BRITISH COLUMBIA
The Best Place on Earth

July 12, 2010

File Number: 2913958

To the reader:

The Ministry of Environment (MoE) and other provincial agencies have been engaged in management and conservation of boreal caribou for many years. Recently, MoE worked in partnership with the Ministry of Energy, Mines and Petroleum Resources to develop a plan for boreal caribou management and natural gas development. The attached document, "*Projected Boreal Caribou Habitat Conditions and Range Populations for Future Management Options in British Columbia,*" provides a technical analysis of a range of options for boreal caribou management in BC. This report was completed under contract and received technical peer review. Government considered information and options in the report in the development of its plan to manage boreal caribou and the petroleum and natural gas sector in the northeast of BC.

This report is a significant accomplishment and will continue to assist government in managing boreal caribou. If you have any questions on the attached report or boreal caribou management, please feel free to contact me (250-614-9910).

Sincerely,

Chris Ritchie

Manager, Species at Risk Recovery Implementation
Environmental Stewardship Division, Prince George.

Ministry of Environment

Species at Risk Recovery Implementation
Environmental Stewardship Division
4051 – 18th Avenue
Prince George BC V2N 1B3

Telephone: (250) 614-9910
Facsimile: (250) 565-6940
Website: www.gov.bc.ca/wlap

Projected Boreal Caribou Habitat Conditions and Range Populations for Future Management Options in British Columbia

Prepared by:

Steven F. Wilson, EcoLogic Research

Chris Pasztor, Ecosystems Branch, Ministry of Environment

Sara Dickinson, Land Use Coordination Branch, Ministry of Energy, Mines and Petroleum Resources

Prepared for:

Ministry of Energy, Mines and Petroleum Resources and Ministry of Environment

22 April 2010

Executive Summary

Boreal caribou (*Rangifer tarandus caribou*) in British Columbia (BC) are in decline. BC has a commitment under the *Accord for the Protection of Species at Risk* and the *National Framework for the Conservation of Species at Risk* to protect and recovery boreal caribou. The recovery of boreal caribou is mandated under the federal *Species at Risk Act*. Boreal caribou range overlaps extensively with petroleum and natural gas (PNG) exploration and development activities in northeastern BC. As a result, protecting and recovering boreal caribou has the potential to significantly affect revenues generated by this industry.

The Ministry of Environment and the Ministry of Energy, Mines and Petroleum Resources have collaborated on an analysis of future management options and consequences for boreal caribou in BC. The following are the major conclusions of the analysis:

- Projections of boreal caribou range populations and of management costs are highly uncertain;
- Even with a full moratorium on further PNG exploration and development, BC's boreal caribou population is likely to decline;
- Continuing development without significant changes in footprint management or deferring areas from PNG tenure sales will likely result in the extirpation of boreal caribou from all but one boreal caribou range; and,
- Aggressively restoring habitat significantly improves population projections but the feasibility and predicted outcomes of restoration activities are highly uncertain.

Table of Contents

Introduction

The petroleum and natural gas (PNG) industry in northeast British Columbia (BC) is a major force in the provincial economy. Providing opportunities to purchase sub-surface tenures and develop PNG resources meets government's commitment under the BC Energy Plan (2007).

The range of boreal caribou (*Rangifer tarandus caribou*) overlaps extensively with PNG exploration and development activities. Available data suggest that boreal caribou are in decline in BC and elsewhere within in their range in Canada. The cause of this decline can be ultimately attributed to habitat fragmentation and alteration associated with land use changes and warming temperatures.

The BC government has committed to mitigating threats to boreal caribou and to provide habitat protection, as mandated by the *Species at Risk Act.* To date, no government approved provincial management plan has been developed.

The Ministry of Environment (MOE) and Ministry of Ministry of Energy, Mines and Petroleum Resources (MEMPR) are developing a strategy that balances future opportunities for PNG development with boreal caribou conservation objectives. This report provides the technical background and support for developing a management strategy.

Background

Information on boreal caribou distribution, status, trends and stressors is provided elsewhere (Boreal Caribou Technical Advisory Committee 2004, Environment Canada 2008, Goddard 2009, Thiessen 2009, Culling and Cichowski 2010). This report focuses on the interpretation of this information for management purposes and for predicting future trends in land use and their consequences for the future viability of boreal caribou in BC.

Methods

We reviewed available information and developed a management model to illustrate the most important variables and relationships affecting future boreal caribou populations (Figure 1). The model was based on the relationship developed by Sorensen et al. (2008) that regressed caribou population growth against anthropogenic features (buffered by 250 m) and burned forest <50 years old for boreal caribou herds in northern Alberta. Using this as the basis for projecting populations, we modelled management actions that could modify this relationship in the future.

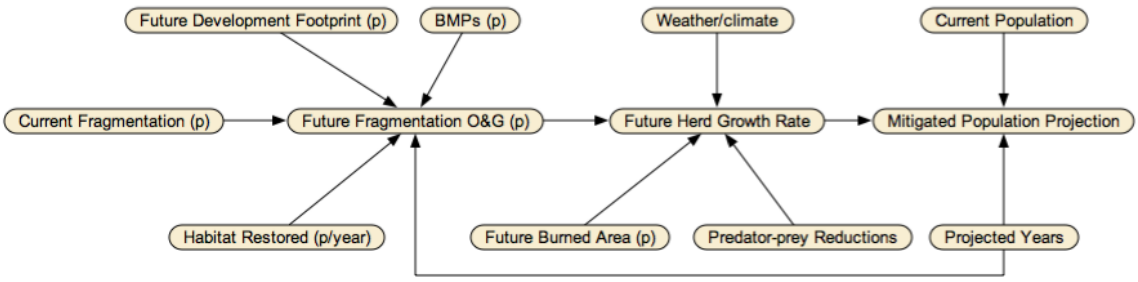

Figure 1. Management model of projected boreal caribou populations in BC. The model relies on the relationship between industrial footprint, burned areas and caribou population growth developed by Sorensen et al. (2008). The model is applied to each BC boreal caribou range to predict future population size.

We expanded this conceptual model into a full Bayesian Belief Network, adding explicit states for each node (variable) and populating conditional probability tables based either on relationships provided by Sorensen et al. (2008) or on interpretation from available literature and expert opinion. A full explanation of each node is provided in the following sections.

The use of a Bayesian Belief Network provided a number of advantages:

1. The relationships between important variables can be captured visually;
2. The model allows a mix of quantitative and qualitative information; and,
3. Uncertainty is accommodated explicitly.

Bayesian Belief Networks are also associated with some drawbacks:

1. The model is not stepwise but simply estimates future conditions based on a series of static inputs; however, outputs at year 50 were not sensitive to this, based on repeated annual runs of the model; and,
2. Outputs are not precise but probabilistic, and are influenced by the number and ranges of states for each node; however, this is appropriate given the considerable uncertainty of several inputs.

The model made a number of simplifying assumptions:

- Boreal caribou populations were modelled on a range-wide basis and there was no distinction made between core areas and ranges (Culling and Cichowski 2010);
- No forestry impacts were projected – PNG development is currently the principal land use in the area but forestry could have significant impacts in the future;
- All PNG tenures will be developed – this is unlikely but the proportion that will ultimately be developed is difficult to predict;
- Fragmentation is the principle driver of boreal caribou population trends – although results from Sorensen et al. (2008) suggest a high correlation between fragmentation and herd growth rates in Alberta, the functional cause of this relationship has not been tested; and,

- There were no carrying capacity estimates assigned to ranges; therefore, any projections of substantially increasing populations might not be realistic.

The model was run for each boreal caribou range in BC. A variety of scenarios were examined:

1. No further development – i.e., equivalent to a moratorium on future oil and gas exploration and development;
2. Committed development only – consequences of allowing only PNG tenures sold-to-date to be fully developed and deferring all future PNG tenure sales; and,
3. Status quo – no change in current tenure sale and resource development policy;

We also projected the effects of different levels of habitat restoration, fire suppression and predator-prey management, on these scenarios, as well as the sensitivity of population projections to various future PNG exploration and development footprints.

Current Fragmentation

The Integrated Land Management Bureau (ILMB) calculated the proportion of boreal caribou ranges currently fragmented by calculating the proportion of range that has burned in the past 50 years (from the Land and Resource Data Warehouse [LRDW]), and the proportion of range affected by anthropogenic development.

Data sources for the anthropogenic features included:

- Forestry roads and cutblocks (from the LRDW);
- PNG roads, pipelines, wells, facilities and seismic lines (from Oil and Gas Commission [OGC] data); and,
- Miscellaneous linear features (from the LRDW).

The miscellaneous linear features layer was originally digitized from 1992 aerial photos and is dominated by old seismic lines that are not found in OGC datasets. There was some question about whether the dataset should be included in the footprint analysis because it was digitized from air photos instead of from lower-resolution satellite imagery, which Sorenson et al. (2008) used for their analysis. Results of the footprint analysis were highly sensitive to the inclusion of the miscellaneous linear features layer.

We found by reviewing visible features on recent 5-m resolution satellite imagery in randomly selected portions of boreal caribou range that most of the lines in the miscellaneous features layer were clearly visible (Figure 2). There were also some visible linear features that were not captured in the miscellaneous linear features layer or in the OGC data. This uncertainty was accommodated by using a range that included a lower fragmentation estimate in the model than calculated from available data. For example, if the calculated fragmentation was 69%, then the model used an estimate of 0.5-0.7 (Table 1).

Table 1. Estimate of the current percent fragmentation by boreal caribou range. Analysis provided by the Integrated Land Management Bureau. The model used a range of estimates.

Range	Total Area (ha)	Area Burned (<50 years) (ha)	Footprint (no misc features) (ha)	Fragmentation (%)	Footprint (misc features included) (ha)	Fragmentation (%)	Modelled (p)
Calendar	494,565	42,004	64,151	13.0	343,684	69.5	0.5-0.7
Chinchaga	1,392,856	58,026	505,835	36.3	1,088,441	78.1	0.6-0.8
Maxhamish	710,232	7,178	120,013	16.9	410,561	57.8	0.4-0.6
Parker	75,222	825	17,592	23.4	48,993	65.1	0.5-0.7
Prophet	119,396	1,206	34,522	28.9	90,757	76.0	0.6-0.8
Snake-Sahtaneh	1,203,438	118,261	484,086	40.2	1,012,914	84.2	0.7-0.9

Future Fragmentation

Future fragmentation was based on the calculation:

*(Future Fragmentation) = (Current fragmentation) + (Future Development Footprint)/50 * (Projected Years) – (Habitat Restored) * (Years) – (Guidelines)*

Future Development Footprint

The future development footprint was based on assumptions regarding the average size of expected PNG development in each gas spacing unit. We did not consider the impact of future forestry development because we could not predict the size of the future cut nor its location within boreal caribou ranges.

We assumed that tenured, but currently undeveloped gas spacing units (estimated by the absence of wells), would be fully developed in 50 years and that the footprint in earlier years would be proportional (e.g., 50% developed in 25 years). We assumed that multiple tenures over the same area would result in no incremental footprint; either due to reclamation of the surface footprint or through re-use of existing infrastructure and roads. MEMPR staff provided footprint estimates for both conventional and unconventional gas development (Table 2). Buffers for unconventional gas access were calculated on a single 2130 m x 100 m footprint because a distribution between linear features and facilities was not provided.

BMPs

Best management practices (BMPs) were included in the model but were assumed to have no effect. The effectiveness of BMPs in Alberta has been equivocal (Bentham 2007). This node can be populated in future when BMPs are developed for BC operators and their effects can be estimated and/or predicted.

Figure 2. Example of seismic lines found in the miscellaneous features layer (top figure, black lines) and OGC seismic data (purple lines) with a 5-m resolution satellite image from the same area.

Habitat Restored

Natural succession is expected to reduce the existing industrial footprint over time. The model assumed that a constant proportion of each range would be restored

each year; however, estimating this proportion, and especially its biological relevance, is very difficult. Research suggests that recovery of old seismic lines is very slow, particularly in wet areas characteristic of boreal caribou habitat (Lee and Boutin 2006). The history of development and habitat characteristics will strongly influence the rate of natural succession.

We used a simple baseline rate of habitat restoration that assumed that 0.10-0.20 (mean = 0.125)% of the range would be restored per year. "Aggressive restoration" was assumed to restore between 0.2-0.5 (mean = 0.35)% per year. These estimates are coarse and further analysis is required to refine parameters.

Table 2. Estimated footprint of future PNG development.

Development	Facility	Size (ha)/length (m)	Buffered by 250 m (ha)	Per Area (ha)	Footprint/gas spacing unit (ha)
Conventional	Well pad	1.44	32.9	159	32.9
	Access	609.3	30.5	159	30.5
				Total:	**63.4**
Shale	Well pad	5.7	51.7	932.4	8.8
	Access	21.3	152.3	932.4	26.0
				Total:	**34.8**

No estimates were available for seismic development; therefore, we assumed that seismic impacts would be equal to the footprint of facilities development (i.e., the footprint modelled was twice that estimated in Table 2).

Future Herd Growth Rate

The future growth rate of boreal caribou was based on the relationship developed by Sorensen et al. (2008):

*(Future herd growth rate) = 1.192 - 0.315 * (Future Fragmentation) – 0.292 * (Future Burned Area)*

The equation was modified for expected effects of weather/climate and possible predator-prey management.

Weather/Climate

We assumed that there was a 70% chance that a warming trend over the next 50 years will result in a 2% reduction in the growth rate of boreal caribou populations as a result of changing predator-prey dynamics. This is a coarse estimate.

Future Burned Area

We assumed that the proportion of ranges burned by wildfire will remain constant. A warming climate might increase the frequency of wildfire, but increased development might also result in more active suppression.

Predator-prey Reductions

Managing predators can affect caribou population growth rates; however, based on experiences with the mountain caribou recovery implementation project, we concluded that there was little chance that actions would be taken that would result in significant changes in the predator-prey system. We estimated that there is a 25% chance that actions will be taken that will be sufficient to increase boreal caribou population growth rates by 1%.

Mitigated Population Projection

The projected population of boreal caribou in each range is calculated according to the equation:

*(Mitigated population projection) = (Current population) * e^(((Future herd growth rate) - 1) * (Years))*

Current Population

Current range populations of boreal caribou are uncertain and based primarily on density estimates. Uncertainty in the inventory was accommodated in the model (Table 3).

Table 3. Range of population estimates for BC boreal caribou herds and estimates used for modelling.

Range	Population estimates (Culling and Cichowski 2010)	Modelled estimate	Modelled Standard deviation
Calendar	154-428	300	100
Chinchaga	250-533	480	49
Maxhamish	220-392	300	76
Parker	7-24	14	11
Prophet	28-79	54	34
Snake-Sahtaneh	359-371	365	56

Projected Years

Footprint and boreal caribou populations were estimated for year 50, to correspond with the expected development horizon of PNG in the region.

Results

Future Management Scenarios

No Further Development

If a moratorium were placed on further PNG exploration and development within boreal caribou ranges, the estimated population in 50 years would be approximately 1306 animals (Table 4). There is a high probability (>40%) that boreal caribou could be extirpated from the Parker and Snake-Sahtaneh ranges.

Table 4. Projected populations in 50 years for boreal caribou ranges in BC under the scenario of no further development.

Range	Population estimate in 50 years	Probability (%) of being critically endangered or threatened (<100 animals)	Probability (%) of Extirpation (<10 animals)
Calendar	257	37.3	5.5
Chinchaga	242	32.4	2.8
Maxhamish	679	5.3	0
Parker	35	28.5	65.4
Prophet	54	55.9	35.9
Snake-Sahtaneh	39	39.2	42.6
Total	**1306**		

Committed Development Only

If only development of committed PNG tenures was allowed to proceed within boreal caribou ranges, the estimated population in 50 years would be approximately 804 animals (Table 5). There is a high probability (>40%) that boreal caribou could be extirpated from the Parker, Prophet and Snake-Sahtaneh ranges.

Table 5. Projected populations in 50 years for boreal caribou ranges in BC under the scenario of committed development only.

Range	Population estimate in 50 years	Probability (%) of being critically endangered or threatened (<100 animals)	Probability (%) of Extirpation (<10 animals)
Calendar	183	44.4	8.7
Chinchaga	181	40.9	5.8
Maxhamish	357	25.5	1.8
Parker	23	23.4	74.3
Prophet	34	49.5	46.4
Snake-Sahtaneh	26	38.7	57.1
Total	**804**		

Status Quo

If no deferrals or management were implemented within boreal caribou ranges, but other management actions were implemented as modelled in other scenarios, the estimated population would be approximately 251 animals (Table 6). There is a high probability (>60%) that boreal caribou could be extirpated from all but the Maxhamish range.

Table 6. Projected populations in 50 years for boreal caribou ranges in BC under the scenario of status quo.

Range	Population estimate in 50 years	Probability (%) of being critically endangered or threatened (<100 animals)	Probability (%) of Extirpation (<10 animals)
Calendar	20	29.0	67.8
Chinchaga	14	14.4	83.5
Maxhamish	201	39.9	8.1
Parker	5	1.5	98.5
Prophet	5	0.9	99.1
Snake-Sahtaneh	6	4.9	95.0
Total	**251**		

Effect of Aggressive Habitat Restoration

One of the principal management actions that can improve range conditions is habitat restoration. When combined with PNG deferrals, population projections improve substantially for all ranges (e.g., Table 7). As noted above, the feasibility and effectiveness of habitat restoration is only coarsely estimated.

Table 7. Estimated effect of aggressive habitat restoration on BC boreal caribou range population in 50 years under the committed development only scenario.

Range	Population estimate in 50 years with committed development only	Population estimate in 50 years with aggressive restoration	Change in estimate (%)
Calendar	183	384	109.8
Chinchaga	181	352	94.5
Maxhamish	357	574	60.8
Parker	23	58	152.2
Prophet	34	97	185.3
Snake-Sahtaneh	26	63	142.3
Total	**804**	**1528**	

Conclusions

The following are the major conclusions arising from our analysis:

- Future population projections and financial impacts are uncertain and model results should be interpreted cautiously;

- Results are highly sensitive to several assumptions; in particular, current habitat fragmentation and the effectiveness of restoration;
- Even with a full moratorium on further PNG exploration and development, BC's boreal caribou population is likely to decline and there is a high probability (>40%) that caribou could be extirpated from two ranges;
- Halting all but the development currently committed on previously sold tenures could result in the a nearly 50% decline in BC's boreal caribou population and could result in the extirpation of caribou from three ranges;
- Continuing development without significant changes in footprint management or deferring areas from PNG tenure sales will likely result in the extirpation of boreal caribou from all but the Maxhamish range; and,
- Aggressively restoring habitat significantly improves population projections, but the feasibility and predicted outcomes of restoration activities are highly uncertain.

Acknowledgements

We wish to thank for following for valuable input during the project: Mike Fournier, Alf Hartling, Mel Henze, Gerry Kuzyk, Mike Lambert, Kaaren Lewis, Norman Marcy, Sadaf Mirza, Ines Piccinino, Dave Richardson, Chris Ritchie, Joelle Scheck, Conrad Thiessen, Kym Thrift, Warren Walsh, and Krista Zens. We would also like to thank staff from the Integrated Land Management Bureau for providing technical support in estimating the current percent fragmentation of boreal caribou range.

Literature Cited

Bentham, P. 2007. Final report: audit of operating practices and mitigation measures employed within woodland caribou ranges. Prepared for: Caribou Landscape Management Association, Peace River, AB, and Forest Products Association of Canada, Ottawa, ON.

Boreal Caribou Technical Advisory Committee. 2004. A strategy for the recovery of boreal caribou in British Columbia. Draft #3. BC Ministry of Water, Land and Air Protection, Victoria.

Culling, D., and D. Cichowski. 2010. Draft - Scientific Update For the Boreal Caribou (*Rangifer tarandus caribou*) in British Columbia, 2010. Prepared for: BC Ministry of Environment, Victoria.

Environment Canada. 2008. Scientific review for the identification of critical habitat for woodland caribou (*Rangifer tarandus caribou*), boreal population, in Canada. Draft.

Goddard, A. D. 2009. Boreal caribou in northeastern British Columbia. Biological rationale, data summary & literature review. Peace Region Technical Report, BC Ministry of Environment, Fort St. John.

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

Sorensen, T., P. D. McLoughlin, D. Hervieux, E. Dzus, J. Nolan, B. Wynes, and S. Boutin. 2008. Determing sustainable levels of cumulative effects on boreal caribou. Journal of Wildlife Management 72:900-905.

Thiessen, C. 2009. Peace Region boreal caribou monitoring: annual report 2008-9. Peace Region Technical Report, BC Ministry of Environment, Fort St. John.