THE EFFECTS OF HUMAN RELATED HARASSMENT ON CARIBOU (*Rangifer tarandus*)

Prepared for

Jim Young

Senior Wildlife Biologist

Ministry of Environment

Williams Lake, BC

by

Lara Webster

August 1997

I. TABLE OF CONTENTS

II. INTRODUCTION

The expansion of human settlements and land developments have accelerated the decline of caribou numbers across the northern hemisphere, but the degree to which specific activities influence caribou population dynamics are still in dispute. Predation, hunting, habitat destruction or any combination of these factors may limit caribou populations. This review focuses on the effects of harassment resulting from human interactions with caribou and caribou habitat, but also examines disturbance impacts on other ungulate species(Appendix 1).

In most cases, direct links between caribou declines and human activities or land uses are as yet unresolved and difficult to isolate, but some immediate and long term impacts of harassment to individual animals have been studied. For the purpose of this literature review the term "harassment" defines a specific human activity resulting in the altering of an animal's behaviour that could potentially increase energy expended or risk of injury to the animal. The effects of pedestrian approaches, habitat alteration (logging, road and seismic development and mining) and vehicular stimuli (all terrain vehicles, snow machines, aircraft and automobiles) on ungulates will be summarised, with special attention to caribou (*Rangifer tarandus*).

Geist (1975) states that during harassment, the regulatory systems require additional energy that would normally be allocated to growth, maintenance or reproduction and that excitation temporarily doubles the energy required for maintenance by increasing metabolism by about 25%. Severe or repeated human harassment could therefore result in reduced growth rates, poor body condition and decreased reproductive rates, that may in turn increase adult and calf mortality.

Caribou are most sensitive to harassment during the calving and rutting periods. During the calving period Mountain and Woodland maternal caribou that depend on limited alpine habitat to space themselves from predators and conspecifics are particularly

sensitive to additional stress, and may suffer the most serious consequence if displaced. Disturbance during the fall rut often results in extremely elevated stress levels. Depending on the level of ungulate response human-related harassment may result in anything from a slight increase in vigilance to panicked flight, with equally variable consequences for the animal (Schideler et al 1986, Jakimchuck 1980).

III. A Review of Caribou Harassment

A. Snowmobiles

Today, ungulate populations that have been neither hunted nor harassed (actively or passively) by snow machines at some time, are exceptions to the norm. However, ungulates will tend to perceive a snow machine as a threat (or potential predator) if the animals have at some time been actively chased or hunted from them (Simpson 1987, Valkenburg & Davis 1983). Caribou "sensitised" in this fashion will experience increased stress from the use of snow machines on traditional winter ranges. The effects this additional stress has on the animals are difficult to quantify. The literature available on the effects of snowmobile disturbance on caribou and other ungulate species may give managers some idea as to where further study should be directed and what steps should be taken to minimise conflicts in the meantime.

Avoidance activity of caribou may involve having to run through deep snow, leave optimal cover/forage, or change normal periods of activity; subsequently these activities could reduce ungulate winter survival and reproduction. Some suggest ungulate management could be enhanced by use of snowmobiles by improving mobility in poor snow conditions (Richens & Lavigne 1978, Eckstein et al 1979). Despite this possible benefit, the vast majority of studies involving snowmobiles and ungulates conclude that the machines stress the animals to some degree, and trails and machines are generally avoided (Simpson 1987, Tyler 1991, Dorrance et al 1975, Freddy et al 1986, McLaren & Green 1985).

Snowmobile activity in caribou winter range increases the amount of energy expended as the animals react to avoid close contact with machines and riders. The amount of energy expended depends on many factors including the following: the degree of previous harassment; animal activity prior to disturbance; snow depth and compaction; visibility;

wind speed and direction; and topographical features (Simpson 1987, Fancy & White 1986, McLaren & Green 1985, Tyler 1991). Tyler (1991) found animals in an un-hunted Svalbard reindeer herd, with no natural predators, during a single response to avoid nearby machines, used a maximum of 4.7% of their daily energy expenditure. This value could increase considerably at times when harsh snow conditions make movement difficult or if the animals were approached repeatedly. Hard running in deep snow for extended periods of time would not only leave caribou in an exhausted state, susceptible to predation, but would also contribute to a loss in body fat crucial for winter survival. The effect of severe harassment involving the active chasing of ungulates has not been investigated in the field, however using a computer simulated model, Hobbs (1989) showed that in times of severe winter conditions, disturbance twice daily (causing 500m flights) almost doubled mortality of unhabituated does. However, in this study deer did not show significant mortality increases during mild winter conditions. For caribou in poor physical condition, or during particularly harsh winters, this increased energy expenditure could seriously threaten winter survival; increasing the chance of death from predation and malnutrition.

Extensive snowmobile activity over important areas of winter forage makes cratering for terrestrial lichens energetically expensive. Fancy & White (1985) found caribou digging for lichens in snow compacted from snowmobiles required 481J/stroke compared to 118J/stroke in uncrusted snow and 219J/stroke in thin crusted snow. They also found that caribou were unable to smell lichens beneath a hard crust prior to digging and crater depths and pawing rates decreased as snow density and hardness increased. As caribou use body fat and protein stores in the winter, this increased energy expenditure may influence body condition and in extreme cases, winter survival.

Simpson (1987) studied the responses of mountain caribou to snowmobile approach. He found that the caribou allowed closer approach when machines were visually identified as opposed to when the source of sound was not visible. Alternately, catching scent of the operator caused caribou to withdraw more quickly regardless of visual stimuli. From

these findings, Simpson concluded that the operator, not the machine, was primarily responsible for high energy responses.

In some areas, experimental disturbance by snowmobilers caused ungulates to alter home ranges or habitat use. Deer were displaced from areas immediately surrounding active snowmobile trails and showed an increase in activity during a normally inactive period (Eckstein et al 1979). In Dorrance's (1975) work, deer were not only displaced, but also increased their home range size and expended more energy during periods of snowmobile activity. Simpson's mountain caribou study concluded that large groups of fast moving machines and human scent caused mountain caribou to abandon an area previously used as winter habitat. Areas of high quality winter habitat in the Quesnel Highland, such as the Mica Mountain and Yanks Peak areas receive minimal use by caribou during late winter when heavy use by snowmachines becomes an almost daily occurrence (Young pers. com.). Where suitable winter range is scarce, disturbance to caribou may shift them into less preferred habitat, increasing the risk of mortality. In addition, alpine dwelling caribou displaced to steeper, less preferred habitats may suffer increased mortalities from avalanches.

Snowmobile trails provide hard packed travel corridors for predators to move into the alpine (Bloomfield 1979, Neumann & Merriam 1972). Wolf predation is often responsible for adult mortality and low recruitment in caribou populations (Bergerud & Ballard 1988, Gasaway et al 1983, Seip 1991, Stevenson & Hatler 1985). Although there is normally minimal overlap between wolf and caribou winter ranges, these trail networks allow easy access to alpine and forested winter range areas, potentially increasing predation rates on caribou and upsetting the delicate predator/prey relationship so critically relevant to conservation strategies.

Heavy snowmobile use in caribou winter range can cause the daily energy expenditure of the ungulates to increase, wolf predation to rise and displacement of animals from traditional range to occur. Light snowmobile use may not necessarily cause caribou to abandon the area, especially if riders are careful not to actively harass wildlife

encountered. For animals that perceive humans as a threat, the additional stress caused by snowmobile harassment, intentional or unintentional at a time when caribou are relying heavily on fat reserves may lead to physical exhaustion and eventual death from malnutrition or predation. Predator access to winter range via snowmobile trails is not a factor that will decrease if snowmobile numbers are reduced.

B. Helicopter/Fixed-wing Aircraft

Numerous studies have been carried out on the effects of aircraft disturbance on ungulates, but the significance of aerial harassment on caribou is still under discussion. Low level flights over ungulate species may lead to immediate physical injury or death, increased energy expenditures that may reduce survival or reproductive rates and long term behavioural changes such as displacement from traditional ranges. The level of reaction of the ungulates to the aircraft appears to vary by species, season, quality of cover nearby and the altitude or distance of the flight from the animal.

Sudden intense noises resulting from low altitude flights often elicit a "startle reflex" that can increase the chance of physical injury or death from trampling or poor navigation of terrain. From late May to early July caribou calves are young and vulnerable, making this type of harassment especially threatening (Harrington & Veitch 1992, Gunn et al 1985, Calef et al 1976). Caribou also experience an increased sensitivity to aircraft during the rut, sometimes running hard for prolonged periods of time even after the aircraft has left the immediate area (Calef et al 1976). This type of disruption not only increases risk of physical injury to the animals, but may interrupt normal mating behaviour, potentially decreasing the productivity of the herd.

Prolonged physical responses to aircraft harassment increase daily energy expenditure of the animals and may have long term impacts as well as the immediate risks listed above. Although energy expended in avoidance activity is usually low for flight distances greater than 400m from the animals (MacArthur et al 1982, Harrington & Veitch 1992,

Calef et al 1976), flights lower than 100m almost always cause the animals to startle and run, utilising energy reserves (Luick et al 1994, Harrington & Veitch 1991, Cote 1996, Valkenburg & Davis 1983, Stemp 1983). Numerous instances of high stress response resulting from low-level flights could increase caribou mortality and displace caribou from the disturbance area.

A significant loss of body fat may result in increased mortality and decreased reproductive success since females in good condition are more likely to ovulate and conceive (Cameron et al 1993). A study by Gerhart et al (1996) found mammals are unlikely to survive more than a 33% loss of body protein, and poor winter nutrition for caribou can result in a 29% reduction. Luick et al (1994) predicted aircraft over-flights would have a minimal effect on caribou fecundity. However, the computer simulated model in this study was based on energy expended by caribou habituated to over-flights (Delta caribou Herd). The additional stress of low altitude over-flights poses a potential threat to unhabituated caribou herds that have been actively harassed and perceive aircraft as a threat to survival.

The quality and distance to appropriate security cover for the ungulates has a direct effect on the intensity and duration of the flight response (Stemp 1983, Cote 1996). This factor may have significant effects for ungulates such as mountain sheep and goats that use steep terrain for predator avoidance. Caribou rely more heavily on spacing and speed to avoid predation but may respond to light harassment by imposing a topographical barrier between themselves and the disturbance.

Caribou calf survival is negatively effected by frequency of exposure to low flying jet aircraft immediately after calving (Harrington & Veitch 1992). It has been shown that low level flights interrupt caribou nursing behaviour (Gunn et al 1983). During the first week of life, lactation demands of caribou calves are greatest and any lactation reduction has serious consequences for growth and survival of the calves (Parker et al 1990). Other studies on mountain sheep and goats have also shown decreases in calf survival with increased aircraft disturbance. Joslin (1986) noted that helicopter seismic activity peaked

with peak decline in reproduction of mountain goats in the area. Over the period of seismic activity the number of adult females decreased by fifty percent and the number of kids correspondingly decreased. For this study the impacts of hunting, grazing, timber harvest and weather were ruled out as primary causes for the decline, however stress induced disease could have been a contributor. Aircraft disturbance resulting in reduced lactation productivity, disrupted nursing behaviour and increased risk of stress induced disease may negatively effect caribou populations.

The long term implications of ungulate displacement and social group disintegration caused by aircraft disturbance are difficult to study. Cote (1996) found helicopter flights caused the disintegration of Mountain goat social groups on a number of occasions as harassed animals split up and fled for cover. Although many studies noted an immediate displacement of animals from the disturbance area, it was often difficult to determine how temporary the resulting displacement was. For example, moose increased their home range sizes substantially during helicopter disturbance, but returned to normal size within one week after the disturbance (Andersen et al 1996). Displacement of caribou cow/calf pairs due to helicopter disturbance may interrupt the imprinting of traditional home ranges for calves and could affect the productivity and survival of herds with limited suitable habitat in which to space out (Gunn et al 1983).

It is possible for ungulates to become habituated to aircraft. Habituated animals do not associate aircraft with danger and as a result experience minimal additional energy expenditures when overflown. Captive deer and sheep that did not perceive aircraft noises as a threat became quickly habituated to simulated noises (Weisenberger et al 1996). Similarly, caribou herds consistently over-flown but not chased or hunted by aircraft reacted less to this type of disturbance over time (Davis et al 1985, Valkenburg & Davis 1983). Animals that have been actively chased or harassed by aircraft will likely become sensitised to the disturbance, reacting more energetically to a perceived threat (Stemp 1983, Harrington & Veitch 1991). Comparative research carried out on one group of caribou constantly over-flown but not threatened by military aircraft (Delta Caribou Herd, DCH) and another seldom exposed group (Western Arctic Caribou, WAC)

showed that the "unhabituated" animals fled more often and ran for longer periods when disturbed by aircraft (Valkenburg & Davis 1983). It appears that the deciding factor lies in whether the animals associate the disturbance type with danger or not. The WAC are pursued from snowmobiles (another loud mechanical stimuli) and sometimes aircraft, whereas the DCH are less subject to direct human provocation and do not associate the over-flights with predation.

The consequences of aircraft disturbance will inevitably vary from one caribou herd to the next depending on the amount and type of previous exposure. There is a general consensus that over-flights greater than 300m above ground level are unlikely to have significant impacts. Caution should be especially exercised during the fall rut and May-June calving period, to avoid startling the animals during these sensitive periods.

C. All-terrain Vehicles

All terrain vehicles (ATVs) in caribou habitat may negatively impact habitats and wildlife. Use of ATVs when the ground is free of snow may increase the stress level of the animals, displace cow/calf pairs, increase hunter success and damage important winter forage. The resulting added stress during the summer months could increase predation and reduce the fecundity of lactating females and calf growth rates.

Destruction of winter forage by high ATV use could potentially contribute to poor nutrition, reduced birth rates and early calf survival. The terrestrial lichens some caribou depend upon during the winter season are extremely slow growing, with long regeneration periods. Since the majority of palatable lichens are found in open old growth pine forests, it is possible these areas could overlap with ATV use. Other important lichens growing on alpine ridges may be at risk from ATV damage. These lichens provide forage when caribou feed at higher elevations where windswept ridges are exposed.

ATV use, where permitted can allow hunters and poachers easier access into remote caribou habitat. Use of a motorised vehicle effectively increases the area hunters are able to search, and is therefore likely to increase annual hunter harvest.

ATV use in the alpine during the calving period may displace caribou out of their traditional alpine calving areas. Since caribou use these high elevation areas to space themselves from predators at a vulnerable time, displacement into less preferred habitat could lead to increased predation, and imprinting of calves on poorer habitat.

Yarmoloy et al (1988) hypothesised that if feeding and resting patterns of deer were disrupted by ATV harassment at the time when the females were "fattening up" prior to mating, their body condition might be affected and thus reproduction. After habituating deer to non-aggressive ATV use, three does were chosen and chased for 15/30 days (nine minutes/day). Harassed females experienced a decrease in reproduction, shifted feeding into darkness, used cover and left their home ranges more often. It was also noted, as does were harassed, flight distance from the ATV's increased. This type of reaction was similar to the anticipated "sensitising" effect of snowmachines on deer and caribou. Since adult female caribou have been known to experience a 32% fat reduction over the lactation period (in addition to 45% fat and 29% protein losses over winter) there is concern that ATV induced stress at this time could decrease reproductive success and survival (Gerhart et al 1996).

For caribou, female body condition during the rut (in October) and throughout the pregnancy (until late May, early June) is critical to reproductive success. Females in good condition are more likely to ovulate, and early calf survival is mainly influenced by condition of the mother during late pregnancy (Cameron et al 1993). Since caribou are dependent on the flight response at an early age to escape from predators, it is imperative they grow strong quickly. Parker et al (1990) found high growth rates (during the first week and after day 75) and daily energy expenditures in caribou neonates were largely due to the extremely rich milk produced by lactating females (high in protein, energy content and dry matter). The cost to produce such high energy/protein rich milk and the

resulting weight loss by lactating caribou stresses the importance of good forage and weight gain accompanied by low stress conditions prior to the fall rut, as calf survival is strongly correlated to pre-calving maternal body condition.

D. Pedestrians

Caribou and other ungulates perceive humans as predators, and because of this, pedestrian approaches elicit greater cardiac and behavioural responses from ungulates than mechanical stimuli (Andersen et al 1996, Eckstein et al 1979, Freddy et al 1986, MacArthur et al 1982, Simpson 1987). Documented cases of ungulate responses to humans on foot primarily concern active avoidance and a corresponding increase in energy expenditure (Freddy et al 1986, Eckstein et al 1979, Richens & Lavigne 1978, Ferguson & Keith 1982). For example, Freddy et al (1986) noted that the activities of deer were interrupted more by people than snowmobiles. Deer in this study ran longer, ran more frequently and expended more energy (using approximately 3-5% of their daily metabolizable energy) avoiding pedestrians. Numerous exposure to such stimuli may potentially have the same effects as snowmobiles and aircraft.

Two reasons ungulates respond strongly to pedestrians are: the relatively silent approach and sudden appearance. The closer any stimulus is able to approach an ungulate before triggering flight response, the longer the resulting flight distance and time for heart rate to return to normal (Andersen et al 1996). Subtle noises caribou are unable to pinpoint are more likely to be associated with predators than steady state noises from mechanical stimuli (Jakimchuk 1980). The sudden appearance of a pedestrian, approaching animals from over a ridge elicited the greatest response from mountain sheep (MacArthur et al 1982). Studies of ungulate responses to domestic dogs, accompanying pedestrians are inconclusive. Stemp (1983) found mountain sheep heart rates increased minimally in response to a leashed dog, whereas MacArthur (1982) noted the greatest impact under these circumstances. Harassment by pedestrians and domestic dogs, especially during the calving period may increase risk of caribou calf abandonment and physical injury

(from the "startle-reflex"). Silent approaches by humans that mimic stalking of natural predators (human hunters and wolves) are considered most threatening by ungulates and may significantly increase the animal's daily energy expenditure.

Although few studies have been completed exclusively on the effects of pedestrian harassment on ungulates, cases of displacement from home ranges and altered habitat use have been documented (Ferguson & Keith 1982, Dorrance 1975, Whitten & Cameron 1983). An in depth study by Kuck et al (1985) concluded that elk responded more strongly to direct human harassment than to simulated mine noises (100 decibels). Disturbed cow/calf pairs tended to use random-seeming selections of habitats, used larger areas, moved greater distances and more readily abandoned the calf rearing area. Abandonment of the calving grounds is unusual for elk, as they show fidelity to calving grounds similar to caribou. In another study, deer changed their home ranges entirely due to combinations of snowmobile and pedestrian harassment in the area (Dorrance 1975). Human activities surrounding the Prudhoe Bay oil field have caused displacement of Central Arctic caribou, but the specific reason is most likely a combination of pedestrian and other harassment types (Whitten & Cameron 1983). For caribou with limited suitable range, habitat displacement or loss there of, could result in higher mortality rates due to increased predation risk and poorer forage quality. Caribou can distance themselves from predators at calving time by retreating to high alpine areas. Habitat displacement by pedestrians from these relatively safe alpine habitats could be particularly problematic if the calves that are not taken by increased predator numbers imprint on poor habitat and return there to calve when they reach adulthood.

E. Mining/seismic exploration

Ungulates appear to be most sensitive to loud disturbance types such as mining and seismic exploration shortly before and immediately after young are born and during the rutting season. These disturbance types increase the distances moved by the animals and may effectively decrease reproductive success.

Two mountain goat populations were helicopter surveyed over a five year period to determine the possible effects of seismic exploration in the Rocky Mountains (Joslin 1986). Mountain goats in the impacted area moved away from human activity and declined significantly in number. Prenatal stress is of particular concern, since the young are extremely sensitive and rapidly developing. Although no goats abandoned their home range entirely during this study, the number of adult females and kids in the area of high seismic activity dropped by about 50% . This reproductive decrease coincided with the peak in helicopter based seismic activity and once seismic activity ended productivity improved. A stress induced disease such as bronchio-pnemonia may have been a contributing factor, since the stress induced by seismic activity seems to be cumulative.

Loud noises associated with mining and seismic activity were found to negatively impact radio-collared elk in two studies. Combinations of simulated mine noises (100 decibels) and pedestrian harassment of elk during the calving period caused disturbed calves to move farther, with greater change in elevation and use larger areas than undisturbed calves (Kuck et al 1985). Three cow/calf pairs abandoned the disturbance (and traditional calving) area entirely (Kuck et al 1985). Knight (1981) found, although, elk remained in their home ranges, animals located close to seismic activity moved about twice the distances as individuals residing outside of the disturbance area. This doubling of daily movements not only utilises the energy reserves of the animal, but could also disrupt rut activities, especially if the harem is broken up and the social order of the group is upset.

Bradshaw (1994) studied the effects of loud noises (firing of cannons) that simulated petroleum exploration on caribou in the Arctic. He found that animals subjected to this type of activity avoided the disturbance area (linear displacement) and increased their daily movements during and well after the disturbance occurred. The resulting daily energy expenditure of impacted caribou increased by almost 21% and daily movements remained significantly greater in the two days following the cannon-blast disturbance. In a simulated model, Bradshaw demonstrated that in several areas, winter petroleum

exploration was sufficient to cause significant weight loss in caribou. Relatively frequent, unpredictable disturbance types appear to have the greatest potential for survival difficulties.

F. Roads/traffic/ pipelines

Linear transport systems can directly increase caribou mortality by vehicular collisions and indirectly impact the population by increasing predator access to range and creating physical or behavioural barriers to movement. In some cases habituation seems to be possible, but there are also documented cases of increased stress from fast moving vehicles, disruption of migration routes and displacement of maternal females from calving areas resulting in habitat abandonment and increased caribou density.

In the past decade increased road densities and fast-moving vehicular traffic have resulted in numerous ungulate collisions across the province. This direct effect can have significant impacts on small caribou herds (Stevensen & Hatler 1985, Edmonds & Bloomfield 1984). In addition, salt applied as a melting agent is reported to attract ungulates to roads. Railway networks through caribou range also contribute to collision mortalities (Stevenson & Hatler 1985). A tendency to inhabit isolated areas and to space out over large areas may reduce the risk of collision for caribou, when compared to deer and moose. Studies show combinations of fencing and wildlife passages for high volume and speed travel ways are the most effective means to reduce ungulate traffic collisions (Bruinderink & Hazebroek 1996).

The combined effects of illegal and legal hunting are most destructive to wildlife populations when access is increased (O'Neil 1993, Lyon 1984). As more logging roads are constructed, the isolated habitat preferred by the caribou becomes more and more rare. Animals that may have habituated to road activity during construction are particularly vulnerable when access is improved (Frederick 1991). Caribou are

particularly susceptible to overharvest due to their curious nature, low reproductive rates and seasonal migrations.

Increased access provided for wolves by transportation corridors can be an important limiting factor for caribou populations. By controlling wolf numbers with experimental control programs, it has been shown that caribou population numbers and calf survival can be directly linked to the amount of wolf predation (Gasaway et al 1983). Wolf predation on juveniles is often responsible for low recruitment in caribou populations (Bergerud & Ballard 1988, Gasaway et al 1983, Seip 1991). Wolf tracks on roadways and nearby kills provide strong evidence wolves use roads for travel (Edmonds & Bloomfield 1984, Miller 1983).

Construction of pipelines in caribou habitat are not usually disruptive unless moving objects (resembling predators) are observed together with elevated pipelines resembling concealing habitat (Curatolo & Murphy 1986). Caribou reacted significantly to coupled stimuli such as active roads adjacent to unburied pipelines. Caribou tended to cross more often at buried pipelines or "dirt ramps" where there was less visual stimuli and the least resistance. Ramps such as these may be useful to minimise impacts after production and traffic decrease at such sites. The tendency of caribou to readily cross a single structure but not two in conjunction (ie. pipeline and road) suggests that separation of roads and pipelines would minimise potential barriers to the caribou.

Ungulate habituation to road traffic is possible, but seems to depend once more on the degree of previous harassment and the amount of alternate suitable habitat available (MacArthur et al 1982). MacArthur et al (1982) suggested that ungulates such as caribou accustomed to more isolated habitats would likely have increased heart responses of greater duration than the sheep in his harassment study. Horejsi (1981) found caribou strenuously exert themselves for a short period of time when they encounter a fast moving vehicle, the period of time depending on the rate of the vehicle's approach. For caribou and other ungulates with plentiful habitat available, it appears displacement from areas (with the exception of migratory corridors) surrounding speedways is most often

the result (Dau & Cameron 1986, Horejsi 1981, Nellemann & Cameron 1996, Rost & Bailey 1979, Whitten & Cameron 1985). This does not appear to be the case with migration routes, as crossings are necessary at some point. Two studies have found that at the current vehicle/road densities, caribou herds continue to use traditional migration routes even if they are intersected by major roadways (Johnson & Todd 1991, Miller 1983). In each study reviewed, authors acknowledge that as traffic increases in frequency, disruption of normal migration routes in the region are likely to occur.

Continued increase in the number of man made linear developments could eventually disrupt the normal movement and migration routes of caribou (Johnson & Todd 1991, Curatolo & Murphy 1986, Dau & Cameron 1986, Bergerud et al 1984). Studies completed in the Kootenays and in Alaska found migration routes remain unchanged in spite of highway obstructions (Miller 1983, Johnson & Todd 1991). It has been shown, however, that roads can cause caribou and other ungulates to be displaced from native home ranges and that they are especially sensitive at calving time. Aerial population surveys conducted for 4 years prior to construction and 4 years following an Alaskan roadway's completion ultimately resulted in displacement of maternal females from the surrounding areas (Dau & Cameron 1986). Nellemann & Cameron (1996) found that by avoiding roads and production related facilities, access and use of preferred calving habitat was restricted. Caribou density was lowest within 4km of roads and facilities. All of the Alaskan caribou in the study, especially cows with calves preferred terrain with higher summer forage thus maximising the energy intake over time when lactation and parturition make it most necessary. In both cases, the resulting loss of habitat was not enough to cause increases in mortality. In mountain and woodland caribou habitat where alpine calving grounds (used for increased security from predators) are in short supply, such displacement by human activities might tend to have more serious implications. For example, in northern Ontario it has been shown that woodland caribou did not use cut portions of traditional wintering areas for up to 12 years after road networks and clearcuts were established (Cumming & Beange 1993). In four cases, caribou sightings and tracks decreased drastically or ceased entirely where winter ranges

were cut while caribou sign in unlogged areas remained plentiful (Cumming & Beange 1993).

Logging and silvicultural practices and the road networks that must accompany them may alter caribou behaviour. In addition to providing winter forage, old growth forests allow easy movement and provide thermal cover and security from predators. Chubbs et al (1993) found that woodland caribou previously occupying mature forest (particularly maternal females) moved away from clear-cutting in the area. It also appeared that caribou continued to increase distance from clearcuts the following summer. These results imply that fragmentation of habitat by numerous small clear-cuts may have the most severe effect on caribou. On the other hand, during winter in the Quesnel Highland, caribou have been observed in active logging blocks where large quantities of arboreal lichen are available on the ground due to the limbing and topping of felled trees (Young pers. com.). The predator aviodance strategy adapted by caribou involves maintaining low densities and spacing themselves from predators and conspecifics (Seip 1991, Racey et al 1991). Lesser amounts of suitable habitat in which to space out effectively increases caribou density and thus, the risk of predation.

One should note that road-cutblock combinations can have particularly significant effects when logging roads are located directly adjacent to cleared land. Since ungulates often minimise vehicular and other human related disturbances by imposing some type of topographic barrier, un-buffered, highly visible cuts extending to the road may increase disturbance levels as well as hunter success (Stemp 1983, O'Neil 1991).

Near the Dempster Highway, traffic and hunters were likely to have the greatest effect on crossing sites, but also wolves, photographers and recreationalists may have influenced caribou movements (Miller 1983). Bergerud et al (1984) found no direct evidence that habitat alterations or human disturbances effected herd productivity (for the 8 herds included in the study) however, they did note blocking of natural migration routes by physical barriers, creation of firing lines by hunting along a corridor, or intense harassment would result in a loss of useable space and therefore a decrease in herd

population. The variability and interconnected nature of ungulate population dynamics make it extremely difficult to project levels of harassment necessary to precipitate significant declines in individual populations.

IV. Summary

The ability of caribou to habituate to human presence in their home range appears to depend on the degree of previous harassment and hunter presence. In areas where man is not associated with danger, animals may quickly habituate to human disturbance and thus become more prone to poaching and hunting, or in the case of roads and vehicles, road kill; all of which result in increased mortality rate. Where caribou have been hunted or chased (passively or actively) herds are more likely to experience additional stress from associating man with danger, and are especially sensitive during the calving and rut periods. Harassment of unhabituated caribou to human disturbance may have immediate impacts as well as long term effects.

Where humans or their machines are perceived as a threat, caribou often experience increased stress levels and subsequently expend more energy attempting to avoid the disturbance. Flight is the most common response for unhabituated animals that perceive humans as predators. This flight response uses up vital body reserves, increases the chance of physical injury or death during stampedes and may cause herd fragmentation. Utilisation of essential body fat and protein, especially during harsh climatic conditions, can lead to increased cow/calf mortality, and may effectively reduce productivity of the herd.

Long term displacement from home range (especially during calving period) may result in increased mortality, decreased reproductive success, increased predation, altered habitat use and decreased caribou densities. Human activities within caribou range which do not necessarily destroy caribou habitat may still result in a functional loss of usable space by the disturbance and resulting displacement. The relatively isolated areas caribou live in may make them more responsive to human disturbance, eliciting high stress responses. Human activities such as hiking, snowmobiling, low altitude flights and ATV use, which briefly stress caribou are likely to have significant negative effects if animals are displaced out of their preferred habitat. Displacement to poorer habitat

where adequate forage may not be available or predators exist in greater numbers could potentially result in caribou population declines.

Habitat alteration resulting from human activity is not the focus of this report, but is directly linked to harassment since it has been shown to alter caribou behaviour and increase risk of injury to the animal. Land clearing practices reduce available cover and forage, increase hunter visibility, and may create winter barriers to caribou movement, while roads and trails increase hunter success rates and provide improved travel corridors for wolves. Increased hunter and predator access and decreased habitat quality and availability may result in higher caribou mortality rates and/or displacement from traditional home ranges.

The concept of caribou harassment is extremely complex, as responses to different activities and developments are dependent on numerous factors which may be encountered in various combinations and intensities. Whether animals are habituated to human presence or not, the majority of studies reviewed in this paper conclude that the net effect on individually harassed caribou is negative. In order to draw conclusions at the population level, more study is required and researchers must keep in mind that the variation in responses between individuals and from herd to herd make generalisations difficult and sometimes unreliable. Management of caribou populations with respect to human related harassment must address both the maintenance of suitable habitat and regulation of hunter harvest.

V. Recommendations

- Do not attempt to habituate animals to human related disturbance.
- Limit general flight altitudes in caribou habitat to above 300m.
- Restrict recreational access to alpine areas during calving (mid-May to July).
- Zone snowmobile and ATV use away from core caribou winter range particularly where terrestrial lichen is essential to caribou winter survival.
- Limit snowmobile and ATV use in areas that may stress animals.
- Promote further study concerning long term effects of human related harassment.
- Minimise visibility of area surrounding active roads to screen animals from vehicular disturbance and reduce hunter success.
- Caribou population surveys should be scheduled to avoid peak calving and rutting periods.
- Population surveys should be planned with the objective of minimising the duration of disturbance to each encountered group while maximising the aircraft's altitude but still allowing animals to be classified. When animals are encountered in rough terrain where there is a high risk of injury if chased, or in dense cover where extra time is required to classify all animals, discretion should be used to minimise disturbance, and as a result, likely all animals will not be classified.

VI. References

Andersen**,** Reider, John Linnel & Rolf Langvatn. 1996. Short term behavioural and physiological responses of moose to military disturbance in Norway. *Biol. Conserv.* **77** (2-3): 169-176.

Bergerud, A.T. and W.B. Ballard. 1988. Wolf predation on caribou: The Nelchina Herd case history, a different interpretation. *J. Wildl. Manage*. **52** (2): 344-357.

Bergerud, A.T., R.D. Jakimchuk & D.R. Carruthers. 1984. The buffalo of the North: Caribou and human developments. *Arctic,* **37** (1): 7-22.

Bloomfield, M.I. 1979. The ecology and status of mountain caribou and caribou range in central British Columbia. M.Sc. thesis, University of Alberta, Edmonton. 318p.

Bradshaw, Corey J.A. 1994. The effects of petroleum exploration on woodland caribou in northeastern Alberta. M.Sc. thesis, University of Alberta, Edmonton.

Bruinderink, G. and E. Hazebroek. 1996. Ungulate traffic collisions in Europe. *Conserv. Biol.* **10** (4): 1059-1067.

Calef**,** G.W., E.A. DeBock & G.M. Lortie. 1976. The reaction of barren-ground caribou to aircraft. *Arctic,* **29**:201-212.

Cameron, R.D., W.T. Smith, S.G. Fancy, K.L. Gerhart & R.G. White. 1993. Calving success of female caribou in relation to body weight. *Can. J. Zool*. **71**: 480-486.

Chubbs, Tony, Lloyd Keith, Shane Mahoney & Michael McGrath. 1993. Responses of woodland caribou (*Rangifer tarandus caribou*) to clear-cutting in east-central Newfoundland. *Can. J. Zool*. **71**: 487-493.

Cote**,** S.D. 1996. Mountain goat responses to helicopter disturbance. *Wildl. Soc. Bull*. **24** (4): 681-685.

Cumming, H.G. and D.B. Beange. 1993. Survival of woodland caribou in commercial forests of northern Ontario. *The Forestry Cronicle*. **69** (5): 579-588.

Curatolo**,** James and Stephen Murphy. 1986. The effects of pipelines, roads, and traffic on the movements of caribou, *Rangifer tarandus*. *Can. Field-Nat.* **100** (2): 218-224.

Dau, J.R., and R.D. Cameron. 1986. Effects of a road system on caribou distribution during calving. *Rangifer* Spec. Issue No. **1**: 95-101.

Davis, J.L., P. Valkenburg & R.D. Boertje. 1985. Disturbance and the Delta caribou herd. In *Proceedings of the First North American Caribou Workshop,* ed. Martell, A.M. and D.E. Russel. Whitehorse, Yukon.

Dorrance, M.J., R.D. Jakimchuck & E.R. Carruthers. 1975. Effects of snowmobiles on white-tailed deer. *J. Wildl. Manage*. **39** (3): 563-569.

Eckstein, R.G., T.F. O'Brien, O.J. Rongstad, & J.G. Bollinger. 1979. Snowmobile effects on movements of white-tailed deer: A case-study. *Envir. Conserv.* **6** (1): 45-51.

Edmonds, E.J. and M. Bloomfield. 1984. A study of woodland caribou (*Rangifer tarandus caribou*) in west central Alberta, 1979-1983. Rept. by Prov. of Alberta, Energy and Renewable Resources, Fish and Wildlife Div. 203p.

Fancy, S.G. and R.G. White. 1985. Energy expenditures by caribou while cratering in snow. *J. Wildl. Manage*. **49** (4): 987-993.

Fancy, S.G. and R.G. White. 1986. Predicting energy expenditures for activities of caribou from heart rates. *Rangifer,* Special Issue No.**1**: 123-130.

Ferguson, Michael A.D. and Lloyd B. Keith. 1982. Influence of nordic skiing on distribution of moose and elk in Elk Island National Park, Alberta. *Can. Field-Nat.* **96** (1): 69-78.

Freddy, David J., B.M. Whitcomb & M.C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. *Wildl. Soc. Bull*. **14** (1): 63-68.

Frederick, Glenn P. 1991. Effects of forest roads on grizzly bears, elk and gray wolves: A literature review. USDA Forest Service Kootenai National Forest.

Gasaway, William C., Robert O. Stephensen, James L. Davis, Peter Shepherd & Oliver E. Burris. 1983. Interrelationships of wolves, prey, and man in Interior Alaska. *Wildl. Monographs* (ISSN:0084-0173, no 84) 49p.

Geist, V. 1975. Harassment of large mammals and birds. Rep. to the Berger commission submitted by Arctic Gas Study Ltd. Calgary, Alberta. 62p.

Gerhart, K.L., R.G. White & R.D. Cameron. 1996. Body composition and nutrient reserves of arctic caribou. *Can. J. of Zool*. **74** (Ja): 136-146.

Gunn, A., F.L. Miller, R. Glaholt & K. Jingfors. 1985. Behavioural responses of barren-ground caribou cows and calves to helicopters on the Beverly herd calving grounds, Northwest Territories. In *Proceedings of the First North American Caribou Workshop,* ed. Martell, A.M. and D.E. Russel. Whitehorse, Yukon, p10-14.

Harrington, F.H. and A.M. Veitch. 1991. Short-term impacts of low-level jet fighter training on caribou in Labrador. *Arctic,* **44** (4): 318-328.

Harrington, F.H. and A.M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter over-flights. *Arctic,* **45** (3): 213-218.

Hobbs, N.T. 1989. Linking energy balance to survival in mule deer development and test of a simulation model. *Wildlife Monographs*. **101**: 1-39.

Horejsi, B.L. 1981. Behavioural response of barren ground caribou to a moving vehicle. *Arctic,* **24:** 180-185.

Jakimchuck, R.D. 1980. Disturbance to barren-ground caribou: A review of the effects and implications of human developments and activities. R.D. Jakimchuck Management Associates Ltd., Sidney, B.C. 121p.

Johnson, D. and Michael Todd. 1977. Summer use of a highway crossing by mountain caribou. *Can. Field-Nat*. **91**: 312-314.

Joslin, Gayle. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain front. In *Proc. Fifth Bienn. Symp. North. Wild Sheep and Goat Council.* Missoula, Montana. p253-268.

Knight, James E. 1981. Effect of oil and gas development on elk movement and distribution in Northern Michigan. In *Transactions of the 46th N. American Wildlife and Natural Resources Conference*. ed. Kenneth Sabol. Washington D.C. 1981. p349-357

Kuck, Lonn, Gay Hompland & Evelyn Merrill. 1985. Elk calf response to simulated mine disturbance in Southeast Idaho. *J. Wildl. Manage*. **49** (3): 751-757.

Luick, B.R., J.A. Kitchens, R.G. White & S.M. Murphy. 1994. Modelling energy and reproductive costs in caribou exposed to low flying military jet aircraft. *Rangifer* Spec. Issue No. **9**: 209-212.

Lyon, Jack L. 1984. Road effects and impacts on wildlife and fisheries. In *Proceedings of the Forest Transportation Symposium*. Casper, Wyoming. Forest Service, Region 2, Denver. p98-118.

MacArthur, R.A., V. Geist & Ronald Johnston. 1982. Cardiac and behavioural response of mountain sheep to human disturbance. *J. of Wildl. Manage.* **46**: 351-358.

McLaren, Margaret A. and Jeffrey E. Green. 1985. The reactions of muskoxen to snowmobile harassment. *Arctic,* **38** (3): 188-193.

Miller**,** Frank L. 1983. Some physical characteristics of caribou spring migration crossing sites on the Dempster Highway, Yukon Territory. In *Proceedings of the First North American Caribou Workshop,* ed. Martell, A.M. and D.E. Russel. Whitehorse, Yukon.

Nellemann, Christian and Raymond D.Cameron. 1996. Effects of petroleum development on terrain preferences of calving caribou. *Arctic,* **49**: 23-28.

Neumann, Peter W and Merriam Gray. Ecological effects of snowmobiles. 1972. *Can. Field-Nat*. **86** (3): 207-212.

O'Neil, Grady. 1993. Access development in the Peace-Liard Sub-region (1975-1992) and it's potential impacts on wildlife: Draft. Ministry of Environment, Ft. St. John.

Parker**,** K.L., R.G. White, M.P. Gillingham & D.F. Holleman. 1990. Comparison of energy metabolism in relation to daily activity and milk consumption by caribou and muskox neonates. *Can. J. of Zool*. **68**: 106-114.

Racey, Gerald D., K. Abram, W.R. Darby, H.R. Timmermann & Q. Day. 1991. Can woodland caribou and the forest industry coexist: The Ontario scene. *Rangifer* No.1 - Vol. XII. Proceedings of the 5th North American Caribou Symposium.

Richens, V.B. and G.R. Lavinge. 1978. Response of white-tailed deer to snowmobiles and snowmobile trails in Maine. *Can. Field Nat.* **92** (4): 334-344.

Rost, G.R. and Bailey, J.A. 1979. Distribution of mule deer and elk in relation to roads. *J. Wildl. Manage*. **43** (3): 634-641.

Seip, Dale R. 1991. Predation and caribou populations. In *Proceedings of the 5th North American Caribou Workshop*, Yellowknife, N.W.T.

Shideler, R.T., H.H. Robus, J.J. Winters & M. Kuwada. 1986. Impacts of human developments and land use on caribou: A literature review, I. A world-wide perspective. Alaska Dep. Fish & Game, Div. Habitat, Tech. Rep., 86-2.

Simpson**,** Keith. 1987. The effects of snowmobiling on winter range use by mountain caribou. Wildlife working report *WR-25.* Wildlife branch, Nelson BC.

Stemp, R.E. 1983. Heart rate responses of bighorn sheep to environmental factors and harassment. M.Sc. Thesis*,* University of Calgary, Alberta. 314p.

Stevenson, S.K. and D.F. Hatler. 1985. Woodland caribou and their habitat in southern and central British Columbia, Volume 1. Land Management Report. No. 23. British Columbia Ministry of Forests, Victoria. 355p.

Tyler, N.J.C. 1991. Short-term behavioural responses of Svalbard reindeer *Rangifer tarandus platyrhynchus* to direct provocation by a snowmobile. *Biol.Conserv.* **56**: 179-194.

Valkenburg, P. and J.L. Davis. 1983. The reaction of caribou to aircraft: A comparison of two herds. In *Proceedings of the First North American Caribou Workshop,* ed. Martell, A.M. and D.E. Russel. Whitehorse, Yukon, p7-9.

Weisenberger, Mara E., Paul Krausman, Marc Wallace, Donald De Young & O. Eugene Maughan. 1996. Effects of simulated jet aircraft noise on heart rate and behaviour of ungulates. *J. of Wildl. Manage*. **60** (1): 52-61.

Whitten, K.R. and R.D. Cameron. 1985. Distribution of calving caribou in relation to the Prudhoe Bay oil field. In *Proceedings of the First North American Caribou Workshop,* ed. Martell, A.M. and D.E. Russel. Whitehorse, Yukon, p28-29.

Wiltshire**,** Howard, Susan Shipley & John Nakata. 1978. Impacts of off-road vehicles on vegetation. *Trans. N. Am. Wildl. Resour. Conf*. **43**: 131-139.

Yarmoloy, Cornel, Max Bayer & Valerius Geist. 1988. Behaviour responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. *Can. Field-Nat*. **102** (3): 425-429.

Young, Jim. Personal Communication 1997. B.C. Ministry of Environment and Lands, Wildlife Branch. Williams Lake, B.C.

VII. Appendix 1