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# MODELING

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## Caribou Habitat Assessment and Supply Estimator (CHASE):

### Using Modeling and Adaptive Management to Assist Implementation of the Mackenzie LRMP in Strategic and Operational Forestry Planning

#### *DRAFT RESULTS*

R. SCOTT MCNAY<sup>1</sup>, KATHRYN L. ZIMMERMAN<sup>2</sup>, AND RICK ELLIS<sup>3</sup>

DECEMBER 20, 2002

<sup>1</sup>Slocan Forest Products Ltd, PO Box 310, Mackenzie, BC, V0J 2C0, mcnays@mackenzie.slocan.com

<sup>2</sup>Bionetworks Consulting, 3479 Rosia Rd., Prince George, BC V2K 4Y5, kathiz@telus.net

<sup>3</sup>R. Ellis and Associates Inc., 1296 Laurel Rd., Sidney, BC, V8L 5K8, ellis@islandnet.com

Prepared for Slocan Forest Products Ltd., Mackenzie Operations under contract #FIA C02050-400301

**CITATION:** McNay, R. S., K. L. Zimmerman, and R. Ellis. 2002. Caribou Habitat Assessment and Supply Estimator (CHASE): Using modeling and adaptive management to assist implementation of the Mackenzie LRMP in strategic and operational forestry planning. *DRAFT RESULTS*. Wildlife Infometrics Inc. Report No. 060. Wildlife Infometrics Inc., Mackenzie, British Columbia, Canada.



**Omineca Northern Caribou Project**

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**DRAFT RESULTS**

by

**The CHASE Modeling Team  
(Scott McNay, Project Leader / Coordinator)  
(Kathi Zimmerman, Editor)  
(Rick Ellis, Facilitator)**

**December 20, 2002**

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## ABSTRACT

This report discusses several results from the Caribou Habitat and Supply Estimator (CHASE) model. CHASE has been developed as a strategic and operational planning tool for use in the management of caribou populations (*Rangifer tarandus caribou*) and their habitat in the Mackenzie Timber Supply Area (TSA). Refer to Wildlife Infometrics Report No. 55 entitled “Caribou Habitat Assessment and Supply Eestimator (CHASE): Using Modeling and Adaptive Management to Assist Implementation of the Mackenzie LRMP in Strategic and Operational Forestry Planning” for theoretical information.

CHASE results have been developed into “standard” products in the form of posters that depict the amount, spatial, and temporal distribution of various caribou range types. Examples and interpretation of results are provided to aid the model user in analysis of caribou seasonal ranges or entire herd areas.

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## 6.0 RESULTS AND INTERPRETATIONS

As described in chapter 2 of this report, there are a number of ways the model can be used for strategic and operational (Forest Development) planning. There are a number of results of the model runs that will likely be of interest in most applications. These typical results have been developed into “standard” products of the model in the form of posters that depict the amount and spatial distribution of the various range types (by preference classes) over time. These standard results are presented in section 6.1. The interpretation of results is presented in section 6.2. In addition, results can be interpreted for complete caribou herd areas rather than just seasonal ranges, as described in section 6.3. The “standard” model results can then be applied to management decision making. Additional possible applications of the model are described in section 6.4.

To date the model has only been run using the LRMP scenario, one of four scenarios specified in section 2.3.2. For any specific management question the model can be run in a gaming mode, that is, set up to explore alternatives specified by the user. There are a number of built-in management levers that can be used in a gaming (see section 2.2), however, due to the extensive time requirements for running the model at present, no gaming runs have been conducted.

### 6.1 PRESENTATION OF RESULTS

The results presented are from a run of the model using the LRMP Management Scenario for the Wolverine Herd area. Additional results will be available from other scenarios when they are complete. An example of the products prepared to present results is available online at <http://www.slocan.com/irm/projects/caribou/model/poster.html>.

Two formats were used to present the model results:

1. Maps were generated for two specified timesteps (2000 and 2100) for each sub-model and for predation risk
  - Maps were produced in ArcView then exported as an image in jpeg format. Each script that has an ‘Output’ of a grid, will export a jpeg
2. Graphs and tables of the area of the final output nodes of each sub-model were produced by state value and patch size, in 10 yr intervals
  - Tables from Access were exported to Excel, where the graphs and tables were produced

Maps, graphs and tables were displayed in PowerPoint for the final posters presented at workshops. Descriptions of the specific results presented for each sub-model are described below.

#### 6.1.1 Moose and Wolf Relationship Model

Example results presented:

- Moose Density Netica model
- Graphic and equation describing factors influencing subsistence hunting (proximity of moose winter range to First Nations communities and roads)
- Year 2000 and 2100 maps of subsistence hunting levels
- Year 2000 and 2100 maps of winter moose habitat values
- Year 2000 and 2100 maps of summer moose habitat values

- Tables and graphs of the area of each seasonal habitat value class over time
- Year 2000 and 2100 maps of winter moose densities, displaying all cutblocks created in the previous 40 years, and all roads created in the previous 20 years
- Year 2000 and 2100 maps of summer moose densities, displaying all cutblocks created in the previous 40 years, and all roads created in the previous 20 years
- Table showing relationship between moose density, wolf density, predation risk, and caribou habitat value reduction
- Text box describing Proximity Risk and Direct Risk (influence of roads and moose habitat)
- Year 2000 and 2100 maps of winter predation risk levels
- Year 2000 and 2100 maps of summer predation risk levels

### **6.1.2 Calving and Summer Range Model**

Example results presented:

- Year 2000 and 2100 maps of calving and summer range preference classes
- Capability map with definition: the Calving and Summer Range "Capability" Map represents the distribution of habitats preferred or avoided by caribou given that predators exist (e.g. avoidance of valley bottoms due to predation risk), however habitat quality has not yet been reduced in value according to the level of predation risk present. This map is intended to show the maximum habitat value possible before the influence of predators. This map can then be compared to different harvest scenarios, since the impacts of forestry practices on calving and summer ranges are primarily through increased predation risk (i.e. harvesting typically does not occur directly within these high elevation habitats, but when development occurs adjacent to calving and summer ranges, predation risk begins to influence habitat preference by caribou). It was recognized that by not including predation from permanent moose/wolf habitats, the "potential" map might not be as complete or accurate as it could be. In addition, the elimination of predators may result in a different "capability" or maximum distribution of habitat values.
- Calving and Summer Range Netica model
- Table of the area of each preference class over time, with natural disturbance and capability values
- Graphs of the area of each preference class over time, compared to the standard deviation of the five natural disturbance scenarios
- Table of the area of each preference class by patch size class over time, with natural disturbance and capability values. The patch size categories used in all the sub-models were: 1 – 10 ha, 11 – 40, 41 – 80, 81 – 125, 126-1000, >1000 ha.
- Graphs of the area of each preference class by patch size class over time, compared to the standard deviation of the five natural disturbance scenarios

### **6.1.3 Pine-Lichen Winter Range**

Example results presented:

- Year 2000 and 2100 maps of Pine-Lichen Winter Range preference classes
- Capability map with definition: the Pine-Lichen Winter Range "Capability" map represents the distribution of habitats preferred by, of no preference to, or avoided by caribou, however habitat quality has not yet been reduced in value according to the level of predation risk

present. This map is intended to show the maximum habitat value possible before the influence of predators. This map can then be compared to different harvest scenarios, since one of the primary impacts of forestry practices on pine-lichen winter ranges is increased predation risk. It was recognized that by not including predation from permanent moose/wolf habitats, the "potential" map might not be as complete or accurate as it could be. In addition, the elimination of predators may result in a different "capability" or maximum distribution of habitat values.

- Pine-Lichen Winter Range Netica model
- Table of the area of each preference class over time, with natural disturbance and capability values
- Graphs of the area of each preference class over time, compared to the standard deviation of the five natural disturbance scenarios
- Table of the area of each preference class by patch size class over time, with natural disturbance and capability values
- Graphs of the area of each preference class by patch size class over time, compared to the standard deviation of the five natural disturbance scenarios

#### **6.1.4 High-Elevation Winter Range Model**

Example results presented:

- Year 2000 and 2100 maps of High-Elevation Winter Range preference classes and an overlay of the areas capable of supporting arboreal lichen
- HEWR Capability map and arboreal lichen capability map with definitions
- High-Elevation Winter Range Netica model
- Table of the area of each preference class over time, with natural disturbance and capability values
- Graphs of the area of each preference class over time, compared to the standard deviation of the five natural disturbance scenarios
- Table of the area of each preference class by patch size class over time, with natural disturbance and capability values
- Graphs of the area of each preference class by patch size class over time, compared to the standard deviation of the five natural disturbance scenarios

#### **6.1.5 Movement Corridor Model**

Example results presented:

- Year 2000 and 2100 maps of Movement Corridor preference classes
- Capability map with definition
- Movement Corridor Netica model
- Table of the area of each preference class over time, with natural disturbance and capability values
- Graphs of the area of each preference class over time, compared to the standard deviation of the five natural disturbance scenarios
- Graph of road densities within the movement corridors over time

## 6.1.6 Timber Flow and Operational Considerations

Example results presented:

- Map of the Wolverine area showing Landscape Unit (LU) boundaries
- Graphic displaying indicators of timber flow and operational costs  
Graph display of distance of roads to be built under the LRMP disturbance scenario across all LUs over time  
Table of area harvested under the LRMP disturbance scenario in each LU over time
- Graph display of area harvested under the LRMP disturbance scenario in each LU over time
- Example graph displays of conifer volume harvested under the LRMP disturbance scenario by slope class for 6 out of 25 LUs
- Example graph displays of volume harvested under the LRMP disturbance scenario by tree species and dbh class for 2 out of 25 LUs

## 6.2 EVALUATION AND INTERPRETATION OF MODEL RESULTS

### 6.2.1 General Evaluation and Interpretation of Model Results

Model interpretations are based on the ability of the model to predict answers to questions of interest to managers. The following questions are the focus of the current interpretations:

**NOTE TO REVIEWERS: PLEASE LIST ADDITIONAL QUESTIONS (AND ANSWERS) THAT SHOULD BE ADDRESSED IN THIS SECTION.**

1. *How much of each range type (by category – preferred, equivocal, avoided) will there be in the area?*
  - This can be evaluated quantitatively from tables and graphs of the area (ha) of each preference class (where applicable) over time. In addition, this can be evaluated visually by looking at the maps (provided for each ten year timestep).
2. *How have the amounts of each range type changed over the time horizon of the model?*
  - This can be evaluated by comparing the area of each range type (by preference class where applicable) over time using either the tables or graphs provided.
3. *How has the overall spatial distribution of each range type changed across the herd area?*
  - Although there are a number of possible statistical ways of presenting distribution information, at this time a visual scan of the maps available is considered the best evaluation technique (maps are available for each ten year timestep of the model and can be run as a “movie” to see changes in distribution of habitats over time). If there are areas of concern regarding distribution of habitat then these can be explored in more detail.
4. *How has the patch size distribution of the range types changed over the time horizon of the model?*
  - This can be evaluated using tables of both the area in each patch size category and the number of patches in each patch size category (by preference class where applicable), or using graphs depicting the area of habitat in each patch size category over time. The patch size categories used are based on those recommended in the LRMP.

5. *How does the amount of habitat in each range type compare to the amount that would be present under a natural disturbance regime?*
  - The range of variation expected under a natural disturbance regime is portrayed in the tables and graphs depicting the amount of habitat predicted over time, and on the tables and graphs of the amounts and distribution of patch sizes over time. The expected range of the amount of habitat (by preference class where applicable) under a natural disturbance regime is presented as a baseline for comparison and interpretation.
  
6. *How does the amount of habitat in each range type compare with what might be possible under a management regime designed to optimize the amount of the range type?*
  - In order to evaluate the “capability” of the area with respect to the various range types, a map of capability is presented. This depicts the maximum amount of habitat (usually the preferred class) that would be available if there were no reduction of habitat value due to predation risk or disturbance, and the age class structure of the habitat was optimum. This amount of habitat is not likely to occur in reality, however it does provide a comparative base for evaluation of other results.
  
7. *As the amounts of habitat in each range type changes, when should managers become concerned?*
  - The proposed approach to determining important or critical changes in habitat is via a set of “red flags” – a set of criteria that would indicate significant events in the predicted future supply of habitat. This raises the question of what magnitude of change constitutes a red flag? This question cannot be completely answered without considering whole herd level population responses. The planned follow-up modeling regarding whole herd population response to habitat will address the question of the carrying capacities of the range types and consequently the linkage of habitat change to population change. However, in the short term the following red flags are proposed:
    - a) When the amount of the preferred class of any range type falls below the 25<sup>th</sup> percentile of the natural disturbance range, this is a flag of concern (the 25<sup>th</sup> percentile is a soft target)
    - b) When fluctuations in the amount of the preferred class of any range type become large (potentially leading to problems such as lag effects) , this is a flag of concern – measured as a 25% change in the amount of predicted habitat over 10 years (soft target).
    - c) When the amount of preferred habitat of any range type reaches 50% of its current amount, this is also a flag of concern.
    - d) When the amount of any range type falls below the minimum of the natural disturbance range, this is of significant immediate concern (the minimum of the natural disturbance range is a “hard target”)
    - e) As interpretation continues, it is expected that other “hard targets” will be established for specific range types (e.g. PLWR may be the current limiting factor regarding caribou populations; predation risk on movement corridors may become a limiting factor in the future)
  
8. *Is the amount of one range type limiting the numbers of caribou (i.e. the limiting factor)? If so, which range type is limiting? If one range type is limiting, and others are in “abundance” does this mean that the abundant range types can be managed “down” to levels that support the numbers of caribou supported by the limiting range type?*

- It is likely that one range type is limiting population numbers, however this hasn't been determined in the model as yet. It is likely that the number of caribou that can be supported by a hectare of habitat will vary with range type and the length of time during a year that the caribou depend on that range type. Thus, there is no direct correspondence in value to caribou between a hectare of one range type and a hectare of another. Since the area of all range types is dynamic over time it is possible that at some point over the length of the simulation that the limiting range type will change. These types of tradeoffs and specific interpretations for individual range types are further developed in section 2.2.2.

9. *How is the amount of habitat in each range type linked to the numbers of caribou?*

- This question cannot really be answered without considering whole herd level population responses. The follow-up modeling regarding whole herd population response to habitat will address the question of the carrying capacities of the range types and consequently the linkage of habitat change to population change.

## 6.2.2 Evaluation and Interpretation of Specific Model Results

These model interpretations are based on the results of the specific range type models:

### **Moose and Wolf Relationship Model**

1. *What is the area under risk of predation?*

- The area under risk of predation is depicted on the maps and in tables developed for this part of the model.

2. *What is the distribution of the risk of predation areas?*

- Although there are a number of possible statistical ways of presenting distribution information, at this time a visual scan of the maps available is considered the best evaluation technique (maps are available for each ten year timestep of the model and can be run as a “movie” to see changes in distribution of area under risk of predation over time). If there are areas of concern regarding distribution of the risk of predation then these can be explored in more detail.

3. *Should road deactivation be considered as a tool to minimize the loss of caribou to subsistence hunting?*

- At present this analysis is not a model product, however the model could be adopted to allow road closures to be a management lever, and then it would be possible to compare the human harvest decrease on caribou due to road closures with the impact of the decrease in human hunting harvest of moose and the consequent increase that the increased numbers of moose would have on predation risk.

4. *Can hunting of moose to low numbers be used as a method of indirect “wolf control” and consequently reduce predation risk to caribou?*

- The model is set up to allow this to be evaluated. However, no gaming runs have been done to date.

## Calving and Summer Range Model

Reviewers: questions???

### Pine-Lichen Winter Range

1. *Can the amount of PLWR that currently exists be maintained over time?*
  - The model predicts there will be a significant reduction in the amount and patch size of preferred and equivocal PLWR in the first 20 years of model runs (2000 to 2020). This is expected because the current situation is considered to be an artefact of historic human activity and past disturbance.
2. *Why will the patch sizes decrease when the LRMP strategy is designed to maintain large patches?*
  - There is an initial decrease in patch size predicted by the model due to one very large patch (>1000 ha), and a number of large patches (125 – 1000 ha) being fragmented by roads in the first 10 years of the model run.
3. *Is PLWR essential or can HEWR be a substitute?*
  - This is a question of caribou biology rather than the model prediction; however, the current thinking is that caribou could persist without PLWR, but probably at significantly lower densities (e.g. Takla herd). Consequently, if the desire is to maintain the current “ecological situation” then the system of red flags described previously is relevant to PLWR.
4. *Is the amount of the preferred class of PLWR limiting to caribou?*
  - This is commonly thought to be the case however this question will be further explored using the model.

### High-Elevation Winter Range Model

1. *Is the area of HEWR that provides arboreal lichens specified separately from other HEWR?*
  - The arboreal lichen areas are depicted as an overlay on the maps.
2. *Is there a patch size decrease of HEWR similar to that for PLWR?*
  - The model depicts that the number of very large patches (> 1000 ha) will decrease in a fashion similar to PLWR due to road fragmentation.
3. *Is HEWR essential? Will this range type ever be limiting to caribou?*
  - This is a question of caribou biology rather than the model prediction, however the current thinking is that caribou require HEWR in times of high snow on PLWR areas. The ratio of PLWR and HEWR can be evaluated in the model. The planned follow-up modeling regarding whole herd population response to habitat will address the question of the carrying capacities of the two range types and consequently the amounts of each needed to support any desired caribou population.
4. *Can HEWR replace PLWR when it is unavailable, or are both range types essential?*
  - The model predicts the amount of both winter habitats. This is a question of the current understanding of caribou behaviour and biology. At the present time, the model does not

evaluate this question, however it could be addressed in the planned follow-up modeling regarding whole herd population response to habitat change. In order to explore this possibility from a management viewpoint a planned future product for operational use is a map depicting both HEWR and PLWR.

5. *How important is the juxtaposition of PLWR and HEWR and corridors between them?*
  - The relationship between the two habitats is considered important, however no specific measures are provided in the model. It is assumed that caribou can travel long distances between these range types. Movement corridor information portrays the potential barriers between these ranges due to predation risk.

## **Movement Corridor Model**

1. *If movement corridors are areas where caribou are being preyed upon at significantly higher levels than other areas, then should there be special model interpretation techniques, or specific timber harvesting regimes for these areas?*
  - Movement corridors could become a “gauntlet” for caribou. The current model products depict the area of movement corridors and the density of roads (roads being the key to an increase in predation risk in the model). It appears that the loss of 50% of a corridor to high predation risk could have a significantly different impact on caribou numbers than the loss of 10% of all 5 corridors to high predation risk, even though the total area impacted would be about the same. At present a number of specific interpretations are being considered for movement corridors, including:
    - a. Use a different set of red flag thresholds (higher amounts of low predation risk in movement corridors may be required compared to other habitats)
    - b. Treat corridors individually to evaluate whether there are at least two low predation corridors available to caribou at any one time. This may be translated into a constraint in the development of an area with respect to when and where roads and blocks are built in corridor areas.
    - c. In addition there are a number of biological questions that could be addressed, such as: Will caribou go down a corridor regardless of predation risk? Can they determine predation risk in advance or is it simply a case of the ones who choose high predation risk corridors suffer a higher mortality rate? Do caribou choose the use of movement corridors according to any predictable criteria?
2. *If movement corridors become areas of high predation risk do they become limiting to caribou and consequently the amounts of other habitat are less important?*
  - The model does not currently address this question, however the planned follow-up modeling regarding whole herd population response to habitat will address the question of the impact of predation in movement corridors on caribou population and then link this back to caribou density in other habitat types.

## **Forestry Information**

1. *Does the specific development plan used in the model have to be followed to get the result indicated for caribou, or are alternative development plans likely to have similar results for caribou?*
  - The model results depict only one, stochastically generated, development pattern within the constraints of the LRMP scenario. There are other development scenarios possible that may be better or worse for both caribou and the value of timber harvested. Additional runs (perhaps 10) will be conducted and the development “space” mapped out over time indicating the mean and standard deviation of the specified timber values and piece sizes at each timestep.
  
2. *If the results of the model run indicates that this development scenario will result in an unfavourable mix of species and piece sizes harvested, what are the options to introduce a harvest pattern that is more favourable to mill profitability?*
  - The model is based on the assumption that the entire profile of timber used in the TSR will be logged. If this is the basis of concern then the fundamental issue of what is in the timber harvesting land base will have to be addressed, and this is outside of the direct scope of the model.
  - If the pattern of development used in the model appears to be “unrealistic” from a timber harvesting perspective a number of options are possible. The results of further modeling (as described briefly in question one above) will provide a range of values within which harvesting might occur. The model can also be used to evaluate any long-term development plan of roads and cutblocks designed by forest companies. The model will then predict the results for both caribou habitat and timber values.

### **6.3 OTHER MODEL APPLICATIONS**

This section could include a description of additional applications of the model. For example:

- Use of range types and value ratings as strata for census
- Evaluation of management options in Omineca Park