

**FIA-FSP project number:** Y081259

**Title:** Enhancing the resilience of the Tweedsmuir-Entiako caribou to the current Mountain Pine Beetle outbreak.

**Project Start Date:** April 1, 2007

**Project Length:** 2 years

**Project End Date:** March 30, 2009

### **Project Purpose and Management Implications**

The range of the Tweedsmuir-Entiako caribou (*rangifer tarandus caribou*) population coincides with an area that is experiencing an unprecedented mountain pine beetle (*Dendroctonus ponderosae*; MPB) outbreak in the Greater Tweedsmuir Ecosystem (GTE) in central British Columbia (Eng et al. 2005, Cichowski and Banner 1993). This caribou herd belongs to the west-central metapopulation, which is part of the declining Southern Mountain population of woodland caribou and have been designated as threatened (NCTAC 2004, COSEWIC 2005). The caribou rely on mature forest to provide winter range. Areas of mature forest provide their preferred food, terrestrial lichens, and it provides security cover from predators, mainly wolves and bears (Seip and Cichowski 1996, Cichowski and McLean 2005). In addition, large contiguous areas of mature forest allow caribou to shift their use of the landscape, within and between years, making their location and movement less predictable to predators. Changes in forest structure, resulting from the current MPB outbreak, could alter habitat availability and cause a shift in the predator-prey dynamics in the caribou's winter range. Moose and deer potentially benefit from an increase in young seral forest, and with an expanded prey base the number of wolves may increase. This increase in the density of wolves can compromise the viability of local caribou populations (Wittmer et al. 2005).

There is a pressing need for forest managers to determine appropriate strategies to enhance, as best as possible, the adaptive capacity of the Tweedsmuir-Entiako caribou to the current MPB outbreak. Information is required on what areas are appropriate for forest salvaging activities and road building and which are not, and on where stand tending can lead to an accelerated recruitment of good caribou habitat (Bunnell et al. 2004). However, there are numerous uncertainties associated with this issue. For example, there are uncertainties about the post MPB structural composition of caribou habitat, including the length of time for MPB killed stands to fall down, the potential shift in sub-canopy vegetation from lichen mats to other cover types (Williston and Cichowski 2004), and at what point do these stands no longer provide adequate caribou habitat and how fast do they recover (Coates et al. 2006). Compositionally, there are shifts in forest pattern and age structure that may suit other ungulates, risking a shift in predator-prey dynamics that may compromise the viability to the caribou population (Bunnell et al. 2004), but it is unclear how this dynamic may unfold.

The goal of this project is to evaluate current woodland caribou habitat, how it is being modified by the current MPB outbreak, and which forest management strategies have potential to enhance the resilience of the Tweedsmuir-Entiako caribou population; all in the context of landscape change, ecological and wildlife response uncertainties, and current knowledge gaps. The approach uses collaborative modelling; influence diagrams (McNay et al. 2006), and scenario analysis techniques (Peterson et al. 2003) to capture existing research and opinions on caribou and habitat ecology. Scenario analysis and assessment is a systematic way of gaining insights into complex and uncertain futures (Peterson et al. 2003). The results of this project will be applied by engaging resource managers in the Nadina and Vanderhoof Forest Districts, including forest licensees, Morice-Lakes Innovative Practices Agreement (IFPA) participants, the government ministries of Environment,

Forests and the Integrated Land Management Bureau, and First Nations. Input from resource managers and First Nations will be solicited through workshops to describe the project and to develop forest management scenarios. Project results will be applied in the development of Recovery Action Plans for the northern caribou in the SMNEA. As well, the Nadina Forest District will use the caribou, moose and deer seasonal habitat maps generated from the project to inform operational forestry activities as part of the Forest Stewardship Planning process.

## Methodology Overview

### **Objective**

#### *Tweedsmuir-Entiako Caribou Range Base Line*

Spatial information will be organized in a GIS and used to meet the landscape modelling, data distribution and cartographic objectives of the project. Data from Cichowski and MacLean (2005) will be integrated, including caribou telemetry locations, habitat interpretations and lichen mapping. Additional data modelling of topography will be done to capture soil moisture (Fall and Morgan 2000) and to generate terrain curvature and ruggedness indices (Apps et al. 2001).

Satellite imagery will be georectified to the existing spatial data and land cover will be classified. A confusion matrix will be constructed by comparing the classified image with existing forest inventory data and linked project plot data (FIA-FSP M075047) to validate the classified image. Tweedsmuir Park spatial ecological data will be generated based on old (1950s) generalized forest cover data, topographic modelling and the classified imagery.

The historic reconstruction of the GTE will use existing historical Landsat imagery. Images will be purchased to create a 5-7 year time sequence of landscape change. Classified imagery will be verified with current and historic ecosystem plot data.

### *Objective 2*

#### *Synthesize Existing Information*

Team will review existing literature on caribou ecology and response of caribou to natural and human disturbance, with a focus on the Tweedsmuir-Entiako caribou. Based on this information, conceptual models of seasonal moose, deer, wolf, and caribou habitat, and models of threats to caribou populations will be constructed, including models of predator-prey dynamics. Conceptual models will be drafted into influence diagrams and describe the likely state of seasonal caribou habitat given observed environmental condition, the potential status of other ungulates and wolves. The diagrams will define the key environmental correlates, latent variables and response variables.

Empirical data and expert opinion will be gathered through formal workshops with caribou and forest ecologists to refine the influence diagrams. The team will formalize the diagrams into Bayesian Belief Networks (BBNs) to capture the environmental correlates, disturbance factors and response conditions following the methodology of McNay et al. (2006).

Results of caribou habitat and population ecology studies in adjacent areas, such as the Itcha-Ilgachuz and Rainbow mountains (Apps et al. 2001) and Chase, Scott, Takla and Wolverine herds (McNay et al. 2006) will be used to calibrate and validate components of the models developed for the GTE.

First Nations will be engaged through our traditional knowledge protocol. The BV Research Centre – the proponent- has established guidelines for the consideration of Traditional Knowledge (TK)

into research projects. Following these guidelines will allow us to engage meaningfully with First Nations. The guidelines emphasize First Nations participation at higher levels of research design and implementation. The methodology in this project is intended to be evolving in order to change with the capacity and needs of each First Nation in our study area. In this regard, we strive for flexibility and innovation, rather than a standardized approach. The BV Research Centre has established relationships with several First Nations, including the Office of the Wet'suwet'en. This project includes a capacity building component for relevant First Nations. More specifically, we have included a monetary allocation for First Nations to help facilitate communications with us. Where appropriate, we ensure that the First Nation receives technical deliverables (such as map sets, GIS information, etc) to increase their technical capacity to manage their traditional territories. All project extension materials are forwarded to the relevant First Nations. The strength of the BV Research Centre's existing relationships with community members, scientists, government and industry, and First Nations groups, uniquely positions us to effectively incorporate First Nations interests into our project. A copy of the Centre's current TK guidelines has been attached to this project.

### *Objective 3*

#### *Scenario Analysis of Future Landscape Condition*

There are two existing landscape projection models, one in the Nadina (Steventon 2006 M07-5006) and one in the Vanderhoof Forest District (DeLong 2006). These two models and the data for Tweedsmuir Park will be integrated into a Tweedsmuir-Entiako Landscape Model (TELM). The area will be represented at a resolution of 1 ha per grid cell, and will incorporate recent timber supply reviews (Morice, Lakes Timber Supply Areas and Vanderhoof Forest District). The landscape models will be implemented using the SELES (Spatially Explicit Landscape Event Simulator) modelling system (Fall and Fall 2001). This software is a flexible tool for building and processing grid-based, spatio-temporal models that has been used for a wide range of related projects, including the provincial MPB projection model (BCMPB, Eng et al. 2005), and other caribou projects in west-central BC (McNay et al. 2006). Using it will facilitate interoperability of our models with those from linked projects. The landscape model will include processes of forest management, stand aging and succession, MPB dynamics (downscaled from BCMPB), road development, and fire. Output from the landscape projection model will be input into the BBN models to conduct caribou analysis of the landscape projections.

A set of scenarios will be designed to evaluate a range of future conditions, such as 1) current management, and 2) management applies no salvage, moderate salvage or aggressive salvage. Models will be verified by aligning current timber management scenarios with timber supply review results, sensitivity analysis of key model parameters, and by having model output reviewed by timber management and forest ecology experts.

### *Objective 4*

#### *Enhancing the Resilience of Caribou Population to Landscape Change*

Scenario analysis results will be used to gain insights into the factors that enhance or limit the capacity of the caribou herd to adapt to landscape level disturbance, such as, structure of post-disturbance stands, availability of alternative habitat, movement barriers, predator-prey dynamics, and the impact of forestry activities. Strategies will be identified that provide the most robust approach to maintaining caribou habitat when faced with landscape dynamics resulting from a range MPB and fire scenarios and the uncertainty of how caribou will respond to landscape change.

## Project Scope and Regional Applicability

The chief benefit of the project's products will be to inform our audience of the potential consequences of current policy on the Tweedsmuir-Entiako woodland caribou. As well, the project will identify alternative management strategies designed to enhance the resilience of this woodland caribou herd to the impact of MPB and timber salvaging operations. This project will generate 3 major products: 1) base line GTE data including a historic landscape reconstruction based on 1970's satellite imagery of the landscape composition and pattern; 2) a habitat supply model for the Tweedsmuir-Entiako caribou; and 3) a journal publication that describes the analysis of current policy, provides alternative options, and delivers guidance to inform MPB-related decisions.

This project's results and methodologies are relevant to any landscape where there is high uncertainty in the supply of wildlife habitat, particularly areas undergoing landscape change driven by climate change related dynamics such as MPB. In general, the resilience approach to habitat supply modelling developed by our project will provide a practical basis for exploring a variety of wildlife habitat issues that are impacted by spatio-temporal landscape dynamics. The project's target audience is resource managers and decision-makers responsible for developing strategies concerning the MPB outbreak and its impact on the Tweedsmuir-Entiako caribou herd and other herds that will experience the MPB epidemic. Because the MPB outbreak could have wide-ranging impacts and our project addresses both timber and wildlife values, there will be several beneficiaries of this project's results. Project participants include Forest industry, British Columbia provincial forest planning and environment offices, conservation groups and First Nations.

## Interim Conclusions

### *Objective 1*

#### *Tweedsmuir-Entiako Caribou Range Base Line*

In the first year, we collated existing spatial and attribute data for the GTE. Data was collected from provincial warehouses, local archived data, and data associated with past Tweedsmuir Caribou projects (Cichowski and MacLean 2005). Data includes caribou and moose telemetry, terrestrial lichen, forest inventory, terrain, ecosystem mapping, roads, rivers and lakes. The data was organized into a project data warehouse. Mapping of season solar radiation, terrain roughness and soil moisture for species habitat mapping was also organized into the project warehouse.

The availability of satellite imagery ranging from 2007 to 1974 was assessed. Existing imagery was used as much as possible and additional data was purchased in an attempt to get as complete as possible transition of landscape state from 1974 to 2007. All images were georectified to the existing spatial data. Land cover in the imagery was classified for further analysis and to provide extension material.

### *Objective 2*

#### *Synthesize Existing Information*

Literature on caribou ecology and response of caribou to natural and human disturbance, with a focus on the Tweedsmuir-Entiako caribou has been reviewed and a report has been generated (Cichowski 2008).

To gather additional empirical data and expert opinion of the Tweedsmuir caribou and the dynamics of the GTE two workshops were held. The first workshop was focused on terrestrial lichen and landscape dynamics and was held with caribou and forest ecologists and used to construct the conceptual models of the GTE system from a landscape ecology perspective. The second workshop

included wildlife biologists and was used to develop conceptual models of woodland caribou population dynamics. Based on the results of these workshops the core team developed preliminary Bayesian Belief Networks (BBNs) to capture the environmental correlates, disturbance factors and response conditions following the methodology of McNay et al. (2006).

Using the information gathered through the background report and from the workshops, conceptual models of winter ungulates, wolf, and caribou habitat, and models of threats to caribou populations have been constructed, including models of predator-prey dynamics. Conceptual models have been drafted into preliminary influence diagrams that describe the likely state of seasonal caribou habitat given observed environmental condition (figure 1), the potential status of other ungulates (figure 2), and of the influence of various elements of the Tweedsmuir system on the caribou population (figure 3). The diagrams define the key environmental correlates, latent variables and response variables. These variables are then used in the landscape simulation models for the scenario modelling.

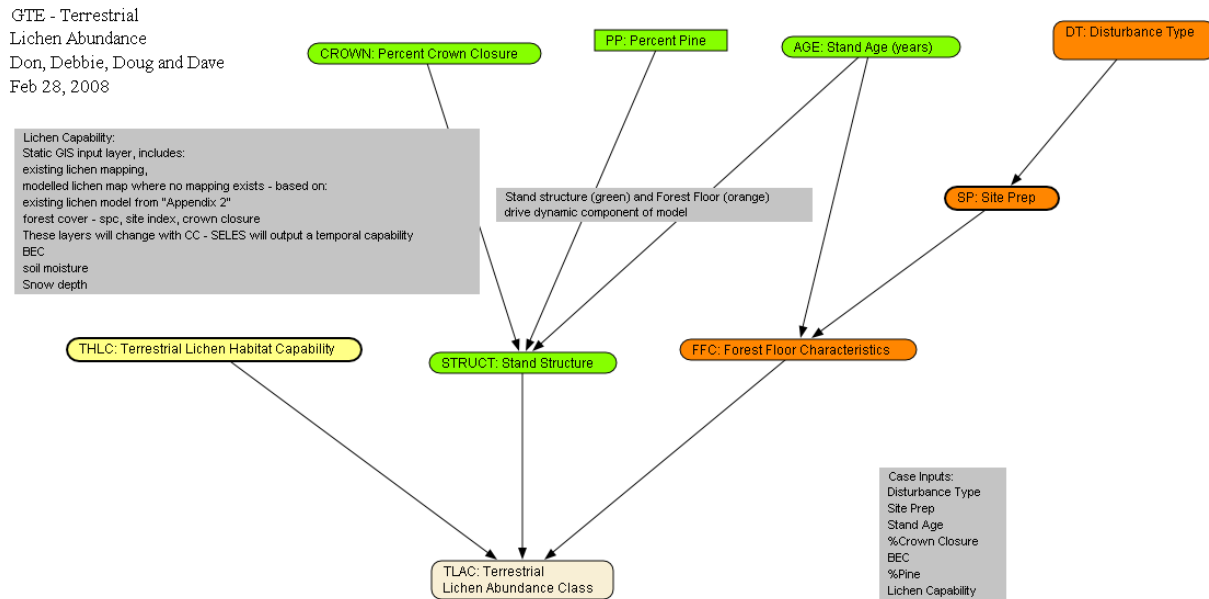


Figure 1. Influence diagram describing terrestrial lichen abundance in the Tweedsmuir-Entiako study area

GTE - Other Ungulates  
 Don Morgan  
 Jan 22, 2008

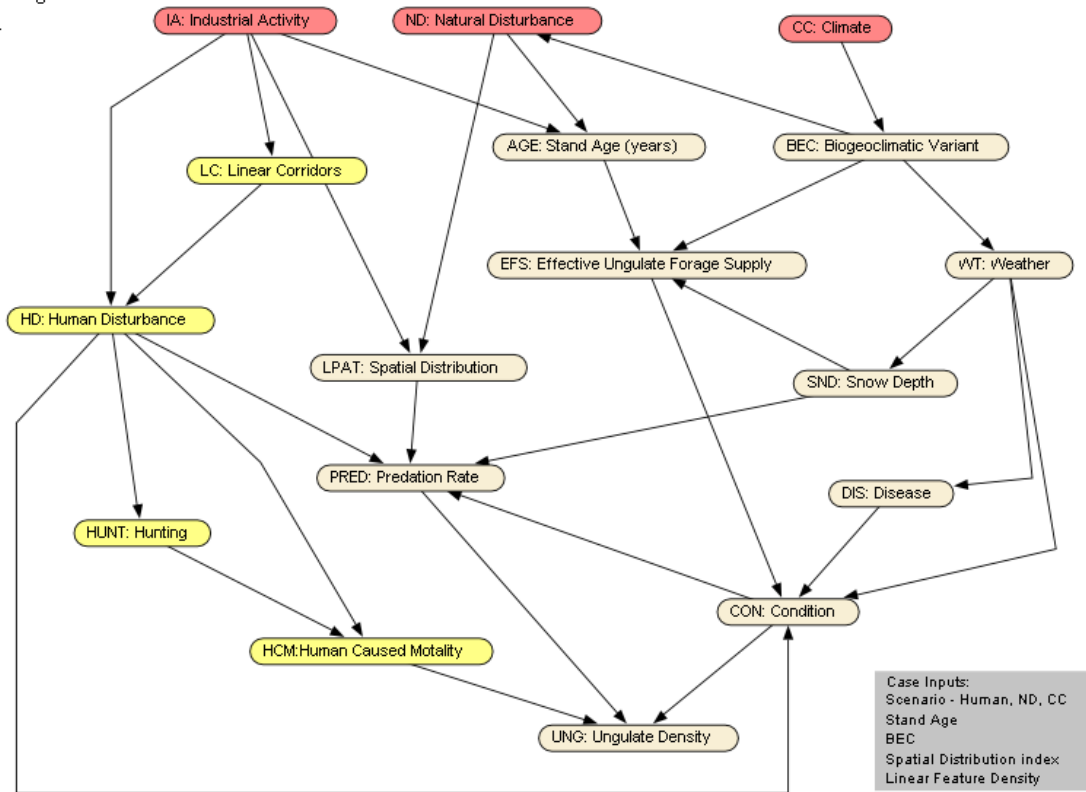


Figure 2. Influence diagram describing ungulate density in the Tweedsmuir-Entiako study area.

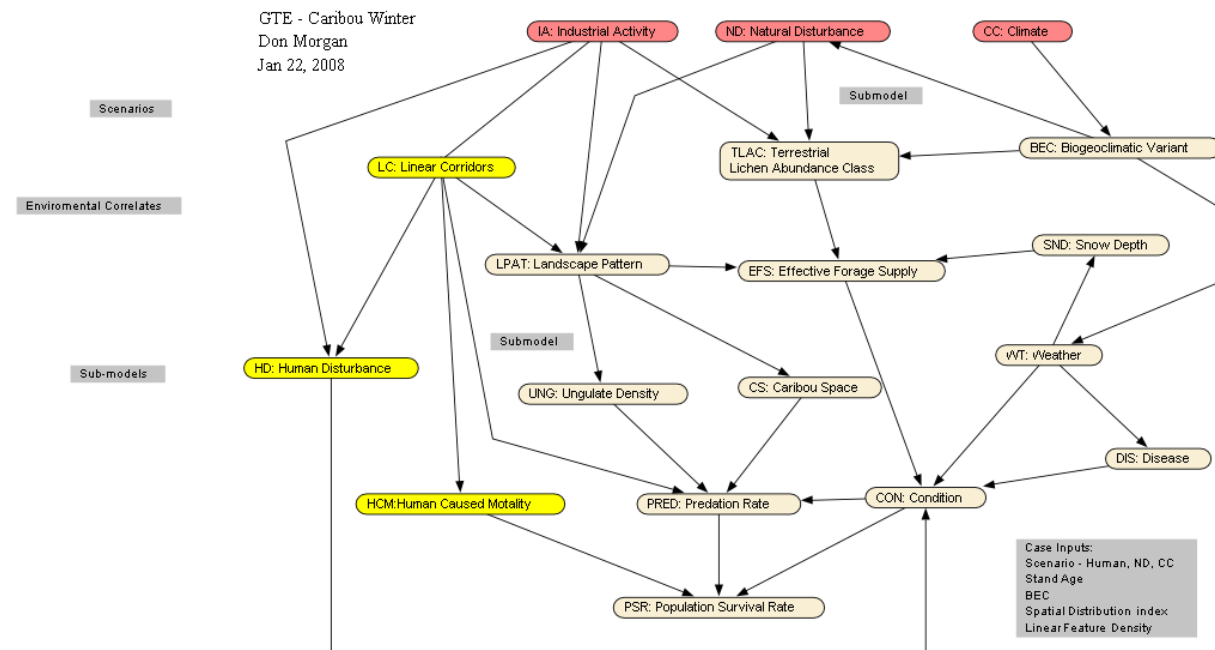


Figure 3. Influence diagram showing caribou winter habitat in the Tweedsmuir-Entiako study area.

In the first year of the project we conducted preliminary First Nations consultation. We discussed

the project with the Office of the Wet'suwet'en and refined a communication and information sharing protocol. In addition, we drafted a letter for distribution to all of the First Nations in the study area. This letter will be distributed in the second year and workshops with the First Nations will be conducted to share information on woodland caribou ecology and GTE landscape dynamics.

### *Objective 3*

#### *Scenario Analysis of Future Landscape Condition*

Under the first year of funding preliminary work has been done to integrate two existing landscape projection models, one in the Nadina (Steventon 2006 M07-5006) and one in the Vanderhoof Forest District (DeLong 2006). Once completely integrated these two models and the data for Tweedsmuir Park will be integrated into a Tweedsmuir-Entiako Landscape Model (TELM).

The majority of the activity for this objective is planned for 2008/2009.

### *Objective 4*

#### *Enhancing the Resilience of Caribou Population to Landscape Change*

This activity is planned for 2008/2009

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