

RÉPONSE COMPORTEMENTALE DES CARIBOUS DES  
BOIS AU HARCÈLEMENT PAR LES MOTONEIGES

par

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## SOMMAIRE

J'ai effectué des expériences pour tester l'effet des activités de motoneigistes sur les comportements du caribou des bois (*Rangifer tarandus caribou*) dans les montagnes côtières du Yukon, Canada. Bien qu'il y ait de plus en plus d'inquiétude en rapport avec les activités de loisirs situées dans les régions d'habitat hivernal du caribou, il existe encore très peu d'information pour aider les gestionnaires dans leurs décisions en ce qui a trait à l'utilisation de l'arrière pays. Les activités de motoneigistes pourraient changer les comportements du caribou durant le broutage, causer leur délaissement de l'habitat, de même que rendre la région plus accessible aux prédateurs qui prennent avantage de la neige compactée que laissent les motoneiges sur leurs passages.

Ces approches expérimentales ont été utilisées dans des régions avec et sans l'activité motoneigiste. Je cherchais à identifier quels aspects de l'activité motoneigiste affectent le comportement du caribou, à documenter le niveau d'activité motoneigiste dans l'aire d'hiver du troupeaux de caribous 'lbex', à déterminer si les régions clés d'habitat hivernal sont utilisées extensivement par les motoneigistes, et à formuler des recommandations pour un programme d'éducation dédié envers les motoneigistes.

Je n'ai pu montrer aucune relation solide entre les facteurs contrôlables de comportement du motoneigiste et l'initiation de la réaction de fuite du caribou. La vitesse de la motoneige, le nombre de motoneiges, et l'angle d'approche n'ont pas affectés la réaction des caribous. Les groupes de caribous mâles permettaient aux motoneiges d'approcher plus près que ne le faisaient les groupes maternels (formés de femelles avec ou sans veaux et de jeunes caribous âgés d'un an) (moyenne = 189 ( $\pm 21$  SE) m vs. 289 ( $\pm 28$  SE) m). Pour les groupes qui ont pris la fuite devant l'approche d'une motoneige, la distance initiale de fuite est la même pour les mâles (moyenne = 227 ( $\pm 43$  SE) m) que pour les groupes maternels (moyenne = 282 ( $\pm 30$  SE) m). Ces derniers étaient plus prompts à fuir à l'approche d'une motoneige (82%) que les groupes de mâles (50%), et passaient plus de temps en mouvement et à montrer une vigilance accrue après avoir été dérangés. Plus les groupes de mâles étaient larges, plus l'approche était tolérée jusqu'à des distances moindres avant de fuir. Ceci n'était pas le cas pour les groupes maternels. Les groupes maternels passaient

plus de temps à courir (moyen =117 ( $\pm$ 36 SD) seconds) que les groupes mâles (moyen =20 ( $\pm$ 6 SD) seconds) après un dérangement. J'ai estimé qu'une seule réaction au dérangement pour le mâle et la femelle caribou crée une augmentation, respectivement, de 0.68% et 1.2% des dépenses énergétiques journalières. Les caribous n'ont montré aucune évidence d'habituation au cours d'un seul jour ou au cours d'une saison. Lorsque les motoneiges n'étaient pas présentes, le temps passé à se nourrir, au repos, et en état de vigilance et déplacement ne différait pas pour les deux sexes entre les groupes observés dans des régions qui recevaient les visites de motoneiges et celles qui ne les recevaient pas.

Les traces de neige compactée laissées par le passage des motoneiges étaient utilisées fréquemment par les canis lupus. Ces corridors de voyage représentaient pour eux un moyen de déplacement à basse demande d'énergie. Les traces de motoneiges ont le potentiel d'augmenter la détection et le taux de rencontres entre loups et caribous. Réduire la prolifération de traces de motoneiges dans cette région pourrait réduire la prédation du loup sur le caribou.

Mes recommandations sont de garder une distance de 500 metres ou plus entre les motoneigistes et les caribous, donner de l'information sur l'écologie du caribou aux motoneigistes, et réduire le flot de prolifération de traces de motoneiges sur le terrain d'habitat hivernal du caribou. Les motoneigistes peuvent contrôler leurs effets sur le comportement des caribous avec plus de succès s'ils maintiennent une distance suffisante, limitent leurs temps d'observation lorsqu'il y a indication que les caribous sont dérangés par leur présence, et utilisent des sentiers déjà établis.

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## INTRODUCTION

As outdoor recreation in natural areas continues to grow, so do concerns over its effects on wildlife. Wild animals may associate human presence with predation risk, diverting time and energy from activities that enhance fitness and ensure survival (Frid and Dill, 2002). Recreation represents a form of human intrusion into natural areas that is short term and often doesn't change habitat structure (Riffell *et al.*, 1996) but brings people into contact with wildlife, resulting in direct and indirect effects on wildlife individuals and populations (Cole and Landres, 1996). As recreation in natural areas is predicted to increase over the next several decades (Swarthout and Steidl, 2001), so will the resulting effects on wildlife (Mann *et al.*, 2002). Recreation has the potential to change wildlife behaviour, social structure and predator/prey relationships as well as possibly affect populations through unrecoverable energy losses due to harassment and habitat avoidance (Holmes *et al.*, 1993; Taylor and Knight, 2003). With increasing recreational activities in wildlife habitat, managers require methods to quantify its effects and develop management techniques to minimise them (Miller *et al.*, 2001). Wildlife managers must assess the effects on wildlife of interactions with recreationists and offer recommendations for mitigation.

The problem of human disturbance of wildlife is common throughout the world. Disturbance causes an animal's behaviour to deviate from normal patterns (Frid and Dill, 2002). Human disturbance, more specifically, causes a change in metabolism and/or behaviour of an animal (Bolduc and Guillemette, 2003). Disturbance effects are easy to document qualitatively but are difficult to quantify and eliminate (Anderson and Keith, 1980). Although there is merit in addressing the ethical question of whether it is acceptable to disrupt wildlife by engaging in recreational activities, human disturbance of wildlife becomes ecologically important when it affects survival or fecundity of a population (Gill *et al.*, 2001). In addressing the concern over disturbance to wildlife, investigators commonly focus on the short-term behavioural reactions of wildlife during disturbance events and then attempt to extrapolate their results to potential population consequences (Harrington and Veitch, 1992). This tenuous approach has led to the suggestion that evidence is available to support virtually any conclusion regarding the significance of disturbance on wildlife (Bergerud *et al.*, 1984). The effects of wildlife disturbance may ultimately be best understood through the study of population dynamics (Bergerud *et al.*, 1984), requiring long-term data on disturbed and undisturbed populations.

Faced with an immediate potential problem from expanding recreational activities, however, managers require information over the short term. The investigation of behavioural response to disturbance has provided insights into possible population consequences where long-term population data are lacking (Gill *et al.*, 2001). These investigations must take into account both behavioural change and the frequency of disturbance (Enggist-Dublin and Ingold, 2003). To address the biological significance of disturbance without long-term population data, current research follows a multi-step approach. Assessing behaviour change resulting from disturbance, estimating the frequency of disturbance, addressing the likelihood of habituation, calculating the energetic consequences of behavioural responses, determining range avoidance and incorporating predator/prey relationship changes all help to address the likely consequences of disturbance (Gill *et al.*, 1996; Dyer *et al.*, 2001; Fortin and Andruskiw, 2003; Reimers *et al.*, 2003; Taylor and Knight, 2003).

Woodland caribou (*Rangifer tarandus caribou*) are of high conservation concern in North America (Committee on the Status of Endangered Wildlife in Canada, 2003) and experience varying levels of recreational activity in their habitat. As a species that may be affected by outdoor recreation, it is ideally suited for study during the energetically challenging period of winter. Snowmobiling has expanded into natural areas, at times overlapping winter caribou habitat. Managing access to natural areas in the face of a growing number of recreational vehicles during all seasons has become a challenge for wildlife managers (Loeks, 2000). My research addresses the possible effect of recreational snowmobiling on a woodland caribou herd in the Yukon.

The Ibex woodland caribou herd (ICH) winters west of Whitehorse, Yukon (60.7°N, 135.1° W), and was the subject of this investigation into the behavioural effects of snowmobile activity on caribou. This herd's winter range receives high recreational snowmobile use. Local interest groups demand tangible evidence of snowmobile effects on the ICH before participating in programs that may restrict their activities. Study objectives include experimentally testing what aspects of snowmobiling affect the behaviour of caribou, describing levels of snowmobile activity on this herd's winter range, determining where areas of high recreational use overlap key caribou winter habitat and formulating 'caribou friendly' snowmobiling recommendations to be applied through an education program for area users.

Specific hypotheses to be tested are:

1. Caribou spend more time in vigilance, movement and flight upon detecting snowmobiles.
2. Actions of snowmobilers while near caribou influence caribou reaction. Snowmobile groups, who approach directly, move about quickly and frequently, and travel in large and noisy groups will elicit stronger behavioural reaction from caribou than would small, quiet, slow moving groups.
3. Caribou select habitats partly to avoid snowmobile activity.

Here, I first review disturbance effects and likely consequences for caribou. Much work has already been done on caribou behaviour and reaction to disturbance pertaining to industrial development (Cameron *et al.*, 1992; Bradshaw *et al.*, 1997). Other investigations of caribou and reindeer reaction to disturbance, however, did not include behaviour observations of undisturbed animals (Tyler, 1991; Mahoney *et al.*, 2001; Reimers *et al.*, 2003). Such a comparison will address potential subtle but insidious effects of recreational activity on wildlife. To do this, I compared the behaviour of undisturbed and disturbed caribou in areas exposed to high snowmobile recreational use as well as in areas of no snowmobile use. I addressed the frequency of use by snowmobilers in an area and compared it to the location of key caribou-use areas. I also calculated the likely energy expenditures resulting from a typical snowmobile/caribou interaction. A comparison of my results with those of similar work on caribou and reindeer will be discussed. Assessment of caribou and reindeer reaction to snowmobiles has only been done in areas with few predators. The influence of potential predation on caribou behaviour is reviewed. I will discuss the management implications of frequent recreational activity in caribou winter range for the ICH and the potential for habituation by caribou to snowmobile activity on trails. I will conclude by providing recommendations of methods to mitigate effects of snowmobile activity on caribou behaviour.

## Effects of Disturbance

Although disturbance of caribou has been purported to cause death, reduced reproduction and range abandonment, reliance on undocumented generalizations confounds our understanding of caribou reaction to disturbance (Bergerud *et al.*, 1984). The question of whether behavioural change has ecological consequences at the population level is technically problematic to answer. It may be more cost-effective to introduce mitigative measures given evidence of behavioural change even without determined population consequences, rather than invest resources documenting a specific effect on survival and/or reproduction after the effect occurs (Galicia and Baldassarre, 1997). Disturbance of wildlife from human activities has been documented for various species, particularly birds and ungulates. Disturbance effects range from subtle behavioural changes to habitat avoidance. Stimuli that disturb wildlife range from inanimate objects such as trails to busy industrial complexes. Although wildlife has evolved with natural disturbances, it may not persist in areas where disturbance demands adaptations beyond natural ranges (Noss, 1996).

Caribou may avoid suitable range when subjected to extreme and persistent harassment (Bergerud *et al.*, 1984). Avoidance of suitable range results in habitat loss and possibly a population decline due to food competition if alternative suitable habitat is unavailable (Vistnes and Nellemann, 2001). Predator use of snowmobile trails increases the predation risk of these linear features, which may contribute to habitat loss if caribou avoid areas of high predation risk (James and Stuart-Smith, 2003).

Caribou and reindeer avoid roads (Dyer *et al.*, 2001; Dau and Cameron, 1986), power lines, cabins (Vistnes and Nellemann, 2001) and industrial developments (Whitten and Cameron, 1983; Cameron *et al.*, 1992; Bradshaw *et al.*, 1997; Nellemann and Cameron, 1998). Female reindeer with calves show greater avoidance of infrastructure than males, even in periods of low or no human use (Vistnes and Nellemann, 2001). During late winter in Alberta, caribou, possibly as an antipredator response, avoid seismic cut-lines that are regularly used by predators (Dyer *et al.*, 2001). Road avoidance was pronounced in open conifer wetland compared to closed conifer wetland, possibly because closed habitat shields caribou from seeing and hearing traffic (Dyer *et al.*, 2001). All sex and age classes of reindeer and caribou

avoid disturbance (Nellemann *et al.*, 2001), but males are generally more tolerant than lactating females (Cameron *et al.*, 1979; Whitten and Cameron, 1983; Dau and Cameron, 1986; Murphy and Curatolo, 1987; Nellemann and Cameron, 1998). In summer, during the biting insect season, disturbance may be tolerated in favour of insect relief offered by infrastructure like oil well-sites and raised gravel roads (Fancy, 1983).

Disturbance may also become a barrier to caribou movement, adding to functional habitat loss. Caribou in northern Alaska cross roads less often during times of high summer traffic, and when raised pipelines and roads are adjacent (Murphy and Curatolo, 1987). Klein (1971) observed loss of habitat to reindeer when they no longer crossed a railway. The Prudhoe Bay oilfield complex of heavy and extensive industrial development is an effective barrier to caribou movement (Whitten and Cameron, 1983). Industrial infrastructure such as oilfield developments increase caribou movement even though displacement and habitat avoidance are not demonstrated (Bradshaw *et al.*, 1997).

Disturbance-related changes in activity stress the energy budget of cervids who maximize their energy intake by grazing selectively on high-quality patches of forage (Vistnes and Nellemann, 2001). Subtle changes in grazing patterns can influence animal performance (White, 1983). Oilfield pipelines, seismic lines and road developments increase caribou movement (Bradshaw *et al.*, 1997). Vigilance behaviour can be increased by the experience of disturbance, such as hunting (Baskin and Hjaltén, 2001). Other observed effects of disturbance on caribou behaviour include decreased lying time and increased locomotion time (Murphy and Curatolo, 1987).

Avoidance of snowmobiles has been documented for moose (*Alces alces*) (Colescott and Gillingham, 1998), white-tailed deer (*Odocoileus virginianus*) (Dorrance *et al.*, 1975; Richens and Lavigne, 1978; Eckstein *et al.*, 1979), muskoxen (*Ovibos moschatus*) (McLaren and Green, 1985), reindeer (Tyler, 1991; Reimers *et al.*, 2003) and caribou (Simpson, 1987; Mahoney *et al.*, 2001). Reaction by caribou may depend on snowmobile proximity, rate and angle of approach, number, noise level, suddenness of appearance, and the caribou's previous experience (Barichello, 2000). Environmental conditions, body condition and habitat quality may also affect the reaction of ungulates to snowmobiles (Skogland and Grovan, 1988; O'Donoghue, 2000). Such reactions include increased vigilance, increased heart rates,

displacement and range abandonment (Moen *et al.*, 1982; Kuck *et al.*, 1985; Simpson, 1987; Tyler, 1991; Mahoney *et al.*, 2001). Human scent may also alarm caribou (Cameron *et al.*, 1979; Simpson, 1987).

Caribou response to a moving vehicle on a road may be relative to the rate of approach rather than movement alone (Horejsi, 1981). Ecotourists hiking near caribou in winter did not cause caribou to run but did reduce feeding and resting, and increased vigilance (Duchesne *et al.*, 2000). Mule deer (*Odocoileus hemionus*) change behaviour more often and for longer periods when exposed to hikers compared to snowmobiles (Freddy *et al.*, 1986). Snowmobiles caused white-tailed deer to run but deer returned to forage near trails once snowmobiling ended for the day (Eckstein *et al.*, 1979). Persons walking also elicited stronger avoidance reactions by white-tailed deer, where deer often ran out of sight of the trail, compared to snowmobile encounters, where they often remained in sight of the trail (Richens and Lavigne, 1978). Daily use of trail areas by deer changed after the first snowmobile of the day appeared (Eckstein *et al.*, 1979).

Overt behavioural reaction may not be the only indicator of disturbance. Captive white-tailed deer, disturbed by snowmobiles, increased heart rates dramatically for two minutes following passage, even in the absence of overt reaction (Moen *et al.*, 1982).

Reindeer response to hunting disturbance varied according to physical condition. Reindeer in good condition aggregated and stood alert, making undetected approach by predators or hunters very difficult and conserving stored energy. Those in poor condition increased travelling time, risking predation but increasing their chances of finding better habitat (Skogland and Grovan, 1988).

Caribou herds are frequently exposed to linear disturbance. Snowmobiles are not confined to designated routes in alpine areas. The ICH offers an opportunity to examine effects of non-linear disturbance on this herd.

## Consequences of Disturbance

Bergerud *et al.* (1984) suggested that caribou can withstand periodic severe disturbance without harmful effects on productivity and survival. However, persistent energy expenditure may have negative consequences for caribou. Strong reactions to disturbance such as violent running may cause injury and death (Calef *et al.*, 1976), although wildlife is generally well adapted to escape behaviour and death during flight is not common. Increased susceptibility to predation may result from disturbance. Caribou are more vulnerable to predation if they react to disturbance by increasing their movement rates (Phillips and Aldredge, 2000). The effects of disturbance are likely proportional to its frequency (Bradshaw *et al.*, 1998).

A caribou's time budget is closely linked to its energy budget; time spent foraging and ruminating represents energy intake, while time spent at rest, in locomotion and vigilance represents energy expenditure (Fancy and White, 1985; Komers *et al.*, 1994). In summer, caribou walking at the energetically optimal speed of 3.0 to 4.1 km/h (Fancy and White, 1987) expend 46% more energy than when standing (Fancy and White, 1986). A confounding factor in understanding the energetic implications of increased movement is snow depth, which increases locomotor energy requirements, restricts forage opportunities, increases energy requirements and alters habitat selection and movement patterns (Fancy and White, 1985; 1986; 1987). Caribou have the second lowest foot loading (body weight/foot area) of any ungulate species (Fancy and White, 1987). Snow properties (depth, crust, hoof penetration), however, influence the cost of locomotion, increasing with sinking depth, and greatly increasing when the surface crust breaks (Fancy and White, 1987). Areas of intensive snow compaction, such as snowmobile trails, affect the forage energy required through the need for more frequent movement to find untrammelled snow. Cratering in snowmobile-compacted snow requires more than a four-fold increase in energy (Fancy and White, 1985).

Increased feeding rates or loss of feeding time due to disturbance are difficult to measure. Night time activity by caribou may assist in recovering energy lost due to daytime disturbance (Maier and White, 1998). This may result in over-estimations of the energetic costs associated with disturbance (Bradshaw *et al.*, 1998).



Effects of disturbance may include changes in body condition, affecting parturition rate, calf survival and ultimately the population (Cameron and Verhoef, 1994). A reduction in female caribou body mass and condition may reduce fetal growth, resulting in low birth weights (Cameron *et al.*, 1993), increased possibility of abortion and later parturition (Vistnes and Nellemann, 2001). Under-nutrition following conception would likely prolong gestation and delay parturition (Cameron *et al.*, 1993). Delays in parturition, and therefore lactation, reduce the already short time available to recover condition while on high-quality summer range. Reduction of calf weight gain and survival or in replenishment of body reserves may lead to low pregnancy rates (Cameron *et al.*, 1993; Cameron and Verhoef, 1994). Poor post-partum body condition also reduces milk production during early lactation, retarding calf growth (Vistnes and Nellemann, 2001) and further decreasing the chances of survival (Adamczewski *et al.*, 1987). Caribou fetal weight is strongly correlated with winter maternal condition, as poor condition retards fetal growth and reduces perinatal calf survival (Adamczewski *et al.*, 1987; Cameron *et al.*, 1993).

Caribou response to aircraft suggests that frequent overflights by low-flying jet fighters during calving and the post-parturition period decrease calf survival (Harrington and Veitch, 1992). These authors note that extended feeding may make up for energy loss from disturbance, whereas the physiological response of depressed lactation that limits calf milk intake may result in greater energetic loss.

Winter survival in caribou may be affected by disturbance if large energetic losses are not compensated. Caribou annually gain and lose deposits of fats and proteins which help them survive the long winters when access to forage is restricted by snow (Adamczewski *et al.*, 1993). Cold stress and heat conservation require adjustments of caloric intake (McEwan and Whitehead, 1970). Generally, energy demands in caribou are greatest at the end of winter, but by this time fat reserves may be depleted; the required energy needs can only be met through forage intake (Adamczewski *et al.*, 1993).

Added energy costs from disturbance may have a greater effect on calves which have higher energy requirements than adults because of their smaller body size and lower reserves, possibly leading to greater winter mortality (Adamczewski *et al.*, 1987).

Linear features such as roads and trails may change predator/prey relationships. Wolves (*canis lupus*) prey on caribou (Seip, 1992; Farnell *et al.*, 1996; Farnell *et al.*, 1998; Hayes *et al.*, 2003) and regularly use roads and trails (James and Stuart-Smith, 2000). Packed snowmobile trails may provide wolves with increased mobility and therefore available energy, which is likely to increase prey encounter rate and hunting success. This may affect a caribou herd through both increased direct mortality and avoidance of habitat near trails (James and Stuart-Smith, 2000). In the ICH key winter range for adult male caribou, snowmobiles are not confined to designated trails and leave compacted tracks throughout the area. How wolves use such a spider's web of tracks and how caribou react to this has yet to be documented.

## **Habituation**

It may be adaptive for wildlife to habituate to frequent, potentially disruptive disturbance from human activity (Holmes *et al.*, 1993). Habituation is defined as a waning response to a repeated, neutral stimulus (Whittaker and Knight, 1998). Habituation occurs when individuals minimise or cease responding to a stimulus (Conomy *et al.*, 1998). Energy costs may still increase even though the individuals show no overt reactions (Harper and Eastman, 2000). Heart rate increases lead to energy expenditure, even in the absence of overt responses to stimuli (Moen *et al.*, 1982; Fancy and White, 1986).

There is no consensus on whether or not caribou can habituate to human activities in key habitat (Maier *et al.*, 1998; Duchesne *et al.*, 2000; Vistnes and Nellemann, 2001; Kingsmill, 2003). Baskin (2001) felt that frequent contact with humans might lead to habituation in wild reindeer. Mahoney *et al.* (2001) suggested that caribou partly habituated to snowmobiles in western Newfoundland. Svalbard reindeer habituated to hikers in summer even though those herds experienced hunting each autumn (Colman *et al.*, 2001). Avoidance of road and oil producing infrastructure by female caribou was documented Alaska's north slope oilfields and after a decade no habituation of caribou was observed, indicating a low likelihood of potential habituation (Dau and Cameron, 1986).

Unhunted white-tailed deer may habituate to snowmobile traffic but no habituation was noted in a hunted population (Dorrance *et al.*, 1975). Hunted deer increased home range size,

movement rates and avoided trail areas, even at low traffic densities, compared to the un hunted population where deer only avoided immediate trail areas. White-tailed deer heart rate changes did not suggest habituation to snowmobile passage. Direct approaches elicited greater increases in heart rate than oblique approaches (Moen *et al.*, 1982).

Proximity to busy recreation areas coupled with previous pursuit by snowmobiles will likely be key factors in determining whether habituation of caribou to snowmobiles occurs. Novel stimuli that threaten, pursue or otherwise cause discomfort will hinder habituation. However caribou may habituate to predictable, non-threatening stimuli, including various forms of traffic (Mahoney *et al.*, 2001).

## **Finding Solutions**

People's perceptions of their effects on wildlife influence how they behave while in wildlife habitat (Taylor and Knight, 2003). If people are unaware that they affect caribou, they are unlikely to change their own behaviour. Outdoor recreation has often been labelled 'non-consumptive' implying that some activities (such as hunting, mining, forestry) affect wildlife while non-consumptive activities (such as snowmobiling) do not (Pomerantz *et al.*, 1988; Parent and Weatherhead, 2000). Recent research, however, suggests that non-consumptive recreation may affect wildlife individuals, populations and communities (Boyle and Samson, 1985; Gill *et al.*, 2001; Frid and Dill, 2002). In British Columbia, disturbance from snowmobiling has been described as the greatest perceived threat to Mountain caribou populations from recreation activities (Simpson and Terry, 2000). Public education will be necessary to change the perception of the effect of recreation on wildlife. Because the conservation of wildlife may require the imposition of limits on recreation, managers must identify what thresholds of disturbance may affect wildlife and must propose mitigative measures to conserve wildlife populations in recreation areas.

# CHAPTER 1

## BEHAVIOURAL RESPONSE OF WOODLAND CARIBOU (*RANGIFER TARANDUS CARIBOU*) TO SNOWMOBILE DISTURBANCE IN AN ALPINE ENVIRONMENT

### Introduction to article

The manuscript “Behavioural response of woodland caribou to snowmobile disturbance in an alpine environment” results from an investigation of the effects of recreational snowmobile activity on the behaviour of caribou of the Ibex herd (ICH), Yukon, Canada. This herd is increasingly exposed to snowmobiles and other recreational activities such as dog sledding in its winter range. These increased activities coincide with a stalled population recovery. By understanding the effects of recreation on this herd, my research provides solutions to alleviate possible effects from this activity.

A comparison of caribou behaviour in control and affected areas had not been previously applied to caribou disturbance research. Previous research, and all previous work on how caribou and reindeer react to snowmobiles took place where wolves did not exist. I anticipated different reaction distances by the Ibex caribou from other studied herds due to the presence of wolf predation on the ICH.

The Ibex caribou had greater reaction distances to snowmobiles than caribou and reindeer elsewhere. Females had stronger reaction to disturbance than males. In the absence of snowmobiles, caribou did not behave differently between areas used and unused by snowmobiles. Habituation to snowmobile disturbance was not observed over the course of

the study. Wolves frequently used snowmobile trails. Recommendations to caribou managers on how to mitigate effects of snowmobiles on caribou include the implementation of a vigorous snowmobilers education program with setback distance of 500 metres between caribou and snowmobiles, stemming the proliferation of trails in caribou winter range, continued monitoring of traffic in caribou winter range, assessment of education program effectiveness, limitation of 'off-trail' use in key areas, and an investigation of wolf use of snowmobile trails.

Co-author Thomas Jung participated in the design of this study, collection of data, as well as in suggesting methods for analysis and manuscript reviews. Co-author Marco Festa-Bianchet was an integral part of this study with suggestions on field methods, analysis and manuscript revisions. This article will be submitted to *Conservation Biology* for publication.

# Behavioural Response of Woodland Caribou (*Rangifer tarandus caribou*) to Snowmobile Disturbance in an Alpine Environment

RH: Powell *et al.*

Woodland caribou behavioural response to snowmobiles

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## Abstract

Recreational activities on caribou winter range are increasingly of concern, yet little data exist to guide management policies. We experimentally tested the effect of snowmobile activity on woodland caribou (*Rangifer tarandus caribou*) behaviour in the Coast Mountains, Yukon, Canada. Snowmobile activity may change woodland caribou foraging behaviour, cause habitat abandonment, or increase access for wolves that use snowmobile trails. Snowmobile speed, group size or approach angle did not affect caribou reaction. Groups of mature males allowed closer approach by snowmobiles than did maternal groups (containing cows, calves and yearlings) (mean 189 ( $\pm 21$  SE) metres vs. 289 ( $\pm 28$  SE) metres). For those groups that ran from the approaching snowmobile, initial flight distances did not differ between male (mean 227 ( $\pm 43$  SE) metres) and maternal (mean 282 ( $\pm 30$  SE) metres) groups. Maternal groups were twice as likely to run from an approaching snowmobile than male groups, and spent more time moving and being vigilant after disturbance. As male group size increased, flight distance decreased. This was not the case for maternal groups. Following disturbance, maternal groups spent more time running (mean 117 ( $\pm 36$  SE) seconds) than did male groups (mean 20 ( $\pm 6$  SE) seconds). We estimated that a single response to disturbance by a female caribou increases daily energy expenditure by 1.2%. Neither sex showed any evidence of either habituation or sensitization, over a single day or over the season. When snowmobiles were not present, time spent feeding, resting, vigilant and moving did not differ for either sex between areas that did and did not experience snowmobile use. Wolves frequently used snowmobile trails, possibly leading to increased predation on caribou. We recommend a distance of 500 metres or more between snowmobilers and caribou, informing snowmobilers about caribou ecology, and stemming the proliferation of snowmobile trails in caribou winter range.

Key words: woodland caribou, *Rangifer tarandus caribou*, human disturbance, flight initiation, snowmobile

## Introduction

Snowmobiling is growing in popularity as a form of winter recreation in Canada (Pannell Kerr Forster Consulting, 2001). Recent advances in snowmobile technology along with increased popularity have resulted in snowmobile use in increasingly remote and rugged terrain that was previously inaccessible. Snowmobiling disturbs wildlife, but managers know little about the effects to wildlife from such disturbance (Simpson, 1987).

The effects of snowmobile disturbance on caribou (*Rangifer tarandus*) and reindeer behaviour have been examined in Alaska (Smith, 1988), British Columbia (Simpson, 1987), Scandinavia (Klein, 1971; Tyler, 1991; Reimers *et al.*, 2003), and Newfoundland (Mahoney *et al.*, 2001). Reactions of caribou to direct approach by a single snowmobile were comparable in areas with no predation and limited hunting and in areas with predation but no hunting (Tyler, 1991; Mahoney *et al.*, 2001; Reimers *et al.*, 2003). These reactions included increased vigilance, movement and flight (running from the disturbance) and reduced feeding. Behavioural changes as a result of disturbance lead to increased energetic expenditures and potential loss of habitat through avoidance (Simpson, 1987). Little is known about snowmobile effects on caribou in areas where wolves occur. In the face of a growing recreational snowmobile industry, information on disturbance where predators exist is needed to mitigate snowmobile effects on wildlife.

The Ibex Herd (ICH) of woodland caribou experiences disturbance from snowmobiles. The Southern Lakes Region, Yukon, which includes the ICH winter range, is used by up to 2 000 snowmobiles in winter, mostly for recreation (Klondike Snowmobile Association, unpublished data). Whitehorse, with the Yukon's only major airport, is the hub of regional snowmobiling and is ideally placed to support winter tourism with its infrastructure, access to trails, nearby wilderness and viewable northern wildlife. Local tourism groups are marketing the long snowmobiling season to non-residents and an increase is expected in snowmobile visits to the area (P. Greenlaw, Klondike Snowmobile Association, personal communication). The ICH has been the subject of an intensive, multi-agency recovery effort (Southern Lakes Caribou Recovery Program) that was prompted by the herd's decline to near extirpation in 1992. Efforts were made to temporarily eliminate hunting pressure and restrain land development



within the herd's range. Hunting pressure on the ICH is low because harvest by licensed hunters has been prohibited since 1993, and a community-level ban on hunting the herd is decreed and enforced by resident First Nations. Some animals may occasionally be taken illegally. Given the herd's proximity to Whitehorse and the elaborate network of trails throughout its highly scenic winter range, the ICH is exposed to the highest levels of snowmobile activity of any Yukon caribou population (Environment Yukon, unpublished data).

We examined caribou reactions to experimental snowmobile approaches and caribou behaviour in areas that do and do not receive snowmobile activity. We sought to identify what aspects of snowmobile activity affect caribou behaviour, document snowmobile activity levels in the winter range of the ICH, determine whether key winter habitat is heavily used by snowmobiles and formulate recommendations for an education program for snowmobilers.

## **Methods**

### **Study Area**

The ICH caribou are non-migratory and range just west of Whitehorse (60.7°N, 135.1° W). The herd appears to be part of a larger meta-population of woodland caribou in the Coast Mountains of south-central Yukon and adjacent British Columbia, which is collectively known as the Southern Lakes Caribou (Farnell *et al.*, 1996) (Figure 1). The ICH typifies the non-migratory ecotype of woodland caribou (Bergerud and Snider, 1988): it is distributed at relatively low densities, females disperse to calve, and exhibit strong fidelity to calving sites and winter range. The ICH winters predominately in alpine and subalpine areas, above the treeline. In contrast, most other woodland caribou in the Yukon winter in forests (Kuzyk *et al.*, 1999). This population underwent considerable decline before 1993, when a recovery effort saw a five year growth period followed by five years of no growth: it is currently estimated at about 450 animals (Figure 2) (Environment Yukon, unpubl. data), substantially reduced from an estimated 2000+ animals in the early 20<sup>th</sup> century (O'Donoghue, 1996). The ICH exists in a multi-predator and multi-prey system. Likely predators of the ICH include gray wolf (*Canis lupus*), grizzly bear (*Ursus arctos*) black bear (*Ursus americanus*), golden eagle (*Aquila chrysaetos*), humans and, perhaps, wolverine (*Gulo gulo*), coyote (*Canis latrans*), and lynx

(*Lynx canadensis*). Other ungulates in the range of the ICH include moose (*Alces alces*), thinhorn sheep (*Ovis dalli*), mountain goat (*Oreamnos americanus*), and small populations of mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*). Densities of grizzly bear and wolves in the mid-1980s were estimated at 16 and 12 per 1000 km<sup>2</sup>, respectively (Larsen *et al.*, 1989). Moose were plentiful in the study area prior to the 1990s, but have since decreased dramatically due to grizzly bear predation upon calves (Larsen *et al.*, 1989) and over-hunting (R. Florkewicz and R. Ward, Environment Yukon, personal communication). Thinhorn sheep are believed to be plentiful in suitable habitat, while mountain goats are confined to a few massifs (J. Carey, Environment Yukon, personal communication). No density data are available for the other species.

The ca. 2800 km<sup>2</sup> range of the ICH lies within the Yukon Southern Lakes Ecoregion (Boreal Cordillera Ecozone; Ecological Stratification Working Group 1996). More than 75% of the study area is above the treeline (ca. 1,200 mASL). Alpine tundra and alpine shrub habitats are most common, interspersed with boreal forest in subalpine habitats. Precipitous mountains are rock and icefield strewn at the highest elevations. Dwarf birch (*Betula* spp.) and willows (*Salix* spp.) are the dominant vegetation on more gentle slopes and summits. Sub-alpine slopes are forested with subalpine fir (*Abies lasiocarpa*), white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*). Alpine areas and sub-alpine forests contain frequent patches of lichen (*Cladina* spp.). The climate is semi-arid: snow depths are generally >80 cm from November to April. While Pacific coastal weather systems have a moderating effect, winter temperatures often fall below -20° C. High winds are common in winter, producing areas of hard snow surface.

Behavioural data were collected in two areas; Golden Horn plateau (60.58° N, 135.08° W) has a relatively high concentration of male caribou and the highest known snowmobile use of the winter range (Environment Yukon, unpublished data). The majority of the herd's maternal groups winter in the Rose Creek basin (60.42° N, 135.75° W). This valley system is currently experiencing relatively low levels of snowmobile use.

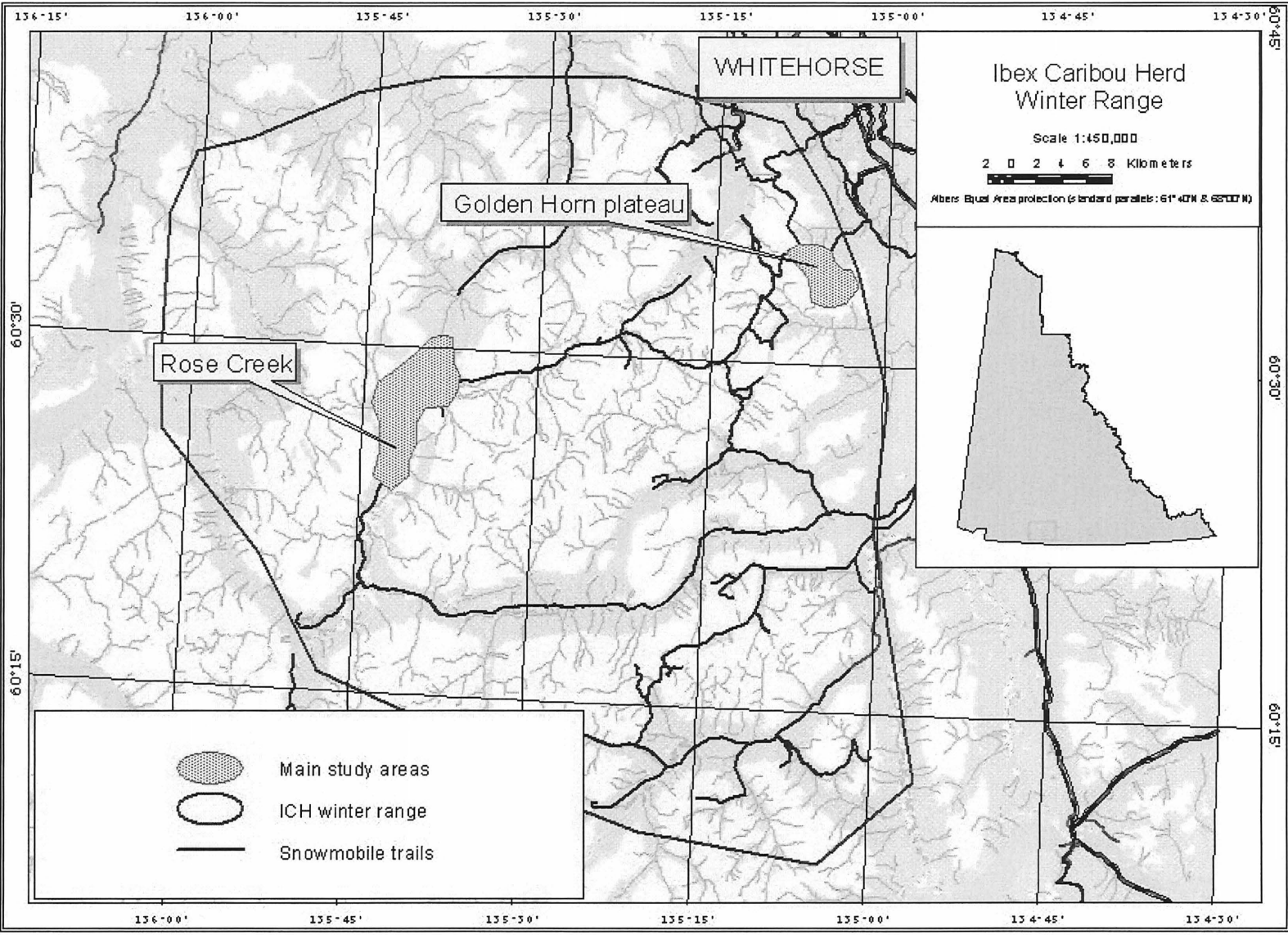


Figure 1: Ibex Caribou Herd Winter Range and regional snowmobile trails

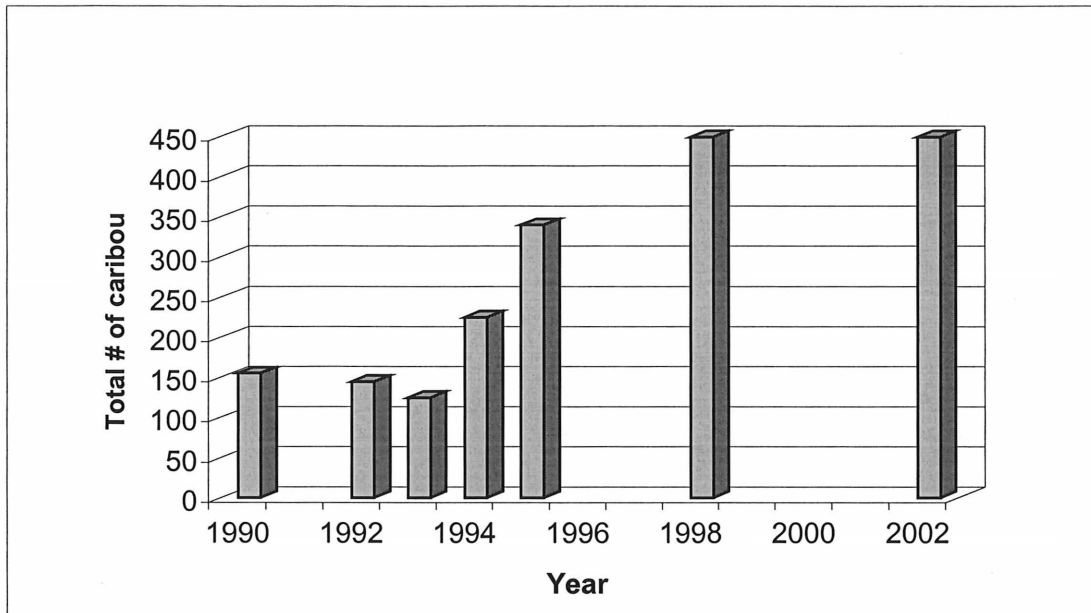


Figure 2: Population estimates of the Ibex Caribou Herd from helicopter censuses (Environment Yukon, unpubl. data)

### Activity Monitoring

The number of snowmobiles entering the study area was monitored at access points to each study area between 1999 and 2003. Electronic traffic counters (Model No. 3031 or No. 3034, Golden River Traffic Systems, Bicester, Oxfordshire, UK) placed under trails recorded snowmobile traffic, providing an index of the number of snowmobiles in the study area and their temporal patterns. However, total activity was unknown because other access points allowed snowmobile use of this region.

### Experimental Design

We conducted behavioural observations of woodland caribou following the *Before, After, Control, Impact* (BACI) experimental design (Green, 1979). *Control* observations took place in areas >2 kilometres from known snowmobile travels routes or of anywhere a snowmobile had travelled that winter. *Impact* observations were conducted in areas that regularly experienced snowmobile disturbance but while snowmobiles were not present. *Before* observations were done on selected caribou 30 minutes before disturbance. *After* observations were conducted on focal caribou within the 30-minute period following disturbance.

## Behavioural Observations

Behavioural observations were conducted from January to mid-April 2003. Caribou were sexually segregated during this period. Male groups were mostly observed in January and February when they were accessible. Groups of cows, calves and yearlings (maternal groups) were observed primarily in March and April when they were accessible and the location of male groups became unpredictable.

Behaviour was recorded with the focal sampling technique (Altmann, 1974). Focal animals were chosen from others in the group by sightability and distinguishable features (antler or pelage characteristics, calf at heel, presence of radio collar). To reduce the probability of observing the same individual repeatedly (Machlis and Dodd, 1985), a group of caribou would not be considered for observation more than once every 3 days, unless individuals were clearly distinguishable.

The same focal animal was followed continuously, if possible, throughout the pre-disturbance period, during and up to 30 minutes post-disturbance. The *during* period ended once the disturbing snowmobile was no longer detectable. *Control* and *impact* observations were approximately of the same duration, and took place when snowmobiles were absent. Focal observations that lasted less than 10 minutes were discarded.

Ten adult female caribou were equipped with a VHF radio-collar (Telonics, Mesa AZ). Caribou were located using radio signals and also visually located using binoculars (8X32) and field scopes (20X60) from high elevation points and open areas.

Snowmobiles were used to access the study site and approach the caribou. The Animal Care Committee of the Université de Sherbrooke approved all experimental methods. Upon encountering caribou near a trail, observers either continued past or retreated, depending on the terrain and availability of nearby observation points. A total number of "passes" (which included experiments and other encounters with tourists) per observed group per day was recorded. A "pass" was an encounter between caribou and a snowmobile less than one kilometre away, where the caribou had likely detected the snowmobile(s). Upon finding an observable group of caribou, researchers, cryptically dressed, positioned themselves 400 to

2000+ metres away and used terrain and vegetation to conceal themselves. Previously disturbed caribou were not considered for *before* observations until 30 minutes after any likely detection of the researchers.

The nearest distance that a snowmobile experimentally approached a focal animal, and the distance at which the caribou became vigilant, alert, or fled were calculated using a GPS (Trimble GeoExplorer II, Trimble, Sunnyvale, CA) and associated software (PathFinder Office 2.51). Terrain, cover and snow conditions greatly influenced the closest distance that a snowmobile was able to approach caribou: most of the closest approach distances (91.5%) were less than 500 m (mean 194 m  $\pm$  84 m SD).

Behaviour was recorded as feeding, resting, vigilant, moving or social interaction. Response variables were described as in Table 1. Other independent variables assessed during each approach included time of day (morning, mid-day or afternoon), group size, group type (male or maternal group), speed of approaching snowmobile (>20km/h, <20 km/h), whether or not the snowmobile stopped while nearest to the caribou, number of snowmobiles, previous snowmobile use of area that winter, snow depth, caribou use of area, temperature and wind speed.

Table 1: Caribou response variables recorded during experimental snowmobile disturbance trials, Yukon, 2003.

Response	Description
Awareness Distance	First indication of detection of approaching snowmobile
Disturbance Distance	Focal animal commences constant vigilance
Flight Initiation distance	Initial running from disturbance occurs
Closest snowmobile distance	Post initial flight nearest distance (may be less than FID)
Principal activity	Feeding or not feeding
Area abandonment	Focal animal total flight exceeded 1 km
Flight time	Duration of initial and subsequent flight periods
Disturbance time	Duration of disturbed behaviour

### Statistical Analyses

Analyses were performed with SYSTAT 9.0, SPSS 10.0 and S-Plus 2000. All reaction variables were tested for normality using the Shapiro-Wilk test (Zar, 1999). Disturbance distance and Flight Initiation distance met normality standards after square root transformation (Zar, 1999). Male and maternal group data were considered separately.

Because group size varied according to sex, relationships between response variables and group size were tested separately for males and females. A Pearson's Chi-square analysis was used to test the difference between male and maternal groups' propensity to flee.

Behavioural variables were converted to proportions of total time spent feeding, resting, vigilant and moving. Caribou were involved in social interactions for less than 0.01% of observation time, therefore the category *Social* was not considered in the final analysis. Combining *during* and *after* samples, the proportion of time spent in each of the 4 behavioural categories was compared by sex to assess behavioural differences between group types in reactions to disturbance. *Before* samples were then compared by sex to assess differences

pre-disturbance. Focal animal activity was examined using Pearson's Chi-Square (Zar, 1999) *before* and *after* disturbance to examine if one sex was more likely to commence feeding following disturbance.

Behaviour pre- and post-disturbance was compared using multivariate analysis of variance (MANOVA). This multivariate approach compared the effects of sex, *before* and *after*, and time of day on frequencies of behaviour (Scheiner and Gurevitch, 1993). The same procedure was then applied to *control* and *impact* data.

Flight Initiation Distance was considered the key response variable. The effects of independent variables on flight initiation distance were assessed using a General Linear Model, which incorporated all independent variables sampled, including group type. Models were reduced to their most significant form using stepwise procedures.

The probability that caribou would abandon an area following disturbance by snowmobiles was analysed with logistic regression. Preliminary multivariate models were built and reduced with stepwise procedures. Area abandonment likelihood was compared between group types using Chi-square (Zar, 1999).

The time required by a focal animal to return to normal activities following disturbance was from the first reaction to disturbance until resumption of pre-disturbance behaviour. Total time moving was calculated only for focal animals that fled during disturbance trials. To calculate energy used avoiding snowmobiles, total time walking and trotting was converted to a horizontal distance of travel estimate over medium soft snow conditions. Walking speed was assumed to be 4 km/h (Fancy and White, 1987). Trotting and running were considered to be the same and assumed to be twice that speed. The net cost of locomotion for caribou is calculated as kJ per body weight and distance covered (2.64 kJ/kg/km; Fancy and White, 1987), so, for example, a 120 kg female would require 316.8 kJ to travel 1 km, and a 180 kg male would consume 475.2 kJ to travel the same distance, independent of speed. Total daily energy expenditure (DEE) has been estimated at 16 MJ for a female barren ground caribou in mid-winter (Adamczewski *et al.*, 1993). This DEE estimate was applied to calculations.



## Results

A total of 79 male caribou were observed during morning (8% of observations), midday (65%) and afternoon (27%). The database included 25 *before* periods, 42 *after* periods, 17 *impact* area observations and 10 *control* area observations. Observations of groups (mean group size 8,  $\pm 4$  SD) containing focal animals lasted from 20 minutes to approximately 2 hours. Twenty-six focal male caribou were observed during disturbance experiments with 81% of the disturbances involving a single snowmobile while the remaining involved 2 or 3 snowmobiles. Air temperatures and wind speeds varied from  $-20^{\circ}\text{C}$  to  $+1^{\circ}\text{C}$  and 0 kph to 15 kph during observations. Most (85%) of the groups observed during experiments had been previously disturbed that day by passing snowmobiles. Data from non-experimental snowmobile disturbance by recreationists were incomplete and are not included in the final analyses.

We observed 161 individual female caribou (mean group size 13,  $\pm 13$  SD) during mornings (12%), midday (59%) and afternoon (29%), including 32 *before* observations, 68 *after* observations, 36 *impact* area observations and 38 *control* area observations. Air temperatures and wind speeds varied from  $-25^{\circ}\text{C}$  to  $+8^{\circ}\text{C}$  and 0 kph to 20 kph during observations. Of maternal group experimental disturbances 68% (37) were conducted with one snowmobile while the remaining experiments used 2 or 3 snowmobiles. Of the groups observed during experimental observations, 65% had already experienced snowmobile disturbance that day.

### Reaction to Disturbance by Snowmobiles

For males, group size was negatively correlated with disturbance distance, flight initiation distance and closest approach distance but none were significant (Table 2). Maternal group reaction to an approaching snowmobile was independent of group size.

Table 2: Correlation of group size and behavioural reactions of male and maternal woodland caribou groups to snowmobile distance (m) in an alpine environment, southwest Yukon, winter 2003.

Behaviour	Male <sup>a</sup>			Maternal <sup>b</sup>		
	<i>n</i>	<i>r</i> <sup>c</sup>	<i>P</i>	<i>n</i>	<i>r</i> <sup>c</sup>	<i>P</i>
Awareness	26	-0.15	0.45	33	-0.14	0.42
Disturbance	19	-0.46	0.04	32	-0.15	0.39
Flight Initiation	13	-0.54	0.05	27	0.11	0.55

<sup>a</sup> group size ranged from 2 –14 males

<sup>b</sup> group size ranged from 2 –81 females/juveniles

<sup>c</sup> Pearson correlation

Maternal group reaction distances to approaching snowmobiles tended to be larger than for male groups (Table 3), but the only significant difference was with respect to the closest snowmobile distance.

Table 3: Mean difference (SE) in response distances (m) between male (*n* = 26) and maternal (*n* = 37) caribou groups experimentally provoked by snowmobiles in southern Yukon, winter 2003.

Variable	Group Type		<i>t</i>	<i>P</i>
	Male	Maternal		
Awareness Distance (m)	764 (88)	707 (68)	0.50	0.61
Disturbance Distance (m)	384 (71)	508 (52)	-1.69	0.09
Flight Initiation Distance (m)	227 (43)	282 (30)	-1.18	0.24
Closest Snowmobile Distance (m)	189 (21)	289 (28)	-2.77	<0.01

Maternal groups ran from approaching snowmobile(s) more often than males (50% vs. 18%,  $\chi^2=6.74$ ,  $p<0.01$ ).

## Behaviour comparison

Given that maternal groups were more likely to take flight during disturbance than male groups, behaviour *before* and *after* disturbance was compared between group types (Figure 3). A comparison of principal activity post-disturbance indicated that males were nearly three times more likely than maternal groups to feed following disturbance ( $\chi^2=6.17$ ,  $df=1$ ,  $P=0.013$ ).

A multivariate analysis of variance test compared the proportion of time each group type spent feeding, resting, vigilant and moving. We first compared behaviour before and after disturbance, then contrasted areas never used by snowmobiles (*control*) with areas used by snowmobiles but while no snowmobiles were present (*impact*) (Table 4). Male and maternal groups spent differing amounts of time in the four behaviours, and differences appeared before and after disturbance. However, time budgets did not differ between control and impact areas.

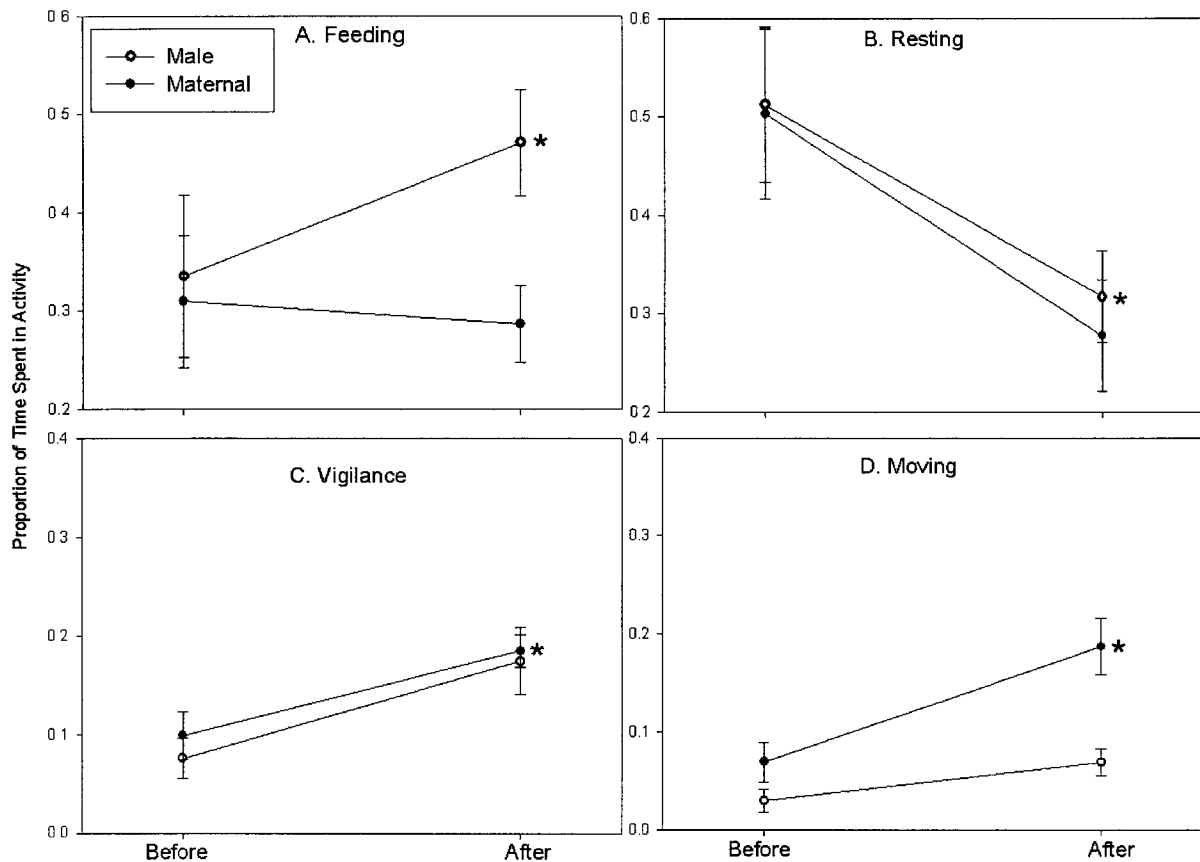
Table 4: Multivariate analysis of variance (MANOVA) for the effect of group type (male and maternal groups), snowmobile disturbance (disturbed vs. undisturbed or in areas exposed and not exposed to disturbance), and their interaction on woodland caribou behaviour (4 categories: feeding, resting, vigilance, moving) in southwest Yukon, winter 2003.

Comparison	Treatment	Test Statistics			
		Wilk's lambda	F	df	P
Time: Before and after snowmobile disturbance	Group Type	0.941	2.251	4, 160	0.043
	Disturbance	0.880	5.470	4, 160	<0.001
	Interaction	0.960	1.652	4, 160	0.164
Area: Exposed vs. not to snowmobiles	Group Type	0.976	0.584	4, 94	0.675
	Exposure	0.950	1.246	4, 94	0.297
	Interaction	0.958	1.021	4, 94	0.401

Two-way analysis of variance revealed that male groups increased time spent feeding ( $F=6.362$ ,  $df=1,2$ ,  $P=0.013$ ) and decreased time spent resting ( $F=6.654$ ,  $df=1,2$ ,  $P=0.012$ ) following a disturbance. Time spent vigilant or moving were not different. The opposite occurred in females: feeding and resting time were no different but vigilance increased following disturbance ( $F=10.830$ ,  $df=1,2$ ,  $P=0.001$ ), as did movement ( $F=4.077$ ,  $df=1,2$ ,

p=0.045). Time of day had no effect on the proportions of time spent feeding, resting, vigilant or moving (Figure 3).

Figure 3: Mean proportion of time spent in A. Feeding, B. Resting, C. Vigilance and D. Movement by woodland caribou in male or maternal groups before and after snowmobile disturbance, southwest Yukon, 2003



\* significantly different by observation period but not by time of day

Snowmobiler behaviour was assessed in a General Linear Model using stepwise regression for each caribou group type. The only variables affecting Flight Initiation Distance were group size for males and wind speed for maternal groups. Stopping during an approach tended towards allowing snowmobile(s) to get closer overall. Flight initiation distances decreased with increasing group size for males and with increasing wind speed for maternal groups (Table 5). None of the measured variables influenced area abandonment by either group when assessed by stepwise logistic regression.

Table 5: General Linear Model (GLM) of the flight initiation distance response (m) of male ( $n = 13$ ) and maternal groups ( $n = 26$ ) of caribou provoked by snowmobiles, southwest Yukon, 2003. The GLM explained 49% and 18% of the variation in flight initiation distance for male and maternal groups, respectively.

Sex / Model Term		F-ratio	Estimate	df	P
Male	Caribou group size	5.807	-0.816 ± 0.27	2,10	0.036
	Stopping <sup>a</sup>	4.118	-2.201 ± 1.08	2,10	0.069
Maternal group	Wind speed (km/hr)	5.364	-0.576 ± 0.25	1,25	0.029

<sup>a</sup> whether or not snowmobile stopped during approach

### Recreation Activity

There were approximately 396 kilometres of major snowmobile trails in the ICH winter range. Many more minor trails exist, and off-trail riding is common above the treeline throughout the study area, decreasing in density with increasing distance from Whitehorse. Traffic levels were estimated from available traffic counters and field observations, giving an approximate index of winter snowmobile activity. The Golden Horn plateau region experienced the highest use within the study area, which included extensive off-trail riding, with a mean of 6.6 ( $\pm 7.6$  SD) snowmobiles/day during weekdays and 15.8 ( $\pm 14.6$  SD) snowmobiles/day during weekends, for a mean of 9.4 ( $\pm 10.9$  SD) snowmobiles/day. The Rose Creek basin is further from Whitehorse and did not show an obvious weekend peak. It experienced fewer than 2 snowmobiles/week, or a winter mean of  $<0.3$  snowmobiles/day. Travel in this region was generally restricted to one main trail.

### Energy expenditure

Following disturbance, total flight times were shorter for males than for maternal groups (Table 6). A mean flight by a 180 kg male (mean weight for ICH male: Environment Yukon,

unpublished data) after provocation, would consume approximately 108 kJ, or 0.68% of DEE. For a 120 kg female (mean weight of ICH female: Environment Yukon, unpublished data), a mean flight response would consume approximately 205 kJ, or 1.28% of DEE. Time to return to pre-disturbance behaviour was shorter for both group types when flight did not occur during disturbance (Table 7).

Table 6: Comparison of time spent moving (seconds  $\pm$  SE) following experimental disturbance by snowmobile according to caribou group type, southwest Yukon, winter 2003.

Movement	Male	Maternal	Test Statistics		
			<i>t</i>	df	<i>P</i>
first flight bout	17 (5)	18 (5)	-0.055	19	0.59
total running	20 (6)	117 (36)	-2.63	23	0.02
total walk	201 (46)	393 (67)	-2.28	24	0.03

Table 7: Return to normal time (seconds  $\pm$  SD) for male and maternal groups when flight did and did not occur from experimental snowmobile approaches, southwest Yukon, winter 2003.

	Flight	No flight	Test Statistics		
			<i>t</i>	df	<i>P</i>
Male	1294 (760)	18 (5)	-2.38	14	0.03
Maternal	1434 (486)	509 (316)	-5.20	14	<0.01

## Discussion

Maternal caribou groups showed greater propensity to flee approaching snowmobiles than adult male groups, while behaviour of both group types differed between pre- and post-disturbance periods. These results are consistent with expectations. Feeding behaviour of

Svalbard reindeer was similar among males, females and calves during periods of no disturbance (Tyler, 1991). Because calves are at greater risk of predation, females with calves should display stronger anti-predator behaviour (Main and Coblenz, 1990). Mahoney *et al* (2001), however, found that in Gros Morne, Newfoundland maternal caribou groups had shorter flight initiation distances from an approaching snowmobile than did adult only groups. Mahoney *et al.* (2001) attributed this to high snowpacks, which entailed greater energy expenditure during running, and an absence of wolves. Ibex herd males allowed closer overall approach by snowmobiles. Awareness, disturbance and flight initiation distances were not different between male and maternal groups, but maternal groups tended to react sooner. Maternal groups also displayed a higher level of vigilance and movement and were therefore more likely to suffer an energetic cost of disturbance than male caribou. Males, with lower reaction distances to approaching snowmobiles and increased feeding time following disturbance, return more rapidly to fitness-enhancing activities following disturbance.

Caribou behaviour in control areas was compared to impact area behaviour to determine if caribou were affected by snowmobile use of a region when snowmobiles were not present. No differences were found over the course of this study, suggesting that strong and lasting effects on behaviour did not persist in high-use recreation areas when snowmobiles were not present.

The effects of snowmobile disturbance on caribou behaviour were shorter when caribou were not made to run during the encounter. Feeding after disturbance was frequently interrupted by vigilance and movement, suggesting a lower forage intake than undisturbed periods. However, the greatest energy expenditures occurred when caribou ran due to the snowmobile encounter. Nearly triple the amount of time was needed for caribou to resume normal behaviour when they ran from snowmobiles compared to when they did not (Table 7). The actual effects are likely to be greater because this comparison was limited to cases when caribou did not completely abandon the area under observation (move >1km). This period of increased movement and vigilance indicates that an encounter with a snowmobile that results in the caribou running is energetically costly. Caribou require much more energy for locomotion than for resting (Fancy and White, 1987).

Snowmobiler actions were assessed to investigate what factors increase caribou reaction to snowmobile presence. Male caribou flight initiation distance decreased with increasing group size. When reindeer were approached on foot, flight initiation distance also decreased with increasing group size, although there was no correlation between group size and detection distance (Baskin and Hjalten, 2001). When a snowmobile stopped during the approach, caribou appeared to decrease flight initiation distance. Perhaps stopping a snowmobile upon sighting a male group may decrease their reaction. Stopping may be less threatening to male caribou groups than continued approach. For maternal caribou groups, however, these snowmobiler actions did not influence reaction. The ICH animals tested also did not vary their response according to either direction or speed of approaching snowmobiles. These results are surprising as direction and speed of an approaching object, combining to give the *loom rate* (Frid and Dill, 2002), have been suggested as affecting the reaction of caribou to a moving vehicle (Horejsi, 1981). Speed of approach would be difficult for caribou to assess unless terrain was flat and offered a continuous view of the approaching disturbance, which does not always occur in ICH range. A false visual impression of approach speed was likely as the snowmobile would appear, and then often be hidden by terrain or vegetation before reappearing much closer. Noise increase, however, was likely continuously perceivable and possibly compensated for some of the 'sudden' appearances of a snowmobile in close proximity. Snowmobile group size (range 1 –3) did not affect flight initiation distance variation.

We could not demonstrate any strong relationship between controllable factors in snowmobiler behaviour and flight initiation reaction by caribou. Snowmobilers can best limit their effect on caribou by maintaining sufficient distance (>500 metres), stopping upon encountering caribou and limiting the time spent watching when caribou are disturbed by their presence.

Two previous studies attempted to quantify the reaction of caribou to approaching snowmobiles; one in Gros Morne, Newfoundland (Mahoney *et al.*, 2001) and the other in Revelstoke, British Columbia (Simpson, 1987). Two other studies focussed on reindeer; one on Svalbard reindeer, Spitzbergen, Norway (Tyler, 1991) and the other on Setesdal-Ryfylke reindeer in southern Norway (Reimers *et al.*, 2003). The Gros Morne study differentiated between adult-only groups and adults with calves, whereas the Svalbard study and the Setesdal-Ryfylke studies did not, pooling all observations. In the British Columbia study,



experimental approaches of caribou by a snowmobile were performed, but distances were estimates by eye and sample sizes were small, making comparison with other studies difficult.

Median awareness distances were similar between ICH and Norwegian reindeer but higher for ICH than for Gros Morne caribou (Table 8). Disturbance distance medians varied between herds and group type, with Gros Morne caribou with calves demonstrating the shortest reaction and maternal group of the ICH and Svalbard reindeer reacting the furthest. Flight initiation distances, the measurement least prone to observer bias, varied widely between herds, and it was much greater for maternal groups at ICH caribou than in Gros Morne. Svalbard reindeer demonstrated the lowest reaction. These differences may be attributable to sub-specific behavioural variation combined with each herd's experience of disturbance by snowmobiles, hunting and predation (Mahoney *et al.*, 2001). Both the ICH and the Gros Morne herds have experienced hunting during the time of the studies, although within Gros Morne National Park hunting does not occur and in the ICH winter range hunting continues at low levels. Reimers (2003) suggested that greater experience with snowmobile disturbance and lack of predation accounted for lower flight initiation distances in Gros Morne caribou and Svalbard reindeer than Setesdal-Ryfylke reindeer. The overall higher flight initiation distance of ICH caribou may reflect sensitivity to possible predation by wolves or by snowmobile-based hunters, which were common until 1993 and occasionally since. Male ICH caribou are exposed to frequent snowmobile disturbance, which may have resulted in some level of habituation translating into lower flight initiation distances. Maternal ICH caribou experience much less exposure to snowmobile disturbance than males, and inhabit regions that are prone to illegal snowmobile-based hunting (Environment Yukon, unpublished data). This may account for a different sensitivity to disturbance between the two group types of ICH caribou. It is likely that predation threat to male and maternal groups is similar in the ICH, as wolves exist throughout their range (Larsen *et al.*, 1989). Wolves and snowmobiles are unlikely to represent an equal threat to caribou, but we suspect that the presence of wolves increases caribou wariness of other land-based objects, including snowmobiles.

Table 8: Comparison of median response distances (metres) to snowmobile disturbance by Ibex caribou, Gros Morne caribou, Svalbard reindeer and Setesdal-Ryfylke reindeer.

Behaviour	Ibex <sup>A</sup>		Gros Morne <sup>B</sup>		Svalbard <sup>C</sup>	Setesdal-Ryfylke <sup>D</sup>
	Male	Maternal group	Adult only	w/ calf		
Awareness	592	698	288	252	640	533
Disturbance	292	421	240	174	410	280
Flight Initiation	199	285	186	123	80	216

<sup>A</sup> wolf predation, low snowpack, moderate snowmobile disturbance, hunted by snowmobile

<sup>B</sup> no predation, high snowpack, high snowmobile disturbance, hunted-not by snowmobile

<sup>C</sup> no predation, low snowpack, low snowmobile disturbance, hunted-not by snowmobile

<sup>D</sup> no predation, low snowpack, low snowmobile disturbance, hunted-not by snowmobile (Mahoney *et al.*, 2001; Tyler, 1991; Reimers *et al.*, 2003)

The predator/prey dynamics of caribou and wolves have been the subject of considerable discussion (Bergerud and Elliot, 1986; Seip, 1992; Dale *et al.*, 1994; Adams *et al.*, 1995). Recent work has underlined how predator behaviour may affect predation rates, particularly when predators use of linear corridors (James and Stuart-Smith, 2000; Dyer *et al.*, 2001). In northern Alberta wolves travel 2.8 times faster on linear corridors than in the forest and caribou mortalities from wolf predation were closer to linear corridors than were live caribou locations (mean difference 316 metres) (James and Stuart-Smith, 2000). Snow depths greater than 50 centimetres affect wolf travel, and where compacted snow trails and snowmobile trails are available, wolves and coyotes (*Canis latrans*) regularly use them (Crête and Larivière, 2003). Bergerud *et al.* (1984) noted that wolf use of snowshoe trails, roads and seismic lines gives hunting advantage and possibly lead to caribou avoidance of trails. The maximum killing rate of a searching predator depends on the rate of detection and encounters with prey (Bergerud and Page, 1987). Snowmobile trails are likely to increase detection, encounter and kill rates of caribou by wolves. Because the caribou's antipredator strategy is to reduce predator encounter rates (Bergerud and Page, 1987), they are likely to avoid snowmobile trails.

In the ICH winter range, caribou use of snowmobile trails seldom exceeded 300 metres. Wolves used trails frequently, travelling on trails up to 16 km at a time. Trails appeared to hold little benefit for caribou but held large benefits for wolves. Enhanced predation may partly explain the present population stagnation for the ICH, particularly considering the low current availability of moose. In the alpine areas of the ICH winter range, trail avoidance may

require caribou to stop using entire valleys. Avoidance of snowmobile trails by caribou was not clearly demonstrated in this research and should be further addressed to assess the effect such trails may be having on wolf/caribou dynamics.

Snowmobiles represent a potential threat to caribou, but it seems unlikely that caribou confuse snowmobiles with wolves. On two occasions the react of caribou to approaches of dog teams was observed, once for a maternal group and once for a male group. On the occasion with male caribou, the dog team approach followed a path identical to 6 previous snowmobile passes in the same hour. Caribou reaction to dog team presence in each case involved panicked, prolonged fleeing. Typical responses to snowmobile disturbance involved trotting away with frequent stops to look back. Although a rigorous comparison between caribou reaction to dog sleds vs. snowmobiles has not been done, it would seem that dog sled traffic would have a greater negative effect on caribou at the same traffic levels.

Bergerud *et al.* (1984), in a review of eight North American caribou herds, concluded that there was no convincing evidence that disturbance had adversely altered herd productivity or mortality rates. The approach of measuring energetic expenditure in caribou may be more expedient when addressing potential population consequences than long-term population studies which can be affected by other variables. Estimated energy costs of one flight from a snowmobile approach in an ICH male and maternal caribou averaged 0.68% and 1.28% of DEE, respectively. This calculation follows methods used by Reimers *et al.* (2003) who disagreed with the method proposed by Bradshaw *et al.*, (1998), which included additional energy consumption from excitation. By using only distance travelled, calculations may underestimate the energetic cost of disturbance. Additional factors (prolonged increased heart rates, effects of exponentially increasing energy requirements associated with speed and snow depth, animal fitness and coat, slope costs or gains) are very difficult to measure and were not incorporated into the calculations, but are likely to increase the energetic cost of each disturbance event. Therefore, our DEE estimates likely represent the minimum cost of a caribou running once from a snowmobile. Bradshaw (1998) estimated that one similar flight reactions in caribou could potentially cost 15% of DEE. Such differing results from comparable flight distances complicate interpretation of actual energetic costs, but reinforce the idea that energy expended from snowmobile disturbance has the potential to affect caribou if frequencies of disturbance are high and habituation does not occur.

The ICH experiences the highest continuous winter traffic of any caribou herd on winter range in Yukon. Snowmobiling is not evenly distributed across the ICH, but nearly all parts are accessed by snowmobiles. Areas near Whitehorse receive the highest visitation (mean of 9 ( $\pm$  11 SD) snowmobiles/day) while areas over 30 kilometres from the city have about 3% of that. Old mining roads provide ideal corridors through the low-lying forest into the alpine and once above treeline, snowmobile traffic is not limited to established trails. This use pattern affects male caribou more than maternal ICH caribou due to their use of the winter range.

Evidence of trail avoidance has not been documented for this herd. Adult male caribou groups were frequently seen throughout the study period in the Golden Horn plateau region, although the number of individuals varied greatly and, at times, caribou were not found there. Although trail use data for the Golden Horn plateau region are only available since 2001, snowmobile activity here is suspected to have been steadily increasing (P. Greenlaw, Klondike Snowmobile Association, personal communication). The distribution of the ICH in winter and of recreation activity suggests adult male caribou groups have been burdened with the majority of snowmobile disturbance costs for this herd. Habituation, if occurring in male caribou, may require longer than one winter to measure. No trend in male flight initiation distance was observed during this study. Maternal groups showed no temporal trends in flight initiation distances over the winter. Habituation, if it can occur in ICH, is likely a long-term process spanning more than one season of experience. Energy savings due to habituation may not appear soon enough to offset disturbance costs on ICH maternal groups should their winter range experience large and sudden increases in snowmobiling. Maternal ICH groups have likely not been greatly affected by snowmobile disturbance because their winter range doesn't receive high use. Large increases in snowmobile activity would likely increase energy costs on maternal ICH caribou with potentially noticeable effects on the population.

This region is likely to experience a steady increase in snowmobile traffic in the foreseeable future (P. Greenlaw, Klondike Snowmobile Association, personal communication), resulting in more caribou/snowmobile encounters. Although the male caribou groups continue to use high traffic areas, increased snowmobile encounter rates may result in range abandonment. Maternal caribou groups demonstrated a lower tolerance to snowmobile activity. Increases in

snowmobile encounter rates are also likely to result in energy costs that result in range abandonment.

Many other factors may affect caribou reaction to disturbance. Inclement weather, has been argued to affect caribou populations (Ouellet *et al.*, 1996). Milder winters, when energy requirements are easier to satisfy, may lower tenacity to food patches, possibly resulting in higher flight initiation distances. Winter severity may, therefore, influence individual decisions to leave high-quality food during a disturbance (Frid and Dill, 2002). In Gros Morne, Newfoundland, winter severity affected caribou flight initiation distance, with deeper snowpacks resulting in lower flight initiation distances (Mahoney *et al.*, 2001). Reluctance to flee when running requires more energy may be misinterpreted as habituation, and may interfere with decision making when regulating access to caribou habitat.

## **Management Implications**

We examined the behavioural reaction of caribou that were experimentally exposed to snowmobile disturbance. A brief comparison of present range use to the density of snowmobile trails and use frequency suggested different levels of disturbance for male vs. maternal ICH caribou groups. Trail avoidance was beyond the scope of this study, but should be investigated. Previous studies of caribou/snowmobile interactions focussed on the immediate reaction of caribou to disturbance from direct approach provocation without examining behavioural differences between disturbed and non-disturbed caribou groups. To obtain an understanding of the longer-term behavioural implications of disturbance we refined data collection methods. Caribou ranges that experience high snowmobile use require development of methods to reduce effects of recreational traffic on caribou. In the absence of legislation, voluntary compliance to proposed solutions is key to successful mitigation of snowmobiling effects on the ICH. It is likely that, when informed about the effects of their activities on caribou, the majority of snowmobilers in this region would comply with recommendations for riding in caribou areas.

Energetic consequences to individuals are likely to appear in both sexes should this region receive large increases of snowmobile activity. Habituation to snowmobiles, while suggested in caribou elsewhere, was not apparent in the ICH and may not offset increased energy requirements from disturbance. Female caribou energy requirements are very high in late winter when fetal growth is most rapid (Adamczewski *et al.*, 1993). Coupled with higher reaction distances, this is where the largest energetic effect and possible herd consequences may occur if maternal groups experience increased exposure to snowmobile disturbance.

Snowmobile group size, speed, direction of approach and loudness did not affect caribou reaction. However, further study of snowmobile loudness effects on caribou reaction is recommended due to the large difference in sound emissions by snowmobiles.

Given the current low recreational use occurring in the Rose Creek area, continued monitoring and no promotion of this region is recommended. It is likely that emphasis on this area's wildlife values may attract more snowmobile traffic. Little local knowledge, incomplete trail information, un-maintained rough trails, no emergency assistance and large distance from communities currently dissuade all but the more determined snowmobilers from visiting this region. Without promotion, current use levels are not likely to rise quickly. Reduced snowmobile traffic would likely benefit wintering maternal groups. Continued low use, at least, would be preferable to increased snowmobile traffic.

The current high use of the Golden Horn plateau, however, requires a proactive approach. Easy access, current trail maintenance accessing alpine areas, proximity to residential areas and other high use trails, viewsapes and forecasted increases in winter tourism point to an increase in snowmobile visits to this region. Restriction of access by snowmobilers can be achieved only by voluntary compliance and would remain unenforceable. In light of the lack of legislative support to shelter caribou from disturbance effects, managers should consider a vigorous education program in partnership with local snowmobile and other outdoor recreation organisations to mitigate disturbance effects. We recommend that such a program for backcountry travellers include information on caribou natural history and viewing opportunities, regional trail options, the effects of off-trail riding on wildlife, and continued incentives to report wildlife sightings.

In order to reduce energetic expenditures by caribou, increase potential for habituation and spatially buffer caribou from disturbance, the reduction of off-trail travel in favour of established trail use and non-disruptive wildlife viewing is necessary. Facilities, such as viewing stations, maintained trail networks, and signage will likely be required to accomplish this. Current trail networks offer round trip routes and high probability caribou viewing opportunities. They are, however, un-maintained and difficult at times, and riders often choose to create their own routes. Success in confining snowmobile use to trails in other provinces suggest that a developed and maintained trail system, sensitive to caribou habitat, coupled with a vigorous education program, is a cost-effective solution to reducing effects of snowmobile disturbance on the Ibex caribou herd.

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## CONCLUSION

Several studies have addressed how caribou respond to industrial development, linear features, and disturbance from aircraft and land vehicles. In this study I examined caribou behavioural reaction to approaching snowmobiles and explored the likely population consequences, given the current pattern and future trends of winter recreational activity. I found reluctance by local Yukon interest groups to accept the extrapolation of results of similar work from other regions. Caribou and reindeer disturbance research in Newfoundland and Norway already suggested that snowmobiles would cause caribou to run if approached too closely. This study was initiated to gather evidence of ICH reaction to snowmobiles so that local interest groups would accept local conclusions and recommendations more readily than those found in the literature. I modified methods used in previous caribou/reindeer snowmobile disturbance to assess whether caribou behave differently in areas regularly used by snowmobiles even when the latter are not present. An examination of the energetic consequences for caribou from snowmobile encounters expanded the applicability of this study to determine how recreational snowmobiling affects the ICH. Due to the presence of wolves in the ICH winter range, I was also able to discuss possible consequences that predation pressure has on caribou reaction to recreational disturbance.

Evidence of caribou behaviour change in the presence of snowmobiles, coupled with the extensive snowmobile traffic in this caribou herd's winter range, led me to conclude that recreational snowmobiling affects the ICH, but that those effects are not evenly distributed through the herd's winter range. Maternal caribou groups demonstrated greater overall reaction to approaching snowmobiles than did male groups: greater propensity to flee, higher movement and vigilance rates, and more incidences of range abandonment. Energetic consequences of flight from a single provocation are twice as high for maternal groups than for male groups and range about 1.28% and 0.68% of DEE, respectively. Caribou behaviour was not noticeably different between 'impact' areas and 'control' areas, indicating that a landscape of disturbance was either not present or did not strongly influence overt behaviour. Caribou did not demonstrate habituation to snowmobiles. Snowmobiler actions had little influence on caribou reaction. Mitigating disturbance is likely best accomplished by maintaining a minimum distance of 500m from caribou. Predators use trails left by

snowmobiles, which likely affect the predator/prey dynamics between caribou and wolves. These results may not pertain to populations that occupy winter ranges in forested environments.

Whether these activities affect population dynamics and contribute to the current stagnation of the population is unclear. In this work I did not examine caribou displacement from suitable habitat by snowmobile activity or trails, or the changing nature of the relationship between wolves and caribou. It is likely that some avoidance of suitable habitat is resulting from the recreational use of caribou winter range, because caribou did move away from snowmobiles and sometimes left the area completely. It is also likely that some effect on the relationship between caribou and wolves has occurred due to recreational snowmobile use of the caribou winter range, because it was evident that wolves used snowmobile trails. Evidence needs to be gathered before conclusions on these two topics can be made. Quantifying these effects at the population level will be technically problematic. Given that the investigation necessary to determine population effects is unlikely to be conducted by the Yukon Department of Environment or other research bodies, effort is required to mitigate current effects, even though proof of population consequences is not in hand. A proactive education and monitoring program is recommended to reduce winter recreation effects on this herd. This education and monitoring program should aim to decrease off-trail travel and channel use to designated trails, inform snowmobilers of distances to stay back from caribou and reduce all travel in key late wintering areas of maternal groups.

## RECOMMENDATIONS

“Caribou management in Yukon should emphasize non-consumptive values where the species is in close contact to urban areas or intense human activity” (Environment Yukon Caribou Management Guidelines). In the situation facing the ICH, the exposure to intense human activity and the close contact with the urban area has been demonstrated, but the non-consumptive nature of recreational use has not. Given that this herd occupies range that already experiences substantial human use, there is an opportunity to raise awareness in the community that, if successful, may modify area user behaviour, reducing effects of their presence on wildlife.

The greatest benefit to the ICH would be the elimination of all human intrusion into key caribou winter range. However, this is impractical and not likely possible. In an effort to reduce overall disturbance to the herd, I recommend creating proper trails and viewing sites that confine traffic rather than disperse it. Habituation is more likely when traffic is predictable, reducing disturbance of caribou. While it is not a goal to increase visitation, it will never the less be a product of such work. However, with a better informed user group there is an opportunity to modify human behaviour in the backcountry and add overall benefit to this herd through reduced trails, predictable trail use, reducing human activity in other key caribou areas (through satisfying viewing opportunities closer to town), more informed people watching for illegal caribou hunting and creation of a supportive resident base who are more likely to voluntarily comply with temporal and spatial restrictions around key wildlife habitat. My specific recommendations are:

- Continue traffic monitoring in high use areas, specifically the Golden Horn plateau.
- Implement a snowmobiler education program. This should include:
  - A stakeholder workshop approach to developing an action plan
  - Clear messages of ethics when travelling near wildlife
  - Trail Guide of region-includes educational messages
  - Trail maintenance on main trails through key area
  - Wildlife viewing lookouts-identified within the Trail Guide
  - Request for wildlife sighting reporting-details in the Trail map
  - Signage at each trailhead-messages of education program

- Demonstrate the set back distance in key habitats with signage
- Continue to employ Game Guardians to monitor herd and area use
- Develop a methodology to assess compliance to education program
- Create an action plan to mitigate or restrict access to key maternal group wintering areas should traffic levels in these regions increase substantially
- Investigate range and trail avoidance by caribou
- Investigate wolf use of trails
- Work with Klondike Snowmobile Association in their development of a 'caribou friendly' trail network to absorb regional traffic

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