ARCTIC
VOL. 58, NO. 1 (MARCH 2005) P. 44–54

Monitoring Barren-Ground Caribou Body Condition with Denésǫłiné Traditional Knowledge

P.O'B. LYVER[1] and ŁUTSËL K'É DENE FIRST NATION[2]

(*Received 20 January 2003; accepted in revised form 22 June 2004*)

ABSTRACT. Information from aboriginal elders and hunters on changes in barren-ground caribou (*Rangifer tarandus*) body condition can assist current management systems. Interviews with Denésǫłiné elders and hunters from Łutsël K'é, Northwest Territories, Canada, provided information on caribou body condition and environmental conditions. Hunters were accompanied in the field and asked to give a qualitative assessment of body condition for adult female caribou they harvested. Elders and hunters reported temporal and geographic variation in caribou body condition. Adult female caribou are selected in late winter (February to April) and bulls in fall (September) and spring (May) because they are fat. Hunters reported that adult female caribou were fatter during late winter in 2000 than in 2001. This difference was consistent with body condition impressions recorded in field surveys. Reports from hunters in interviews that adult female caribou were fatter in February than in March and April 2001 were also supported by hunters' field impressions. Hunters identified areas where adult female caribou were in better condition than in other areas in 2000 and 2001. The number of caribou harvested and years of hunting experience influenced the distribution of hunters' impressions of body condition. Interviews with hunters offer an inexpensive, repeatable approach to monitoring caribou body condition and range limitations, although ecological implications must be carefully interpreted.

Key words: Denésǫłiné, hunters, elders, traditional knowledge, caribou, body condition, monitoring program

RÉSUMÉ. Des renseignements fournis par des aînés et des chasseurs autochtones sur les changements concernant l'état corporel du caribou des toundras (*Rangifer tarandus*) peuvent s'avérer utiles pour les systèmes actuels de gestion. Des entrevues menées auprès d'aînés et chasseurs Denésǫłiné de Łutsël K'é, dans les Territoires du Nord-Ouest au Canada, ont fourni des renseignements sur l'état corporel du caribou et sur les conditions environnementales. On a accompagné les chasseurs sur le terrain et on leur a demandé de faire une évaluation qualitative de l'état corporel des caribous femelles adultes qu'ils prélevaient. Les aînés et les chasseurs ont rapporté des variations temporelles et géographiques dans l'état corporel du caribou. Les femelles adultes sont prélevées à la fin de l'hiver (de février à avril) et les mâles à l'automne (en septembre) et au printemps (en mai) alors que ces animaux ont de bonnes réserves de gras. Les chasseurs ont rapporté que les caribous femelles adultes étaient plus grasses à la fin de l'hiver de 2000 que de celui de 2001. Cette différence allait de pair avec la perception relative à l'état corporel consignée lors des études sur le terrain. Les rapports de chasseurs affirmant lors d'entrevues que les caribous femelles adultes étaient plus grasses en février qu'en mars et avril 2001 étaient aussi corroborés par la perception des chasseurs sur le terrain. Ces derniers ont identifié des zones où, en 2000 et en 2001, les caribous femelles adultes étaient en meilleure condition physique qu'à d'autres endroits. Le nombre de caribous prélevés et les années d'expérience fondée sur la chasse influençaient la distribution de la perception des chasseurs relative à l'état corporel. Bien que l'interprétation des répercussions environnementales exige une certaine prudence, les entrevues menées auprès des chasseurs offrent néanmoins une approche peu coûteuse et reproductible pour suivre l'état corporel du caribou et les limites de son territoire.

Mots clés: Denésǫłiné, chasseurs, aînés, savoir traditionnel, caribou, état corporel, programme de suivi

Traduit pour la revue *Arctic* par Nésida Loyer.

INTRODUCTION

Community-based environmental monitoring programs can increase the involvement of user groups in wildlife research and management (Legat, 1998; Parlee, 1998). Knowledge gained through these programs can inform government, industry, and academic institutions on aspects of wildlife ecology and (potential) environmental and human impacts. Growth of this knowledge sector in Canada has been driven largely by comprehensive land-claim settlements (Treseder et al., 1999), the desire of aboriginal communities to increase their contribution and participation in environmental management (Simpson, 2000), and aboriginal concerns that current wildlife management regimes are inadequate to protect their interests (Legat, 1998). Barren-ground caribou (*Rangifer tarandus*)

[1] Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada; present address: Landcare Research, P.O. Box 69, Lincoln, 8152, Canterbury, New Zealand; lyverp@landcareresearch.co.nz
[2] P.O. Box 28, Łutsël K'é, Northwest Territories X0E 1A0, Canada

represent an important wildlife resource about which northern aboriginal groups are increasingly providing information for management (Kofinas et al., 2003).

Barren-ground caribou (*R. t. groenlandicus*) are a highly valued renewable resource for aboriginal groups in Canada's Northwest Territories (Smith, 1978; Berkes, 1998). The co-management of caribou would benefit from the joint application of scientific and traditional knowledge (Kofinas et al., 2003). It is important, therefore, to establish collaborative processes that accommodate guardianship practices and ideologies from both aboriginal and eurocentric cultures. Caribou body condition is recognized by both aboriginal people and scientists as an important indicator of herd well-being (Gerhart et al., 1996; Kofinas et al., 2003). Northern aboriginal people are very conscious of caribou fat because it is an important dietary component. To hunters, variations in fat deposits can signal environmental limitations in the caribou range (Kofinas et al., 2003). For biologists, fat is directly linked to productivity parameters such as pregnancy rates, calf survival rates, age to first breeding, and breeding pauses in cows (Thomas, 1982; Cameron, 1994; Gerhart et al., 1996, 1997; Thomas and Kiliaan, 1998b; Allaye Chan-McLeod et al., 1999).

This research is part of a community-based program that uses traditional knowledge to monitor caribou herd health. Our objective was to use information from hunters' field impressions and from interviews with elders and hunters to monitor caribou body condition. Through these methods, we attempted to understand how temporal (i.e., annual, seasonal, and within-season) and geographic differences in caribou fat and environmental conditions observed on the caribou range might influence interpretations from indigenous user groups. We were interested in whether hunters' impressions of body condition recorded in interviews after winter were similar to those recorded in the field. As part of this inquiry, we wanted to determine whether a hunter's experience, or the number of caribou a hunter harvested, or both, affected his perception of body condition. The results of our research will provide guidelines for future community-based caribou monitoring programs.

METHODS

Hunter Interviews

Our research was conducted in the Denésǫłiné (Chipewyan) community of Łutsël K'é (62˚24′N, 110˚48′W), located in the east arm of Great Slave Lake, Northwest Territories, Canada (Fig. 1). Structured interviews with Łutsël K'é hunters (hunters more than 25 years old who hunted regularly) were conducted immediately after the late winter (February-to-April) hunting period. Interviews were conducted primarily in English, independent of other hunters, and usually lasted no more than 20 minutes. Thirty male hunters were interviewed in May 2000, and 39 hunters (37 men and two women) in May 2001.

After preliminary discussions with hunters, a qualitative index (i.e., skinny, not so bad, fat, really fat, or unsure) was developed to assess caribou body condition. Hunters were asked to provide an overall impression, using these ratings, of the body condition of adult female caribou harvested over late winter. They were also asked to give their general impressions of fat in the brisket, back, stomach, and kidney regions, using the ratings none, some, quite a bit, lots, or unsure. Femur marrow colour and texture were rated as red/runny, pink/greasy, cream/solid, or unsure.

In more general questions, hunters were asked (1) the number of years that they had been hunting; (2) the number of times they had gone out hunting between February and April; (3) the number of caribou shot each trip; (4) the areas where they had hunted between February and April; (5) whether they noticed year-to-year differences in late-winter body condition of adult female caribou; (6) whether female caribou body condition had changed between February and April, and if so, how; (7) their general impressions of body condition (i.e., poor, fair, or very good) of adult female and male caribou in each month of the year, and (8) information regarding environmental conditions (i.e., depth and condition of snow) the preceding fall and winter.

Elder Interviews

Semi-directed interviews were conducted with elders from Łutsël K'é between July and November 2000. A person was considered an elder if he or she was over the age of 60, the minimum age designation for elders recognized by the Łutsël K'é community. (This is a community-specific decree and may not apply to other aboriginal communities in Canada.) Interviews were conducted in Denésǫłiné and recorded using a VHS system in the homes of the participants. The 31 elders (21 men and 10 women) interviewed represent 89% of the elders residing in Łutsël K'é at the time of the interviews. Usually the Denésǫłiné-speaking person who had conducted the interview translated the narrative orally to a second person, who transcribed it into English. Elder interviews focused on themes such as (1) annual variation in body condition of caribou; (2) potential reasons for annual variation in caribou condition; (3) fat deposition sites on a caribou from which condition is assessed; (4) selection criteria for caribou based on season, gender, and age; and (5) geographic variation in caribou body condition.

Field Assessment of Caribou Body Condition

Three observers accompanied Łutsël K'é hunters (n = 36) on hunting forays for caribou between mid-February and April in 2000 and 2001. In 2001, an Inuit hunter from Baker Lake, two Yellowknife hunters from Dettah, and two Dogrib hunters from Fort Rae were also surveyed during this period. The period from 15 February to 30 April is considered to be late winter with respect to caribou

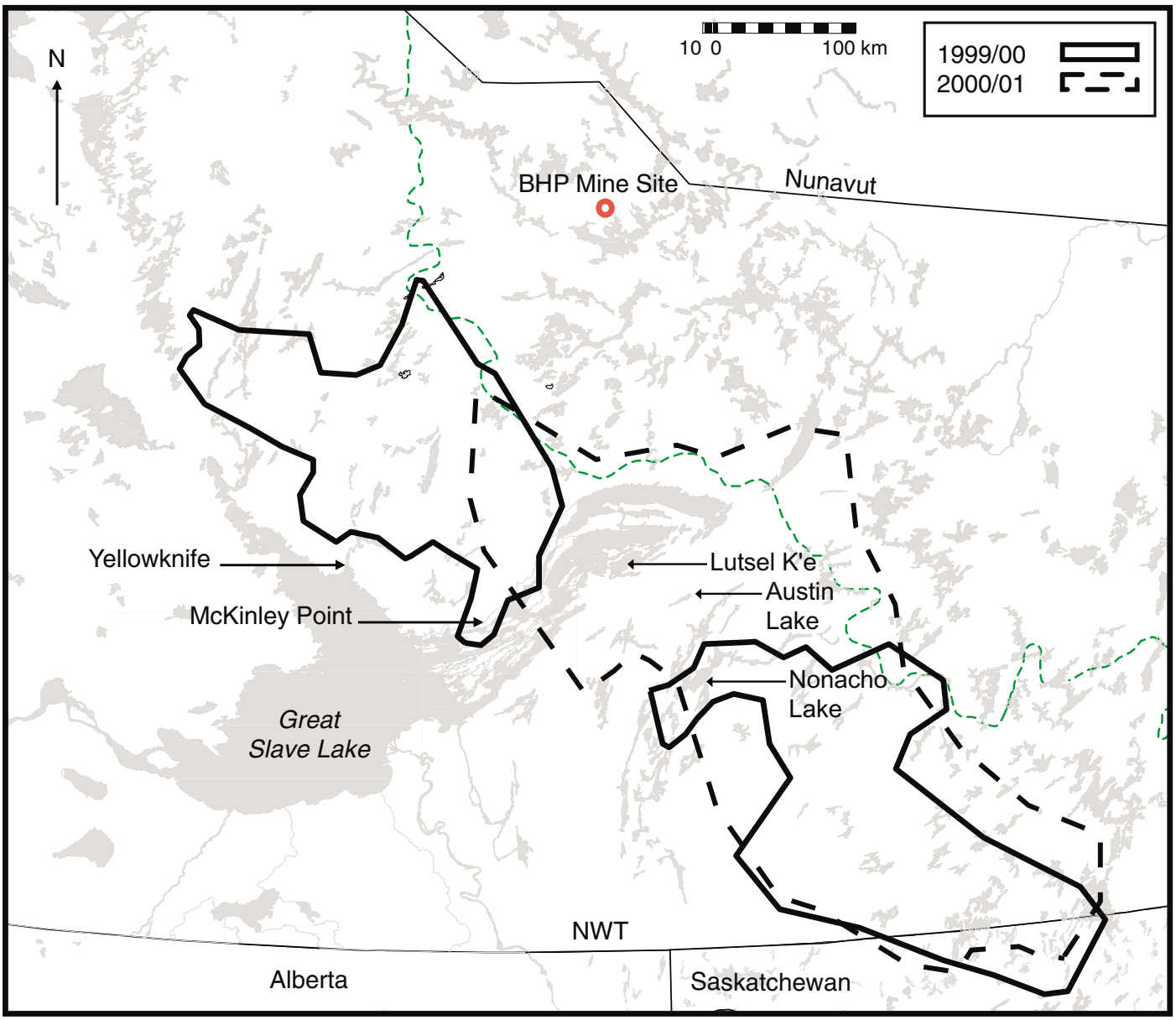

FIG. 1. Location of Łutsël K'é, Austin Lake, and areas used by satellite-collared Bathurst caribou cows during winter (November to February) in 1999–2000 and 2000–01 (modified from Gunn et al., 2001).

ecology because there is still snow on the ground and temperatures are below zero (A. Gunn, pers. comm. 2001).

Hunters provided observers with an evaluation of body condition for each adult female caribou they harvested, using the ratings skinny, not so bad, fat, really fat, or unsure. Numerical ratings were given to four body condition categories: skinny = 1, not so bad = 2, fat = 3, really fat = 4. Hunters' impressions of body condition recorded in the field were compared with those provided in interviews. For both years, the distribution of field impressions for hunters who harvested (a) less than (or equal to) or (b) more than the average number of caribou was assessed using Kolmogorov-Smirnov's two-sample test. The distribution of hunters' impressions in relation to hunting experience was also assessed. Differences in body condition of adult female caribou harvested in 2001 around Łutsël K'é and Austin Lake (50 km southeast of the community) were compared using a Mann-Whitney U-Test. The body condition of mature cows harvested in February, March, and April was also compared using a Kruskal-Wallis one-way analysis of variance.

RESULTS

Annual Variation in Caribou Body Condition

Almost all Łutsël K'é hunters (97%, n = 39) reported that late-winter body condition of adult female caribou sometimes varied between years. Just over three-quarters of hunters (77%) held a similar view regarding adult male body condition. However, a number of hunters (13%) felt

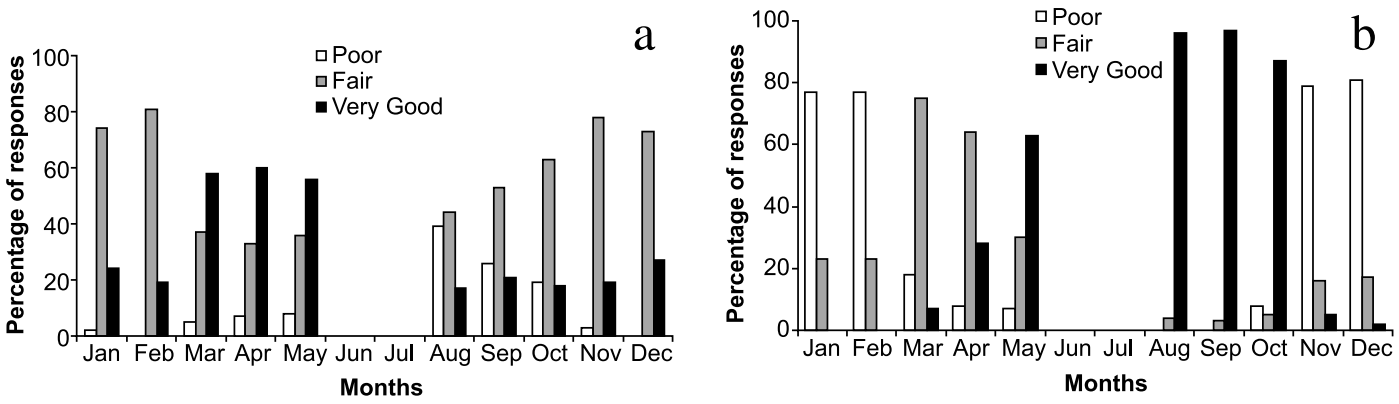

FIG. 2. Łutsël K'é hunters' general monthly impressions of (a) female and (b) male caribou body condition. (Note: Two of the 39 hunters did not provide monthly impressions because they thought body condition varied so much between years.)

the fatness of bulls did not vary between years, and the remaining hunters were unsure. About two-thirds (65%, n = 20) of Łutsël K'é elders who answered the question thought that caribou were fatter in some years compared with others. One-third of the elders did not answer the question or made reference to seasonal variation in body condition rather than annual variation.

The majority (86%) of elder men stated that they used brisket fat as their main indicator of caribou body condition, whereas 80% of elder women used back fat as one of theirs. Elder men also based their assessment on the amount of fat on the back, the kidneys, and around the stomach. In addition to these fat deposition sites, women used the inside of the pelvic bone and around the ribs. Women also noticed that in some years there would be more fat on the hides of caribou.

> I cut the caribou's head off first. Then I turn the caribou onto its back and cut the brisket area. Once you cut the brisket area, if the animal is in good condition, the fat will just expose to you. If you're strong, you cut the legs and pull the hide off, and if the animal is in good condition, the fat will extend from the rump to the shoulder. (Noel Drybones, 2000)

> The fat you will see around the inside of the pelvic bone, on the rump, and around the ribs. If you see fat when cutting the brisket, you know you have a fat caribou. If you cut the brisket and don't see fat, you know you have a skinny caribou. (Alice Michel, 2000)

Seasonal Variation in Caribou Body Condition

Seasonal variation in adult male and female caribou body condition is widely recognized by the Denésǫłiné. Seventy percent of the hunters (n = 30) interviewed in 2000 stated they preferred to target adult female caribou during late winter; 23% had no preference for cows or bulls, and the remainder selected adult males. They decide to harvest adult female caribou during late winter because they are fatter then (Fig. 2a). Also, adult female caribou body condition was considered to be less variable through the year than that of adult males (Fig. 2a). An estimated 74% of caribou harvested by hunters in late winter 2000, and 90% in late winter 2001, were adult females.

Just under one-half of elders (44%, n = 41 responses) indicated they preferred to harvest adult female caribou in the winter and spring months, while more than one-third (34%) stated that cows could be harvested at any time when they are available.

> We hunt females year-round. They are hunted in winter, but the best time of all is in the spring [March–April]. (J.B. Rabesca, 2000)

Adult male caribou are selected for harvest during the fall (September), before they lose condition during the rutting period, and in spring (May), when they begin to regain body fat (Fig. 2b). An estimated 93% (n = 29) of caribou harvested by hunters in September 2000 were bulls. Almost half the elders identified fall as the most popular time for harvesting bulls (45%, n = 38 responses) because they are fat, while almost a quarter (24%) also believed spring is a good time to take bulls.

Intra-seasonal Variation in Body Condition

Łutsël K'é hunters reported that during late winter 2000, adult female caribou harvested from the Nonacho Lake region (80 km southeast of Łutsël K'é) were in better condition than the cows harvested from the McKinley Point-Yellowknife region (90 km west of Łutsël K'é, Fig. 1). Twenty-eight (93%) of the 30 hunters interviewed identified Nonacho Lake as the area where they most commonly hunted caribou during late winter 2000. Elders also referred to caribou groups' overwintering in the two different areas and being in noticeably different condition.

> On the north side of the lake [Great Slave Lake] by McKinley Point the caribou are really skinny. The caribou that travel down south [around Nonacho Lake] and then come back up here [Łutsël K'é] are fat because they spend all their time feeding. (Liza Casaway, 2000)

TABLE 1. Hunters' field impressions of body condition of adult female caribou harvested during February (n = 48), March (n = 84), and April (n = 44) 2001, expressed as percent of caribou rated in each category. (Note: the category "really fat" was removed from the analysis.)

	Monthly Field Impressions of Body Condition (%)		
Hunters' impressions	February	March	April
Skinny	6	23	34
Not so bad	63	54	50
Fat	31	24	14
Really fat	0	0	2

One-third of hunters believed that the caribou they harvested between February and April 2001 were all from the same herd, but varied in condition according to the area where they were harvested. It was reported that caribou around Austin Lake were fatter than those around the community (Fig. 1). An assessment of field impressions indicated that adult female caribou harvested around Austin Lake were in slightly better condition than those harvested around the community ($U_{29, 147} = 1646$; $p = 0.05$).

About one-quarter of hunters noticed a decline in adult female caribou condition between February and April 2001. Field impressions showed that adult female caribou harvested in February (mean rating = 2.3) were fatter than those harvested in March (mean = 2.0), and April 2001 (mean = 1.8; $H_c = 9.138$, df = 2; $p = 0.01$, Table 1). Note: When hunters' field impressions were initially assessed, no interaction was detected between "date" and "area" ($F = 0.10$, df = 1; $p = 0.747$). A difference in body condition between herds was another popular explanation (given by 42% of hunters) for intra-seasonal variation.

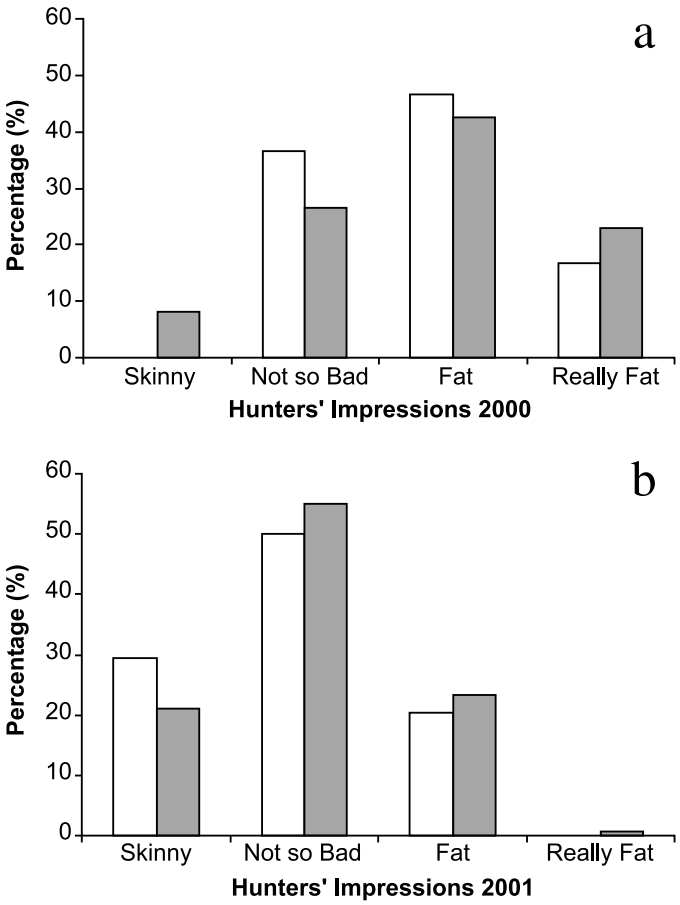

FIG. 3. Łutsël K'é hunters' impressions of adult female caribou body condition in late winter recorded in (a) 2000 (n = 30 hunter interview responses; n = 87 field impressions), and (b) 2001 (n = 44 hunter interview responses; n = 176 field impressions; Kofinas et al., 2003). White bars show impressions recorded in interviews at the end of each season, and grey bars those for each animal harvested while in the field.

Reasons Suggested for Changes in Caribou Body Condition

Łutsël K'é elders and hunters reported that caribou body condition varied because of (1) forest fire frequency or severity (or both); (2) declines in the quality and availability of vegetation; (3) weather-related variables (deep snow and ice); (4) disturbance (mining development and hunting pressure); and (5) the distance caribou had to migrate, which was often estimated on the basis of reports from other communities and how far south the hunters had to travel to harvest animals.

> Caribou migrate all over the place. Even though the snow is deep, they know where there is a lot of food. Burnt areas are one of the reasons why the caribou get skinny. If [a burnt area] is on their migration route, they will just keep migrating through it. They stick to their migration routes. They don't just deviate off their trail to feed. Forest fires are more severe now than in the past. In the past, there were so many caribou, but now there aren't many because of the forest fires. Forest fires kill a lot of species. A lot of things are gone. There weren't so many forest fires in the past. (Maurice Lockhart, 2000)

> Deep snow doesn't necessarily mean the caribou will be skinny, but out on the barrens when the snow is really hard packed, and in the forest when the snow is crusted, it is harder for the caribou to break through that for their food. (Jim Fatte, 2000)

Hunters' Impressions of Body Condition

Hunter's impressions of adult female caribou body condition recorded in the field and in interviews were similar in both 2000 ($\chi^2 = 3.722$, df = 3, $p = 0.2931$; Fig 3a) and 2001 ($\chi^2 = 1.414$, df = 2, $p = 0.4930$; Fig 3b; Kofinas et al., 2003). Field and interview values from the "really fat" category in 2001 were omitted because both were less than 5, which made the chi-square approximation unreliable. Both impressions of body condition from hunters, in interviews ($\chi^2 = 13.944$, df = 1, $p < 0.001$) and in the field ($\chi^2 = 60.267$, df = 3; $p < 0.001$), indicated that adult female caribou were in better condition in 2000 than in 2001.

TABLE 2. Hunters' impressions of fat quantities at four deposition sites on adult female caribou harvested between February and April in 2000 and 2001. (Values expressed as percentage of hunter responses.)

	Hunters' Impressions (%)			
Fat deposition site	None	Some	Quite a bit	Lots
2000:				
Brisket	0	30	50	20
Back	0	40	40	20
Stomach	0	37	37	27
Kidneys	0	27	53	20
2001:				
Brisket	5	66	24	5
Back	20	55	18	7
Intestine	5	38	33	23
Kidney	0	33	41	26

Greater amounts of fat were also reported on the brisket ($\chi^2 = 11.554$, df = 1, $p = 0.001$) and rump ($\chi^2 = 8.750$, df = 1, $p = 0.003$) of adult female caribou in 2000 (Table 2). Annual differences in fat quantities around the stomach or around the kidneys were not detected (Table 2). Colour and texture of femur marrow were not included because 50% of hunters were unsure about this body condition characteristic.

Variation in Hunters' Impressions of Body Condition

Field impressions of body condition were recorded from 18 hunters for 87 adult female caribou in 2000 and from 34 hunters for 176 cows in 2001. In 2000, the majority of the samples (93%) were collected at Nonacho Lake (55˚10' N, 110˚10' W), while in 2001, 84% of the samples were collected immediately around Łutsël K'é.

Interviews were conducted with 30 Łutsël K'é hunters in May 2000 and 39 in May 2001. The 30 hunters (mean = 35 years of hunting experience, range 15–57 years' experience) interviewed in May 2000 had participated, on average, in 6.5 (SE = 0.90; range = 1–20 trips) hunting trips between February and April and harvested an average of about 25 caribou (SE = 5.0; range = 7–100 caribou). In contrast, the 39 hunters (mean = 32 years hunting experience, range = 5–58 years' experience) interviewed in 2001 had participated, on average, in 14 trips (SE = 1.7; range = 1–36 trips) and had harvested an average of about 46 caribou (SE = 6.5, range = 2–144 caribou).

Between February and April 2000, one-fifth of the hunters (those who harvested more than the average number of caribou) harvested 58% of the caribou. Similarly, in late winter 2001, one-third of the hunters harvested 69% of the caribou. In 2000, a difference in distributions of interview impressions was detected between hunters who harvested 25 or fewer caribou and hunters who harvested more than 25 caribou ($D = 0.833$; $p = 0.002$; $n_1 = 24$, $n_2 = 6$). In 2001, no difference was detected between hunters who harvested 46 or fewer caribou and those who harvested more than 46 caribou ($D = 0.0$; $p > 0.05$; $n_1 = 26$, $n_2 = 13$). However, when

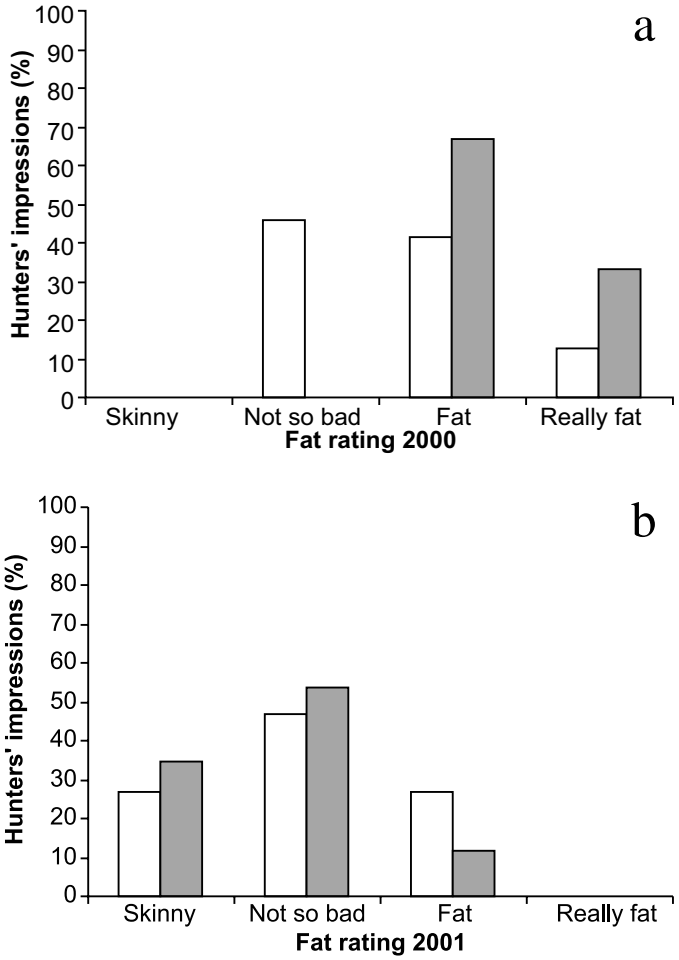

FIG. 4. Hunters' interview impressions of adult female caribou body condition in late winter of (a) 2000 and (b) 2001. White bars show impressions recorded from hunters who harvested 25 or fewer caribou, and grey bars, those from hunters with more than 25 caribou.

the critical number of caribou harvested by hunters in 2001 was lowered to 25, as in the previous year, a difference in the distribution of impressions emerged ($D = 0.950$; $p < 0.001$; $n_1 = 15$, $n_2 = 24$). In 2000, hunters who harvested more than 25 adult female caribou thought the caribou were generally fatter than those hunters who harvested 25 or fewer caribou did (Fig. 4a). In 2001, in contrast, hunters who harvested more than 25 adult female caribou thought they were generally thinner than those hunters who harvested 25 or fewer did (Fig. 4b).

A difference in distributions of body condition impressions was found in 2000 between hunters with 35 years or less of hunting experience and those with more than 35 years' experience ($D = 0.733$; $p = 0.001$; $n_1 = 20$, $n_2 = 10$). Similarly, a difference was detected in 2001 between hunters with 32 years or less of experience and those with more than 32 years' experience ($D = 0.521$; $p = 0.008$; $n_1 = 21$, $n_2 = 18$). Hunters who had more than 35 years of experience in 2000 reported that adult female caribou were generally thinner than did hunters with 35 years or less (Fig. 5a). In contrast, hunters who had more than 32 years of experience in 2001 thought cows were fatter than did

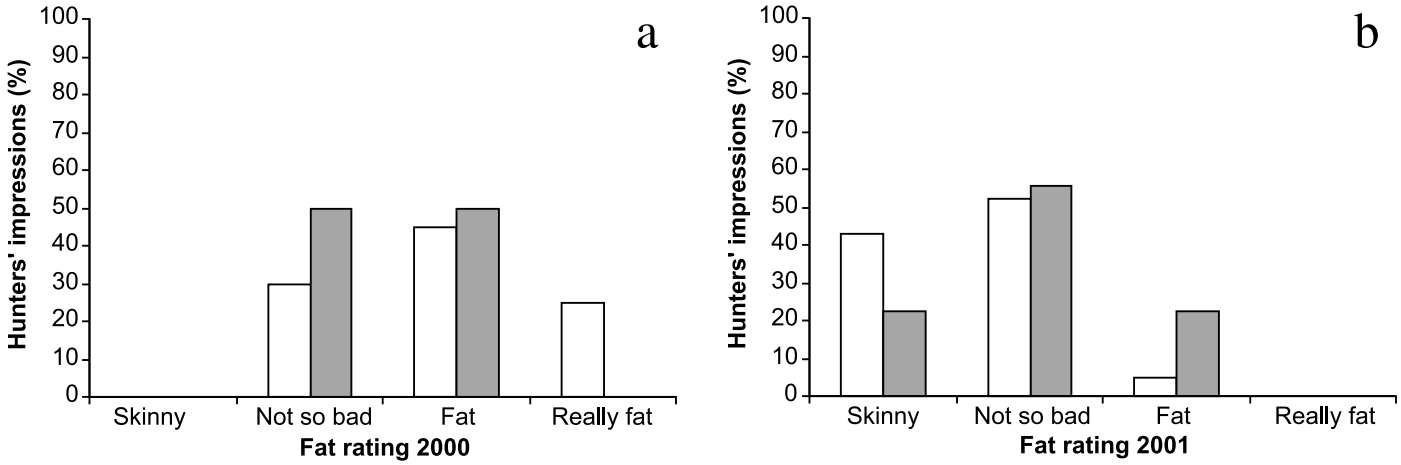

FIG. 5. Hunters' interview impressions of adult female caribou body condition in late winter of (a) 2000 and (b) 2001. White bars represent hunters with hunting experience of 35 years or less (2000) or 32 years or less (2001); and grey bars, those with experience of more than 35 years (2000) or more than 32 years (2001).

hunters who had 32 years' experience or less (Fig. 5b). No correlation was detected between hunters' experience and the number of caribou they harvested during late winter in either 2000 (r_{xy} = -0.246; p = 0.190; n = 30) or 2001 (r_{xy} = -0.20; p = 0.222; n = 39).

DISCUSSION

Assessment of Caribou Body Condition

Men and women differed in their prioritization of fat deposition sites used to assess caribou body condition. Men are most likely to use brisket fat because they make their first incision in the brisket when skinning the animal. Back fat is also easily observed once the animal is skinned, so for both men and women, the back is an ideal deposition site at which to assess body condition. Caribou are usually cut up before being brought home; therefore, the amount of fat inside the pelvic bone and over the ribs is also easily observed during preparation for cooking. Monitoring interviews with men and women should be designed according to their prioritization of fat deposition sites.

A few women elders noticed more fat on the skins of caribou in some years. Women generally obtain hides from the same hunter, so they would become accustomed to his skills at skinning. This would allow annual differences in fat on the skins to be estimated for a monitoring program. However, this method of assessment is probably less commonly used now than in the past, when the community relied more heavily on caribou hides for clothing. Caribou meat and fat still make up a large proportion of the Denésǫłiné diet (E. Marlowe, pers. comm. 2001); therefore, the relative impressions of body condition gained from the processing and cooking of animals would still be expected to be reliable. The hunters' preference for fat caribou means that any body condition measures based on harvested animals are likely to be on the high side. At times, however, when female caribou were disturbed or in small, isolated groups, harvests usually became quite random, as hunters simply took whatever animals were available or closest (Lyver and Gunn, 2004).

Use of Hunters' Impressions from Interviews

The majority of Łutsël K'é hunters recognized that female caribou body condition could vary from year to year. This fact suggested it was possible to monitor body condition trends on the basis of hunters' impressions. Hunters reported that adult female body condition was better in 2000 than in 2001. They also identified greater amounts of fat on the brisket and rump in 2000. These specific fat deposition sites could offer additional easily observable measures to corroborate hunters' overall impressions of body condition.

Impressions of adult female caribou body condition obtained in interviews at the end of the late-winter hunting period in 2000 and 2001 were very similar to hunters' impressions of individual caribou harvested in the field (Fig. 3a, b). This similarity suggests that hunters' impressions from interviews could be used to evaluate general female caribou condition. Also, this method can be used to determine how hunters treat variability in caribou body condition each year. Perceptions of caribou obtained from field surveys provide only a subsample of the animals that each hunter harvests in a season, and this sample may not necessarily be representative of body condition. Unless each hunter is followed throughout the entire season, a comparison between field and interview impressions provides a way to check the trends obtained from field assessments. The use of both field and interview evaluation methods in a monitoring program would be ideal.

The interview technique alone would involve less time and financial commitment by communities than would be required if observers were to accompany hunters into the field each year. Hunters may also find one interview at the end of the late-winter hunting period or at the end of each month more acceptable than having an observer accompanying

them on hunting forays. The technique could easily be applied in other communities that harvest caribou, which would reduce the effect of geographic variability if hunters are harvesting from different areas of the range or segments of a herd.

Other Temporal Variation in Body Condition

Identification of seasonal variation in caribou harvest patterns (which are based on body condition) is important for determining a sampling regime for a community-based monitoring program. It is essential that monitoring fit in with the practices of the community because hunters do not like harvesting animals primarily for study purposes (G. Kofinas, pers. comm. 2002). Harvest patterns within each community may vary depending on preferences for cows or bulls and the time of year at which caribou are available. Some studies indicate that the body condition–fecundity relationship is most reliable if caribou cows are sampled during fall (Cameron et al., 1993). However, Denésǫłiné hunters harvest few adult female caribou during fall because caribou bulls are in peak condition during that time and are preferred for nutritional purposes. Thomas and Kiliaan (1998b) reported it was possible to use adult females from the Beverly herd in late winter to monitor condition and fecundity, which fitted with the harvesting behaviour of Łutsël K'é hunters.

Temporal bias can occur if impressions are accrued over a short time frame during late winter. Hunters who harvested solely in February would have thought the animals were fatter than would those hunters who harvested in March/April. Therefore, it is imperative that monitoring programs establish the time frame over which hunters form their opinions. A change in body condition over a few months may offer insights into recent limitations in the environment (e.g., rain or thawing causing icing and compacting of snow). In late February 2001, the temperature rose above 0˚C on three consecutive days, causing a widespread thawing event in the Łutsël K'é region (Environment Canada, 2001). As a result, compacting or crusting of snow, or both, may have impeded foraging and caused caribou to lose condition in the following months. Snow density and presence or absence of crusting can exert a controlling effect over the energetic costs of cratering to reach the forage (Gunn and Skogland, 1997). Also, a snow crust that would almost support the weight of a caribou before it collapsed raises the cost of walking by 570% (Fancy and White, 1985). Greater snow depth in certain years is reported by Łutsël K'é people and biologists to be the cause for reduced body condition in caribou (Crête and Payette, 1990; Gunn and Skogland, 1997). However, some of the more experienced local hunters and trappers believe that the depth of snow has been gradually decreasing over the years and may be less of an influencing factor (F. Abel, pers. comm. 2001; A. Catholique, pers. comm. 2001; P. Enzoe, pers. comm. 2001). Hunters' knowledge gained by observing changes in body condition and the environment can provide insights into this cause-and-effect relationship.

Geographic Variation in Body Condition

There was general recognition from elders and hunters that geographic differences occur in caribou body condition. Hunters preferred expending more time and financial resources to reach what they thought were fatter caribou around Nonacho Lake rather than harvesting those animals located to the west at McKinley Point, even though this latter group was relatively more accessible. They suggested disturbance, pollution, and a poorer quality of feed as reasons for the thinner animals at McKinley Point. A similar situation arose in 2001, when some hunters preferred to harvest what they recognized as better animals from the Austin Lake area rather than those found directly around the community. In this case, the satellite collar data did not show two distinct segments of the Bathurst herd, as they had done in the previous year (Fig. 1). Continual disturbance from hunters was postulated as a cause for thinner adult female caribou around Łutsël K'é.

It is essential to identify the scale at which geographic variation is occurring to understand hunters' interpretations of body condition and herd health. Geographic bias may limit a hunter's capacity to predict overall body condition if the harvest is procured from a relatively small area around his community. Presumably, the opinion of a hunter who harvested from a wider area would be more reliable. Also, caribou cows generally limit their movements during late winter (February–April; Thomas et al., 1998), so hunters could be harvesting from a relatively small, static portion of the population. However, this result may depend largely on the timing and routes caribou use in their spring migration and the availability of caribou to the hunter.

The Department of Resources and Economic Development regularly supplied the Łutsël K'é community with satellite maps showing positions of the collared Bathurst caribou cows, so the hunters could have formed their impressions of caribou distribution with the aid of these maps. However, no body condition data were available to the hunters, so it is assumed that their impressions of condition were largely acquired from harvesting experience. Similarly, Thomas and Kiliaan (1998a) observed geographic variation in body condition between two segments of the Beverly caribou herd that had overwintered in different parts of the range. Therefore, consideration of geographic variation is important for any monitoring program if generalizations about herd body condition are to be made. The problem with assessing geographic variation is that hunters prefer not to harvest in areas where they think the caribou are thinner. This makes it difficult to obtain measures or impressions from these areas.

Herd range is also an important consideration when assigning body condition ratings to specific herds. Given the overlap of the known winter range of the Bathurst herd

with those of the Beverly and Ahiak (Queen Maud Gulf) herds, the presence of animals from the two latter herds could not be excluded from this assessment (A. Gunn, pers. comm. 2002). However, satellite collar information and DNA analysis indicated a high likelihood that animals harvested in this study were from the Bathurst herd (Gunn et al., 2001; K. Zittlau, pers. comm. 2001).

Accounting for Experience and Sample Size Variation in Body Condition Assessment

Łutsël K'é hunters conducted about twice as many hunting forays and harvested about twice as many caribou in late winter in 2001 as they did in 2000. The larger harvest is largely attributed to overwintering of caribou close (20 km) to the community in 2001. It is expected that the hunters' precision in predicting general body condition would improve in such a year because their perceptions are formed from a larger sample of animals.

One-third (or less) of the hunters were responsible for harvesting about two-thirds of the animals each year. It could be important to include impressions from this group of hunters in a monitoring program because the high number of animals they observe to form their impression could increase the reliability of the monitoring effort. Differences in the distribution of body condition impressions were detected between those hunters who harvested more than 25 adult female caribou and those who harvested 25 or fewer. If the assumption that harvesting more caribou gives a more reliable impression is correct, then only impressions from hunters who harvest more than 25 caribou over a season should be used.

The amount of hunting experience also affected the distribution of hunters' impressions from interviews. The most experienced hunters are not always the ones harvesting the most caribou. Even so, we assume that hunters with more experience would be better placed to determine body condition because they have observed variability from a greater number of years to which they can compare current levels.

More experienced hunters could harvest fatter caribou, although this correlation is not supported by the data (Fig. 5a). An independent assessment of animals harvested by each of the hunters would be required to properly test this theory. Other body condition studies suggest that this sort of hunter bias is not a problem if the selection criteria are consistent (Kofinas et al., 2003). The value of community monitoring programs is their ability to offer a 'relative trend' in body condition between years. This ability is demonstrated by hunters in this study, who regardless of their experience or the number of caribou they harvested, reported that adult female caribou were fatter in 2000 than in 2001 (compare Fig. 4a with 4b; and Fig. 5a with 5b). Even so, communities should address these sources of variability by recording areas, dates, and numbers of caribou harvested and the experience of the hunters reporting.

The Value of Elder "Baseline" Knowledge

It was evident from interviews that some Łutsël K'é elders had formed impressions of caribou body condition for that particular year consistent with that of the hunters. Elders were aware of the geographic variation in caribou body condition during late winter 2000. This indicated that active hunters were constantly updating the elders on the state of the caribou. Using current information and past experience, elders can advise on potential trends or changes in caribou condition, caribou movements, or the state of the environment. Many explanations for differences in body condition could be related to burn histories, changing snow conditions, and disturbance (Kendrick et al., in press). The extensive time many of the elders have spent on the land, much of it harvesting caribou, provides them with the baseline knowledge from which to make these predictions. Similarly, Ferguson (2000) found that Inuit elders using updates from hunters about wildlife could synthesize complex geographic and temporal interrelationships and then provide advice and predictions about the environment.

CONCLUSION

The development of a monitoring program for evaluating caribou body condition can build management capacity within northern communities. Historical knowledge of elders can provide baselines against which to gauge recent changes in caribou body condition and range. Local staff can measure fat indices, record hunters' field impressions of harvested caribou, and conduct interviews with hunters in the community. Financial incentives can be offered to hunters in exchange for the opportunity to record their impressions of the caribou they harvest and their participation in interviews. To maximize reliability, communities should compare trends in body condition using both field and interview techniques. If funding is limiting, communities have the option of using the cheaper interview technique. One interview at the end of winter is less of an imposition for hunters, although monthly interviews could provide information on temporal changes in body condition and variations in hunters' assessments. Records of where hunters harvested their caribou are crucial to account for geographic variation. Hunting experience and number of caribou harvested by each hunter are less important if only the trends in annual body condition are crucial. Hunters' field impressions from harvested adult female caribou can predict outcomes such as pregnancy probabilities (Lyver and Gunn, 2004). Similarities between field and interview body condition impressions suggest it may be possible to estimate fecundity from interview impressions alone. However, the interpretation of body condition and its relationship to fecundity needs careful consideration. Better body condition and higher pregnancy rates may not necessarily indicate that herd numbers are increasing. Fewer animals may mean there is more forage available; hence, they become fatter.

Community-based caribou monitoring programs offer the opportunity for communities and biologists to build a collaborative partnership to manage a renewable resource. Monitoring caribou body condition provides the common ground on which to develop this relationship.

ACKNOWLEDGEMENTS

Special thanks must go to the Łutsël K'é Lands, Wildlife, and Environment Committee and people of Łutsël K'é for allowing this research to occur within their community. This paper would not have been possible without the input and co-operation of elders and hunters. My thanks to Raymond Marlowe and Ernest Boucher, for assisting with data collection in the field, and to Nancy Casaway, Marcel Basil, and Kathleen Lockhart, for translating and transcribing elder interviews. A special thank-you must also go to Fikret Berkes for his guidance and support. This project was funded primarily by New Zealand's Foundation for Research, Science, and Technology. Funding also was received from Fikret Berkes (University of Manitoba), with logistical support from the Łutsël K'é Dene Band, Tom Coles (Łutsël K'é Northern Co-op), and the Łutsël K'é Royal Canadian Mounted Police. Thanks also must go to Anne Gunn and the anonymous referees for their review of this manuscript; to Anne Gunn for information regarding the Bathurst caribou herd; and to Anne Kendrick, Brenda Parlee, and Steve Ellis for their support throughout this study.

REFERENCES

ALLAYE CHAN-McLEOD, A.C., WHITE, R.G., and RUSSELL, D.E. 1999. Comparative body composition strategies of breeding and nonbreeding female caribou. Canadian Journal of Zoology 77(12):1901–1907.

BERKES, F. 1998. Indigenous knowledge and resource management systems in the Canadian Subarctic. In: Berkes, F., and Folke, C., eds. Linking social and ecological systems: Management practices and social mechanisms. Cambridge: Cambridge University Press. 98–128.

CAMERON, R.D. 1994. Reproductive pauses by female caribou. Journal of Mammalogy 75:10–13.

CAMERON, R.D., SMITH, W.T., FANCY, S.G., GERHART, K.L., and WHITE, R.G. 1993. Calving success of female caribou in relation to body weight. Canadian Journal of Zoology 71: 480–486.

CRÊTE, M., and PAYETTE, S. 1990. Climatic changes and caribou abundance in northern Quebec over the last century. Rangifer 3:159–165.

ENVIRONMENT CANADA. 2001. National climate and information archive. Climate data online. Daily Data Report, February 2001. http://www.climate.weatheroffice.ec.gc.ca/Welcome_e.html. Accessed November 2004.

FANCY, S., and WHITE, R.G. 1985. Energy expenditure by caribou while cratering in the snow. Journal of Wildlife Management 49:987–993.

FERGUSON, M.A.D. 2000. Utilizing indigenous knowledge in environmental research and assessment. In: Baker, M., and Belliveau, G., eds. Proceedings of the Effects of Noise on Wildlife Conference, 22–23 August 2000, Institute of Environmental Monitoring and Research, Happy Valley–Goose Bay, Labrador. Terra Borealis 2:15–18.

GERHART, K.L., WHITE, R.G., CAMERON, R.D., and RUSSELL, D.E. 1996. Estimating fat content of caribou from body condition scores. Journal of Wildlife Management 60(4):713–718.

GERHART, K.L., RUSSELL, D.E., VAN DE WETERING, D., WHITE, R.G., and CAMERON, R.D. 1997. Pregnancy of adult caribou (*Rangifer tarandus*): Evidence for lactational infertility. Journal of Zoology 242:17–30.

GUNN, A., and SKOGLAND, T. 1997. Responses of caribou and reindeer to global warming. In: Oechel, W.C., Callaghan, T., Gilmanov, T., Holten, J.I., Maxwell, B., Molau, U., and Sveinbjörnsson, B., eds. Global change and Arctic terrestrial ecosystems. New York: Springer. 189–200.

GUNN, A., DRAGON, J., and BOULANGER, J. 2001. Seasonal movements of satellite-collared caribou from the Bathurst herd. Final Report to the West Kitikmeot/Slave Study Society. Yellowknife: Wildlife and Fisheries Division, Resources, Wildlife and Economic Development, Government of the Northwest Territories. 63 p.

KENDRICK, A., ŁUTSËL K'É DENE FIRST NATION, and LYVER, P.O'B. In press. Denésǫłiné (Chipewyan) knowledge of barren-ground caribou (*Rangifer tarandus groenlandicus*) movements. Arctic 58(2).

KOFINAS, G., LYVER, P.O'B., RUSSELL, D., WHITE, R., NELSON, A., and FLANDERS, N. 2003. Towards a protocol for community monitoring of caribou body condition. Rangifer 14:43–52.

LEGAT, A. 1998. Caribou migration and the state of the habitat. Annual Report. Yellowknife: West Kitikmeot/Slave Study Society. 59 p.

LYVER, P.O'B., and GUNN, A. 2004. Calibration of hunters' impressions of female caribou body condition indices to predict probability of pregnancy. Arctic 57(3):233–241.

PARLEE, B. 1998. Community-based monitoring: A model for northern communities. Master of Environmental Science Thesis, University of Waterloo, Waterloo, Ontario, Canada. 131 p.

SIMPSON, L. 2000. Indigenous knowledge and western science: Towards new relationships for change. In: Oakes, J., Riewe, R., Koolage, S., Simpson, L., and Schuster, N., eds. Aboriginal health, identity and resources. Winnipeg: Native Studies Press. 186–195.

SMITH, J.G.E. 1978. Economic uncertainty in an 'original affluent society': Caribou and caribou eater Chipewyan adaptive strategies. Arctic Anthropology 15(1):68–88.

THOMAS, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. Canadian Journal of Zoology 60: 597–602.

THOMAS, D.C., and KILIAAN, H.P.L. 1998a. Fire-caribou relationships: (I) Physical characteristics of the Beverly herd, 1980-87. Canadian Wildlife Service Technical Report Series No. 309. Edmonton, Alberta. 178 p.

———. 1998b. Fire-caribou relationships: (II) Fecundity and physical condition of the Beverly herd. Canadian Wildlife Service Technical Report Series No. 310. Edmonton, Alberta. 96 p.

THOMAS, D.C., KILIAAN, H.P.L., and TROTTIER, T.W.P. 1998. Fire-caribou relationships: (III) Movement patterns of the Beverly herd in relation to burns and snow. Canadian Wildlife Service Technical Report Series No. 311. Edmonton, Alberta. 176 p.

TRESEDER, L., HONDA-McNEIL, J., BERKES, M., BERKES, F., DRAGON, J., NOTZKE, C., SCHRAMM, T., and HUDSON, R.J. 1999. Northern Eden: Community-based wildlife management in Canada. Canadian Circumpolar Institute Occasional Publication 46. Edmonton: University of Alberta. 92 p.