PO Box 7950 Stn Main • Winnipeg, Manitoba Canada • R3C 0J1
(204) 360-4394 • sjohnson@hydro.mb.ca

June 18, 2012

Ms. Cathy Johnson
Secretary, Clean Environment Commission
305-155 Carlton St.
Winnipeg, MB R3C 3H8

Ms. Johnson

RE: Bipole III Transmission Project – Information Request #1 Caribou

Please find enclosed responses to the Caribou Information Requests which were submitted to Manitoba Hydro on May 18th 2012.

We trust the enclosed responds appropriately to your request. Should you have any questions or require further clarification of our comments and information requests please do not hesitate to contact us.

Regards,

Original Signed by Shannon Johnson

Shannon Johnson
Manager Licensing and Environmental Assessment Department
820 Taylor Ave (3)
Winnipeg, Manitoba
R3M 3T1

sj/tk

Clean Environment Commission

Bipole III Transmission Project

Information Request #1 – Caribou

CEC-MH-Caribou

June 2012

Manitoba Hydro

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-1

Question:

P. 39: “Metrics that were significantly different (defined as showing more than 40% difference in mean value) between the two groups were identified as possible metrics to be used in defining and modeling woodland caribou calving habitat”. The rationale for this value as being considered important, as opposed to 20% or 60%, needs to be stated.

This approach used to qualify importance of habitat has not appeared in the literature. How was it derived? And has its applicability been tested, how and where?

The approach used to qualify calving habitat is not referenced, and has not appeared in peer reviewed literature. Again how was it derived and has it been rigorously tested?

The methods used, if adopted from the existing peer-reviewed literature, should be cited as such.

The methods as presented lack statistical rigour; it would be wise to explore other means of identifying important metrics of calving areas. For example, the methods of Van Moorter et al. 2009 (Oecologia 159:669-678) may apply here. These authors compared site characteristics at bed-sites of roe deer fawns to that of paired random points. The analysis suggested by Manly et al. (2002, p. 152. [Manly BFJ, McDonald LL, Thomas DL, McDonald TL, Erickson WP (2002) Resource selection by animals, 2nd edn. Kluwer, Dordrecht]) for these discrete-choice problems is a logistic regression using the difference scores for the habitat variables between the selected and the paired site with a zero intercept. Such an analysis is easy, statistically defensible, and can include habitat variables not considered, e.g., continuous variables such as 'distance to edge'.

Please either apply the suggested methods or provide a clear and supported explanation why not and explain how and why alternate methods can and will be used.

Response:

Relative to animal behaviour the Van Moorter et al. (2005) analyses suggested by the reviewer were considered. Unfortunately, they are inappropriate for the data collected as they require paired used and unused areas, i.e., resource selection sampling protocol C (Manly et al. 2002). The Van Moorter analyses would require the identification of calving areas (available data) and paired empty areas, i.e., areas known to be empty of calving caribou (unavailable data). The November 2011 technical report used data up to March 31,2011. The updated analysis includes new data for the calving season in 2011, increasing the sample size and has been refined by analysing the data with a Resource Selection Function (RSF) use-availability comparison where availability is characterized as a set of randomly placed hexagons; this follows study design 2 and sampling protocol A (Thomas and Taylor 1990, Manly et al. 2002).

In reference to the rationale for metrics to include in candidate resource selection function (RSF) models, summary statistics were calculated independently for each factor in each of the sets of used and available hexagons. The large amount of variation in the values observed for each habitat variable or landscape measure and the need to create a small set of candidate RSF models where some level of *a priori* support exists (Burnham and Anderson 2002) led to development of screening criteria for identifying habitat types and patch metrics to include in candidate RSF model. In addition to consideration of habitat and landscape features known to be related to woodland caribou behaviour elsewhere, any land cover class that occupied less than 5% of available habitat was excluded; as variances tended to be high for most patch metric and distance parameters, any measure that did not show mean use as greatly different relative to its availability was excluded. All candidate models were constructed from the remaining sets of variables.

The analysis for calving habitat is complete. Winter analysis is being reviewed with an anticipated completion by the end of June, 2012. Supplemental material is provided in *CEC/MH-Caribou-Appendix A*.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-2

Question:

P. 42: "Naosap calving patches contained 38.4% coniferous cover types and 25.1% wetland cover types, while calving patches used by the other range consisted of 26.7% coniferous habitat and 62.8% wetlands. This result is expected given there are typically two "ecotypes" of boreal woodland caribou in Manitoba, bog-dwelling and forest-dwelling (Schindler, 2006)."

This conclusion is not supported by the analysis. It cannot be determined if in either case calving patches are really different from each other (no statistics are presented); nor can conclusions be drawn about sub eco-type based on this comparison. The calving-habitat analysis is not well referenced, and has not appeared in current literature. The robustness of the conclusions cannot be confirmed, as the methods seemingly have yet to be evaluated in the peer-reviewed scientific literature.

Please provide the supporting documentation for these conclusions and/or undertake alternate accepted methods of analysis.

Response:

The best fit RSF models of calving habitat have now been used to describe calving habitat selection in the Wabowden and The Bog evaluation ranges as the final preferred route (FPR) bisects potential calving habitat. This follows the approach recommended in questions 4 and 5. The FPR does not intersect Naosap or Reed Lake calving areas and have not been considered as the focus of the analyses is on the Bog and Wabowden herds. Also see *CEC/MH-Caribou-Appendix A*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-3

Question:

P. 42: "However, to ensure high quality habitat, rather than more marginal habitat on the periphery of the core that was being sampled for model development; the 70% isopleth was used."

As this applies to caribou winter habitat, the choice of this isopleth as opposed to 60% or 50% should be referenced. What is normal for caribou, or other ungulates, in defining core ranges? Reference to the literature is needed to support the chosen methods.

Response:

Core use area identification is based on methods developed for moose by Van der Wal (2004) in determining core range for collared moose and adapted for boreal woodland caribou in eastern Manitoba (Schindler et.al 2006). The utilization distribution (UD) isopleth contour representing the area where animals spend the greatest amount of time in the least amount of area was determined as the isopleth value at which the first derivative of the exponential model equals one (Van der Wal, 2004). This method was used by Schindler et al (2006) in assessing the effects of a logging road on winter habitat use by boreal woodland caribou in eastern Manitoba. Using this method, adaptive kernel analysis for each animal by winter month and all animals by winter month were conducted using the Home Range Extension (HRE) in ArcEdit (Rogers & Carr, 1998). Analyses of the various ranges in Schindler et al. 2006 resulted in an Isopleth value of 59%. By replicating this analysis on individual animals and by pooled samples for all winter months, the results remained consistently within one or two percentages of this value. This approach to defining core areas in Manitoba was further adopted by the Eastern Region Boreal Woodland Caribou Committee in determining management zones and boreal caribou habitat management objectives. Using a 70% kernel in the current study provides a slight over-estimate of core area, but accounts for all of the observed variation in this estimate across populations. This provides a conservative estimate more conducive for environmental assessment and management purposes.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-4

Question:

Pp. 42-43. Again, these methods to measure habitat selection are not those available in the current literature. For such a large dataset available on animal movements, it would be expected that more conventional models of habitat selection would be used. This might include resource selection functions (RSFs), or even comparisons of home range habitat selection using selectivity ratios (see Manly et al. 2002 for both types of approaches). RSF models present powerful and easy to use tools to statistically evaluate resource variables that indicate probability of occurrence (review in McLoughlin et al. [2010] Journal of Animal Ecology 79: 4-12). They are the mainstay of current analyses of habitat selection. Almost all major projects with the aim of quantifying the relative importance of habitat variables to species probability of occurrence use these methods. Also see:

Boyce, M.S. & McDonald, L.L. (1999) Relating populations to habitats using resource selection functions. Trends in Ecology& Evolution, 14, 268–272.

Boyce,M.S., Vernier, P.R., Nielsen, S.E.& Schmiegelow, F.K.A. (2002) Evaluating resource selection functions. Ecological Modelling, 157, 281–300.

Please provide justification for the methods used and indicate the rigour by which they have been tested. If these methods are found wanting please indicate what conventional methods will be used, how they will be applied and what the expected product(s) will be, and how long it will take to provide these products?

Response:

Please see response for question *CEC/MH-Caribou-5* and *CEC/MH-Caribou-Attachment A*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-5

Question:

Pp. 87 to 91: Given the widespread use of RSF modelling in the current literature, it is surprising that these methods were not used to assess caribou habitat selection, and instead non-statistical, non-rigorous approaches as described on P. 39-43 (results from Pp. 87-91) were adopted.

Given the abundance of data on caribou movements and habitat metrics available, and enormous cost in data acquisition, the data appear to be analyzed using untested or out-of-date methods that are inconsistent with the current state of the art in modelling animal movements and habitat selection. This leaves the reader to question whether the conclusions, the effects, the assessment of significance and mitigation of the effects are credible.

Please comment on how these data are to be analyzed, how conclusions were reached and the justification and support for the methods and conclusions.

Response:

Resource selection functions (RSF) modelling has been completed for both calving and winter core area habitat selection for both the Bog and Wabowden herds. Multiple candidate RSF models were evaluated in each case and were compared with Akiake's Information Criterion (AIC) analyses to select the best model for each herd in each season. See *CEC/MH-Caribou-Appendix A* for additional detail.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-6

Question:

Pp. 94: Again, such abundant data on wolf movements should have a much more rigorous approach to analysis of habitat use and selection**. RSF modelling and production of maps showing probability of occurrence would be so valuable here**.

Response:

Wolf collaring was undertaken by Manitoba Conservation in collaboration with Manitoba Hydro. The objectives of this collaring and monitoring program were not specific to Bipole III. These data were considered to be ancillary in providing evidence of wolf use of linear features (specifically highway and transmission lines). Wolf monitoring was compromised by both collar failures and chew-offs. It was also difficult to find wolves or packs that were associated specifically with local boreal woodland caribou populations. Also, many collared wolves were highly mobile and travelled in and out of the Project Study Area, far beyond the boundaries of the evaluation ranges.

With respect to habitat selection, the wolf data do not lend themselves for resource selection functions (RSF) modeling due to small sample sizes relative to specific evaluation ranges, and lack of data for all seasons, particularly during summer, when most caribou predation events occur. There is potential for this wolf study to provide valuable information to the collaborating agencies on broader ecological process and interactions between wolves and boreal woodland caribou sharing the same range. Presently, there are insufficient samples of wolves and caribou in the same or overlapping ranges.

The study team is evaluating the utility of additional wolf telemetry data and would recommend a more rigorous distance to linear feature analysis. Recommendations on this specific analysis are being developed and could be completed in early July 2012 for inclusion into the Supplemental Caribou Technical Report.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-7

Question:

Pp. 99 presents information on caribou mortality patterns from collared caribou. Much more can be done with these data to inform about caribou-habitat-wolf dynamics in the study area. For example, the approaches of McLoughlin et al. (2005) present a couple of fairly straight-forward approaches that might be considered. Perhaps compare selection models obtained for caribou while they are alive to where they are found when dead (where their collars are picked up at wolf kills sites). Or better yet, use a survival analysis to ask what is different in terms of habitat use or exposure to disturbance that allows some caribou to live (1) or die (0) during the period of study, using a simple logistic regression model (similar to what we use in medicine to test survival probabilities of patients).This would better inform as to what attributes of habitat are more or less likely to be associated with wolf predation events, and if this is modified by attributes such as distance to linear features, or extent of range burned by fire, or the interaction between the two (e.g., to model cumulative effects).The reference (using caribou) is:

McLoughlin, P.D., Dunford, J.S. &Boutin, S. (2005) Relating predation mortality to broad-scale habitat selection. Journal of Animal Ecology, 74, 701–707.

Using a survival model like that in McLoughlin et al. (2005) would allow the authors to better quantify conclusions using statistics, instead of simply anecdotally reporting that: “The lowest rate of wolf predation on collared females (5%) was observed in the Wabowden range, which is characterized by the greatest degree of habitat fragmentation and anthropogenic disturbance.”The lack of statistical rigour in the authors’ analyses does not provide confidence in the conclusions.

Please provide a more rigorous analysis of these data to provide credible conclusions about the effects.

Response:

Based on the limited data available, known caribou mortality due to wolves is low. The cause of mortality is not known for all dead caribou; with only two caribou mortalities attributable to wolf predation for each of the Wabowden and Bog herds. Consequently there is an inadequate sample for the type of assessment conducted by McLoughlin et al. (2005) who had 55 samples of caribou that had died of predation. There are insufficient data to conduct such analysis at this time.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-8

Question:

P.106 Analysis of use of adjacent areas does not provide conclusions that can be treated with confidence. Rigorous methods to model use of areas adjacent to linear features, relative to what may be expected from random, are available (see papers cited by the authors, such as Dyer et al. 2001, 2002). The before-and-after situation presented here for Wuskwatim would be a perfect place to see this type of analysis. It cannot be told whether the differences obtained, e.g., at 500 m, is something that is different from what we might expect from random (no statistics presented). Dyer's approach would tell us this. It is very easy to do.

Response:

See response for question *CEC/MH-Caribou 9*. Also see *CEC/MH-Caribou-Attachment B*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-9

Question:

P. 107. Caribou avoidance of linear features may be on a finer scale than as modeled, e.g., <500 m.

Please provide comment on the methods and the choice of the scale used as to their applicability and conclusions and/or provide more refined analysis that brings greater credibility to the conclusions.

Response:

A revised linear feature avoidance analysis based on distance to disturbance (in this case, various classes of linear development) was conducted in The Bog and Wabowden evaluation ranges and along the Wuskwatim transmission line based on (Dyer, Neill, Wasel, & Boutin, 2002). Three different classifications of linear features were assessed including transmission lines, highways, and sections of parallel transmission lines and/or highways. Proportion of caribou observations have been compared to an analysis of habitat composition within distance to development buffers (500 m). This analysis has been augmented by incorporating rates of movement within the distance buffers to detect movement responses for animals that crossed the linear feature.

Based on the results of the above analysis, significant differences in habitat composition within buffers have been observed. This is mainly due to the location of the linear features being assessed in relation to core winter range. In many cases, linear features have been constructed along geological features where adjacent habitat is significantly different on each side of the linear feature being assessed. This confounds avoidance with differences in habitat quality on either side of the feature. Consideration to applying a random road analysis similar to (Dyer, Neill, Wasel, & Boutin, 2002) is possible, however the differences in habitat composition among buffers and that some linear features are on the edge of core areas is problematic. Additional random road analysis is being evaluated for areas along the Wuskwatim transmission line in the Wimapedi-Wapisu range. See attachment *CEC/MH-Caribou-Appendix B* for additional details.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-10

Question:

P. 146 and 147 Tables 37 and 38 are not very informative. There is no supporting analysis to support the conclusions made.

Given that additional analysis is required, the conclusions provided on Table 37 and 38 should be able to be supported with statistically tested data.

Response:

The significance of the residual environmental effects based on the results of the updated analysis is dealt with in the response to question *CEC/MH-Caribou-21*.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-11

Question:

P. 163 and Table 38 on p. 147 Stating that range habitat is not suitable for deer and thus disease is not of importance...it is suspected that such a large corridor, kept clear, will become a highway for deer and thus the potential to introduce meningeal worm to the affected ranges may be higher than predicted (although these predictions have not been stated).

Has there been any investigation and analysis for how deer have exploited previous linear disturbances in the boreal forest in Manitoba, perhaps after similar constructions such as Bipole I and II?

What has been the experience with deer moving up established corridors?

A significant effect of Bipole III on caribou,may be how it might enhance the spread of white-tailed deer and hence meningeal worm into woodland caribou habitat.

As such, a more rigorous treatment of this scenario is required. In cooperation with Manitoba Conservation and Water Stewardship (MCWS) the spread of white-tailed deer up the corridor shouldbe modelled in some way, and intensely monitored (perhaps with snow tracking or trail cameras, required reporting of observations), with deer sampled often and tested for disease.

Mitigation may involve special culls of deer along this corridor.

How might climate change allow for the host snail to exist along the corridor? Where are the northern bounds of the host snail and thus the disease at this moment? Wasel et al. 2003 (Journal of Wildlife Diseases, 39: 338-346) showed it to be right on the doorstep of the project, in the Interlake region and to the northeast of Lake Winnipegosis with a hotspot right along the path of the preferred route. Wasel et al. 2003 is already dated, what is the current state of the spread of this disease in Manitoba?

Please comment on Fig. 1 of Wasel et al. 2003 and how the disease overlaps with the proposed corridor, and what might this mean for intrusion of deer, the snail, and hence the disease into caribou habitat.

Please consult with MCWS or others regarding the current state of knowledge regarding white-tailed deer distribution as well as meningeal worm prevalence in the province and provide suggested mitigation measures to prevent this affliction, to the extent possible, in elk, moose and caribou along Bipole III.

Response:

Though initially identified through the literature review and Caribou Technical Experts workshop, and as a result referenced in both the Environmental Impact Statement (EIS) and the Caribou Technical Report as a potential effect, subsequent discussions with wildlife staff in Manitoba Conservation and Water Stewardship (MCWS) and a further review of the available scientific literature would suggest the spread of the meningeal worm *Parelaphostrongylus tenuis*(*P. tenuis*) north along the Bipole III transmission line is not likely to occur.

Despite the presence of existing long term south/north linear corridors (transportation and transmission corridors) in central and western Manitoba, white-tailed deer have not been successful in establishing local populations in boreal forest habitats associated with The Bog range. Occasionally individual animals have been sighted as far north as Thompson, but these sightings are neither frequent nor regular. That being the case it is not expected that sufficient numbers of deer would use the Bipole III right of way to effect the transmission of *P. tenuis*, i.e., it will not lead to the establishment of new white-tailed deer populations.

Additionally, a local population of white-tailed deer has existed in The Pas area for several decades now, presumably as a result of the agricultural activity that occurs there, and there have been no reported cases of affected caribou (or moose) in this area of the province. This would suggest the natural P. tenuis transmission cycle (which includes the normal host – white-tailed deer – and intermediate host – several species of terrestrial gastropods including snails and slugs) – has not been able to become established in the north.

MCWS has not identified *P. tenuis* to be a major concern or issue to caribou (or moose) in this area of the province in the past nor has MCWS communicated an expectation that this will become a concern in the immediate future. As a result MCWS has not undertaken any *P. tenuis* monitoring to date, nor is any planned. There is no scientific data or anecdotal information to suggest that the *P. tenuis* range has changed since that documented by Wasel et al 2003(who in their publication noted that the distribution appeared to have changed little since the previously published survey for *P. tenuis* distribution in 1972).

As a result no monitoring or mitigation measures related to the Bipole III transmission line are recommended for implementation at this time.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-12

Question:

P. 156...the “Reduced Lambda Hypothesis”. **Please cite where this comes from.**

Response:

This term was derived from the following information and will be redefined in the supplemental report as factors in population decline. The current literature links anthropogenic disturbance with increased rates of mortality that exceed recruitment (surviving calves) resulting in population decline. Factors in population decline are summarized below and will be clarified in the supplemental report.

Factors in population decline: The literature is consistent regarding the cause and effect of decline. These include anthropogenic disturbance yielding an increase in early seral stage forests. This change in habitat at the broad scale leads to an increase in the abundance and distribution of moose into critical boreal woodland caribou habitat, followed by increase in wolves (in search of primary prey such as moose, etc.) and incidental predation on boreal woodland caribou. The potential for increased incidental predation on boreal caribou can have significant implications on the sustainability of boreal caribou populations through slight decreases in survival and recruitment, with the primary cause being predation (Schaefer 2003; Vors *et al. 2007*). The response of boreal caribou to separate or “space away” from predators and their primary prey on the landscape is thought to be influenced by habitat alteration and linear development (James 1999; Dyer *et al. 2002*).

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-13

Question:

P. 32... "Aerial surveys were designed to provide estimates of caribou winter density based on observations of animals and tracks." The details on how density estimates were calculated are lacking, other than reference to methods utilized by Manitoba Conservation. How estimates of density were computed for species from helicopter and fixed wing surveys needs to be presented. For example, were density estimates achieved by assuming that all animals within an effective survey strip width were seen? If there was no correction for decreasing visibility with distance from the transect line, then estimates will be biased (but to what extent is unknown). What is the nature of the data available? Can a proper distance-based survey analysis be conducted? This would require information on the length of the transect, and the perpendicular distance from the transect line where groups of caribou (or other species) were encountered. Then, using commonly available software programs, such as "Program Distance" densities can be computed based on "effective strip widths", which models the decline in sightability of caribou as they are encountered (sighted) by the survey aircraft as they occur farther and farther away from the transect line. The commonly applied method allows a presentation of confidence intervals around density estimates, so it is known how likely it is that the surveys were able to capture the true density estimate for an area. The widely read textbooks on distance survey sampling are:

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., and Thomas, L. (2001). *Introduction to DistanceSampling.*Oxford: Oxford University Press.

Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., and Thomas, L. (eds) (2004). *Advanced DistanceSampling.*Oxford: Oxford University Press.

Please provide a detailed description of sampling methods. If possible apply them appropriately and provide an updated analysis of the results.

Response:

See response for question *CEC/MH-Caribou-14*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-14

Question:

P. 82-85…the results of the surveys do not provide much information, other than presence/absence. Only by conducting an analysis as described above, can interpretations with respect to densities be made.

If this is all that can be done with the data, because they were conducted without the ability to estimate densities, this needs to be stated.

Response:

The terminology on Page 32 (of the EIS) was incorrect. Aerial track and observation data were used to assess course scale distribution rather than density of caribou across the broad study area as part of assessing alternative routes. The objectives of using these data were to augment historical and current telemetry data to identify areas of caribou occupation relative to the alternative routes being assessed. Existing Manitoba Conservation data from aerial transect track and observation surveys were conducted in 2004, 2005, 2008, 2009 and 2010 in various locations across the study area as part of fecal DNA research. Project specific surveys were conducted using similar methods in 2010 and 2011 to fill gaps in areas where no coarse scale distribution data were available. As none of these surveys were intended to determine caribou densities, and no data on distance from aircraft to groups were collected, distance-based density calculations are not possible.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-15

Question:

P. 94… "In the census area (17,000 km^2), 83 wolves were observed amongst 20 packs or lone animals. An approximate density of 5 wolves per 1,000 km^{2}was estimated." This estimate seems to be on the low side for areas occupied by wolves in North America (see Messier1994, *Ecology* 75:478-488). The estimate presented appears to only be based on the counts of wolves actually observed (4.88 wolves per 1000 km^2)…this should be stated as a minimum count based on actually observed animals. It is not based on survey results using distance sampling or mark-recapture. Were all estimates of animal density computed this way? Only based as minimum densities based on survey effort (only those animals counted are used to estimate density); if so if any animals were missed during a survey (not seen, which is highly likely), then the surveys will be biased low.

Please clarify the methodology used and the conclusions provided. Is further analysis possible to provide a more confident estimate? If so, provide these results.

Response:

These analyses should not have indicated estimated density. These are minimum counts based on actual animals observed. Surveys have been updated to include counts from the winter of 2012. Further analysis is not possible in the absence of measures of detectability.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-16

Question:

P. 98...Results of the calf recruitment data show surprisingly low calf recruitment. For comparisons, see McLoughlin et al. (2003). On first glance, it would appear that these caribou populations will be declining with such low calf recruitment.

Following accepted methods of determining the population finite rate of increase, lambda, from calf recruitment data and adult mortality data, what are the current estimates of population trajectory? This information/analysis is essential to understand current population trajectories prior to the project commencing. It will also determine what and if mitigation action will be effective.

See this paper for a method to compute population trajectories from the balance between recruitment and adult mortality data:McLoughlin, P.D., E.H. Dzus, B. Wynes, S. Boutin. 2003. Declines in populations of woodland caribou. *Journal of Wildlife Management, 67*(4): 755-761.

Please provide this analysis, including assumptions, justifications, references and conclusions.

On page 7 the authors note that only one range, Naosap, is considered at risk based on the Manitoba Strategy...but it appears that all or almost all should be in a state of decline given the astonishingly low recruitment data, which in some cases was zero calves recruited during the years of study.

Please provide further analysis of available data as described above for all herds that may be impacted by Bipole III.

Response:

See response to question *CEC/MH-Caribou-17* and draft material from supplemental report in *CEC/MH-Caribou-Attachment C*.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-17

Question:

The analysis of demography appears to be very weak given the amount of data on survival and recruitment available (see questions *CEC/MH Caribou-7 and CEC/MH-Caribou-16*)**.**

Is this analysis waiting for additional data on collared caribou and wolves? If so, when can we expect a thorough analysis of demography using accepted methods?

Response:

Agreed, calf recruitment is surprisingly low and is consistent with population decline; however, annual variation is expected and will require monitoring in subsequent years. Survival analyses have been completed using the Mayfield (1975) method; recruitment assessed as a binary variable; and population growth analyses completed following Caughley (1977) and using Monte Carlo simulations. These methods are consistent with those employed elsewhere (Rettie and Messier 1998, McLoughlin et al. 2003). Population growth rates are now presented for each population monitored in the Supplemental Caribou Technical Report. See *CEC/MH-Caribou-Attachment C*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-18

Question:

Map 7…With almost 100% overlap between core ranges of Reed Lake and Naosap, and similarly high overlap between Wheadon and Wimapedi-Wapisu, why are they considered separate caribou populations? The data seem to show far too much overlap to conclude that these are separate ranges?

Can justification and reasoning be provided for this? Will any changes in the amalgamation/separation of herds change the analytical results, conclusions, impacts or mitigation measures relative to Bipole III?

Response:

See response to question *CEC/MH-Caribou-20*

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-19

Question:

P. 16...the authors state: "The sustainability of a local population can be encapsulated by Lambda (the population growth rate); which describes a ratio of recruitment (calf fecundity and survival) against mortality (number of surviving adult females)." Lambda (the greek letter lambda) is actually defined as the population finite rate of increase. It is the annual growth rate of the population when growth is discrete in nature (i.e., based on a single season of births). When it is greater than 1.0, the population is growing (i.e., 1.10 means the population is growing by 10% per year), at 1.0 it is stable, less than 1.0, it is declining. **Some more information for the readers here would be helpful. There are many references on this, perhaps citing a textbook would be helpful here.**

Response:

Agreed. Clarification is required. Assessing population growth or decline (re. response to question 12), has been assed using the method employed by Rettie and Messier (1998), annual survival rates and September recruitment rates were combined to calculate Caughley's (1977) survival-fecundity rate of increase, *rs*, for the herds for which data for both parameters were available. Survival-fecundity rates of increase were also transformed to Lambda values for comparison with other studies. The Supplemental Technical Report provides a preliminary comparison of disturbance regime assessments to rates of increase (Lambda), for a number of local ranges where survival and recruitment rates are available. These are preliminary and will be updated by September 2012 after the results of this year's recruitment surveys. It would be very useful to include this information, but it will not be available at the time of supplemental filing.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-20

Question:

P. 25...Why just present the 90% kernel range bounds? Why not all the analyses? It is understood that the 90% bounds were used to define preferred route maps, but it is also necessary to see where the total ranges are mapped. Where they overlap might tell us about how to better identify ranges (point 18, above). E.g., are the 60% cores of Reed Lake and Naosap still on top of each other? If so, then these ranges should be considered one and the same, which may require changes to routing, management and mitigation action.

Please comment on this and provide any clarifications needed.

Response:

MCWS considers Reed Lake and Naosap to be separate ranges. In the development of evaluation ranges it was understood that there is no standardized approach for determination of local population ranges for management or environmental assessment. In Manitoba and across Canada, there is significant variation among jurisdictions as to how local populations are delineated. It is recognized that there could be other range delineations; however, the criteria used to develop the evaluation ranges are sound and based on Minimum Convex Polygons for each herd using all available data. The distinction between Naosap and Reed is consistent with Manitoba's Conservation and Recovery Strategy for Boreal Woodland Caribou in Manitoba (2006). These range delineations have been updated using the most current data available. Although there is significant overlap between these two ranges, they each have fidelity to calving areas associated with Naosap Lake (Naosap evaluation range) and Reed Lake (Reed

Lake evaluation range) with discernibly different wintering areas. Similar rationale was applied to the Wimapedi-Wapisue and Wheadon River caribou groupings.

This approach was considered a precautionary approach to assessment. Splitting versus lumping of caribou populations is under debate nationally. For the purpose of this assessment, the ranges were split in order to be consistent with MCWS's assessment. By lumping populations into meta-populations, the assessed effects of the final preferred route (FPR) would be reduced as the total area of the FPR would become regionally insignificant. Consequently the assessed effects of the FPR on local populations would likely be lost amidst regional effects.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-21

Question:

Considering further analysis as described above, provide an updated effects assessment and where effects are considered residual and significant, provide specific mitigation plans in as much detail as possible (with assumptions, justification and references), developed in consultation/cooperation with MCWS.

Response:

Effects assessments are provided in the EIS and further documented in the November 2011 Caribou Technical Report. Any new effects assessments resulting from the further analysis described above (Q. 20) on the final preferred route (FPR) will be reported in the Supplemental Caribou Technical Report. Associated mitigation plans will be included in the Environmental Protection Plan for the project.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-22

Question:

Provide a complete cumulative effects assessment for caribou, considering all past (Hydro and others), present and projected future projects.

Response:

A comprehensive cumulative effects assessment will be included in the Supplemental Caribou Technical Report which will be provided to the CEC, by Manitoba Hydro. It will incorporate the methods used by Environment Canada's Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal Population in Canada by assessing current and future range disturbance regimes.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-Appendix A

Calving Habitat Selection

Woodland caribou respond to habitat at various scales. These analyses examine behaviour within the population range of each of the two woodland caribou herds. The coarser scale selection, i.e., the selection of the population range from within the region, was not examined but should represent the scale at which more important behavioural decisions are made (Rettie and Messier 2000, Gustine et al. 2006a, 2006b).

Methods

The calving area habitat selection study design corresponds to study design 2 and sampling protocol A as described by Manly et al. (2002); use hexagons represent calving areas used by marked individuals and available area is represented by a large sample of hexagons placed randomly within each population range.

To create candidate models the summary data for the use and available hexagons were screened. Any land cover class that occupied less than 5% of available habitat was excluded; as variances tended to be high for most patch metric and distance parameters, any measure that did not show mean use as < 50% or >200% relative to its availability was excluded. This was done independently for each of the Wabowden and Bog herds. The list of retained variables retained for each herd (Table 1) includes peatland habitat, dense conifer forest and measures related to habitat fragmentation (median and mean patch size) and amount of disturbance (distance to young forest). These are variables that have been identified as important habitat variables in other studies of woodland caribou inhabiting similar areas (Stuart-Smith et al. 1997, Rettie and Messier 2000, McLoughlin et al. 2005, Brown et al. 2007).

Table 1: Parameters retained for modelling habitat selection for the Wabowden and Bog herds following preliminary screening.

Herd	Land Cover Classes	Patch Metrics	Distance Measures
Wabowden	Water, ShrubTall, WetTreed, WetShrub, WetHerb, ConDens	MedPS	DistYoun
Bog	Water, WetTreed, WetShrub, WetHerb, ConDens	MedPS, MPS	DistYoun

Seven and ten candidate models were created for Wabowden and the Bog herds respectively; the difference a consequence of two separate patch metric measures being retained for the Bog. It was not necessary to rescale the data prior to conducting the analyses (Boyce et al. 2002). Logistic regression was applied to the sets of 200 ha hexagons for each of the Bog and Wabowden caribou herds. Model selection was based on unbiased estimator (AIC_c value; Anderson 2008, p. 60) resource selection functions (RSFs) were produced for each herd. Following selection of the optimal model for each herd that model was also applied to the other herd to check for fit. The RSFs identify habitat attributes important to individual female woodland caribou during the calving season (Gustine et al. 2006a).

Results

For the Bog caribou herd, the best model and four of the top five models all contained the three wetland habitat types and distance to young forest (Table 2). Although the initial parameters differed between the two herds, when the parameters from the top model for the Bog herd were applied to the data for the Wabowden herd the model fit was better than the best model from the initial set of Wabowden models (Table 3). While the model parameters are the same for the top models for each herd, the coefficients differ (Table 4). All models take the form:

$$w(x)=\exp(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \ldots + \beta_p x_p)$$

where β_i are the selection coefficients estimated from the logistic regression for each of the p parameters and x_i are the measured values for those parameters.

Table 2. Models, number of parameters, Akaike's Information Criterion, and Δ AIC_c for models for calving habitat selection analysis for the Bog caribou herd (n = 587 hexagons: 30 calving areas and 557 random).

Model[a]	K	AIC_c	Δ AIC_c
DistYoun + MPS + WetHerb + WetShrub + WetTreed	6	207.27	0.00
DistYoun + MPS + WetHerb + WetShrub + WetTreed + ConDens	8	209.21	1.94
DistYoun + WetHerb + WetShrub + WetTreed + ConDens	7	209.23	1.96
ConDens + DistYoun + ShrubTall + Water	6	210.54	3.27
DistYoun + WetHerb + WetShrub + WetTreed + ConDens + Water	8	211.01	3.74

[a] Parameters in models: see definitions of Land Cover Classes for WetHerb, WetShrub, WetTreed, ShrubTall, ConDens, and Water. MPS is mean patch size of habitat polygons within the hexagon; DistYoun is distance to young forest from the patch centroid.

K – the number of parameters in the model

AIC_c – Akaike's Information Criterion corrected for small sample sizes

Δ AIC_c – difference in AIC_c from the best model

For both herds the coefficients indicate positive relationships with the three wetland cover types in the models, i.e. a preference for wetland habitat. The negative relationships observed with mean patch must be regarded cautiously as the confidence intervals for both herds include zero, suggesting that there may be no consistent response to patch size. The key difference between the models for the two herds is the coefficients for distance to young forest observed; the coefficient is positive in the model for the Bog herd and negative in the model for the

Wabowden herd. This suggests that within their population ranges Wabowden animals have a preference for young forests while Bog herd animals avoid young forests.

Table 3. Models, number of parameters, Akaike's Information Criterion, and Δ AIC_c for models for calving habitat selection analysis for the Wabowden caribou herd (*n* = 602 hexagons: 35 calving areas and 567 random).

Model[a]	*K*	AIC_c	Δ AIC_c
DistYoun + MPS + WetHerb + WetShrub + WetTreed	7	226.65	0.00
ConDens + DistYoun + ShrubTall + Water	6	226.84	0.21
ConDens + DistYoun + MedPS + ShrubTall + Water	7	228.38	1.73
ConDens + DistYoun + WetHerb + WetShrub + WetTreed + Water	8	231.22	4.57
ConDens + DistYoun + MedPS + ShrubTall + WetHerb + WetShrub + WetTreed + Water	10	231.57	4.92

[a] Parameters in models: see definitions of Land Cover Classes for WetHerb, WetShrub, WetTreed, ShrubTall, ConDens, and Water. MPS is mean patch size of habitat polygons within the hexagon; MedPS is median patch size; DistYoun is distance to young forest from the patch centroid.

K – the number of parameters in the model

AIC_c – Akaike's Information Criterion corrected for small sample sizes

Δ AIC_c – difference in AIC_c from the best model

Table 4: Resource selection function (top AIC model) parameters and their coefficients (95% Confidence Intervals in parentheses) for the Wabowden and Bog caribou herds.

Parameter	Wabowden herd model coefficient	Bog herd model coefficient
B0: Intercept	-4.539 (-6.009 to -3.068)	-7.060 (-9.347 to -4.773)
B1: DistYoun	-0.502 (-0.805 to -0.199)	0.298 (0.139 to 0.457)
B2: MPS	-0.073(-0.148 to 0.002)	-0.022 (-0.064 to 0.020)
B3: WetHerb	0.026 (0.015 to 0.037)	0.025 (0.011 to 0.039)
B4: WetShrub	0.016 (0.004 to 0.028)	0.019 (0.003 to 0.035)
B5: WetTreed	0.026 (0.014 to 0.038)	0.025 (0.011 to 0.039)

Literature Cited

Anderson, D.R. 2008. Model based inference in the life sciences. Springer, New York, NY, USA. 184 pp.

Boyce, M. S., P.R. Vernier, S.E. Nielsen, and F.K.A. Schmiegelow. 2002. Evaluating resource selection functions. Ecological Modelling 157:281-300.

Brown, G.S., W.J. Rettie, R.J. Brooks, and F.F. Mallory. 2007. Predicting the impacts of forest management on woodland caribou habitat suitability in black spruce boreal forest. Forest Ecology and Management 245:137-147.

Gustine, D.D., K.L. Parker, R.J. Lay, M.P. Gillingham, and D.C. Herd. 2006a. Interpreting resource selection at different scales for woodland caribou in winter. Journal of Wildlife Management 70:1601-1614.

Gustine, D.D., K.L. Parker, R.J. Lay, M.P. Gillingham, and D.C. Herd. 2006b. Calf survival of woodland caribou in a multi-predator ecosystem. Wildlife Monographs 165:1-32.

Manly, B.F.J, L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 2002. Resource selection by animals, Second Edition. Kluwer Academic Publishers, Dordrecht, Netherlands. 221 pp.

McLoughlin, P.D., J.S. Dunford, and S. Boutin. 2005. Relating predation mortality to broad-scale habitat seelction. Journal of Animal Ecology 74:701-707.

Rettie, W.J., and F. Messier. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23:466-478.

Stuart-Smith, A.K., C.J.A. Bradshaw, S. Boutin, D.M. Hebert, and A.B. Rippin. 1997. Population parameters of woodland caribou relative to landscape pattern in northeastern Alberta. Journal of Wildlife Management 61:622-633.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-Appendix B

The following is a draft excerpt from the forthcoming Supplemental Caribou report.

Regional Linear Effects Analysis

An analysis of boreal woodland caribou use and movement near existing linear development was conducted for areas near and adjacent to major transmission lines and highways for the Bog and Wabowden evaluation ranges to assess if caribou avoidance of linear features in the Bipole III Study Area is consistent with typical effects of linear development found in the literature. Three different classifications of linear features were assessed and included transmission lines, highways, and sections of parallel transmission lines and/or highways, termed double features. Distance to disturbance buffers were generated around these class features following an approach similar to Dyer et al. (2001). A buffer interval distance of 500m was used based on a previous study conducted in Manitoba to assess the effects of a logging road on caribou use and habitat utilization(Schindler et al., 2007). Six concentric buffers, each with a width of 500 m and a combined width of 3 km were generated on either side of the feature. This distance was selected based on literature that suggest the effects of linear features is typically found within the first two kms (Dyer et al ., 2001, Oberg 2001, Schindler et al., 2007) and greater distances of tolerance thresholds for other anthropogenic disturbances such as forestry up to 13 kms (Vors et al. 2007).

Concentric buffers were created along sections of eight linear features where the Bog and Wabowden caribou winter core use areas intersected one of the following linear feature types (Table 1).

Table 1: Disturbance from development buffers

Buffer Name	Buffer Type	Feature Type	Feature(s) Name
Bog_1	Single Feature	Highway	PTH #10
Bog_2	Single Feature	Highway	PTH #10
Bog_3	Single Feature	Highway	PTH #10
Bog_4	Single Feature	Transmission Line	230 kV transmission line: Overflowing River to Ralls
Bog_5	Double Feature	Highway/Transmission Line	PTH #60 / 230 kV transmission line: Grand Rapids to Overflowing River
Wab_1	Double Feature	Highway/Transmission Line	PTH #6 / 230 kV transmission line: Grand Rapids to Ponton
Wab_2	Double Feature	Highway/Transmission Line	PTH #6 / 230 kV transmission line: Grand Rapids to Ponton
Wab_3	Single Feature	Transmission Line	230 kV transmission line: Jenpeg to Ponton

The concentric buffers were truncated at the point of intersection between the linear feature and the outer boundary of the winter core use area (defined using the 70% isopleth (Section 2.2), perpendicular to the linear feature (Figure1). Animal density metrics were calculated from the available collar data that fell within the boundaries of the evaluation areas. Mean number of animals/km^2 and number of locational fixes (GPS point locations)/km^2 were computed separately for each buffer section.

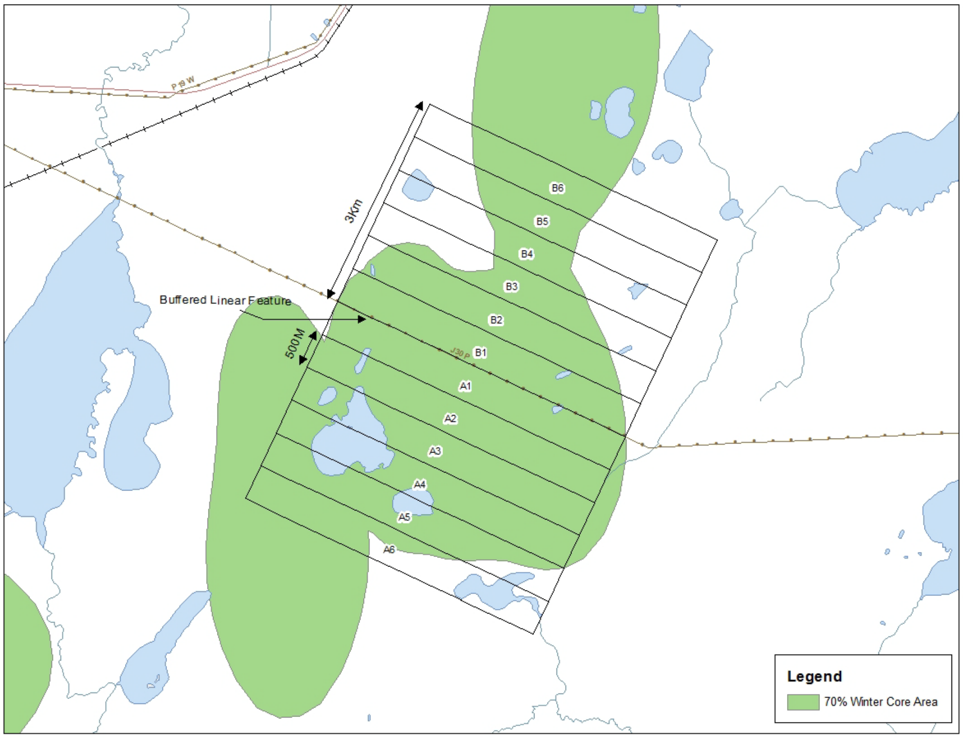

Figure 1: The linear featureissurroundedbyaseriesof12buffered areas (black polygons) at a distance of 500 m each totalling 3 km on each (Total width of 6 km)

Animal movement relative to each linear feature class was assessed using all available collar data from the Manitoba Conservation collaborative monitoring program. Individual class path trajectories were also created with this data, allowing for the assessment of the number of crossing events and the speed of movement across and away from linear features and their successive buffers.

Animals that had path trajectories intersecting core use areas as well as linear feature(s) were utilized in this analysis, resulting in a total of 450,866 path trajectories. Only winter data were utilized and included data from 109 collared caribou between January 2007 and December 2011 for the Bog and Wabowden evaluation ranges combined. The time and distance were calculated for each successive location to determine movement rates in km/hr (Figure 2).

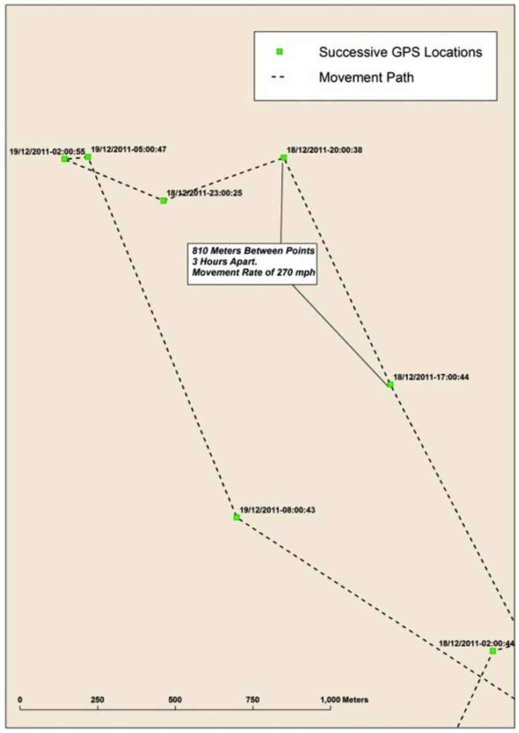

Figure2: Example of the determination of movement paths and speeds from location points

For each buffer, all caribou path segment crossings were enumerated. The rate of movement was recorded to detect differences in movement behaviour at successive distances from each class of linear feature. The total number of crossings and the mean crossing speed (km/hr) were computed for each buffer section to detect potential discrete movements associated with crossing the linear feature being assessed. Figure 3 provides an example of individual animal path trajectory across a double linear feature.

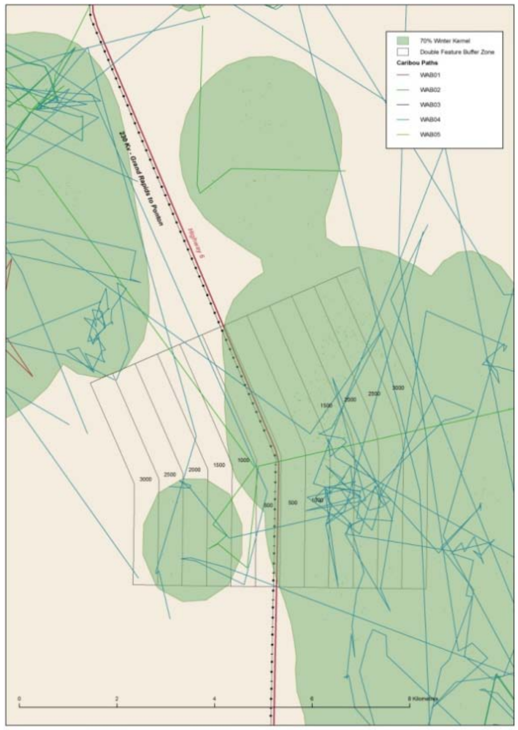

Figure 3: Example of caribou movement paths and core use areas along a paired highway-transmission line (double feature)

All computed metrics, including mean number of animals/km^2, number of locational fixes/km^2, total number of crossings, and the mean crossing speed (km/hr), were plotted against distance from single features (single highways, single transmission lines) and double features (adjacent highways and transmission lines) using CRAN-R, a programming language for statistical computing (R, 2011). For each metric, two graphs plotting metrics against distance were generated. The first series of graphs plotted actual metric values, smoothed using a locally weighted scatterplot smoothing (LOWESS) function. This procedure builds a curve that characterizes the deterministic portion of the dataset based on localized trends (Cleveland and Devlin 1988). LOWESS smoothing is useful for data exploration in datasets that do not exhibit a constant trend, such as animal rates of movement and density with distance from linear features. The second series of graphs plotted mean data values with standard deviation bars against distance from linear features.

Vegetation Type in Relation to Linear Features

To assess the relative effects of vegetation and linear features on caribou movement, LCC cover classes were intersected with the concentric buffers used in the caribou point density and path trajectory analyses. Vegetation cover classes were summarized for each of the six 500 m-wide buffer intervals on both sides of the linear feature(s) and percentage of the total buffer area was computed for each cover class. In addition, the absolute difference in percentage cover for each vegetation class between the sides was calculated for both the total 3 km buffer width (Table 2) and the first 500 m concentric buffer on either side of the linear features (Table 3) to test whether habitat around the features had an influence on animal locations. Overall landcover trends across the features were examined using Correspondence Analysis (Legendre and Legendre 1998). The ordination scores from the first axis were used to typify overall vegetation trends and included distance from feature in multiple regression models examining use adjacent to the features (modified from Dyer et al., 2001).

Linear Feature Effects Analysis

The effects of linear features on the distribution of woodland caribou in the Bog and Wabowden ranges are presented in Figure 4. Statistical intervals are based on buffer distance from each of three classes of linear features: highways (circles); double features (triangles, double features such as Bipole I and II where it parallels major highways); and transmission lines proper (plus symbol). In total four characteristics of animal movement and location were analyzed: mean animals/km^2, mean crossing speed m/hr; number of crossings; and location fixes/km^2. In examining the telemetry, large differences in the number of locational fixes were observed on opposite sides of linear features for both evaluation ranges. Table 2 and 3 were developed to summarize the differences in caribou observations and LCCEB cover classes on each side of a given feature. In many instances, there were large differences observed in animal numbers and corresponding differences are also seen in LCCEB habitat types. For instance, large differences in animal telemetry locations are observed in the Bog 5 buffer that also correspond with large differences in the availability of wetland cover. Similarly in Wabowden, the difference in wetland cover, corresponds with differences in animal telemetry fixes in Wabowden buffers 1 and 2. The total number of animals/km^2 are typically low and little pattern is detected with differences in vegetation. In some buffers, a few individuals comprise many of the observed number of total fixes, suggesting that these animals are spending the majority of their time in the area. Due to a strong apparent trend in habitat, proportion of landcover was explicitly included in multiple regression models examining use vs. distance. When habitat composition is included, regression models were significant ($P < .05$), but only on the habitat coefficient. Distance from the feature and usage trends were weak ($P > .05$). While there is evidence that animal numbers increase with distance from these features, they do not increase dramatically and this trend only becomes significant when habitat is included in the models.

While the differences in telemetry fixes suggest that roads may act as a barrier, vegetation differences might also account for the pattern. The strong asymmetries for some features present a challenge in examining potential road effects, as low and zero values on the less-used side of a feature which can be statistically problematic. To ensure that variance estimates reflect actual variability in use, the comparisons as provided in Figure 4 were done by pooling the most-used side of a feature (i.e. the side with the highest number of telemetry observations. The left side of Figure 4 represents a LOWESS smooth (Legendre and Legendre 1998) of the observed values for the four measured parameters and graphs on the right provide mean and standard error bars for each buffer distance interval.

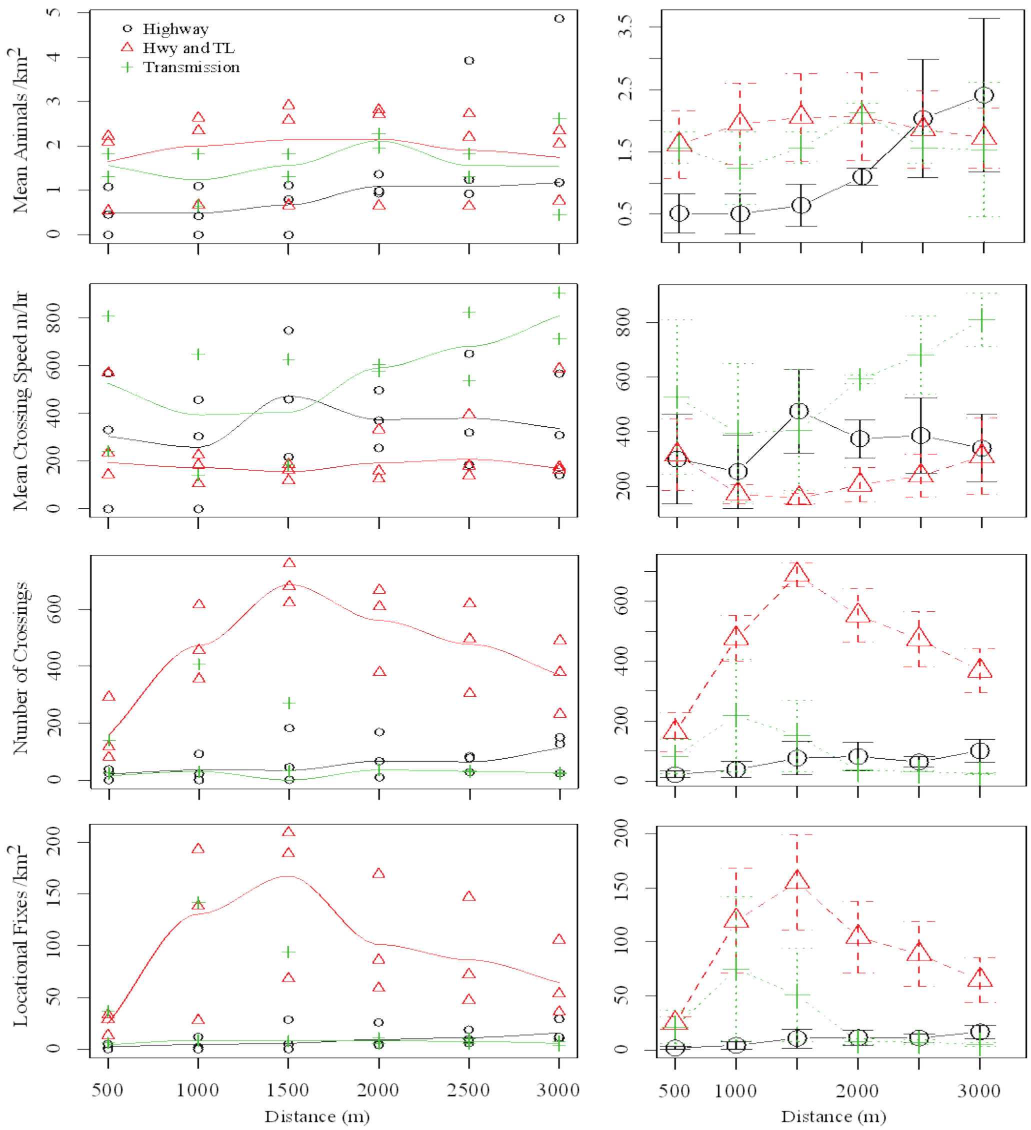

Figure 4: Mean number of animals/km², mean crossing speed (m/hr), number of crossing and number of locational fixes/km² as a function of distance from linear features. The graphs on the left side of the figure represent a LOWESS smooth of the observed values for the four measured parameters and graphs on the right provide mean and standard error bars for each buffer distance interval

Table 2: Absolute difference in percentage vegetation cover, animals/km2 and number of GPS point locations between A- and B-side buffers

	Buffer Name							
LCCEB Cover Class	**Bog 1**	**Bog 2**	**Bog 3**	**Bog 4**	**Bog 5**	**Wab 1**	**Wab 2**	**Wab 3**
Points/km2	14.8	32.2	108.5	22.9	262.7	805.4	417.0	270.0
Animals/km2	2.4	7.7	5.8	3.3	2.5	0.4	3.0	5.5
Water	5.5	0.0	0.3	0.0	0.2	1.9	8.2	11.9
Exposed Land	1.5	0.0	0.0	0.0	0.0	1.6	5.3	0.2
Developed	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0
Shrub Tall	0.0	0.0	0.6	0.0	1.2	0.0	0.8	15.6
Wetland Treed	12.3	68.6	14.5	0.9	42.8	20.3	1.1	2.8
Wetland Shrub	19.4	0.2	8.7	5.7	3.8	3.6	5.4	0.7
Wetland Herb	5.6	50.3	3.8	5.7	39.8	22.3	34.7	23.9
Grassland	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0
Coniferous Dense	1.0	11.0	8.0	0.2	4.0	2.5	6.6	1.9
Coniferous Open	11.1	7.5	9.0	0.8	5.3	0.5	29.8	2.2
Coniferous Sparse	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.6
Broadleaf Dense	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Mixedwood Dense	2.2	0.0	1.4	0.0	0.4	0.2	0.5	4.1

Table 3: Absolute difference in percentage vegetation cover, animals/km2 and number of GPS point locations between A1 and B1 buffers

	Buffer Name						
Description	**Bog 1 (500 m)**	**Bog 2 (500 m)**	**Bog 3 (500 m)**	**Bog 4 (500 m)**	**Bog 5 (500 m)**	**Wab 1 (500 m)**	**Wab 2 (500 m)**
Points/km2	0.6	0.0	0.2	2.6	27.3	31.0	7.1
Animals/km2	0.2	0.0	0.2	0.7	0.1	0.2	0.4
Water	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Exposed Land	1.3	0.0	0.3	0.0	0.2	4.4	28.7
Developed	0.0	0.0	0.0	0.0	5.2	0.0	0.0
Shrub Tall	0.0	0.0	3.9	0.0	9.4	0.0	0.0
Wetland Treed	0.7	37.4	27.0	8.1	26.3	19.2	2.2
Wetland Shrub	2.0	0.0	0.3	6.5	0.4	2.3	0.4
Wetland Herb	0.2	0.0	0.7	5.6	0.3	2.3	36.4
Grassland	1.2	0.0	0.0	0.0	0.6	0.0	0.0
Coniferous Dense	1.0	33.6	17.2	0.3	15.5	4.0	20.7
Coniferous Open	6.5	3.8	1.8	4.3	6.7	9.4	45.0
Coniferous Sparse	0.0	0.0	0.0	0.0	1.6	0.0	0.0
Broadleaf Dense	1.3	0.0	0.0	0.0	0.0	0.0	0.0
Mixedwood Dense	2.2	0.0	8.4	0.0	2.3	1.5	2.0

All of the measured variables in Figure 4 show relatively high variance, even after accounting for use on each side of the features, although the data are less skewed after adjusting for those differences. In all cases, there is some suggestion that the measured parameters increase with distance from the associated feature within the first 1-2 km which would be consistent with the literature on effects of linear development. For mean animals/km^2 the LOWESS smooth was relatively flat, but several buffers in Wabowden create a slight trend in the mean values with distance from highways, indicating that the number of individual animals increases with distance from these features. Mean crossing speeds increase slightly with distance for transmission lines but are relatively flat for the other features, suggesting animals move faster, further from transmission lines. However, the variance is large enough that this may simply be a function of variability in the observations. The strongest trends in this analysis were observed for both number of crossings and locational fixes/km^2. Double features in particular, and to a limited extent transmission lines (with respect to the mean values), show trends with distance. For these latter two parameters, values are low close to the features and increase with distance until 1.5 km from the feature and beyond that show a decline. This suggests that animals avoid spending long periods adjacent to those features and also tend to remain on one side of them, which can be explained in part by the differences in habitat on either side of the feature being assessed. Dyer et al. (2001) found in their study area that habitat was consistent across the buffers being assessed, which is quite different from the results of this analysis.

NOTE: THIS SECTION IS DRAFT

Literature Cited

Dyer, S. J., Neill, J. P. O., Wasel, S. M., & Boutin, S. (2001). Avoidance of industrial development by woodland caribou. *The Journal of Wildlife Management*, *65*(3), 531-542.

Oberg, P. R. (2001). *Responses of Mountain Caribou to Linear Features In a West-central Alberta Landscape*. University of Alberta.

Schindler, D. W., Walker, D., Davis, T., & Westwood, R. (2007). Determining effects of an all weather logging road on winter woodland caribou habitat use in south-eastern Manitoba. *Rangifer*, (17), 23-27.

Vors, L. S., Schaefer, J. a., Pond, B. a., Rodgers, A. R., & Patterson, B. R. (2007). Woodland Caribou Extirpation and Anthropogenic Landscape Disturbance in Ontario. *Journal of Wildlife Management*, *71*(4), 1249-1256. doi:10.2193/2006-263

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-Appendix C

Survival analyses

Based on a mean annual calving date of May 17, annual survival was calculated for a biological year that ran from 17 May of one year to 16 May of the following year; each biological year was named for the calendar year in which it began (e.g., biological year 2010 ran from 17 May 2010 to 16 May 2011). The number of days experienced by live caribou equipped with radio-collars was totalled independently for each year in each herd (these are termed exposure days). Similarly, an annual total of radio-collared caribou mortalities was calculated for each herd in each year. Exposure days from animals with transmitters that failed and whose fate was unknown were included to the last recorded observation. Annual survival rates and 95% confidence intervals were calculated independently for each herd using the Mayfield (1975) method in the computer program Micromort (Heisey and Fuller 1985). A two-year pooled survival analysis was also run for each year. The results appear in Table 1.

Table 1: Caribou herd annual survival rates from radio-collared animals. Values represent survival from 17 May of the nominal year until 16 May of the following year (06 April 2012 in the case of 2011 rates). Values in parentheses are 95% confidence limits.

Herd	2010	2011	Pooled 2010-11
Charron Lake	1.00 (1.00 - 1.00)	0.84 (0.68 - 1.00)	0.88 (0.76 - 1.00)
Harding Lake	0.91 (0.75 - 1.00)	0.80 (0.63 - 1.00)	0.85 (0.72 - 1.00)
Reed Lake	1.00 (1.00 - 1.00)	0.78 (0.56 - 1.00)	0.88 (0.73 - 1.00)
The Bog	0.94 (0.84 - 1.00)	0.77 (0.59 - 0.99)	0.85 (0.75 - 0.98)
Wabowden	0.94 (0.83 - 1.00)	0.78 (0.59 - 1.00)	0.87 (0.75 - 1.00)
Wheadon	0.88 (0.74 - 1.00)	0.94 (0.84 - 1.00)	0.91 (0.82 - 1.00)
Wimapedi-Wapisu	1.00 (1.00 - 1.00)	0.80 (0.64 - 1.00)	0.90 (0.82 - 1.00)

A consequence of assuming that all failed collars represent live animals is that the calculated survival rates are maximum values. If any collars failed at the time of death then the associated survival rates will be over-estimated.

Recruitment

Aerial surveys to determine recruitment were conducted using standard VHF telemetry. Surveys were conducted monthly from May to September of each year and recruitment rates were calculated (separately for each herd) as the number of radio-collared female caribou with calves in September divided by the number of adult females with active collars at that time (Table 2). Winter range surveys, not employing VHF telemetry, were also conducted on some of the ranges. Standard deviations for the overall parturition rate and for recruitment rates of each population were calculated from the binomial distribution (Sokal and Rohlf 1981). The results of both surveys are presented for comparison.

Table 2: Caribou herd mean annual recruitment rates expressed as calves per cow (Standard Errors in parentheses) from September surveys of radio-collared animals and from winter range surveys of random portions of each herd.

Herd	Sept 2010	Winter 2010-2011	Sept 2011	Winter 2011-2012
Charron Lake	No data	No data	0.24 (0.11)	No data
Harding Lake	0.00 (0.00)	No data	0.13 (0.09)	No data
Reed Lake				
The Bog	0.13 (0.07)	0.10 (0.05)	0.06 (0.06)	0.07 (0.03)
Wabowden	0.00 (0.00)	0.00 (0.00)	0.13 (0.09)	0.08 (0.03)
Wheadon	0.00 (0.00)	No data	0.15 (0.08)	0.00 (0.00)
Wimapedi-Wapisu	0.00 (0.00)	0.03 (0.03)	0.29 (0.10)	0.07 (0.02)
Overall	0.03 (0.02)	0.05 (0.02)	0.16 (0.04)	0.07 (0.01)

For the September 2010 and winter 2010-2011 surveys the results are comparable for all herds. The following year the September 2011 survey results for Wheandon and Wimapedi-Wapisu are both higher than the subsequent winter survey results. This result may be a consequence of additional calf mortality between the two surveys or it may be random difference in the survey results. The standard errors suggest that the difference represents a real decline between the two surveys for the for the Wimapedi-Wapisu herd. Recruitment rates can be highly variable among years however the rates observed for the study herds in the years surveyed are comparatively low relative to other boreal caribou populations studied (Rettie and Messier 1998, McLoughlin et al. 2003). Additional years of recruitment data will reveal the whether low recruitment rates persist.

Rates of increase

Following the method employed by Rettie and Messier (1998), annual survival rates and September recruitment rates were combined to calculate Caughley's (1977) survival-fecundity rate of increase, *rs*, for the herds for which data for both parameters were available. Survival-fecundity rates of increase were also transformed to Lamba values (Lambda = e^x where x is the *rs* value) for comparison with other studies. To generate 95% confidence limits for Lambda values 5000 Monte Carlo simulations were run for each herd based on that herd's annual survival and recruitment rates and their standard errors. Results appear in Table 3.

Table 3: Caribou herd annual growth rates (expressed as both *rs* and Lambda) based on survival and recruitment estimates where both were available. *rs* values above 0.00 indicate proportional annual increase and those below 0.00 proportional annual decline. Values in parentheses are 95% confidence limits.

Herd	*rs* 2010	*rs* 2011	Lambda 2010	Lambda 2011
Charron Lake	No data	-0.07	No data	0.94 (0.75-1.13)
Harding Lake	-0.10	-0.16	0.91 (0.77-1.05)	0.86 (0.65-1.05)
The Bog	0.00	-0.23	1.00 (0.88-1.12)	0.79 (0.61-0.98)
Wabowden	-0.06	-0.19	0.94 (0.84-1.03)	0.83 (0.62-1.05)
Wheadon	-0.13	0.01	0.88 (0.74-1.02)	1.01 (0.88-1.13)
Wimapedi-Wapisu	0.00	-0.09	1.00 (1.00-1.00)	0.92 (0.72-1.11)

The results indicate variability in population growth both among years and among herds. The similarity in long-term survival rates noted above (Table 1) is expected; consequently the variation in annual population growth is largely a result of variation in recruitment (Table 2), also as expected (Gaillard et al. 1998).

Literature Cited

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons Ltd., New York.

Gaillard, J.-M., M. Festa-Bianchet, and N.G. Yoccoz. 1998. Population dynamics of large herbivores: variable recruitment with constant adult survival. Trends in Ecology and Evolution 13:58-63.

Heisey, D.M., and Fuller, T.K. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. Journal of Wildlife Management 49: 668.674.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bulletin 87: 456.466.

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

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

Sokal, R.R., and Rohlf, F.J. 1981. Biometry. 2nd ed. W.H. Freeman and Co., New York.

Date	May 18th 2012
Subject	Caribou
Reference	Clean Environment Commission – Caribou Information Request
Source	CEC
Question	CEC/MH-Caribou-References

Anderson, D.R., and K.P. Burnham. 2002. Avoiding pitfalls when using information-theoretic methods. Journal of Wildlife Management 66:912-918.

Burnam, K.P. and D.R. Anderson. 2002. Model Selection and Multi-Model Inference. A Practical Information-Theoretic Approach. 2nd ed. Corr. 3rd printing, 2002, XXVI.Springer.488 p. 31 illus.

Caughley, G. 1977.Analysis of vertebrate populations. John Wiley and Sons Ltd., New York.
Dyer, S. J., Neill, J. P. O., Wasel, S. M., &Boutin, S. 2001. Avoidance of industrial development by woodland caribou.The Journal of Wildlife Management, 65(3), 531-542.

Cleveland, W.S. and S.J. Devlin. 1988. Locally-Weighted Regression: An Approach to Regression Analysis by Local Fitting. Journal of the American Statistical Association, 83(403): 596-610.

Dyer, S. J., Neill, J. P. O., Wasel, S. M., &Boutin, S. 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. doi:10.1139/Z02-060

Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2001. Avoidance of industrial development by woodland caribou. Journal of Wildlife Management, 65(3): 531-542.

James, A. R. C. 1999.Effects of industrial development on the predator-prey relationship between wolves and caribou in Northeastern Alberta. Ph.D Thesis. University of Alberta. Department of Biological Sciences (p. 81).

Legendre and Legendre, 1998 = Legendre, P. and L. Legendre. 1998. Numerical ecology (Second Edition). Elsevier, B.V., Amsterdam, the Netherlands. 853 pp.

Manitoba Conservation. 2006. Manitoba's Conservation and Recovery Strategy for Boreal Woodland Caribou (*Rangifer tarandus caribou*). Winnipeg, Manitoba. 38 pp.

Manly, B.F.J. L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 2002. Resource selection by animals. Second Edition.Kluwer Academic Publishers, Dordrecht, Netherlands.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bulletin 87: 456.466.

Manitoba Model Forest. 2005. Landscape management strategy for the Owl Lake boreal woodland caribou herd, eastern Manitoba: An update of the original 1995 strategy. A report of the Eastern Manitoba Woodland Caribou Advisory Committee to the Manitoba Model Forest. April 2005. Manitoba Model Forest Report 04-2-33. 66 pp.

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

McLoughlin, P. D., Dunford, J. S., &Boutin, S. 2005. Relating predation mortality to broad-scale habitat selection.*Journal of Animal Ecology*, *74*(4), 701-707.

R Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

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

Rogers, A.R and Carr, A.P. 1998. HRE: The Home Range Extension for ArcView™ (Beta Test Version 0.9, July 1998). User's Manual. Available at: http://planet.botany.uwc.ac.za/nisl/computing/HRE/Users%20Manual.pdf

Thomas, D.L., and E.J. Taylor. 1990. Study designs and tests for comparing resource use and availability. Journal of Wildlife Management 54:322-330.

Schaefer, J.A. 2003. Long-term range recession and the persistence of caribou in the taiga. *Conservation Biology, 17*(5): 1435-1439.

Schindler, D. W., Walker, D., Davis, T., & Westwood, R. 2006. Determining effects of an all weather logging road on winter woodland caribou habitat use in south-eastern Manitoba.*Rangifer*, (17), 23-27.

Vander Wal, E. 2004. Core Areas of Habitat Use: The Influence of Spatial Scale of Analysis on Interpreting Summer Habitat Selection by Moose (Alcesalces). Masters of Science Thesis. Lakehead University.

Van Moorter, B., Gaillard, J.-M., McLoughlin, P. D., Delorme, D., Klein, F., & Boyce, M. S. 2009.Maternal and individual effects in selection of bed sites and their consequences for fawn survival at different spatial scales.*Oecologia*, *159*(3), 669-78.

Vors, L. S., Schaefer, J. a., Pond, B. a., Rodgers, A. R., & Patterson, B. R. 2007. Woodland Caribou Extirpation and Anthropogenic Landscape Disturbance in Ontario. *Journal of Wildlife Management*, *71*(4), 1249-1256.

Wasel, S. M., Samuel, W. M., & Crichton, V. 2003.Distribution and ecology of meningeal worm, Parelaphostrongylustenuis (Nematoda), in northcentral North America. Journal of Wildlife Diseases, 39(2), 338-346.