Session three

Caribou & Human Activity

The Eight North American Caribou Workshop,
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Brief communication

Caribou behaviour near BHP's Ekati Diamond Mine, Northwest Territories, Canada, during the first year of construction

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Introduction

The main objective of this study was to measure impacts that mine construction has on caribou, with reference to group size distribution, seasonal movements, and behaviour of the Bathurst caribou herd which migrate through the area.

Study area

BHP's Ekati Diamond Mine is located in the Northwest Territories, Canada, about 300 km northeast of Yellowknife. At approximately 64°40'N latitude and 110°43'E longitude, the mine site is located about 80 km north of the treeline in tundra habitat. The mine occurs within the geological region known as the Slave Geological Province. The 1997 wildlife study area was approximately 1600 km^2. The northern boundary was extended to include the Sable Lake area; a main part of the claim block where exploration was still occurring.

Methods

Fortythree helicopter aerial surveys were flown between 16 May and 2 October 1997 in the study area to document location of caribou groups, plus their size and direction of movement.

Focal animal (reaction to potential stressors) and scan sampling (activity budgets; 8 min interval) were used to document caribou behaviour on the mine site and over 2 km from the mine site (control areas). Behaviours recorded were feeding, bedded, standing, walking, trotting and running. Reactions to potential stressors were noted from 0 (none) to 3 (severe, runs away).

Results

Relative abundance and seasonal movements of caribou

Caribou group size was not affected by proximity to Ekati Diamond Mine during either the northern (n=98, P>0.50) or southern (n=174, P>0.30) migration.

As caribou approached the mine during the northern migration, direction changed (χ^2=7.87, df=2, P=0.02), with an increase in NW movement. No caribou were observed crossing the proposed Misery Road route within 5 km of the mine, but sample size was small (n=19). This area did have over 30% boulders and similar habitat farther from the mine also showed less caribou usage. Further work is required to determine whether observed movement patterns are related to mine construction or to other environmental factors.

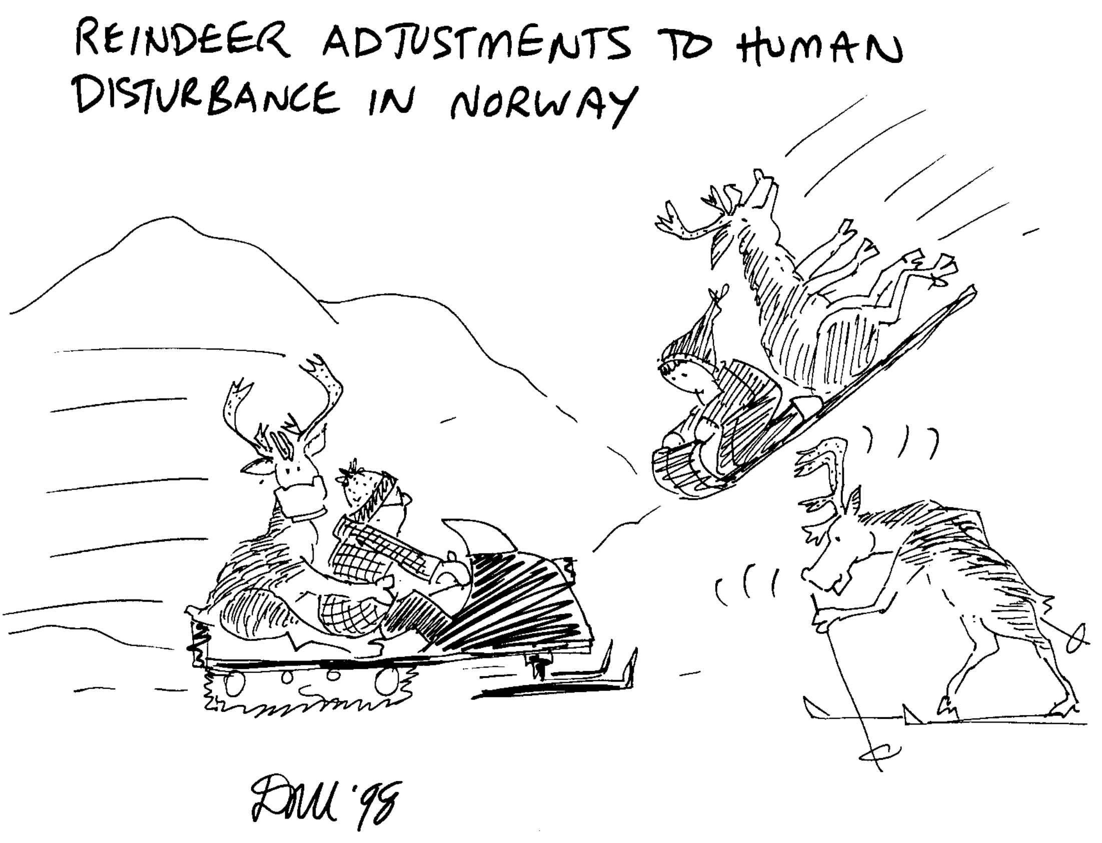
Mine construction and caribou behaviour – Focal animal observations

Caribou did not show any reaction to individual potential stressors, such as truck traffic 60-85% of the time. Running response (type 3 reaction) was only elicited by helicopters flying high or low, and low flying planes. Low flying helicopters were the main cause of disturbance at any level. Overall caribou were being disturbed at any level less than 3% of the time.

Mine construction and caribou behaviour – Scan samples
Movement behaviour (walk, trot, run) was more frequent than comfort behaviour (bed, feed, stand) on the mine site as compared to control sites ($\chi^2=3.24$, df=1, $P=0.07$). Therefore, although not disturbed much by individual stressors, cumulative effect of mine construction activities may reduce caribou comfort behaviours.

Future wildlife effects monitoring
A Mine Operational Phase Wildlife Effects Monitoring Plan was developed using a risk-based planning process. It considered all potential stressors, used previous results to characterize likely exposure and involved aboriginal, government and other stakeholders in its development.

Specific alternate hypotheses concerning mine effects on caribou will be tested in 1998. Results will be used to gauge the efficacy of mitigation measures (such as road construction without berms), to modify mitigation measures as necessary, and to refine the monitoring plan.



Fragmentation, overgrazing and anthropogenic disturbance in Norwegian reindeer ranges

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Abstract: Throughout the last centuries, wild reindeer ranges in Southern Norway have been exposed to substantial increases in human use. Historically, wild reindeer ranges stretched uninhibited across most of the mountains of Southern Norway. The number of human transport corridors, hydroelectric development and associated activities, transmission lines, and orher forms of human "obstacles" have resulted in a fragmentation of the presumed larger range into 26 smaller and more or less isolated populations. In recent decades, possible impacts of fragmentation have been exacerbated by a marked increase in tourism. The present populations have different historical backgrounds. Mixing of wild with once domesticated teindeer, establishment of feral populations, and different environmental conditions, management practices and intensity of human disturbance over time generates inter-population variation. This results in different responses towards human disturbance in each independent population. Response may also vary according to within population variation. Over the last 100 yrs, total wild reindeer range in Southern Norway has decreased, while total number of reindeer, and thus, density, has increased, resulting in substantial overgrazing in a few ranges. This is a combined result of fragmentation and poor management. Effects of disturbance or fragmentation on range access have been documented for some populations. These include loss of peripheral ranges crossed by disturbance corridors and inhibition of traditional movements among ranges, with implications for forage intake and herd productivity. It is possible that an cumulative effect of fragmentation, overgrazing and increase in human disturbance could result in decreased population producrivity. However, it is difficult to generalize and ask; how do wild reindeer react to human disturbances, and will they survive an increase in human activities combined with possible additional fragmentation of their ranges? As we have seen, regardless of fragmentation and overgrazing, separate populations of wild/feral reindeer in Southern Norway differ in their reactions towards anthropogenic disturbances because of their inter- and intra-population variation. We need to ask, can a population survive? We are then asking, can that *population* habituate to human activities and simultaneously adapt to fragmentation and specific management practices? In Norway, ongoing and new research programs have been initiated in separate populations to assess and document interactions between range availability, anthropogenic disturbance, reindeer behavior towards disturbances and herd productivity.

Shifts in the distribution of calving caribou: developing a model for assessing the impacts of development

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Abstract: Fidelity to calving grounds is the accepted standard for identifying discrete caribou (*Rangifer tarandus*) herds. However, quantifying variations in calving distribution has been the subject of considerable debate. We used fixed kernel analyses to estimate spatial properties of the calving distribution of the Central Arctic caribou herd (CAH), 1980-95, based on 183 calving locations from 96 radio-collared females. Size of the total calving area declined from 11 187 km^2 during 1980-1985 to 6585 km^2 during 1990-95. Similarly, size of the concentrated calving area declined from 1209 km^2 during 1980-85 to 483 km^2 during 1990-1995. Calving distribution was bimodal throughout 1980-95, with concentrated calving found both east and west of the Sagavanirktok River. The concentrated calving area east of the Sagavanirktok, without development infrastructures, remained relatively constant in location during 1980-1995. However, the concentrated calving area within the Kuparuk Development Area (KDA) fragmented and shifted south and west. By 1990-95, there was no concentrated calving within the KDA. We conclude that such a shift in calving distribution is the most likely response of the Porcupine caribou herd to future development within its calving ground and should serve as a basis for assessing changes in forage quantify and quality. These changes in forage can then be used to project the effects on calf survival and, hence, population growth under a hypothetical scenario of oil development.

Survival and reproduction of woodland caribou in the boreal region of northern Alberta

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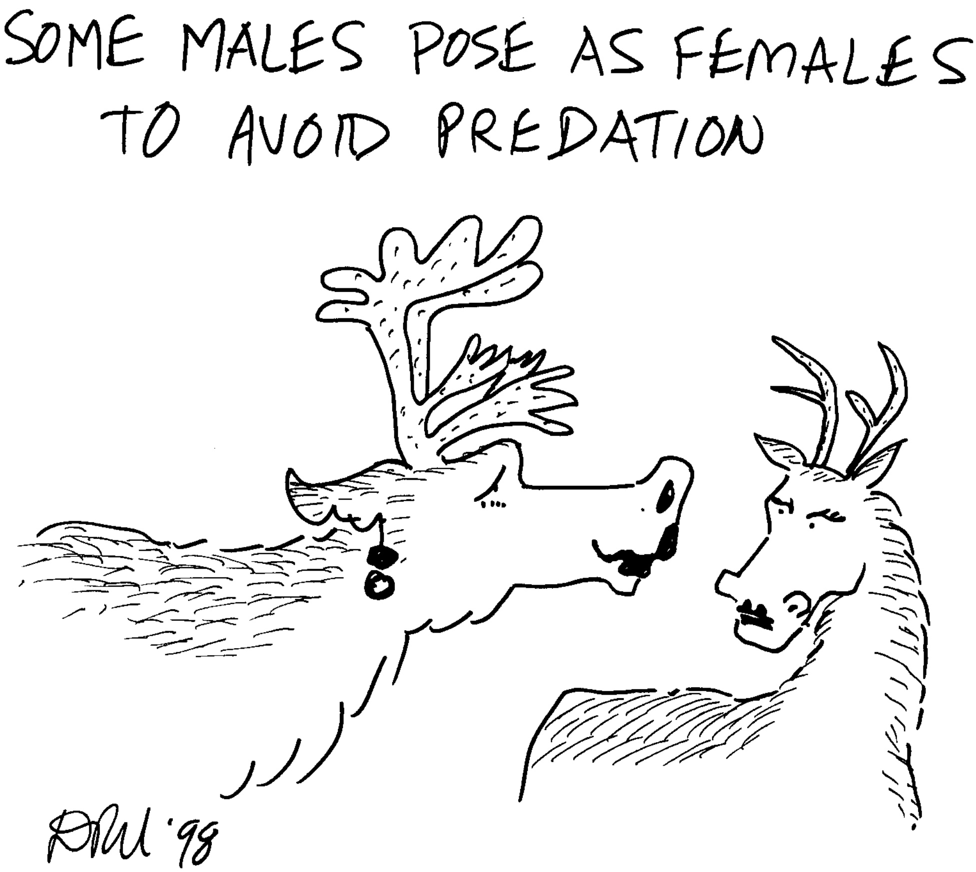
Abstract: A collaborative research program focusing on woodland caribou began in northern Alberta in 1991. The partnership involves representatives from government, industry, universiry and First Nation's. Two main goals exist for the research program: (1) to establish a knowledge base of caribou ecology (e.g., population dynamics, movements, habitat use, etc.); and (2) to evaluate the effects of human activity on woodland caribou. Knowledge acquired through the research program is to provide support for land-use guidelines that will facilitate industrial activity while at the same time conserving woodland caribou populations. This research is conducted by biologists of the Boreal Caribou Research Program (the amalgamated research subcommittees of the Northeast and Northwest Regional Standing Committees on Woodland Caribou). Understanding survival and recruirment are important components of monitoring caribou population dynamics. Since 1991, woodland caribou ecology has been studied in several areas of northern Alberta. A total of 260 caribou have been collared in the areas near Red Earrh (n=36), Caribou Mountains (n=38), Wabasca (n=84), Agnes Lake (n=16), Egg Lake (n=21), Algar Lake (n=18), Crow Lake/other (n=7) and in the Cold Lake Air Weapons Range (n=40). Monitoring of these areas will continue for at least the next two years. In a recent publication, Stuart-Smith *et al.* (1997; *J. Wildl. Manage.* 61: 622-633) reported adult survival in a 20 000 km^2 study area of northeastern Alberta averaged 0.88+/-0.03. Calf survival ro March was 18 calves/100 cows. I will present an update on caribou survival and causes of adult mortality for the northeastern Alberta study areas and compare these values to those for the Red Earth (northcentral Alberta) and Caribou Mountains (northern Alberta near the Northwest Territories border). Implications for population dynamics of woodland caribou will be discussed.



Response distances of Forelhogna reindeer after disturbance by humans on foot or skis

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Abstract: The purpose of rhis study was to measure reindeer fright distances in Forelhogna, Norway, and identify factors involved in Forelhogna reindeer's response towards humans on foot or skis. The study was carried out in March, July and September/October 1996. A comparison among seasons was used in testing whether teindeer in Forelhogna become more shy directly after the hunting season (August 20-September 20) compared to before (July) and winter (March). The reindeer were approached by humans on foot or skis and 5 response distances were measured: sight, fright, flight, running and "curiosity" distance. Seven independent variables (area, season, topography, wind direction, herd size, herd structure and level of insect harassment) were recorded to analyze their individual or combined impacts on the responses recorded. Where the reindeer moved after a provocation in relation to wind direction and terrain was also recorded. When possible, the leader of the group when in flight was recorded for mixed groups. The longest average fright and flight distances ±standard error of the mean, respectively, were recorded in winter (193±16 m, 151±19 m), followed by summer (169±15 m, 142±14 m). The longest running and curiosity distances, respectively, were recorded in summer (487±52 m, 71±36 m) followed by winter (215±30 m, 67±11 m). These 4 distances (same order as above) were shortest in autumn, i.e., after the hunting season (107±9 m, 86±8 m, 198±38 m, 42±11 m). In the winter and autumn seasons, smaller groups (<20) had significantly longer running distances than medium(>20 and <75) and larger groups (>75), with clearer results from the autumn season ($P<0.01$). For the summer season, there were no significant difference between group sizes for running distance. There was no significant difference among days with vs days without insect harassment for any distance. When data was combined for all seasons, the independent variables season and group size, respectively, significantly effected the fright ($P<0.001$, $P=0.004$), flight ($P<0.001$, $P<0.001$) and running ($P<0.001$, $P<0.001$) distances. Large groups showed a curiosity response more often than small groups ($P<0,05$), and when a mixed group showed a curiosity response towards humans, calves <1 yr. were most often the closest animal to the provocer ($P<0.001$). Curiosity distances for adult >1 yr. males and females were almost equal. When provoked, reindeer most often moved up slope 73% (level terrain 11% and down slope 16%) and inro the wind 54% (with the wind 21% and sidewind 25%). When a mixed group (males and females) began to move, it was most often an adult female who led the group ($P<0.05$). Because the fright, flight, running, and curiosity distances were shortest after the hunting season (autumn), we concluded that reindeer in Forelhogna were not more shy (in fact, they were less shy) towards humans after the hunting season compared to before (July) or winter (March).

A methodology for predicting effects of displacement on caribou populations: integrating behavior, habitat value, and population dynamics

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Abstract: We used: 1) observed changes in calving distriburion of the Central Arctic caribou herd (CAH) during a period of increasing oil development, 2) documented avoidance of development infrastructure by parturient caribou, 3) observed changes in the phenology and biomass of caribou forage during a period of climate warming, and 4) observed response in early survival of calves of the Porcupine caribou herd (PCH) to climate induced changes in forage to develop a protocol for assessing potential effects of resource developmenr on the population level of the Porcupine caribou herd. During the period of increasing oil development, 1980-1995, concentrated calving by the CAH gradually shifted south and west until concentrated calving no longer occurred in developed areas. During the warming period, 1985-1996, the amount of forage available to PCH caribou of on 21 June was a function of plant biomass available at calving and the rate of increase in forage during the post-calving period. Similarly, early calf survival was a function of plant biomass at calving and the rate of increase in plant biomass. We shifted the calving distribution of the PCH in relation to hypothesized oil development in a manner observed on the CAH, reinventoried forage available at calving and the post-calving rate of increase inforage, and used the relationship between calf survival and plant biomass to estimate resulting calf survival. Potential effects of development was assessed by comparing estimated calf survival before and after hypothesized redistribution of calving. Potential effects during the period 1985-1990 were minimal, but from 1991 onward potential redistribution of calving caribou substantially reduced calf survival. We will continue to refine and evaluate this model.

Caribou calving grounds - dogma and diversity

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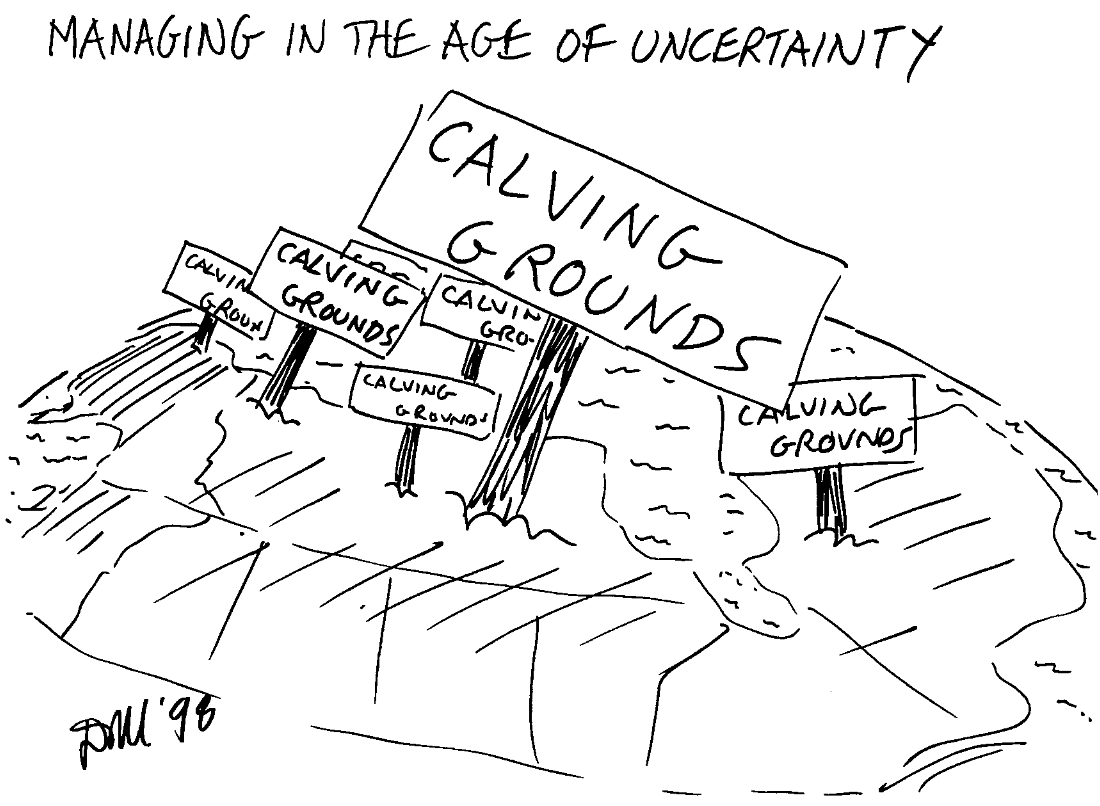
Abstract: Our knowledge for most of the 42 identified caribou calving grounds in the Northwest Territories is fragmentary but is sufficient to reveal the diversity of landscapes and vegetation communities used for calving. We (caribou biologists) frequently state that calving grounds ate the most predictable areas seasonally occupied by caribou. But within the diversity of habitats used for calving there may be different models for fidelity depending on the vegetation and terrain. For three major barren-ground caribou herds in the NWT, we now have about three decades of survey information and satellite telemetry for four years. Individual cows calve at similar locations between years and calving grounds largely overlap between years. However over a longer time scale (decades), calving areas directionally shift and that shift may be rotational with the cows rerurning to areas used decades previously. The fragmentary knowledge that calving ground locations may rotate over decades introduces uncertainty into managing land use activities on calving grounds. And in the face of uncertainty, the precautionary principle should apply to management of caribou calving grounds. (Now published in a report: Gunn & Fournier. 2000. File Rep. No. 123. 177 pp. Available from first author, address above).



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Brief communication

Modeling energetic and demographic consequences of caribou interactions with oil development in the Arctic

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Introduction

We used empirical data from the oilfields and simulation models to assess the energetic and demographic consequences for caribou (*Rangifer tarandus*) encountering oilfield activity and infrastructure. Activity budgets of female caribou moving through an active oilfield during the insect season were used as input for an ENERGY model, which in turn provided the input for a PARTURITION Model, which was used as input into a POPULATION model (Fig. 1). Activity data were collected for Central Arctic caribou herd duting summer in the early 1980s in the newly constructed Kuparuk Oilfield. ENERGY and POPULATION models were developed for the Porcupine caribou herd based on more than two decades of research in Canada and Alaska (Russell *et al.*, in prep.).

Because the models presently are being updated to reflect new findings, the results presented here are preliminary and are intended to demonstrate the conceptual approach, rather than to provide definitive predictions on the impacts of oil development on caribou. Final results will need to be validated by field studies. The potential value of this exercise is to provide a means for quantitatively assessing the impacts of oil development on caribou.

Materials and methods

Activity Budgets

Activity data were collected for Central Arctic caribou herd in the Kuparuk Oilfield during summers 1982-83 (Murphy *et al.,* 1987). Activity budgets were calculated for female caribou under a variety of

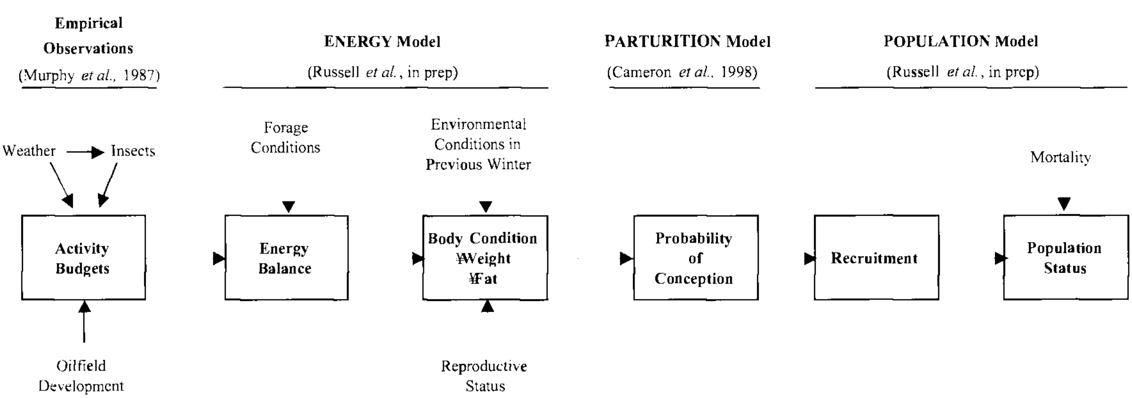

Fig. 1. A conceptual model depicting how empirical data and energy, parturition, and population models will be integrated to predict the effect of oil development on caribou.

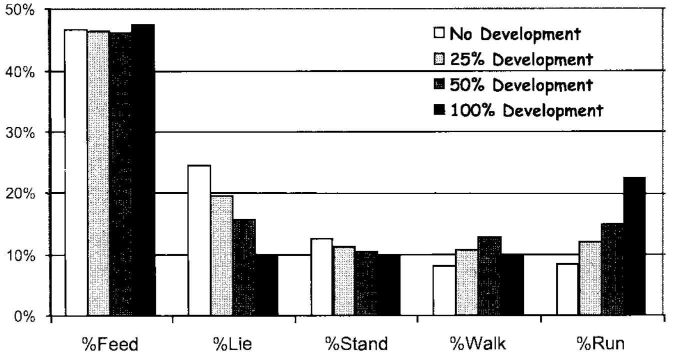

Fig. 2. Activity budgets of female caribou during mid-summer under different development scenarios. Exposure to development ranged from 0 (no development) to 100% development (i.e., animal spent 100% of mid-summer period with 600 m of a pipeline and road with heavy traffic.

insect and disturbance conditions, ranging from mild insect harassment and low disturbance to severe insect harassment and high disturbance (i.e., within 600 m of a pipeline and road with traffic). These budgets then were used to identify distance thresholds where caribou significantly altered their behavior in response to oilfield stimuli. For this modeling exercise, exposure scenarios (time spent in these different conditions) were developed separately for four different summer time periods (post-calving [10-20 Jun], movement [21-30 Jun], early summer [1-15 Jul], and mid-summer [15 Jul-8 Aug]) based on insect conditions recorded during the 1970s - 1990s and on four hypothetical levels of exposure to disturbance, ranging from no exposure to constant exposure (100%). Each exposure scenario (8 scenarios for each season) then was assigned an activity budget derived from empirical data.

Energetics
The ENERGY Model, developed primarily by the Canadian Wildlife Service and the Institute of Arctic Biology (Russell *et al.,* in prep.) simulates the energetic relations of an individual female caribou and predicts metabolizable energy intake (MEI) on a daily basis. Input variables for the model include diet, biomass of forage, nutrient content of forage, and activity budgets. The model was exercised using settings that simulated both harsh and mild winters; however, only the output from the harsh winter scenarios are presented here. The model operates on 15 life-cycle periods; activity budgets during four of these periods (noted above) spanning June-August were modified for this exercise to simulate different insect and disturbance conditions. Output variables used in this exercise include weight of the cow at rut and percent body fat at rut.

Demography
The POPULATION Model, also developed primarily by the Canadian Wildlife Service (Russell *et al.,* in prep.) is linked to the output of the ENERGY Model. For this exercise, fall body fat was used to determine the probability of conception. Other than population size, the values used for the input variables are from the Porcupine caribou herd. Output variables used in this exercise include harvestable surplus and population growth rate assuming a fixed annual harvest.

Results and discussion

Activity Budgets
Insects significantly affected caribou behavior by decreasing time spent feeding and lying and by increasing locomotion. Oilfield disturbance affected caribou primarily by decreasing time spent lying and by increasing locomotion. When caribou were harassed by insects and encountered oilfield disturbances, time spent feeding did not change, although lying decreased and running increased with increasing levels of disturbance (Fig. 2).

Energetics
Summer is a time of energetic stress for female caribou because of harassment by insects and the high costs of reproduction and lactation. The model predicts that very high exposure to disturbance can adversely affect energy balance and cause females to lose fat and body mass (Fig. 3). If caribou were to spend 100% of their time within a zone of high disturbance during a year with severe insect harassment, for example, the model predicts they would lose up to 13% of their body mass (Fig. 3). Under a realistic development exposure scenario, however, an individual animal probably does not spend >25% of their time in a high disturbance zone; at 25% the model predicts <2% loss of body mass (Fig. 3).

Disturbance effects are more pronounced in years of severe insect harassment (Fig. 3), although the effects of disturbance and insects do not appear to be additive. The probability of conception can be

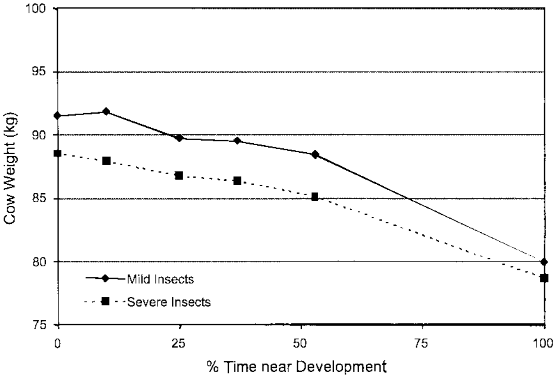

Fig. 3. Effects of insects and disturbance on cow caribou weight in fall as predicted by an ENERGY Model and varied by exposure to oilfield disturbance.

predicted as a function of body fat or body mass in fall (Cameron *et al.*, 1998), therefore, the effects of disturbance on conception rate can be calculated and used as input for the POPULATION Model.

Demography

After a bad winter, a positive rate of growth can be achieved only under mild insect conditions and limited exposure to development (Fig. 4). If caribou were to spend 100% of their time within a zone of high disturbance during a year with severe insect harassment, the population growth rate would decrease by 7% (Fig. 4). Under a realistic development exposure scenario (<25%), the model predicts ≤1% decline in the population growth rate.

Winter conditions appear to have a greater influence on energetics and demography than do insects and disturbance; indeed, the Central Arctic herd experienced a growth phase from 1978 to 1992 when winter conditions generally were mild (Fig. 5).

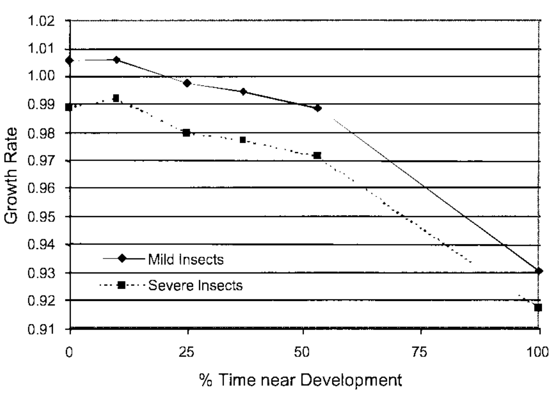

Fig. 4. Effects of insects and disturbance on the population growth rate of an arctic caribou herd as predicted by a POPULATION Model and varied by exposure to disturbance.

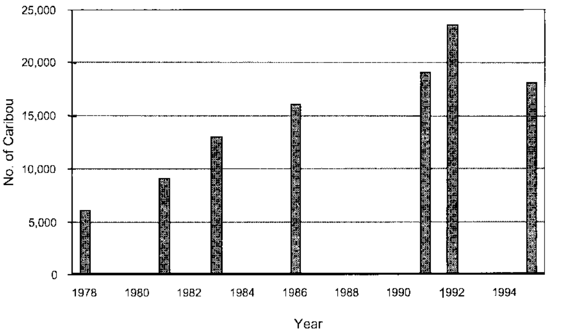

Fig. 5. Population estimates for the Central Arctic caribou herd 1978-1995. Data are from Alaska Department of Fish and Game.

Conclusions

Identifying thresholds of disturbance that cause population-level impacts will provide useful information to assess the costs and benefits of new developments and will help oilfield planners to design infrastructure that accommodates caribou with minimal disruption. Before these models can be applied in this way, however, it will be important to fine-tune all steps in the procedure and to ensure that all empirical input data are as accurate and appropriate as possible. For example, the efficacy of using data from two different herds for model parameters needs to be evaluated. It also is evident from this initial effort that the condition of animals entering the calving season greatly influences model outcomes. Thus, developing clearly defined and defensible rules for exercising the model is essential. We are focusing our current efforts accordingly.

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CONCLUSION: INCREASED LOGGING CAN OCCUR WITH INCREASED AIR TRAFFIC.
AH HA! THEY'RE BACK IN THE CUT BLOCK AGAIN!

Woodland caribou distribution on winter range in relation to clear-cut logging in west central Alberta - preliminary analysis

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Abstract: This study examined the response of a herd of migratory woodland caribou (*Rangifer tarandus caribou*) in west central Alberta to timber harvesting that fragmented about 2% of their winter range. From 1981 to 1996, 45 caribou were radio-collared and monitored during 3 study periods: 1. rhe initiation of timber harvesting activity, 2. the completion of first pass timber harvest (50% temoval), and 3. 1-2 years following the completion of first pass timber harvest on a portion of the winter range. Variables examined were overall winter range size, mean individual winter range size, daily movement rates, distance to closest cutblock, percent of locations in cutblocks on winter range, annual adult survival and calf productivity. Based on preliminary analysis, no population response relative to increased timbet harvesting was detected. In the post harvest study period only 7 of 852 caribou telemetry locations were within a cutblock. Distribution on the winter range varied by study period with movement away from the harvested area during harvest completion and a partial return after harvesting ceased. Distance of radio-collared caribou from the cutblocks was greatest and daily movement rates most restricted during harvest completion. Mean individual winter range size decreased after harvesting was completed but overall herd range size remained the same. Caribou avoided using the area fragmented by logging and concentrated in the undisturbed portion of the winter range. Further analysis will examine in more detail this finding. If fragmentation of the winter range continues through timber harvesting and other industrial activities, the 'spacing out' antipredator strategy used by caribou will be compromised. Based on this initial analysis recommended timber harvesting strategies must ensure 1) sufficient area of usable habitat to support current population, 2) maximization of the volume removed over the smallest area, 3) that forest succession is maintained at the current age and species composition, and 4) avoidance, in the shorr term of presently defined core use areas.

Industrial development and access: effects on movement and distribution of woodland caribou in Northern Alberta

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Abstract: Industtial development and associated road construction have been implicated as factors leading to displacement and declines of ungulates throughout North America. Foresrry and petroleum development have a significant influence on the ground accessibility of many areas throughout Alberta. Woodland caribou are listed as a threatened species in Alberta and, because of this special status, have been the focus of landuse guidelines directed at industry. These guidelines evolved with the intent of minimizing exposure of caribou to human activity through: mapping of caribou zones, application of timing restrictions within some of these zones, and access management. In the absence of conclusive data, the caribou guidelines have applied a conservative approach to industry activity within these zones. A recent, intensive industtial development occurring within caribou zone provided a unique research opportunity to evaluate potential habituation or displacement of caribou. A research project was initiated in 1998 to simultaneously quantify the spatial and temporal use of this development area by humans and caribou. Linear developments (i.e. roads, pipelines) and point sources (i.e. well sites, cutblocks) are documented using a geographic information system. Traffic classifiers have also been deployed to document vehicle volume and type. Caribou movements are being intensively monitored using animal borne GPS collars (n=23). Methods of documenting caribou response and preliminary results are presented.

Fright response of reindeer in four geographical areas in Southern Norway after disturbance by humans on foot or skis

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Abstract: The purpose of this study was to identify factors influencing wild reindeer's fright behavior towards human on foot or skis, and compare this behaviot among 4 geographical areas chosen according to their degree of human activity and hunting. We tested 2 hypotheses; 1.) reindeer that are hunted by humans show stronger fright behavior towards humans after the hunting season than before and 2.) reindeer fright response rowards humans on foot or skis is negatively related to the total level of human activity, including, but not limited to, hunting. Reindeer fright distances were recorded during summer, autumn, and winter in 1 wild, Rondane north/Snøhetta (RN/SH), and 3 feral reindeer populations in Southern Norway; Norefjell (NoF), Ottadalen North (Od), Forelhogna (FoH). The present populations in NoF, Od, and FoH originated from domestic reindeer released or escaped in the 1950s and 1960s. For reindeer in NoF, the total level of human activity has continuously been high, and there was no hunting since the time of their release prior to this study. Reindeet in Od and FoH have been hunted since 1964 and 1956, respectively, and have simultaneously been exposed to a lower total level of human activity compared to NoF. Comparing Od with FoH, human activity in Od is lowest. RN/SH has the lowest level of human activity among the 4 areas, and hunting has occurred since pre-historic time. Fieldwork was conducted during 3 seasons; winter (March), summer (July; before hunting season), and autumn(September/October; after hunring season) in 1992 (NoF and Od), 1993 (RN/SH) and 1996 (FoH). The reindeer were approached by humans on foor or skis and 4 response distances were measured: sight, fright, flight and running. Six independent variables (area, season, topography, wind direction, herd size, and herd structure) were recorded to analyze their individual or combined impacts on the responses recorded. In Forelhogna, the 4 response distances ± standard error of the mean were significantly longer before the hunting season (222±16 m, 169±15 m, 142±14 m and 487±30 m) than after the hunting season (189±11 m, 107±9 m, 86±8 m, 198±38 m). In NoF, Od, RN/SH fright distances before and after the hunting season were almost equal. When data was combined for seasons in each area, the 4 disrances varied significantly among the 4 areas (P<0.001) and were longest in RN/SH (448±24m, 385±24 m, 324±22 m, 2634±350 m), followed by Od (194±8 m, 143±5 m, 91±4 m, 439±72 m) for running distance and FoH (220±19 m, 149±17 m, 122±16 m, 307±59 m) for sight, fright and flight distance. The 4 distances were shortest in NoF (173±14 m, 90±9 m, 38±6 m, 221±36 m). Because all the response distances were not longer after the hunting season than before, we rejected hypothesis 1. At this point, there is not enough evidence to support or reject (test) hypothesis 2. When data were pooled for the 4 areas, geographical area and season had the greatest ovetall effect on the 4 distances (P<0.001 for all distances).