



PROJECT REPORT

Caribou Response to Mountain Pine Beetle Management

An Expert Workshop

**Prince George, BC
April 26, 2007**



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1. INTRODUCTION

The mountain pine beetle (MPB) epidemic now affects most of the interior of British Columbia and will impact habitat of a variety of wildlife species including caribou. Although scientists have not yet completed research to adequately understand these potential impacts, the rate of MPB spread forces resource managers to implement actions now if we hope to provide some mitigation against potential future habitat loss or deterioration. To support development of these strategies and actions, FORREX and the BC Ministry of Environment invited caribou and lichen experts to participate in a meeting to review the pertinent research and to provide comments on the potential impacts of the mountain pine beetle on terrestrial forage lichens and caribou. The general questions to be answered were:

- What do we know about terrestrial forage lichen trends in MPB-affected forests?
- How do we expect caribou to respond to changes caused by the MPB?
- How can we mitigate the impacts of habitat decline?

The desired outcome of this review was to develop one or more prescriptions/recommendations for action to mitigate impacts on, and restore habitat for, caribou in MPB-affected forests. The prescriptions/recommendations for action will be used by the BC Ministry of Environment Mountain Pine Beetle staff as part of their restoration/mitigation program to develop site-specific prescriptions for implementation. The BC Ministry of Environment – Fish and Wildlife staff may also use these prescriptions/recommendations for action in the development/refinement of their programs (e.g., Ungulate Winter Range [UWR] management).

Two recently completed reports served as background for the review and discussion. In the first, Patrick Williston, Debbie Cichowski, and Sybille Haeussler discuss the likely impact of MPB on terrestrial forage lichen communities (Williston *et al.* 2006). In the second report, Debbie Cichowski discusses the effects of the MPB on caribou (Cichowski 2007).

In preparation for the meeting, which was held on April 26, 2007 at the offices of the BC Ministry of Environment Office in Prince George, experts were asked to review the two reports and to be prepared to provide some commentary related to the following questions.

- 1) What do we know about terrestrial forage lichens, caribou and the mountain pine beetle?
 - a. Assuming regional difference occur, what are the primary factors that distinguish those differences?
 - b. Are there any confounding/competing factors?
- 2) How do we expect caribou to respond to the mountain pine beetle infestation?
 - a. In the absence of mitigation, do we expect regional differences?
 - b. Assuming there are differences, are there priorities for mitigation?
- 3) How might we mitigate the effects of the mountain pine beetle on caribou habitat?
 - a. Is mitigation necessary?
 - b. What mitigation strategies/tools are available?
- 4) How do we manage for the possibility that we might be wrong?

For those experts who were not able to attend the meeting, an opportunity was given to provide their input through an interview process or as written submissions prior to the meeting. Interview comments and written submissions have been integrated into the themes listed in the discussion. Sixteen people attended the workshop while four people provided their input through the interview process (see Appendix 1 for a list of participants and interviewees).

2. PRE-WORKSHOP INTERVIEWS AND MEETINGS

In order to develop the questions to guide the workshop discussion, FORREX held a number of conference calls with workshop organizers and advisors (Chris Ritchie, Scott McNay, and Dale Seip). They also helped to generate the initial invitation list which was further supplemented by suggestions from the invitees.

3. SELECTED BIBLIOGRAPHY

Reports and References

Armleder, H.M., S.K. Stevenson, S.D. Walker. 1992. Estimating the Abundance of Arboreal Forage Lichens. B.C. Min. For., Williams Lake. Land Management Handbook field guide insert 7. URL: <http://www.for.gov.bc.ca/hfd/pubs/docs/Fgi/Fgi07.htm>

Armleder, H.M. and S.K. Stevenson. 1995. Silviculture Systems to Maintain Caribou Habitat in Managed British Columbia Forests. *In* Bamsey, C.R. (editor). Proceedings: Innovative silviculture systems in boreal forests. A symposium held in Edmonton, Alberta, Canada, October 2-8, 1994. Pp 83-87. URL: http://nofc.cfs.nrcan.gc.ca/bookstore_pdfs/25732.pdf

Armleder, H.M. and S.K. Stevenson. 1996. Using Alternative Silvicultural Systems to Integrate Mountain Caribou and Timber Management in British Columbia. Rangifer, Special Issue No. 9. Proceedings of the sixth North American Caribou Workshop, Prince George, B.C., Canada, 1-4 March, 1994. Proceedings of the George River Caribou Workshop Labrador City, Labrador, Canada, 27-29 Jan, 1994. Pp 141-148. URL: <http://www.for.gov.bc.ca/hfd/pubs/RSI/FSP/Cariboo/Misc049.pdf>

Armleder, H.M. and M.J. Waterhouse. 1996. Silvicultural Systems for Lodgepole Pine and Northern Caribou. B.C. Ministry of Forests, Cariboo Forest Region. Extension Note #19.

Arthur, W.R. 2001. Kennedy Siding Ungulate Winter Range (UWR) (U-7-001) Report. B.C. Ministry of Water, Land and Air Protection. Prince George, B.C. URL: <http://wlapwww.gov.bc.ca/omr/documents/U-7-001.pdf>

Bunnell, Fred L., Kelly A. Squires, and Isabelle Houde. 2004. Evaluating effects of large-scale salvage logging for mountain pine beetle on terrestrial and aquatic vertebrates. Mountain Pine Beetle Initiative Working Paper 2004- 2. URL: <http://dsp-psd.pwgsc.gc.ca/Collection/Fo143-3-2004-2E.pdf>

- Cichowski, D. 2007. Literature Review: Effects of Mountain Pine Beetles on Caribou. Report prepared for the Alberta Sustainable Resource Development. Edmonton, AB.
- Culling, B. and D. Culling. 2005. Boreal caribou habitat study in Northeastern British Columbia. Annual Progress Report – Year VI: April 1, 2004–March 31, 2005. FIA Project 2346002. URL: <http://www.for.gov.bc.ca/hfd/library/FIA/2005/FIA2005MR081.pdf>
- Goward, T. 2000. Fire, terrestrial lichens, and the Itcha-Ilgachuz caribou. *In* L. Darling (ed.). Proceedings of a conference on the biology and management of species and habitats at risk, Kamloops, B.C., 15-19 Feb., 1999. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. Pp 665-669.
- Kinley, Trevor A., Trevor Goward, Bruce N. McLellan and Robert Serrouya (in press). The Influence of Variable Snowpacks on Habitat Use by Mountain Caribou. *Rangifer*.
- Johnson, C.J., K.L. Parker, D.C. Heard, and D.R. Seip. 2004. Movements, foraging habits, and habitat use strategies of northern woodland caribou during winter: Implications for forest practices in British Columbia. *BC Journal of Ecosystems and Management* 5(1):22–35. URL: www.forrex.org/jem/2004/vol5/no1/art4.pdf
- Jones, E., D. Seip, and M. Gillingham. 2004. Ecological relationships between threatened caribou herds and their habitat in the Central Rocky Mountain Ecoregion. Annual Report April 1, 2003-March 31, 2004. Forestry Innovation Investment – Forest Science Program – Project #Y051035. URL: http://www.centralbccaribou.ca/downloads/Jones_et_al_2004b.pdf
- Miège, D., T. Goward, H. Armleder, M. Waterhouse, and D. Burgess, 2000. Impact of partial cutting on lichen diversity in lodgepole pine forests on the Chilcotin Plateau in British Columbia. Research Branch, B.C. Ministry of Forests, Victoria, B.C. Working Paper 55/2001. URL: <http://www.for.gov.bc.ca/hfd/pubs/Docs/Wp/Wp55.htm>
- Miège, D., H. Armleder, M. Waterhouse, and T. Goward, 2001. A pilot study of silvicultural systems for northern caribou winter range: lichen response. Research Branch, B.C. Ministry of Forests, Victoria, B.C. Working Paper 56/2001. URL: <http://www.for.gov.bc.ca/hfd/pubs/Docs/Wp/Wp56.htm>
- McNay, Scott. 2004. Ecological Factors Affecting Northern Caribou in the Omineca Region, British Columbia. Caribou Study Update FIA Project 2203006. URL: <http://www.for.gov.bc.ca/hfd/library/FIA/2004/FIA2004MR160.pdf>
- McNay, S., D. Heard, R. Sulyma, and R. Ellis. 2006. A recovery action plan for northern caribou herds in north-central British Columbia. Wildlife Infometrics Report No. 161. Wildlife Infometrics, Inc., Mackenzie, BC. URL: http://www.for.gov.bc.ca/hfd/library/FIA/2006/LBIP_2418002k.pdf

- O'Brien, D. 2005. Model for assessment of Northern Caribou population response to projections of seasonal range conditions and predation risk: model description & outputs for sensitivity analysis and testing. Draft Report. FIA Project Number 2347001. URL: <http://www.for.gov.bc.ca/hfd/library/FIA/2005/FIA2005MR127.pdf>
- Rettie, J.W. and F. Messier. 1999. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. *Ecography* 23:466-478.
- Seip, D. and E. Jones. 2004. Ecological relationship between threatened caribou herds and their habitat in the central Rocky Mountains Ecoregion 2003-04 progress report. FII Project R04-018. URL: http://www.for.gov.bc.ca/hfd/library/FIA/2004/FSP_R04-018a.pdf
- Sulyma, Randy. 2004. Pine lichen woodlands, northern caribou and forestry: Adaptive Management of Forestry Practices in Pine-Lichen Woodlands in North Central British Columbia. Project update. FIA Project Number 2203010. URL: <http://www.for.gov.bc.ca/hfd/library/FIA/2004/FIA-04-05-0056.pdf>
- Sulyma, R. and S. Wawryszyn. 2001. Adaptive management of forestry practices in pine-lichen winter range for northern caribou in north central British Columbia. URL: http://www.for.gov.bc.ca/hfd/library/fia/2006/lbip_2418011a.pdf
- Waterhouse, M.J. and H.M. Armleder. 2005. Itcha-Ilgachuz Alternative Silvicultural Systems Project 1995-2005: Research update. B.C. Ministry of Forests and Range – Southern Interior Region. Extension Note RSI-02.
- Williston, P., D. Cichowski, and S. Haeussler. 2006. The response of caribou terrestrial forage lichens to mountain pine beetles and forest harvesting in the East Ootsa and Entiako areas. Final Report - 2005 – Years 1 to 5. A report to Morice-Lakes Innovative Forest Practices Agreement, Prince George, B.C., the Bulkley Valley Centre for Natural Resources Research and Management, Smithers, B.C., and BC Parks, Smithers, B.C. 81p. (FIA-FSP Project Number Y061134)
- Youds, J., J. Young, H.M. Armleder, M. Folkema, M. Pelchat, R. Hoffos, C. Bauditz, and M. Lloyd. 2002. Caribou Chilcotin land use plan: Northern caribou strategy. Caribou Mid-coast Interagency Management Committee. Special Report. Williams Lake, B.C. URL: <http://ilmbwww.gov.bc.ca/lup/lrmp/northern/cclup/index.html>

New and Continuing Projects

- Arsenault, A. 2008. Mountain pine beetle as an agent of enhanced hair lichen biomass, with implications for the winter ecology of mountain caribou. FIA-FSP Project Number M085281.

- Cichowski, D. 2007. Effects of a mountain pine beetle epidemic on Northern Caribou habitat use, migration and population status. FIA-FSP Project Number M075047.
- Cichowski, D. 2007. Effects of a mountain pine beetle epidemic on forest floor vegetation dynamics and regeneration in the Itcha-Ilgachuz caribou winter range in the Quesnel TSA. FIA-FSP Project Number Y071328.
- Cichowski, D. 2008. The response of caribou terrestrial forage lichens to forest harvesting and mountain pine beetles in the East Ootsa and Entiako areas. FIA-FSP Project Number M085226.
- Morgan, Don. 2008. Enhancing the resiliency of the Tweedsmuir-Entiako caribou to the current Mountain Pine Beetle outbreak. FIA-FSP Project Number Y081259.
- McNay, Scott. 2007. Establishing a Science Basis for Recovery of Woodland Caribou in North-central British Columbia. FIA-FSP Project Number Y072136.
- McNay, Scott. 2007. Extension of habitat supply tools: The caribou habitat assessment and supply estimator. FIA-FSP Project Number Y071064.
- McNay, Scott. 2008. Use of adaptive management to mitigate risk of predation for woodland caribou in north central British Columbia. FIA-FSP Project Number Y082065.
- Newsome, Teresa. 2007. Treatment of Repressed Lodgepole Pine Stands. FIA-FSP Project Number M075012.
- Seip, D. 2007. Response of woodland caribou to partial retention logging of winter ranges attacked by mountain pine beetle FIA-FSP Project Number M075049.
- Waterhouse, M. 2008. Silvicultural systems to maintain northern caribou habitat in lodgepole pine forests in central B.C. FIA-FSP Project Number Y081133 (continuing long-term project).

4. WORKSHOP OBJECTIVES AND AGENDA

4.1 Meeting Outcomes and Objectives

The desired outcome of this workshop was to develop one or more prescriptions/recommendations for action to mitigate impacts on, and restore habitat for, caribou in MPB-affected forests. The prescriptions/recommendations for action will be used by the BC Ministry of Environment Mountain Pine Beetle staff as part of their restoration/mitigation program to develop site specific prescriptions for implementation. The BC Ministry of Environment – Fish and Wildlife staff may also use these prescriptions/recommendations for action in the development/refinement of their programs (e.g., Ungulate Winter Range). See Appendix 2 for the agenda for the meeting.

As a result of this meeting:

- 1) Lichen and caribou researchers and others will have increased knowledge of the effects of mountain pine beetle and salvage harvesting on terrestrial lichens and caribou habitat; and
- 2) Lichen and caribou researchers and others will have increased knowledge of steps to be taken to address concerns about the impacts of mountain pine beetle and salvage harvesting on caribou habitat.

5. SUMMARY OF WORKSHOP DISCUSSION

5.1 An overview of current studies including descriptions of the differences in ecological response of caribou to MPB

Discussion in response to questions:

Q. What do we know about terrestrial forage lichens, caribou and the mountain pine beetle?

- a. Assuming regional difference occur, what are the primary factors that distinguish those differences?*
- b. Are there any confounding/competing factors?*

Interviewed experts suggested that we also look to studies done in other countries:

- There is a very large body of scientific literature on lichen woodland ecology by Serge Payette's group in Quebec that should be reviewed for lessons that may apply to BC's lichen-dominated ecosystems. Clearly our systems are very different, but I think much of what they have learned about multi-scale process-based interactions can be adapted to help us understand & better manage our cold and nutrient-poor systems.
- I visited Finland and the Russian Karelia where two very different approaches to forest and caribou management have occurred side by side in very similar environments. There are also important lessons to be learned there about how human intervention affects the balance between caribou and other wildlife and between lichens and other plants.

TABLE 1. Potential impacts of mountain pine beetle on terrestrial lichen

Potential impacts	Confounding/competing factors
Increased competition from vegetation – e.g., kinnikinnick, twinflower	Depends on ecosystem – moister and warmer ecosystems may see more of an effect than drier and colder ones Duration of response is not known Death of pine may result in increased soil moisture due to reduced transpiration and increased availability of soil nutrients, leading to increased competition from other vegetation (if moisture or nutrients were the limiting factors)
Dieback of lichen from increased exposure	Depends on density of pine in stand and percent mortality – likely will not be significant because standing dead trees provide considerable shade and microclimate features
Increased competition from mosses	Especially on moister ecosystems with other species in canopy (spruce, fir)
Increased snow cover and moisture may cause dieback of lichen	
Increased ventilation due to pine mortality could be beneficial to lichen	Depends on the amount of increased ventilation versus the potential negative influence of too much light – likely not significant because standing dead trees provide considerable shading and microclimate modification
Human intervention	Depends on silvicultural system used
<ul style="list-style-type: none"> • salvage harvesting (exposure, slash load) • silvicultural treatments (fertilization) 	Depends on quality of dead trees (amount of slash and whether it is piled versus spread) Depends on amount and response of understory vegetation

In the Itcha-Ilgachuz area of the Chilcotin Plateau west of Williams Lake, British Columbia, there is an ongoing long-term alternative silvicultural systems trial which is looking at the impacts of group selection and irregular group shelterwoods on lichens. The trial was set up in 1995 and the ground lichens were abundant at that time. The trial is located on two unique biogeoclimatic units, the Montane Spruce (MSxv) and the Sub-Boreal Pine Spruce (SBPSxc). Both are very dry and cold with stands dominated by lodgepole pine with little ground vegetation. The area has also been impacted by a mountain pine beetle infestation in the mid- to late-1980s. That infestation killed up to 30% of the lodgepole pine. We did not know the pre-beetle conditions—lichen amounts may have increased or decreased. There was a gradual change in light regime during and following this infestation and the ground lichens flourished, especially in the SBPS unit. In the trial area, partial cutting that produced a light level of overstorey removal (28-39% of the area) still had some impact on lichen levels, but far less than clearcutting which resulted in high lichen mortality and poor condition of much of the surviving colonies because of the rapid exposure to full light. Lichens in all treatments are recovering, but those with substantial residual cover (providing partial shade) still have far more lichen. For more detailed information on this trial, see <http://cfs.nrcan.gc.ca/subsite/ferns/itcha>

In the East Ootsa-Entiako area, the sites are a little moister and warmer and are in the Sub-Boreal Spruce (SBSmc2, and SBSdk), Sub-Boreal Pine Spruce (SBPSmc), and Engelmann Spruce-Subalpine Fir (ESSFmc) zones. In these areas, the understory vegetation, kinnikinnick (*Arctostaphylos uva-ursi*) has increased substantially, outcompeting terrestrial lichens. Other understory vegetation such as twinflower (*Linnaea borealis*), crowberry (*Empetrum nigrum*), and red-stemmed feathermoss (*Pleurozium schreberi*), has also responded positively to the mountain pine beetle infestation. Kinnikinnick was absent one year following wildfire on affected plots. See Williston *et al.* 2006 and Sulyma 2004 for more details.

The Kennedy siding herd of caribou use low-elevation pine stands (Sub-Boreal Spruce – SBSwk2 and SBSvk) in the early winter, but migrate to alpine and subalpine areas for the late winter period as well as during the summer. Succession of terrestrial lichen to mosses and low shrubs is also an issue on these sites. Terrestrial lichens recovered quickly on cutblocks, but were not available to caribou when the snow became deep.

5.2 Problem Analysis

Discussion in response to questions:

Q. How do we expect caribou to respond to the mountain pine beetle infestation?

- a. In the absence of mitigation, do we expect regional differences?*
- b. Assuming there are differences, are there priorities for mitigation?*

Short-term (0–20 years) impacts on caribou:

To date there is no evidence to suggest that the short-term changes to their habitat due to the mountain pine beetle are going to be detrimental to caribou. Some researchers feel that lichen will take care of itself in much of the caribou range better without any human intervention. Short-term strategies should focus on ensuring that sufficient attacked stands are retained for caribou while efforts continue to encourage the development of future suitable habitat. Areas designated as no harvest zones should remain as such while areas in which modified harvesting is being carried out should continue as planned. Even if stands are degraded, it is better than any alternative habitat available and should be retained. However, there may be areas where there may be some potential impacts and where some intervention is warranted. Potential impacts and suggested mitigation strategies are discussed below.

- a) **Fragmentation from wide-scale salvage and access interacting with other land uses will increase predation and may lead to caribou spending more time in less preferred habitat (further contraction of their range).**

Increased access and the cumulative impacts of multiple uses (salvage harvesting, oil and gas exploration, wind power, restoration activities [including silvicultural treatments]) on the landscape are not addressed at the finer scales of management. It is essential that there be a strategic process to select areas for retention of stands affected by the mountain pine beetle and areas for recruitment. The concern is that wide-scale salvage will not be concentrated which could lead to increased fragmentation, invasive species, and predation. The access and fragmentation impacts of management need to be minimized and roads deactivated.

Successional restarts must be planned spatially and will be required in some stands that do not have the economic returns for timber. Planning should strive to maintain the total distribution of lichen sites on the landscape.

Mitigation: Large-scale planning for integrated land use (not just salvage and forestry) is needed with the objective of maintaining caribou habitat (including connectivity and lichen distribution) over larger spatial and temporal scales. Some larger areas need to be left unharvested. Continue with modified harvest area treatments as planned. Provide for future recruitment of caribou habitat (set aside areas that have been salvaged or burnt). Deactivate roads, especially those in prime habitat caribou areas as soon as possible. Road deactivation strategies will depend on road type (primary roads serving large areas [e.g., watershed], or secondary road serving a few blocks), as well as on the need for post-harvest treatments to enhance caribou habitat recruitment or to meet forestry-related obligations. Post-harvest silviculture activities in caribou habitat should be carefully managed; ideally access is deactivated, but there may be some value to post-harvest activities to enhance caribou habitat recruitment. Use traditional ecological knowledge (interviews such as the work that the Species at Risk Coordination Office [SaRCO] has done) and current studies to identify caribou habitat that is outside of designated caribou areas but part of historical distribution to retain the value for future caribou use.

- b) **Terrestrial lichen abundance may decline as availability of soil resources (moisture and nutrients) increase following death of the canopy, resulted in increased competition from other vegetation. In the short term caribou will continue to use terrestrial lichens where they are available but may increase their reliance on arboreal lichens. In the long term some caribou populations may switch to less preferred habitat.**

Kinnikinnick, twin flower, crowberry, and red-stemmed feather moss are examples of vegetation that has been observed to flourish following death of canopy trees in the MPB stands. The impact of competing vegetation varies significantly by ecosystem and limiting resources. The drier sites may not see a significant decrease in the lichen abundance and will likely see a faster recovery of the lichens through the regeneration of the sites. However, observations from the field indicate that the response on the drier sites, especially by kinnikinnick, is highly variable. Data from the Subalpine and Upper Boreal Cordilleran

ecoregions in Alberta¹ indicates similar recovery rates for clearcuts and fires for total lichen at 20–30 years, but preferred forage species (*Cladina* and *Cetraria*) are slower to regenerate. Mesic and submesic sites will likely see increase in understory vegetation that will outcompete the lichens, although again the degree of response is highly variable. We do not know when the increase in the understory abundance will end, but presumably it should end when regeneration begins to outcompete understory vegetation for soil resources. It seems to have taken approximately 30 years in stands that were previously burnt or disturbed. Caribou will continue to use terrestrial lichens where they are available but may increase their reliance on arboreal lichens in the short term when the terrestrial lichens are reduced. The concern is the longer term availability and regeneration of both terrestrial and arboreal lichens on the site.

Mitigation: Prioritize mesic and submesic stands for experimental burning or for harvest for some successional restart (to increase the lichen return and reduce the return interval) and conserve the drier sites with higher terrestrial lichen loads. Do some experimental burning and/or harvest on drier sites. It is important to realize that the regeneration will have a time lag so conservation of any remaining or historical higher-value caribou habitat is critical. Consider a prescribed fire of 1–2 ha (surface); could delimb trees to create fuel to carry the fire and potentially handfall as well. Other silvicultural activities such as stand tending and inoculation with lichen fragments (lichen ‘seeding’) should be explored. Conserve stands with abundant arboreal lichens, especially where they occur in conjunction with abundant terrestrial lichens and lower levels of MPB attack.

c) The MPB-affected stands will not offer snow interception characteristics that live stands offer.

The impact of changes in snow interception characteristics on caribou needs to be considered in terms of different spatial scales and caribou winter habitat strategies. At the landscape scale, it is expected that there will be a mix of dead MPB stands, live stands of other species, young stands, etc. Caribou should not have a problem moving through their range provided there are enough of these other stand types available. And they will continue to use the more open pine stands (dead or alive) that they prefer for terrestrial lichen feeding, despite changes in canopy snow interception. This conclusion is supported by observations of the Entiako herd during the winter of 2006/07. Despite snow levels during the winter of almost twice the normal amount, caribou continued to forage in open pine stands when they came across them.

In terms of winter habitat strategies, for caribou that use low-elevation forests throughout the winter (e.g., Tweedsmuir, Itcha-Ilgachuz), they will probably still continue to use low-elevation forests during the grey-attack stage. For caribou that use low-elevation forests in early winter then move into higher elevations later in winter (e.g., Kennedy-Siding, Chase, Wolverine), they may move up earlier than normal during the grey-attack phase. Work on the Kennedy-Siding and Entiako herds suggest that caribou winter habitat/foraging use is more likely to be influenced by snow conditions/climatic events than by the grey phase of the MPB

¹ As presented by Dr. Joan Snyder and Dr. Paul Woodard (University of Alberta) in ‘Lichen regeneration rates in Alberta following various types of logging and wildfire disturbances.’ Final Report. July 21, 1992.

attack. From observations on the Entiako winter range last winter, grey trees intercept a lot of snow so snow conditions may only be slightly higher in grey-attacked stands than in live stands. However, it seems that the melt–freeze cycles are more of a concern because of tree drip under both dead and live trees that could result in harder digging conditions, and in general a more consolidated snowpack that again could result in harder digging conditions.

Mitigation: Monitor caribou use and snow depth interaction for pattern changes. If observed to be a problem, focus on enhancing recruitment in these stands and on protecting any alternate habitat that has lower mortality.

d) Changes in mountain pine beetle-impacted stands may increase habitat for moose and increase predation, leading to reduction in caribou numbers.

Evidence from both western scientific studies and traditional knowledge shows that the expansion of moose into British Columbia has coincided with caribou population declines. Following MPB, predation on caribou may increase through increased alternate prey, and fragmentation and access due to salvage logging. This is likely more of a concern in the wetter sites and in certain ecosystems. On some caribou winter ranges, preferred caribou habitat does not contain moose forage shrubs; moose forage shrubs tend to occur in wetter riparian areas dominated by spruce or subalpine fir. Therefore, changes in stand dynamics due to mountain pine beetle may not significantly increase moose forage species. This is especially true in the SBPSxc and the MSxv. Caribou and lichen are “stress tolerators,” surviving where resources (e.g., heat, light, water, and nutrients) are limiting (not necessarily all are limiting), and other organisms with greater resource demands are unable to compete effectively. Stress tolerators tend to be slow to recover from change or disturbance and are thus vulnerable, especially when a lot of different changes occur simultaneously. Disturbances that result in an increase in resource availability can result in these species being out-competed by other organisms that are more adaptable or more competitive. However, if the disturbance reduces resource availability (e.g., large severe fires), then it may volatilize resources, further depleting them to the benefit of stress tolerators like caribou and lichen who survive in the marginal habitat types. We have a poor understanding of the interaction between the caribou and other species.

Mitigation: An adaptive management study needs to be set into place to monitor the mitigative actions being implemented and modify the activities or strategies if these negative interactions are observed. Further research (short-term) is needed to better understand the interspecific interactions and the effect on caribou habitat use in the context of MPB effects on the landscape. Consider the value of some predator control. Use traditional ecological knowledge (interviews such as the work that SaRCO has done) and current studies to identify caribou habitat that is outside of designated caribou areas but part of historical distribution to retain the value for future caribou use.

Long-term (>20 years) impacts on caribou:

a) Stands with high MPB mortality may cause impaired movement or displacement of the caribou when the stems fall down.

The concern regarding caribou use of the stands when the trees fall down is impairment to caribou movement both through lack of snow interception and due to high levels of deadfall, leading to potential displacement from these stands. This will depend on initial stand density, percentage of susceptible pine in the stand, and the levels of pine mortality (some stands have quite high mortality). Tree falldown is a long-term impact as the trees could remain standing for significant periods of time, potentially 5 to 20 years depending on ecology of the site. Once the trees fall the adjacent and alternate caribou habitat will become critical.

Mitigation: Monitor caribou range to determine percent pine mortality by stand and the extent of high pine mortality (>50% in high volume stands); this will be a concern for caribou if on a landscape scale the majority of stands fit this criterion. Prioritize the stands with high pine mortality for management (silviculture—thinning or salvage) and conserve areas with lower pine mortality. Undertake analysis to better predict when tree fall may occur. Assess the effectiveness and feasibility of prescribed fire for reducing fallen tree accumulations.

b) MPB-killed trees with abundant arboreal lichens will eventually fall down and at some point become unusable for arboreal lichens.

Although arboreal lichen abundance in MPB-killed stands may increase in the short term due to increased insolation and ventilation, arboreal lichens on grey-attack trees may deteriorate once trees fall down. Once the grey-attack trees fall, arboreal lichen will quickly die.

Mitigation: Ensure recruitment of regeneration for arboreal lichen substrate in the future.

5.3 Recommendations

A Proposed approach for managers (summary by Chris Ritchie):

Subdivide provincial terrestrial lichen-feeding caribou populations into perhaps 4 units: Peace; Mackenzie; Tweedsmuir; Itcha Ilgachuz. Summary tables of habitat use strategies found in both the Recovery Strategy for Northern Caribou for each population in the Southern Mountains National Ecological Area (SMNEA; Northern Caribou Technical Advisory Committee 2005) and in the Compendium of Northern Caribou winter range management guidelines (Cichowski 2005), for all northern caribou populations would be helpful in determining caribou management units.

Within each unit:

- 1) identify areas that have lichen and are likely continue to have lichen persist (Retention), and
- 2) identify the areas that will need periodic disturbance for recruitment (Recruitment).

Within periodic disturbance units (e.g., UWR, Park, suitable THLB unit):

- 1) identify viable/feasible options to successionally restart (e.g., log, mechanical rehabilitation, prescribed fire, fuel managed fire [i.e., preload fuel], other).

Within periodic disturbance units (e.g., UWR or Park):

- 1) deploy a feasible successional restart option to revert to early stand conditions and bring back to pine stand ASAP (stocking, stand tending).

In some areas in both Retention and Recruitment areas:

- 1) conduct small scale treatments like 1–2 ha fires to assess lichen recruitment;
- 2) do a “faux-severe” fire in a retention area to see what the response will be to a fall over-fueled fire and assess impacts;
- 3) maintain high-value arboreal lichen stands in the short term; and
- 4) promote regeneration to speed recovery of arboreal lichens.

FIGURE 1 Recommended Strategy

Strategic planning using adaptive management framework and regional-scale planning for integrated land use (not just salvage and forestry) with the objective of maintaining caribou habitat (including connectivity and lichen distribution) over larger spatial and temporal scales.

We have to think from the bottom up (small spatial scales, short time scales) and the top down (large spatial scales, long time scales) while trying not to forget important interactions that might take place at intermediate scales.

<i>Retention</i>	<ul style="list-style-type: none"> ● Identify areas with lichens that don't need intervention and where lichens will likely persist; prioritize these areas for retention. ● Use criteria including adjacency, leaving the larger areas unharvested. Also provide for future recruitment of caribou habitat (set aside areas that have been salvaged or burnt). ● Focus on areas where the understorey competition will not be likely to limit the lichen regeneration (drier sites with higher terrestrial lichen loads). ● Predator control. ● Leave options open (retain values) for future caribou use outside of identified habitat. ● Use traditional ecological knowledge (interviews such as the work that SaRCO has done) and current studies to identify caribou habitat that is outside of designated caribou areas but part of historical distribution to retain the value for future caribou use.
<i>Recruitment</i>	<ul style="list-style-type: none"> ● Identify areas where lichens need periodic disturbance to restore lichen biomass; prioritize wetter stands for experimental burning or for harvest for some successional restart (try experimental burning to test the hypothesis that there will be an increase in the lichen return and reduced return interval). ● Do analyses to assess where large areas are susceptible to falldown that would eventually impede travel and access to forage and prioritize these areas for access? ● Test the hypothesis that promoting regeneration will reduce competition (depending on ecosystem). ● Prioritize areas that go to moss for harvest or burning for recruitment (using broad-scale planning and ecological zones as a guide). ● Predator control. ● Prioritize the stands with high pine mortality for management (silviculture—thinning or salvage) and conserve areas with lower pine mortality. ● Undertake field studies to better predict when tree fall may occur.
<i>Operational Scale</i>	<ul style="list-style-type: none"> ● Prescribed burns <ul style="list-style-type: none"> ○ Consider an experimental prescribed fire of 1-2 ha (surface), could delimb trees to create fuel to carry the fire and potentially handfall as well. Potentially using test plots in Vanderhoof District ● Post harvest silviculture <ul style="list-style-type: none"> ○ Other silvicultural activities such as stand tending, and inoculation (Kat Enns with MOE in Williams Lake may have some research on inoculation) with lichen fragments (lichen 'seeding') should be explored ● Stocking standards <ul style="list-style-type: none"> ○ Necessary adjustments will depend on ecosystem and desired caribou habitat characteristics ● Manage for competing objectives (see above) ● Manage for understory low shrubs – promote regeneration (testing the hypothesis that managing for low shrubs by increasing regeneration will have a benefit to lichen) ● Access decommissioned <ul style="list-style-type: none"> ○ Will depend on road type (primary haul road serving large area (e.g., watershed) or secondary road serving a few blocks ○ Will also depend on need for post harvest treatments to enhance recruitment or to meet forestry related obligations. ● Harvesting (scale variable by ecosystem) <ul style="list-style-type: none"> ○ Leave standing clumps of trees to provide partial shade for the lichen. ○ Partial cutting systems – single tree and group selection, irregular shelterwood

5.4 Workshop Evaluation and Considerations

As a result of the workshop, 77% of those participants who responded to the survey thought that the meeting was either worthwhile or very worthwhile (see Appendix 3 Workshop Evaluation for more information). All but two respondents felt that they had increased their knowledge of the effects of MPB on terrestrial lichen and caribou habitat, and that the workshop increased their knowledge of the steps to be taken to address concerns about the impacts of MPB and salvage harvesting on caribou habitat.

6. LITERATURE CITED

- Northern Caribou Technical Advisory Committee. 2005. A Strategy for the Recovery of Northern Caribou in the Southern Mountains National Ecological Area in British Columbia. Version 1.0. B.C. Ministry of Water, Land and Air Protection, Victoria, B.C.
- Cichowski, D. 2005. Compendium of Northern Woodland Caribou Forestry Guidelines in British Columbia. Biodiversity Branch, B.C. Ministry of Water, Land and Air Protection, Victoria, B.C.

APPENDIX 1 LIST OF WORKSHOP PARTICIPANTS AND INTERVIEWEES

Name	Affiliation	Participant or Interviewee
Harold Armleder	BC Ministry of Forests and Range – SIR	Participant
Bill Arthur	BC Ministry of Environment	Participant
Kent Brown	Terrestrial and Aquatic Environmental Managers Ltd.	Participant
Debbie Cichowski	Caribou Ecological Consulting	Participant
John Deal	Canfor	Participant
Sean Haughian	University of Northern British Columbia – MSc student	Participant
Doug Heard	BC Ministry of Environment	Participant
Leslie McKinley	BC Ministry of Environment	Participant
Scott McNay	Wildlife Infometrics	Participant
Darcy Peel	BC Ministry of Environment	Participant
Dale Seip	BC Ministry of Forests and Range – NIR	Participant
Randy Sulyma	BC Ministry of Forests and Range – Fort St James District	Participant
Michaela Waterhouse	BC Ministry of Forests and Range – SIR	Participant
John Youds	BC Ministry of Environment	Participant
Michael Gillingham	University of Northern British Columbia	Interviewee
Trevor Goward	University of British Columbia	Interviewee
Sybille Haeussler	Bulkley Valley Centre for Natural Resources Research and Management	Interviewee
Doug Steventon	BC Ministry of Forests and Range	Interviewee
People invited but unable to participate (will be given opportunity to comment on report)		
Phil Burton	Pacific Forestry Centre	
Darwyn Coxson	University of Northern British Columbia	
Elena Jones	Independent Consultant	
Patrick Williston	Gentian Botanical Research	

APPENDIX 2 WORKSHOP AGENDA

Time	Topic	Lead/Presenter
8:15	Coffee	
8:30-9:00	Workshop Introduction, and Introduction of participants	Carolyn Whittaker
9:00-9:30	Caribou researcher update (5 minutes each)	Randy Sulyma Harold Armleder Dale Seip Deb Cichowski Kent Brown Others
9:30-10:00	Workshop discussion Q. What do we know about terrestrial forage lichens, caribou and the mountain pine beetle? a. Assuming regional difference occur, what are the primary factors that distinguish those differences? b. Are there any confounding/competing factors?	Everyone
10:00-10:15	Coffee and Stretch break	
10:20-10:40	Presentation – Caribou research at the Kennedy Siding	Dale Seip
10:40-noon	Workshop discussion Q. How do we expect caribou to respond to the mountain pine beetle infestation? a. In the absence of mitigation, do we expect regional differences? b. Assuming there are differences, are there priorities for mitigation?	Everyone
12:00-1:00	Lunch (provided)	
1:00-1:30	Presentation – Summary of morning hypotheses	Carolyn and Al
1:30-3:00	Workshop discussion (implementation) Q. How might we mitigate the effects of the mountain pine beetle on caribou habitat? a. Is mitigation necessary? b. What mitigation strategies/tools are available?	Everyone Divide into 2 break-out groups
3:00-3:20	Coffee and Stretch Break	
3:20-3:40	Report back from Breakouts (or any groups)	Group leaders
3:40-4:10	Group Summary Discussion How do we manage for the possibility that we might be wrong?	Everyone
4:10-4:30	Session wrap up The discussion will draw on earlier discussion points to capture final comments and to initiate development of next steps.	Carolyn Whittaker
4:30	Adjourn	

APPENDIX 3 WORKSHOP EVALUATION

The evaluation indicated that 77% of those participants who responded to the evaluation thought that the meeting was either worthwhile or very worthwhile. All but two of the respondents felt that they had increased their knowledge of the effects of MPB on terrestrial lichen and caribou habitat and that the workshop increased their knowledge of the steps to be taken to address concerns about the impacts of MPB and salvage harvesting on caribou habitat.

The most useful aspects of the workshop identified by the participants include:

- Pulling experts together to compare research projects and learning and to discuss potential solutions and pitfalls with experts in the field; this larger view and the differences of opinion are essential to prevent the tendency to apply or promote just one solution for all of the caribou habitat.
- The group discussion about lichen–caribou, particularly how lichen respond in different ecosystems to different treatments.
- Network contacts and information on what to focus upcoming research.
- Identification of potential collaborative sample sites.
- Has modified my approach (or at least helped to clarify) current year FSP work.
- Summaries of research were useful particularly Harold, Debbie and Dale.
- Updates on research projects and discussion on future impacts to caribou.
- The planning framework is important.

I wish someone could tell me ...

- Whether caribou select winter ranges based on forage availability or predator avoidance and what effect soil nutrient status has on growth and proliferation of lichen-displacing species.
- If the degree to which caribou lose range due to MPB will eventually be manifest in lower nutritional status.
- How caribou will respond in the long-term?
- Are there detrimental effects? E.g. Large areas with lots of tree fall that impedes movement?
- Lichen dynamics in MPB forests
- What is going to happen when the trees fall over.
- How government will co-operate between ministries to deliver complementary objectives (i.e., capturing economic value from MPB-affected stands while maintaining habitat values across the landscape).
- The key factor affected by MPB that has a negative affect on caribou and its habitat.
- If any treatment (including no action) would reduce lichen and therefore caribou food to a level that would not support caribou.

Next steps:

- Monitoring projects have not been long-term enough to yield necessary data and conclusions.
- Get reviews of the report that comes out of the workshop before the final version is drafted.
- Most of what we need is already available, it just needs to be implemented.
- Useful update but discussion on restoration was inconclusive.
- Need more discussion in the future on this topic.
- Additional workshops in the future to share ongoing research and actions taken.

Other comments:

How does MPB affect non-forage lichen species?
Breakout groups would have been useful.
Ensure to include ecosystem staff in discussions.