Caribou Conservation Conundrum

by
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The following readings are used in the jigsaw activity for this case.

Photo credit: Jon Nickles (U.S. Fish and Wildlife Service)
http://commons.wikimedia.org/wiki/File:Rentier_fws_1.jpg

Group 1 – Caribou Biology

- Reading A: Caribou Background
- Reading B: Status Update for Woodland Caribou
- Reading C: Caribou Calf Mortality
- Reading D: Wolf Predation, Habitat Loss, and Human Activity

Group 2 – Wolf Biology

- Reading A: Wolf Background
- Reading B: Wolf Diet in Northeastern Alberta
- Reading C: Previous History of Wolves in USA
- Reading D: Movement Responses by Wolves to Industrial Linear Features

Group 3 – Landscape and Landscape Changes

- Reading A: Linear Landscape Features and Caribou Survival
- Reading B: Movement Responses by Wolves to Industrial Linear Features
- Reading C: Persistence and Developmental Transition of Wide Seismic Lines
- Reading D: Quantifying Barrier Effects of Roads and Seismic Lines

Group 4 – Food Web Interactions

- Reading A: Habitat Selection and Spatial Relationships of Black Bears with Woodland Caribou
- Reading B: A Typical Food Web
- Reading C: Prey Enrichment, Apparent Competition, and Incidental Predation
- Reading D: Invading White-Tailed Deer Change Wolf–Caribou Dynamics

Group 1 – Caribou Biology

Reading A – Caribou Background

Excerpt: "Caribou are susceptible to and recover slowly from population declines because of their low rate of reproduction. The main factors leading to caribou declines are habitat loss, degradation, and fragmentation, as well as predation. Loss of caribou habitat, which is permanent, occurs when forest is cleared for agriculture, for example. Habitat degradation means a reduction in the amount or quality of caribou habitat, as happens following such events as wildfires or timber harvesting, or through human disturbance. Habitat fragmentation is the breaking up of habitat areas by roads, timber harvest cut-blocks, pipelines, oil and gas well sites, geophysical exploration lines, and other developments.

"Caribou in the boreal forest require large tracts of relatively undisturbed, older forest habitat in order to spread out so they are harder for predators and hunters to find, and to avoid the linear corridors that predators and hunters use to gain easier access to their prey. Older forests tend to be richer than younger forests in the lichens caribou depend on. They are also less favoured by moose and deer, which as prey species of the wolf, attract this primary predator of caribou."

Source: Caribou, *Hinterland Who's Who,* http://www.hww.ca/en/species/mammals/caribou.html, last accessed 02/05/13.

Photo credit: Dean Biggins (U.S. Fish and Wildlife Service) http://commons.wikimedia.org/wiki/File:Caribou.jpg

Group 1 – Caribou Biology

Reading B – Status Update for Woodland Caribou

Excerpt: "There has been extensive monitoring of woodland caribou populations and habitats in Alberta over the last 20 years; Alberta is a leading jurisdiction in Canada with regard to woodland caribou monitoring. In addition, there has been a large amount of recent research conducted in Alberta and elsewhere on woodland caribou, particularly with respect to effects of industrial and other human activities on caribou populations and habitats.

"Woodland caribou in Alberta have experienced significant declines in both number and distribution since 1900. Sixteen woodland caribou populations now remain in the province; adequate population monitoring data are available for 13 of these populations. Of the 13 populations with sufficient monitoring data, 10 are demonstrating population decline. The 10 caribou populations documented to be in decline occupy 83% of the total area of current caribou range in Alberta, and constitute the majority of caribou occurring in the province. Considering current estimates of caribou population sizes, approximately 70% of all caribou in Alberta occur in populations that are known to be declining. Declines are evident across the province and affect caribou populations in both the Boreal and Southern Mountain areas. More provincial caribou populations are now in sustained population decline than was the case when the first edition of the status document was prepared in 2001."

Source: Alberta Sustainable Resource Development and Alberta Conservation Association. 2010. Status of the Woodland Caribou *(Rangifer tarandus caribou)* in Alberta: Update 2010. Alberta Sustainable Resource Development. Wildlife Status Report No. 30 (Update 2010). Edmonton, AB. 88. Available at http://srd.alberta.ca/Fishwildlife/SpeciesAtRisk/DetailedStatus/Mammals/documents/Status-WoodlandCaribou-inAlberta-Jul-2010.pdf, last accessed 01/30/2013.

Group 1 – Caribou Biology

Reading C – Caribou Calf Mortality

Abstract: "Calf mortality is a major component of caribou *(Rangifer tarandus)* population dynamics, but little is known about the timing or causes of calf losses, or of characteristics that predispose calves to mortality. During 1984–87, we radiocollared 226 calves (less than or equal to 3 days old) in the Denali Caribou Herd (DCH), an unhunted population utilized by a natural complement of predators, to determine the extent, timing, and causes of calf mortality and to evaluate influences of year, sex, birthdate, and birth mass on those losses. Overall, 39% of radio-collared calves died as neonates (less than or equal to 15 days old), and 98% of those deaths were attributed to predation. Most neonatal deaths (85%) occurred within 8 days of birth. Few deaths occurred after the neonatal period (5, 10, and 0% of calves instrumented died during 16–30, 31–150, and greater than 150 days of age, respectively). Survival of neonates was lower (P = 0.038) in 1985, following a severe winter, than during the other 3 years. In years other than 1985, calves born during the peak of calving (approx 50% of the total, born 5–8 days after calving onset) experienced higher (P less than 0.001) neonatal survival than did other calves. Grizzly bears *(Ursus arctos),* wolves *(Canis lupus),* and unknown large predators (i.e., grizzly bears or wolves) accounted for 49, 29, and 16% of the neonatal deaths, respectively. The rate of bear-caused mortalities declined (P less than 0.001) with calf age, and bears killed few calves greater than 10 days old. Wolf predation was not related (P greater than 0.05) to calf age and peaked 10 days after onset of calving. Grizzly bear and wolf predation on neonates during the calving season was a limiting factor for the Denali Caribou Herd."

Source: Adams, L.G., F.J. Singer, and B.W. Dale. 1995. Caribou calf mortality in Denali National Park, Alaska. *Journal of Wildlife Management* 59(3): 584–594.

Group 1 – Caribou Biology

Reading D – Wolf Predation, Habitat Loss, and Human Activity

Abstract: "Woodland caribou *(Rangifer tarandus caribou)* and moose *(Alces alces)* populations in the Alberta oil sands region of western Canada are influenced by wolf *(Canis lupus)* predation, habitat degradation and loss, and anthropogenic activities. Trained domestic dogs were used to locate scat from caribou, moose, and wolves during winter surges in petroleum development. Evidence obtained from collected scat was then used to estimate resource selection, measure physiological stress, and provide individual genetic identification for precise mark–recapture abundance estimates of caribou, moose, and wolves. Strong impacts of human activity were indicated by changes in resource selection and in stress and nutrition hormone levels as human-use measures were added to base resource selection models (including ecological variables, provincial highways, and pre-existing linear features with no human activity) for caribou. Wolf predation and resource selection so heavily targeted deer (*Odocoileus virginiana* or *O hemionus*) that wolves appeared drawn away from prime caribou habitat. None of the three examined species showed a significant population change over 4 years. However, caribou population estimates were more than double those of previous approximations for this area. Our findings suggest that modifying landscape-level human-use patterns may be more effective at managing this ecosystem than intentional removal of wolves."

Source: Wasser, Samuel K., Jonah L. Keim, Mark L. Taper, and Subhash R. Lele. 2011. The influences of wolf predation, habitat loss, and human activity on caribou and moose in the Alberta oil sands. *Frontiers in Ecology and the Environment* 9(10): 546–551, doi:10.1890/100071. Available at http://dx.doi.org/10.1890/100071 (last accessed January 29, 2013).

Group 2 – Wolf Biology

Reading A – Wolf Background

Excerpt:

"The wolf:

- has a highly organized social structure centering on a dominant male and a dominant female
- has been exterminated in many parts of North America
- works hard for its food—a pack kills only about one large mammal for every 10 chased
- howls as a form of communication among packs

"Wolves are territorial. Each pack occupies an area that it will defend against intruders. Sizes of territories vary greatly and are dependent on the kind and abundance of prey available.When neighbouring packs trespass into each other's territories, fights often ensue that frequently result in the death of pack members. Subordinate wolves in the hierarchy are often forced out of the packs. When this happens, the lone wolves may find mates, then search for unoccupied areas where they can establish new packs."

Source: Wolf, *Hinterland Who's Who,* http://www.hww.ca/en/species/mammals/wolf.html, last accessed February 5, 2013.

Photo credit: Gary Kramer (U.S. Fish and Wildlife Service), http://digitalmedia.fws.gov/cdm/singleitem/collection/natdiglib/id/203

Group 2 – Wolf Biology

Reading B – Wolf Diet in Northeastern Alberta

"In northeastern Alberta, wolves mainly prey on moose *(Alces alces)* whereas use of woodland caribou *(Rangifer tarandus caribou)* is largely incidental (i.e., moose and caribou comprise >40% and <1% of the wolf diet, respectively; Stuart-Smith et al. 1997; James et al. 2004). Low use of caribou likely stems from their small size and scarcity relative to moose (154 kg/caribou vs 435 kg/moose; 0.04 caribou/km^2 vs 0.24 to 0.53 moose/km^2; mass and density estimates averaged from data in Fuller and Keith 1981; Hauge and Keith 1981; Edmonds 1988; Renecker and Hudson 1993; Smith 1993; Stuart-Smith et al. 1997; Schneider and Wasel 2000; James et al. 2004; also see Cumming et al. 1996 for an explicit description of moose vs caribou profitability). Furthermore, caribou are found in peatlands whereas moose are predominantly found in adjacent uplands (Bradshaw et al. 1995; Stuart-Smith et al. 1997; James et al. 2004; McLoughlin et al. 2005). Habitat segregation should mean that peatlands are a spatial refuge from wolves because wolves spend most of their time hunting in upland habitat (James et al. 2004; also see Holt 1984). The use of spatial refuges has been well documented for a number of caribou herds across Canada and is generally associated with their local persistence (Bergerud and Page 1987; Bergerud 1988; Ferguson et al. 1988; Bergerud et al. 1990; Seip 1992; Cumming et al. 1996; Rettie and Messier 2000)."

Source: McCutcheon, N. 2007. *Factors affecting caribou survival in northern Alberta: the role of wolves, moose, and linear features*. PhD thesis. University of Alberta. 171 pp.

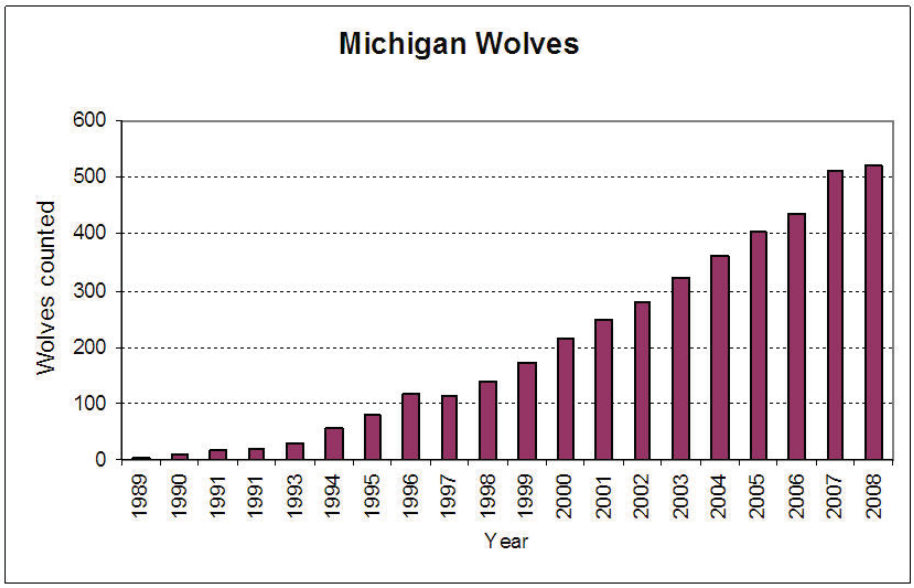
Group 2 – Wolf Biology

Reading C – Previous History of Wolves in USA

- At the federal level, gray wolves were listed as endangered in 1975 due to low numbers as a result of widespread culling. In Wisconsin and Michigan, they were listed as endangered at the state level in 1976.
- Other predators of adult white-tailed deer (grizzly bears, cougars) that were native to these areas were also absent, resulting in white tailed deer being at an historic high.
- Dispersing wolves from Minnesota came into Wisconsin & Michigan in mid-1970s, and wolf population monitoring began in 1979 (see the figure below for the wolf population trend).

Examine the graph below. Why do you think the wolves increased so rapidly? What are some potential consequences? If we cull wolves in Alberta, given this graph, what might be some concerns once the cull has been stopped?

Source: Van Deelen, T.R. 2009. Growth characteristics of a recovering wolf population in the Great Lakes Region. Pages 139–154 In:Wydeven, A.P., van Deelen, T.R., and Heske, E. (editors).*Recovery of Gray Wolves in the Great Lakes Region of the United States: An Endangered Species Success Story*. Springer. New York, NY.



Source: State of Michigan Department of Natural Resources, Wolf Biology and Identification, http://www.michigan.gov/dnr/0,4570,7-153-10370_12145_12205_63607_63608-292026--,00.html#Michigan%20History.

Group 2 – Wolf Biology

Reading D – Movement Responses by Wolves to Industrial Linear Features

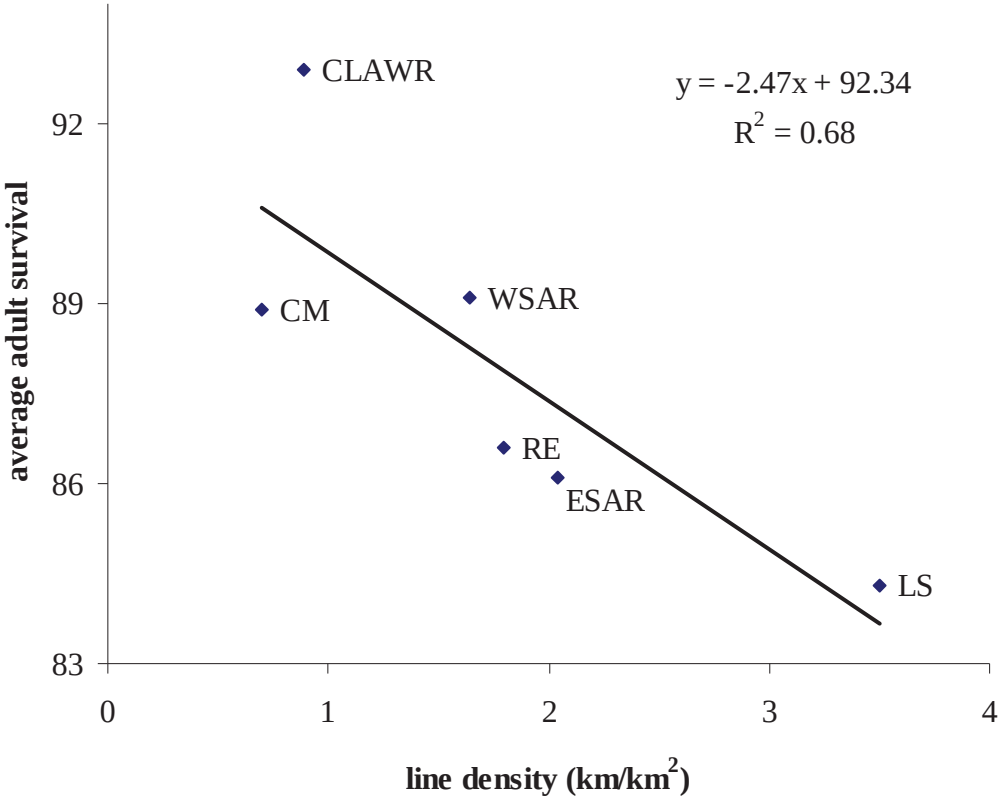
Abstract: "Woodland caribou *(Rangifer tarandus caribou)* populations are declining across most of their range. Predation by wolves *(Canis lupus)* is believed to be the main proximate cause of these declines. However, it has been hypothesized that recent forestry and energy sector activity in caribou range ultimately might have caused population declines by altering wolf–caribou relationships. We tested the hypothesis that industrial linear features influence wolf movements in woodland caribou range in northeastern Alberta, resulting in increased wolf-caused caribou mortalities close to these features. Using step selection functions (SSF) and observed vs. simulated wolf movement paths, we found that wolf movement was influenced by natural linear features (rivers and streams) throughout the year, possibly because they provide ease of travel and high prey abundance. Wolf movement was further influenced by industrial linear features, but use of these features differed depending on line-type and season. Wolves showed strong selection for steps closer to conventional seismic lines during the snow-free season. Likewise, observed wolf movement paths followed conventional seismic lines more closely than simulated paths during snow-free months. Use of seismic lines as movement corridors might result in wolves hunting in caribou-preferred habitats (bogs and fens) more frequently than they did historically, particularly in the snow-free season when most caribou mortalities occur. However, we found no evidence that caribou mortalities occurred closer to industrial linear features than did live caribou. We conclude that wolf use of seismic lines increases predation risk for caribou close to these features, resulting in caribou avoidance of linear developments and thus functional loss of otherwise suitable habitat for caribou."

Source: Latham, A. David M., M. Cecilia Latham, Mark S. Boyce, and Stan Boutin. 2011. Movement responses by wolves to industrial linear features and their effect on woodland caribou in northeastern Alberta. *Ecological Applications* 21:2854–2865. http://dx.doi.org/10.1890/11-0666.1.

Group 3 – Landscape and Landscape Changes

Reading A: Linear Landscape Features and Caribou Survival

Figure 3.1. Average adult female caribou survival as a function of linear feature density (km/km^2) (r^2 = 0.68, based on data in Dzus 2001; Dunford 2003; McLoughlin *et al*. 2003; Neufeld 2006). Different data points represent survival in different caribou ranges across northern Alberta: CM or Caribou Mountains herd, CLAB or Cold Lake Air Weapons Range herd, WSAR or West Side of the Athabasca herd, ESAR or the East Side of the Athabasca herd, REDE or the Red Earth herd, and LS or the Little Smoky herd.



Source: McCutcheon, N. 2007. Factors affecting caribou survival in northern Alberta: the role of wolves, moose, and linear features. PhD thesis. University of Alberta. 171 pp. Used with permission.

Questions to Consider

1. This graph shows the relationship between the density of seismic lines (line density) on the landscape and the average adult survival of caribou. What is the estimated average adult caribou survival in the absence of linear features (i.e., when line density would be zero)?
2. What could be a behavioural adaptation of (a) a predator with respect to the presence of linear features, and (b) prey species with respect to the presence of linear features?

Group 3 – Landscape and Landscape Changes

Reading B – Movement Responses by Wolves to Industrial Linear Features

Abstract: "Woodland caribou *(Rangifer tarandus caribou)* populations are declining across most of their range. Predation by wolves *(Canis lupus)* is believed to be the main proximate cause of these declines. However, it has been hypothesized that recent forestry and energy sector activity in caribou range ultimately might have caused population declines by altering wolf–caribou relationships. We tested the hypothesis that industrial linear features influence wolf movements in woodland caribou range in northeastern Alberta, resulting in increased wolf-caused caribou mortalities close to these features. Using step selection functions (SSF) and observed vs. simulated wolf movement paths, we found that wolf movement was influenced by natural linear features (rivers and streams) throughout the year, possibly because they provide ease of travel and high prey abundance. Wolf movement was further influenced by industrial linear features, but use of these features differed depending on line-type and season. Wolves showed strong selection for steps closer to conventional seismic lines during the snow-free season. Likewise, observed wolf movement paths followed conventional seismic lines more closely than simulated paths during snow-free months. Use of seismic lines as movement corridors might result in wolves hunting in caribou-preferred habitats (bogs and fens) more frequently than they did historically, particularly in the snow-free season when most caribou mortalities occur. However, we found no evidence that caribou mortalities occurred closer to industrial linear features than did live caribou. We conclude that wolf use of seismic lines increases predation risk for caribou close to these features, resulting in caribou avoidance of linear developments and thus functional loss of otherwise suitable habitat for caribou."

Source: Latham, A. David M., M. Cecilia Latham, Mark S. Boyce, and Stan Boutin. 2011. Movement responses by wolves to industrial linear features and their effect on woodland caribou in northeastern Alberta. *Ecological Applications* 21:2854–2865. http://dx.doi.org/10.1890/11-0666.1.

Group 3 – Landscape and Landscape Changes

Reading C – Persistence and Developmental Transition of Wide Seismic Lines

Excerpt: "Seismic exploration is often the first step in the oil extraction process. In brief, it consists of the linear placement of sensitive receivers (geophones) on the ground, i.e. seismic lines. Small explosive charges or mechanical vibrations are created along the ground surface. Geophones record the energy reflected back from subterranean rock and hydrocarbon layers at varying depths. The intensity, wave form, and times for reflection are used to profile the underlying rock layers and potential hydrocarbon layers. Solitary lines of geophones allow for a two-dimensional, cross-sectional resolution while a network grid of geophones with closer spacing produces a more detailed, three-dimensional, topographic map of rock layers. The surface footprint of this exploration can be long linear lines of trails cut into the forest.

"In one of the few studies to examine tree regeneration along seismic lines in Alberta, Revel et al. (1984) found that 23 out of 35 seismic lines in the foothills of the Rocky Mountains had sapling densities of lodgepole pine *(Pinus contorta)*, white spruce *(Picea glauca),* black spruce *(Picea mariana)*, and occasionally balsam fir *(Abies lasiocarpa)* in excess of Alberta's timber regeneration standards. However, there was a significant time lag in achieving these densities (10–30 years) and the height of trees was significantly shorter than those in regenerating trees typically found after harvest. MacFarlane (2003) found no significant differences in the understory vegetation of seismic lines aged from less than 14 years to greater than 23 years in trembling aspen *(Populus tremuloides)* forests of the northeastern Alberta. However, all vegetation communities from all ages of seismic lines were different from interior forest communities. Online communities were unique because they included light tolerant, disturbance associated species."

Source: Lee, P., and S. Boutin. 2006. Persistence and developmental transition of wide seismic lines in the western boreal plains of Canada. *Journal of Environmental Management* 78: 240–250.

Group 3 – Landscape and Landscape Changes

Reading D – Quantifying Barrier Effects of Roads and Seismic Lines

Excerpt: "Woodland caribou in northeastern Alberta tend to be restricted to local populations within peatland complexes (Bradshaw et al. 1995; Stuart-Smith et al. 1997). These populations contain relatively few individuals (Boreal Caribou Research Program, unpublished data), thus the probability of local extinction is high (Richter-Dyn and Goel 1972). Metapopulation theory (Levins 1970) defines dispersal as a key process in the survival of local populations connected by interpatch dispersal. Metapopulations are defined as "systems of such local populations connected by dispersing individuals" (Hanski and Gilpin 1991). Movement between peatland complexes by caribou has been reported in northeastern Alberta (StuartSmith et al. 1997). Any process that affects the connectivity of a landscape will affect dispersal (Fahrig and Merriam 1985; Apeldoorn et al. 1992).

"The effects of habitat fragmentation through habitat loss, avoidance, and the semipermeable barrier effects of roads should be considered in developing strategies to maintain woodland caribou populations in Alberta. Roads that act as semipermeable barriers to caribou movements may make the presence of caribou more predictable in space and time, and hence compromise the 'spacing out' strategy that caribou adopt to reduce predation (Bergerud and Page 1987; Bergerud 1992; James 1999). Barrier effects associated with roads could be more severe at the edges of these peatland complexes, where a combination of inhospitable habitat and man-made barriers could potentially arrest dispersal."

Source: Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2002. Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. *Canadian Journal of Zoology* 80: 839–845.

Group 4 – Food Web Interactions

Reading A – Habitat Selection and Spatial Relationships of Black Bears with Woodland Caribou

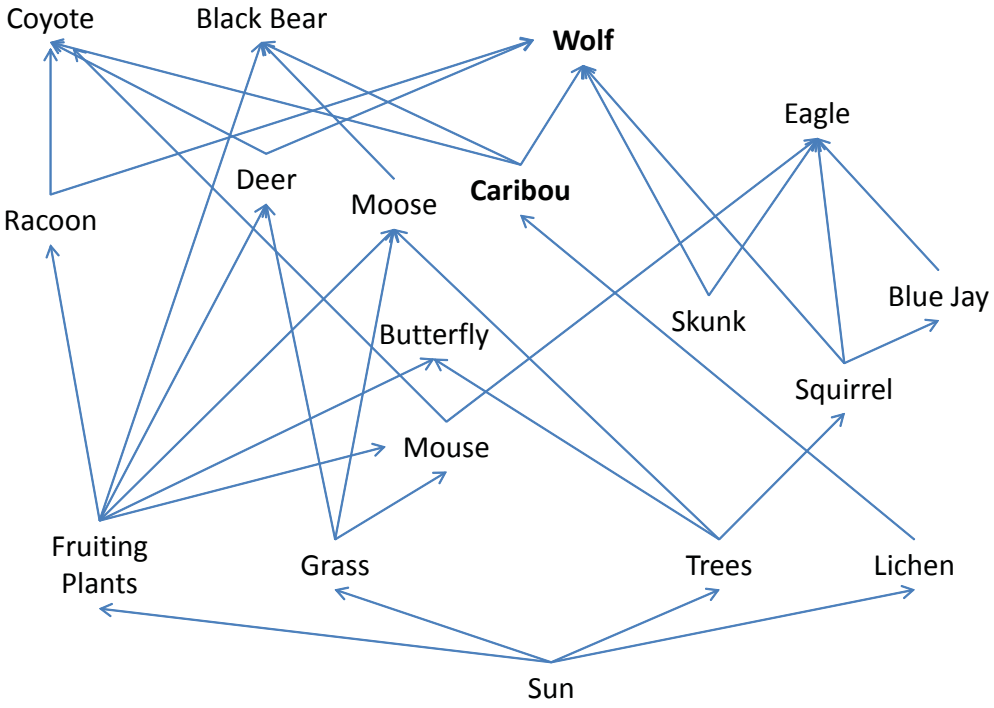
Abstract: "Populations of woodland caribou (*Rangifer tarandus caribou* (Gmelin, 1788)) have declined across much of their range. Wolves (*Canis lupus L.*, 1758) are believed to be responsible for the majority of mortality in adult female caribou; however, we hypothesize that other predators such as black bears (*Ursus americanus Pallas*, 1780) may be important contributors to calf mortality. We assessed habitat selection by black bears and spatial relationships of caribou – black bears during the caribou calving season in northeastern Alberta, Canada. Black bears avoided bogs and fens, while selecting upland mixed woods and various industrial features. Conversely, caribou showed strong selection for bogs and fens relative to bears, supporting the hypothesis that caribou in the boreal forest attempt to minimize predation risk by selecting peatlands to avoid areas frequented by predators. However, habitat selection by individual black bears was highly variable and some bears selected habitats similar to those selected by caribou, i.e., bogs and fens. Bears that specialize on foraging in peatlands might be responsible for some of the predation on caribou calves. Because declines in caribou populations have resulted from a combination of high adult female and calf mortalities, management actions to conserve woodland caribou should consider the entire suite of potential predators rather than focusing only on wolves."

Source: Latham, A.D.M., M.C. Latham, and M.S. Boyce. 2011. Habitat selection and spatial relationships of black bears *(Ursus americanus)* with woodland caribou *(Rangifer tarandus caribou)* in northeastern Alberta. *Canadian Journal of Zoology*, 89(4): 267–277.

Group 4 – Food Web Interactions

Reading B – A Typical Food Web

Consider the following food web. What do you notice about the roles of wolves and caribou and their relationships to other species? The strategy to remove wolves is to poison them with strychnine. How would this strategy impact the food web?



Group 4 – Food Web Interactions

Reading C – Prey Enrichment, Apparent Competition, and Incidental Predation

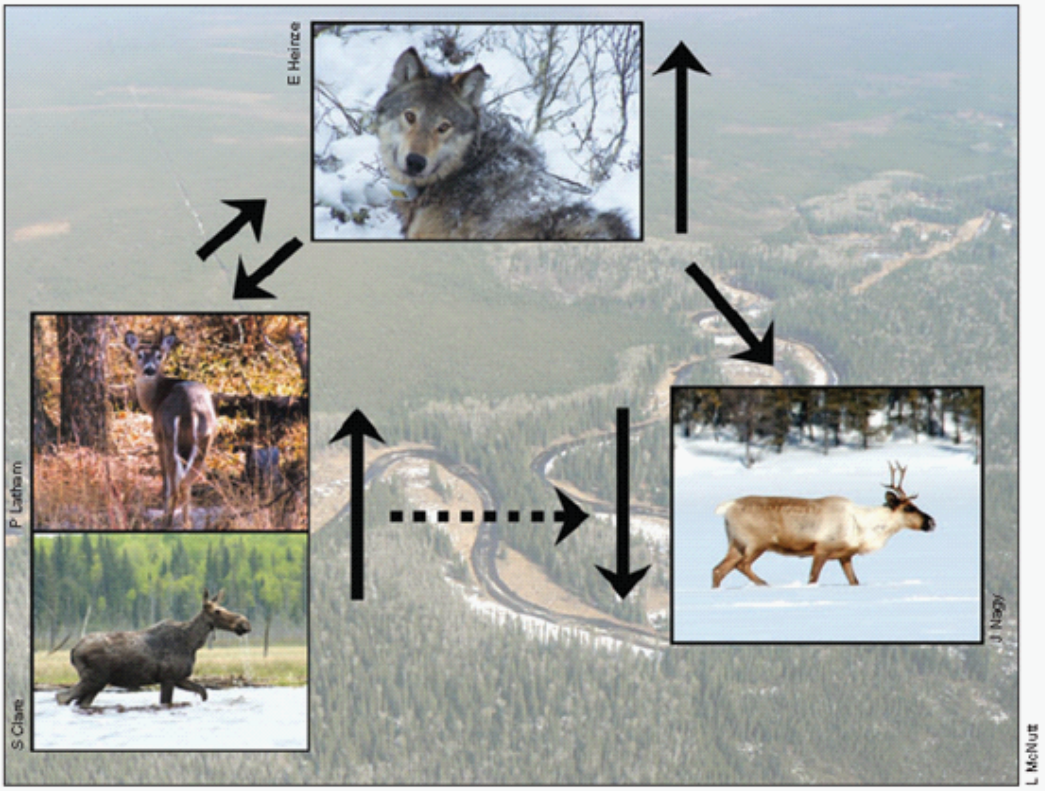


Figure. Prey enrichment, apparent competition, and incidental predation in caribou populations in the oil sands region of Alberta. Populations of wolves and their primary prey, moose, are tightly linked because moose form the bulk of the wolf's diet. Creation of early successional forest by human land use and changing climate has enriched prey biomass in the system by the addition of deer, which has increased wolf densities because wolves have incorporated deer into their diet. Increased wolf numbers have strong effects on caribou numbers by increasing mortality of calves and adults in summer. There is no feedback between caribou and wolves or between caribou and the other ungulates because caribou represent a small proportion of the total ungulate biomass and comprise a small proportion of the wolf diet. Thus, moose and deer numbers affect caribou numbers negatively through the action of their shared predator, the wolf, but not vice versa.

Source: Boutin, S., Boyce, M.S., Hebblewhite, M., Hervieux, D., Knopff, K.H., Latham, M.C., Latham, A.D.M., Nagy, J., Seip, D., and Serrouya, R. 2012. Why are caribou declining in the oilsands? *Frontiers in Ecology and the Environment* 10: 65–67. Figure and caption reprinted with permission.

Group 4 – Food Web Interactions

Reading D – Invading White-Tailed Deer Change Wolf–Caribou Dynamics

Abstract: "Human-caused habitat change has been implicated in current woodland caribou *(Rangifer tarandus caribou)* population declines across North America. Increased early seral habitat associated with industrial footprint can result in an increase in ungulate densities and subsequently those of their predator, wolves *(Canis lupus*). Higher wolf densities can result in increased encounters between wolves and caribou and consequently higher caribou mortality. We contrasted changes in moose *(Alces alces)* and deer *(Odocoileus* spp.) densities and assessed their effects on wolf–caribou dynamics in northeastern Alberta, Canada, pre (1994–1997) versus post (2005–2009) major industrial expansion in the region. Observable white-tailed deer *(O. virginianus)* increased 17.5-fold but moose remained unchanged. Wolf numbers also increased from approximately 6–11.5/1,000 km^2. Coincident with these changes, spatial overlap between wolf pack territories and caribou range was high relative to the mid-1990s. The high number of wolf locations in caribou range suggests that forays were not merely exploratory, but rather represented hunting forays and denning locations. Scat analysis indicated that wolf consumption of moose declined substantively during this time period, whereas use of deer increased markedly and deer replaced moose as the primary prey of wolves. Caribou increased 10-fold in the diet of wolves and caribou population trends in the region changed from stable to declining. Wolf use of beaver *(Castor canadensis)* increased since the mid-1990s. We suggest that recent declines in woodland caribou populations in the southerly extent of their range have occurred because high deer densities resulted in a numeric response by wolves and consequently higher incidental predation on caribou. Our results indicate that management actions to conserve caribou must now include deer in primary prey and wolf reduction programs."

Source: Latham, A.D.M., M.C. Latham, N.A. McCutchen, and S. Boutin. Invading white-tailed deer change wolf–caribou dynamics in northeastern Alberta. *The Journal of Wildlife Management* 75(1): 204–212.