BNF - 1001

Woodland Caribou and the Wuskwatim Hydroelectric Project

James Schaefer
Biology Department
Trent University
Peterborough, Ontario K9J 7B8
Email: jschaefer@trentu.ca

April 2004

James Schaefer is Associate Professor at Trent University. Prior to this university appointment, he served as Regional Biologist with the provincial Inland Fish & Wildlife Division in Labrador. He has studied caribou in Newfoundland & Labrador, Québec, Ontario, and Manitoba.

This document represents a short review of caribou biology, management, and the Environmental Impact Statement (EIS) pertaining to the proposed Wuskwatim hydroelectric project in central Manitoba. The primary focus is on those EIS sections explicit to woodland caribou, especially the Transmission EIS Volume 4 (Wildlife Environment) and Generation EIS Volume 6, Sections 7 (Terrestrial Environment) and 9 (Mammals).

Some features of caribou ecology

The single most salient aspect of caribou ecology and conservation may be space. Indeed, even though all caribou and reindeer belong to one species (*Rangifer tarandus*), two ecotypes are identified based on the extent of their movements and the space-use strategy of females at calving time. Bergerud (1988) distinguished between the migratory ecotype (long distance movements, aggregation of females at calving) and the sedentary ecotype (less extensive movements, over-dispersion of females at calving). The woodland caribou in the Wuskwatim project area belong to this sedentary type. This is part of the "boreal population" listed by the Committee on the Status of Endangered Wildlife in Canada.

The population densities of sedentary caribou tend to be low and relatively invariant. The median density of 28 populations in North America was 0.066 animals/km^2, and the majority (75%) were less than 0.12 animals/km^2 (Schaefer & Mahoney 2003). Bergerud (1992) suggested that sedentary caribou tended to stabilize at 0.06 animals/km^2. Unlike their migratory counterparts, where herds may show 100-fold changes in abundance (e.g., Mahoney & Schaefer 2002b), there is no evidence that sedentary caribou experience dramatic variations in numbers, unless perturbed by humans.

Caribou have immense requirements for space. Home ranges tend to be in the hundreds to thousands of square kilometres. In the Wabowden population, for instance, the average individual home range was 581 km^2 (Brown et al. 2000). Population ranges are considerably larger. The median area of sedentary populations in North America was 9,000 km^2 (Schaefer & Mahoney 2003). Moreover, studies have repeatedly shown that caribou require vast tracts of mature forest (Klein 1982, Schaefer & Pruitt 1991, Terry *et al.* 2000). In southeastern Manitoba, we concluded that forests less than 50 years old (following fire) were unsuitable for woodland caribou (Schaefer & Pruitt 1991).

These demands for space are most acute during calving and post-calving (from late May until late summer). Caribou females "space out", a strategy for avoiding predators (Bergerud 1996), such that they occupy their entire population range during this time (Figure 1). It is hypothesized that the effects of disturbance may be greatest during this season, when young calves are particularly susceptible to predation (Harrington & Veitch 1992). Sedentary females also show strong fidelity to these calving and post-calving sites. Their occupancy is predictable from one year to the next; this is generally not true of winter locations (Brown et al. 2000, Schaefer et al. 2000, Ferguson & Elkie 2004).

There is a fine balance between gains and losses in caribou populations (Bergerud 1974). Females give birth to a single calf, but not in every year. Typically, much mortality occurs in the first few weeks of life (Mahoney et al 1990), such that the rate of recruitment (the number of additions to the adult population) tends to be low to moderate. To offset this limited capacity for increase, the survival of adult females is critical. It is imperative that survival rates remain high, at least 80-85% (Bergerud 1996, Stuart-Smith et al. 1997, Rettie & Messier 1998, Brown et al. 2000). Heightened mortality of adult females, due to predation or hunting for example, tips the demographic balance and causes populations to dwindle rapidly (Schaefer et al. 1999).

Trends in sedentary caribou populations

Woodland caribou are in trouble. In Canada, where they are deemed "threatened", nearly all studies have reported declining populations (Table 1), the recapitulation of a worldwide trend (Mallory & Hillis 1998). In Ontario, for example, forest-dwelling caribou have experienced a dramatic range collapse. Extirpated from one-half of their historic range, they have undergone a northward range recession of 34 km per decade since the late 19th century. If sustained, this implies virtual extirpation from the province before the end of the century (Figure 2; Schaefer 2003). Elsewhere in North America, woodland caribou have disappeared entirely from Vermont (the last caribou was seen in 1840), Prince Edward Island (1873), New Hampshire (1881), Maine (1910), Nova Scotia (1912), Cape Breton (1925), Brunswick (1927), as well as from Minnesota and Wisconsin (Kelsall 1984, Cumming & Beange 1993).

There is no doubt that we are to blame for these declines, although the precise mechanism remains elusive (Bergerud 1974). There is a clear, negative relationship between caribou persistence and human encroachment, whether expressed as the extent of roads (Figure 2), forest harvesting (Schaefer 2003), or a composite indicator. Laliberte and Ripple (2004) used a *human influence index* (which incorporates human population density, landcover changes, access by roads or rivers, and satellite imagery of electrical lighting). This index was compared to an Electivity Index of caribou where negative values indicate avoidance, positive values preference. Of the 17 species of large mammals that showed at least 20% range loss, caribou (and grizzly bears) exhibited the most pronounced sensitivity to human encroachment. With respect to human intrusions, areas of caribou disappearance are the mirror image of their persistence (Laliberte & Ripple 2004).

Anthropogenic habitat alterations bring with them a host of landscape changes that are known to be detrimental to caribou – increases in forest fire frequency, predation, parasitism, and hunting. Increasingly, studies have pointed to refugia from landscape disturbances and these associated factors as key to the persistence of woodland caribou (Bergerud and Page 1987, Seip 1992, Bergerud 1996, Cumming et al. 1996, Stuart-Smith et al. 1997, Rettie and Messier 1998, Nellemann et al. 2003, Schaefer 2003).

Caribou and industrial developments

The most compelling signal of environmental impact on wildlife is demographic, i.e., impairments to survival or reproduction. However, because of the long-lived, mobile nature of caribou, few studies have satisfactorily investigated demographic effects of industrial developments (but see below). Caribou biologists, therefore, generally have relied on the examination of differences in distribution or movements. Given the importance of space in caribou biology, I believe that these attributes are reasonable indicators of anthropogenic impact. For example, restriction of the movements or distribution of parturient females could conceivably compromise their "spacing out" strategy, leading to greater rates of predation, and population demise.

It is important to note that, when inferring impacts, "avoidance" of an affected area need not be complete; nor are anecdotes of animals crossing a corridor a demonstration of the lack of effect. Detrimental effects are demonstrated when use of an area is lower than expected (often determined from a before-after experiment).

There are growing examples of avoidance, well beyond the precise bounds of the landscape change. For example, Shane Mahoney and I (unpublished manuscript) recently investigated the response of caribou from the Middle Ridge herd, Newfoundland, in 9 years of clearcutting (Figure 3). Radiocollared females (but not males; see also Chubbs et al. 1993) exhibited a clear, negative response to clearcuts: they maintaining an average buffer of 9 km from active cutovers which continued to expand after harvest. Such a reaction is consistent with the effects of other anthropogenic landscape changes, where diminished occupancy within 1 km to 5 km is common, although it is occasionally higher, as much as 10 km, for females (Table 2). Dyer et al. (2001) considered their estimate of 250 m from roads and seismic lines as "undoubtedly conservative and a function of small sample size." What is clear is that the physical footprint of industrial developments underestimate the effective loss of caribou habitat (Dyer et al. 2001). In Norway, Nellemann et al. (2003) documented that power lines and roads, covering <1% of reindeer range, left only 25% of the area beyond 4 km of a power line or road.

Differences in this avoidance zone (Table 2) may reflect the degree of human activity associated with the infrastructure (Dyer et al. 2001, Mahoney & Schaefer 2002a, Nellemann et al 2001). This loss of habitat is likely permanent, or at least long-term. In Norway, for example, wild reindeer showed no sign of habituation 6 years after development ceased (Nellemann et al. 2003).

The impact of power lines, in particular, was studied by Nellemann et al. (2001). In 6 of 8 years, diminished use occurred within 2.5 km of power lines (without any specific traffic related to them); density was 79% lower in the 0-2.5 km zone next to the lines versus the 2.5-5 km zone, and females were more sensitive than males. The authors noted that some of these lines were used by hunters and other traffic.

Linear corridors may also fragment caribou range. In Alberta, improved gravel roads with moderate vehicular traffic acted as a semi-permeable barrier to caribou movements, especially in late winter when crossings occurred at 19% of the rate expected (Dyer et al. 2002). Effects were also discernible during other periods; the impact was only marginally significant during calving. The response may depend on traffic volume, but altered caribou behaviour has been detected at as few as 15 vehicles per hour (in Dyer et al. 2002).

In addition to these space use changes, caribou may be at higher risk of predation in the vicinity of linear corridors. James & Stuart-Smith (2000) documented that caribou in Alberta tended to avoid corridors, and that deaths due to predation occurred in closer to corridors than expected. Wolves appear to capitalise on corridors as travel routes, increasing access to caribou range. Humans likely to do the same, but observations of caribou hunting mortality were too infrequent to test this hypothesis rigorously (James & Stuart-Smith 2000).

The Wuskwatim project

The foregoing discussion provides us with some insight of the potential effects of the Wuskwatim hydroelectric development. We can note, in particular, that:

- Caribou operate on broad spatial scales, and need to be managed at commensurate, landscape scales;
- Sedentary caribou appear to be among the most sensitive wildlife species to anthropogenic landscape disturbances;
- The impacts of the project on caribou, both the generation and transmission components, can be anticipated to extend beyond the footprint of the development *per se*.

I have some specific comments on some components of the EIS, below.

The HSI model

In the EIS, alternate routes for the transmission line were evaluated on the basis of caribou habitat types intersected within a 2-km buffer. The HSI approach has its limitations, some of which are acknowledged in the document (Appendix C). Although providing "objective and replicable evaluation" (p.53), the results might also be somewhat misleading. A few points:

- HSI was conducted at the stand level, an inadequate scale to predict caribou occupancy, which is a landscape phenomenon. Forest structure and composition are necessary, but insufficient, attributes for the persistence of woodland caribou. The factors not included in the model (predation, human disturbance, fragmentation; Appendix C, p.4) are often identified as the major limiting factors for forest-dwelling populations.

- The designation of immature forest stands with HSI value of 1 (Table 1-1) is not supported by the literature (e.g., Schaefer & Pruitt 1991).

- A more definitive assessment of alternate routes would be based on space use of caribou in the study area. For instance, evaluation would more convincingly be founded on the number of home ranges intersected by a potential transmission route or the frequency of caribou calving sites in a series of distance classes (up to 10 km) from the transmission route.

Effective habitat loss

It is concluded that both the transmission and generation components of the project will result in effects on caribou that are negative to positive, small, short to long-term, regional and insignificant. Losses due to habitat change are estimated at 0.27 caribou (Transmission EIS, Volume 4, p. 35) to 0.44 caribou (p. 41).

There is inescapable uncertainty with respect to the precise extent of these impacts, but current knowledge (Table 2) clearly implies that the project boundaries *per se* are insufficient. Negative effects on caribou, due to avoidance or heightened mortality, are likely to extend a few hundred metres or perhaps several kilometres. I have explored some plausible scenarios based on 100% loss due to the direct impact of reservoir, road, transmission lines as well as buffers of 250 m, 2.5 km, and 5 km (Table 3) . For simplicity, I assumed that the flooding from the reservoir was a circle of radius of 400 m. The results show a wide range of possible consequences: losses of 230 km^2 for the 250 m buffer, 2032 km^2 for the 2.5 km buffer, and 4073 km^2 for the 5 km buffer (Table 3). These impacts are all considerably larger in magnitude than the 31 km^2 directly impacted by flooding and clearing for rights-of-way.

Based on the density of 0.01 animals/km² (itself a rather low figure), these results suggest that population losses of 2 to 41 caribou (1-21% of the total population) due to diminished habitat from the project. These estimates would not include any mortality from hunting or the disruption of movements across these linear corridors.

Hunting mortality

Increased access by subsistence hunters and poachers would severely jeopardize the persistence of woodland caribou in the study area. As one of the measures to minimize this impact, it is stated that the "Province of Manitoba will be asked to establish a Wildlife Road Refuge under *The Wildlife Act*" (Table 10.7-3). I believe, however, some greater precaution is warranted. Given the clear, detrimental effects of over-harvesting on woodland caribou (Bergerud 1967), such a refuge should be considered a prerequisite, prior to initiation of project construction.

Adaptive management

Predictions of impact have been made. In my view, it is incumbent on the proponent (if this project proceeds) to follow through with testing of these predictions. Indeed, the adaptive management of wildlife, particularly for large-scale developments, means that each such project needs to be treated as an experiment. Long-term monitoring of woodland caribou would support adaptive management, such as the mitigation measures outlined in the EIS.

Baseline data, however, are crucial. Once construction begins, the opportunity for pre-disturbance information is lost forever, a major impediment to understanding (Nellemann et al. 2003). For caribou, such monitoring would entail annual determination of survival rates, movements, home ranges, calving sites (information which can be gleaned from radiotelemetry) and recruitment (which can be gathered from late winter aerial surveys). The benefits of the Wuskwatim project, if approved, must include more than just hydroelectricity. It should include enhanced understanding of the effects of such developments on sensitive species like woodland caribou.

Literature Cited

Bergerud, A.T. (1967) Management of Labrador caribou. *Journal of Wildlife Management*, **31**, 621-642.

Bergerud, A.T. (1974) Decline of caribou in North America following settlement. *Journal of Wildlife Management*, **38**, 757-770.

Bergerud, A.T. & Page, R.E. (1987) Displacement and dispersion of parturient caribou at calving as antipredator tactics. *Canadian Journal of Zoology*, **65**, 1597-1606.

Bergerud, A.T. (1988) Caribou, wolves and man. *Trends in Ecology and Evolution*, **3**, 68-72.

Bergerud,A.T. (1992) Rareness as an antipredator strategy to reduce predation risk for moose and caribou. *Wildlife 2001: Populations* (eds McCullough,D.R. & Barrett,R.H.), pp. 1008-1021. Elsevier, London

Bergerud, A.T. (1996) Evolving perspectives on caribou population dynamics, have we got it right yet? *Rangifer, Special Issue*, **9**, 95-116.

Chubbs, T.E., Keith, L.B., Mahoney, S.P. & McGrath, M.J. (1993) Responses of woodland caribou (*Rangifer tarandus caribou*) to clear-cutting in east-central Newfoundland. *Canadian Journal of Zoology*, **71**, 487-493.

Cumming, H.G. & Beange, D.B. (1993) Survival of woodland caribou in commercial forests of northern Ontario. *Forestry Chronicle*, **69**, 579-588.

Cumming, H.G., Beange, D.B. & Lavoie, G. (1996) Habitat partitioning between woodland caribou and moose in Ontario: the potential role of shared predation risk. *Rangifer, Special Issue*, **9**, 81-94.

Dyer, S.J., O'Neill, J.P., Wasel, S.M. & Boutin, S. (2001) Avoidance of industrial development by woodland caribou. *Journal of Wildlife Management*, **65**, 531-542.

Dyer, S.J., O'Neill, J.P., Wasel, S.M. & Boutin, S. (2002) Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. *J.Wildlife.Manage.*, **80**, 839-845.

Edmonds, E.J. (1988) Population status, distribution, and movements of woodland caribou in west central Alberta. *Canadian Journal of Zoology*, **66**, 817-826.

Ferguson, S.H & Elkie, P.C. (2004) Seasonal movement patterns of woodland caribou (*Rangifer tarandus caribou*). *Journal of Zoology*, **262**, 125-134.

Fuller, T.K. & Keith, L.B. (1981) Woodland caribou population dynamics in northeastern Alberta. *Journal of Wildlife Management*, **45**, 197-213.

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

James, A.R.C. & Stuart-Smith, A.K. (2000) Distribution of caribou and wolves in relation to linear corridors. *J.Wildlife.Manage.*, **64**, 154-159.

Kelsall, J. P. Status report on the woodland caribou *Rangifer tarandus dawsonii* and *Rangifer tarandus caribou*. 1984. Ottawa, COSEWIC.
Ref Type: Report

Klein, D.R. (1982) Fire, lichens, and caribou. *Journal of Range Management*, **35**, 390-395.

Laliberte, A.S. & Ripple, W.J. (2004) Range contractions of North American carnivores and ungulates. *BioScience*, **54**, 123-138.

Mahoney, S.P., Abbott, H., Russell, L.H. & Porter, B.R. (1990) Woodland caribou calf mortality in insular Newfoundland. *International Congress of Game Biologists*, **19**, 592-599.

Mahoney, S.P. & Schaefer, J.A. (2002a) Hydroelectric development and the disruption of migration in caribou. *Biological Conservation*, **107**, 147-153.

Mahoney, S.P. & Schaefer, J.A. (2002b) Long-term changes in demography and migration of Newfoundland caribou. *Journal of Mammalogy*, **83**, 957-963.

Mallory, F.F. & Hillis, T.L. (1998) Demographic characteristics of circumpolar caribou populations: ecotypes, ecological constraints, releases, and population dynamics. *Rangifer, Special Issue*, **10**, 49-60.

McLoughlin, P.D., Dzus, E., Wynes, B. & Boutin, S. (2003) Declines in populations of woodland caribou. *Journal of Wildlife Management*, **67**, 755-761.

Nellemann, C., Jordhoy, P., Stoen, O.-G. & Strand, O. (2000) Cumulative impacts of tourist resorts on wild reindeer (*Rangifer tarandus tarandus*) during winter. *Arctic*, **53**, 9-17.

Nellemann, C., Vistnes, I., Jordhoy, P. & Strand, O. (2001) Winter distribution of wild reindeer in relation to power lines, roads and resorts. *Biological Conservation*, **101**, 351-360.

Nellemann, C., Vistnes, I., Jordhøy, P., Strand, O. & Newton, A. (2003) Progressive impact of piecemeal infrastructure development on wild reindeer. *Biological Conservation*, **113**, 307-317.

Ouellet, J.-P., Ferron, J. & Sirois, L. (1996) Space and habitat use by the threatened Gaspe caribou in southeastern Quebec. *Canadian Journal of Zoology*, **74**, 1922-1933.

Rettie, W.J. & Messier, F. (1998) Dynamics of woodland caribou populations at the southern limit of their range in Saskatchewan. *Canadian Journal of Zoology*, **76**, 251-259.

Schaefer, J.A. & Pruitt, W.O., Jr. (1991) Fire and woodland caribou in southeastern Manitoba. *Wildlife Monographs*, **116**, 1-39.

Schaefer, J.A., Veitch, A.M., Harrington, F.H., Brown, W.K., Theberge, J.B. & Luttich, S.N. (1999) Demography of decline of the Red Wine Mountains caribou herd. *Journal of Wildlife Management*, **63**, 580-587.

Schaefer, J.A., Bergman, C.M. & Luttich, S.N. (2000) Site fidelity of female caribou at multiple spatial scales. *Landscape Ecology*, **15**, 731-739.

Schaefer, J.A. & Mahoney, S.P. (2003) Spatial and temporal scaling of population density and animal movement: a power law approach. *Ecoscience*, **10**, 496-501.

Schaefer, J.A. (2003) Long-term range recession and the persistence of caribou in the taiga. *Conservation Biology*, **17**, 1435-1439.

Seip, D.R. & Cichowski, D.B. (1996) Population ecology of caribou in British Columbia. *Rangifer, Special Issue*, **9**, 73-80.

Smith, K.G., Ficht, E.J., Hobson, D., Sorensen, T.C. & Hervieux, D. (2000) Winter distribution of woodland caribou in relation to clear-cut logging in west-central Alberta. *Canadian Journal of Zoology*, **78**, 1433-1440.

Stuart-Smith, A.K., Bradshaw, C.J.A., Boutin, S., Hebert, D.M. & Rippin, A.B. (1997) Woodland caribou relative to landscape patterns in northeastern Alberta. *J.Wildlife.Manage.*, **61**, 622-633.

Terry, E.L., McLellan, B.N. & Watts, G.S. (2000) Winter habitat ecology of mountain caribou in relation to forest management. *Journal of Applied Ecology*, **37**, 589-602.

Table 1. Rates of population growth (*r*) of sedentary caribou in Canada.

Study location	*r*	Reference
Alberta	-0.04	Fuller & Keith 1981
Alberta	-0.12	Edmonds 1988
Alberta	-0.02	McLoughlin *et al.* 2003
Alberta	-0.08	Stuart-Smith *et al.* 1997
Saskatchewan	-0.05	Rettie & Messier 1998
Manitoba	0.17	Brown *et al.* 2000
Ontario	-0.15	MNR unpublished
Québec	-0.09	Ouellet *al.* 1996
Labrador	-0.22	Bergerud 1967
Labrador	-0.20	Schaefer *et al.* 1999

Table 2. Examples of avoidance distances by caribou of anthropogenic infrastructure and developments, as reported in the literature.

Infrastructure	Avoidance	Reference
Roads and seismic lines	250 m	Dyer et al. (2001)
Oil and gas wells	1 km	Dyer et al. (2001)
Power lines	2.5 km	Nellemann et al. (2001)
Hydroelectric reservoir, access road	3 km	Mahoney & Schaefer (2002a)
Power lines and roads	4 km	Nellemann et al. (2003)
Forest access road	2-5 km	Cumming & Hyer (1998)
Tourist resort	5-10 km	Nellemann et al. (2000)
Clearcuts	9 km	Schaefer & Mahoney (unpublished)
Clearcuts	11 km	Smith et al. (2000)

Table 3. Projected loss of caribou habitat under three scenarios of avoidance beyond the limits of the project.

Project item	Distance (km)	Width (km)	Area directly impacted (km^2)	Additional losses (km^2) with 250 m buffer	Additional losses (km^2) with 2.5 km buffer	Additional losses (km^2) with 5 km buffer
Access road	48	0.06	2.9	24.0	240.0	480.0
Reservoir			0.5	1.3	26.4	91.6
Birchtree to Wuskwatim	45	0.06	2.7	22.5	225.0	450.0
Wuskwatim to Herblet	137	0.11	15.1	68.5	685.0	1370.0
Herblet Lake to Ralls	165	0.06	9.9	82.5	825.0	1650.0
Totals			31.1	198.8	2001.4	4041.6

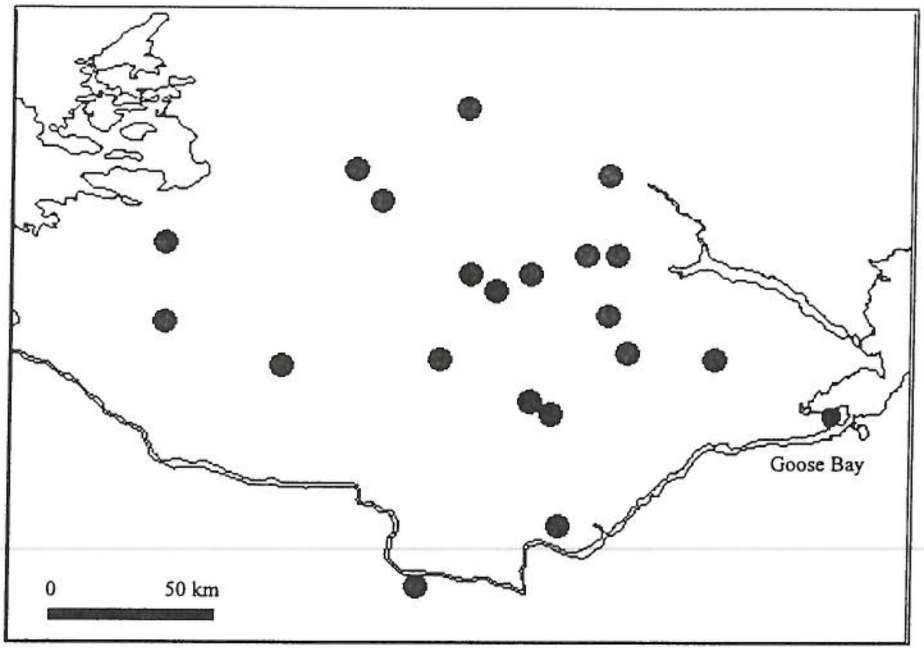

Figure 1. Over-dispersed calving distribution by radiocollared females of the Red Wine Mountains caribou herd, Labrador, 1984. (From Brown 1986, MSc. Thesis, University of Waterloo).

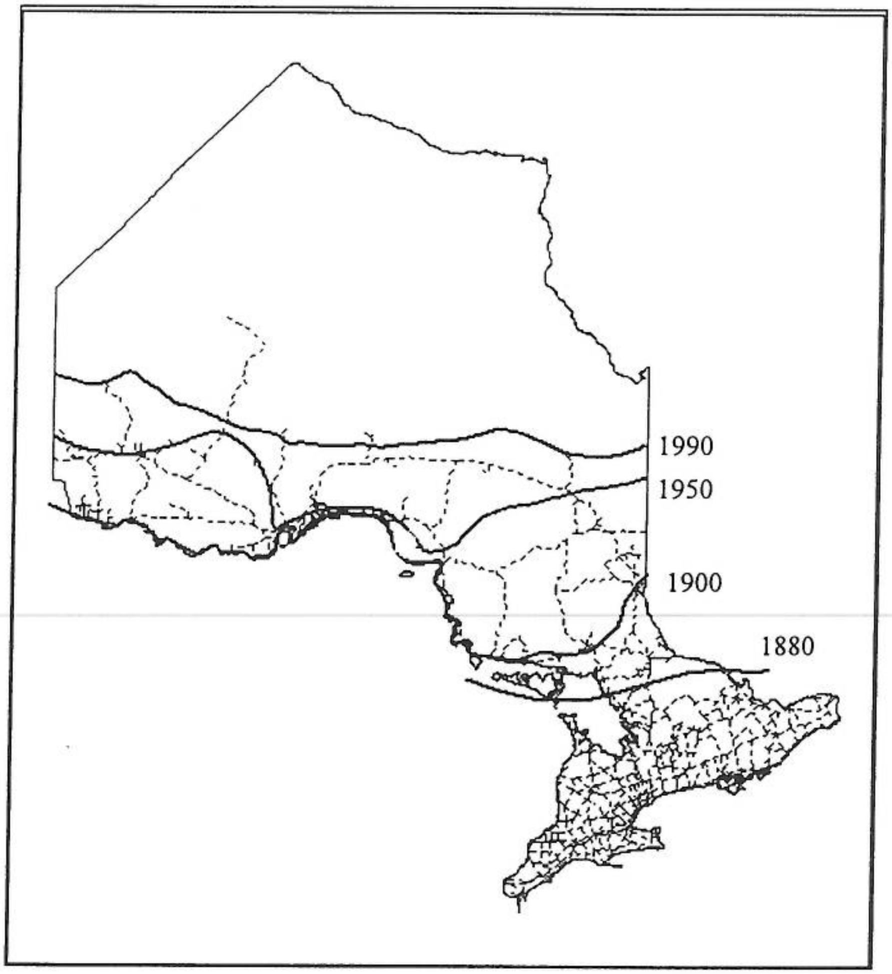

Figure 2. Caribou range recession in Ontario, 1880-1990 (from Cumming & Beange 1993), in relation to current road networks (dashed lines).

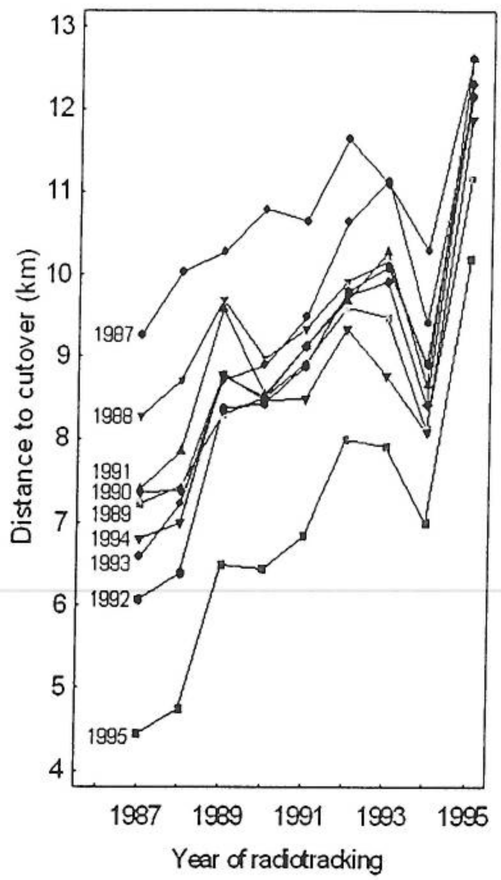

Figure 3. Progressive avoidance by female caribou of the Middle Ridge herd, Newfoundland, to cutovers, 1987-1995. Average distance to the nearest cutover of each age class is shown. (From Schaefer & Mahoney, unpublished manuscript.)