of total "point-in-time" observations of range use by caribou pre- and post-disturbance, by observer team, Beverly calving ground, 1982.

		Pre-disturbance			Post-disturbance		
Range type	Activity	Team 1	Team 2	Team 3	Team 1	Team 2	Team 3
Rock/Sand Barrens	Bedded	0	0	62	0	0	0
	Foraging	0	0	3	0	0	0
Lichen Upland	Bedded	338	78	83	1030	33	68
	Foraging	221	41	29	417	3	43
Dwarf Shrub	Bedded	65	76	2	6	36	2
	Foraging	19	33	11	4	28	6
Meadow	Bedded	157	158	364	31	18	441
	Foraging	160	122	205	36	27	305

Appendix K. Potential distribution (0%) and realized (25-100%) distribution of maintenance activities and behavioural responses by caribou groups during all 2-min scan sampling periods in the three different segments of the disturbance periods during the 16 helicopter landings, Beverly calving ground, 1982.

Proportion of group responding	Approach (n=27[a])	Turn (n=9)	Descent (n=14)	Wind-down (n=19)	Shut-down/ ground activity (n=174)	Wind-up (n=26)	Take-off (n=23)	Last audible (n=15)
<u>Bedded</u>								
0%	5	5	8	14	102	11	14	6
< 25%	6	1	5	5	44	8	6	5
25-50%	9	2	--	--	22	3	1	1
51-75%	6	--	1	--	6	4	2	3
76-99%	1	1	--	--	--	--	--	--
100%	--	--	--	--	--	--	--	--
<u>Foraging</u>								
0%	2	2	7	11	23	2	8	2
< 25%	5	3	3	4	27	10	10	6
25-50%	14	3	2	2	46	7	1	3
51-75%	4	1	1	2	44	1	1	--
76-99%	2	--	1	--	28	6	3	4
100%	--	--	--	--	6	--	--	--
<u>Standing</u>								
0%	25	7	7	7	128	16	15	11
< 25%	2	1	6	10	40	9	7	4
25-50%	--	1	1	1	6	--	1	--
51-75%	--	--	--	1	--	1	--	--
76-99%	--	--	--	--	--	--	--	--
100%	--	--	--	--	--	--	--	--

Appendix K continued

Proportion of group responding	Approach (n=27[a])	Turn (n=9)	Descent (n=14)	Wind-down (n=19)	Shut-down ground activity (n=174)	Wind-up (n=26)	Take-off (n=23)	Last audible (n=15)
Walking								
0%	20	1	1	2	53	10	4	6
< 25%	5	6	5	4	64	7	8	4
25-50%	1	1	5	6	24	6	3	2
51-75%	1	--	2	5	20	3	6	3
76-99%	--	1	--	2	11	--	1	--
100%	--	--	1	--	2	--	1	--
Trotting								
0%	25	5	8	10	146	20	14	13
< 25%	--	3	3	6	20	4	7	1
25-50%	--	--	2	2	4	1	2	1
51-75%	1	1	1	--	--	--	--	--
76-99%	--	--	--	1	4	--	--	--
100%	1	--	--	--	--	1	--	--
Galloping								
0%	27	9	11	16	170	25	17	15
< 25%	--	--	3	3	2	1	4	--
25-50%	--	--	--	--	1	--	1	--
51-75%	--	--	--	--	--	--	--	--
76-99%	--	--	--	--	--	--	--	--
100%	--	--	--	--	1	--	1	--

[a] The number of 2-min scan sampling periods in which the behaviour could have been seen (0%) or was observed (< 25-100%) during each disturbance phase of each of the 16 helicopter landings (summed over days and observer teams).

Appendix L. Distributions of observed values and weighted scores for caribou group maintenance activities and behavioural responses in the three different segments of the disturbance periods during the 16 helicopter landings, Beverly calving ground, 1982.

	Bedded		Foraging		Standing		Walking		Trotting		Galloping	
% Prop. observed	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score
Incoming segment												
< 25	17	17	15	30	19	57	20	80	12	60	6	36
25-50	11	22	21	84	3	18	13	104	4	40	-	-
51-75	7	21	8	48	1	9	8	96	3	45	-	-
76-99	2	8	3	24	-	-	3	48	1	20	-	-
100	-	-	-	-	-	-	1	20	1	25	-	-
Total	37	68	47	186	23	84	45	348	21	190	6	36
Ground activity segment												
< 25	44	44	27	54	40	120	64	256	20	100	2	12
25-50	22	44	46	184	6	36	24	192	4	40	1	12
51-75	6	18	44	264	-	-	20	240	-	-	-	-
76-99	-	-	28	224	-	-	11	176	4	80	-	-
100	-	-	6	60	-	-	2	40	-	-	1	30
Total	72	106	151	786	46	156	121	904	28	220	4	54

Appendix L continued.

% Prop. observed	Bedded		Foraging		Standing		Walking		Trotting		Galloping	
	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score	Obs. value	Wt. score
Outgoing segment												
< 25	19	19	25	50	19	57	19	76	12	60	5	30
25-50	5	10	11	44	1	6	11	88	4	40	1	12
51-75	9	27	2	12	1	9	12	144	-	-	-	-
76-99	-	-	13	104	-	-	1	16	-	-	-	-
100	-	-	-	-	-	-	1	20	1	25	1	30
Total	33	56	51	210	21	72	44	344	17	125	7	72
N[a]	142	230	249	1182	90	312	210	1596	66	535	17	162

[a] N equals the number of 2-min scan samples in which the behaviour occurred for observed values and for the weighted scores N equals the summation of the weighting of the observed values (see text for further explanation). N values for "Incoming segment" equal 179, (912); for "Ground Segment" equal 422, (2,226); and for "Outgoing segment" equal 173, (879), respectively, for the observed values and for (weighted scores). Total sample sizes equal 774 for observed values and (4017) for (weighted scores).