Morice & Lakes IFPA

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Morice & Lakes Innovative Forest Practices Agreement

Project Summary

Ecosystem Management

Forest Productivity

Public Involvement

Adaptive Management

The ecosystem management component of the Morice & Lakes IFPA has embarked on several projects that assess biodiversity, ecological attibutes, and fish and wildlife habitat. These projects will provide important ecological data that will be used in learning scenario development for the IFPA's Sustainable Forest Management Plan.

Habitat Modelling for the Morice & Lakes IFPA

Introduction

Detailed habitat suitability models were developed by Ardea Biological Consulting (Ardea) for selected wildlife species as part of the Morice & Lakes Innovative Forest Practices Agreement (M&L IFPA). The modeling of future forest conditions through a variety of scenarios within the Tesera Forest Estate Model (TFEM) provides an opportunity to model habitat supply for selected vertebrate species of interest to members of the IFPA such as: northern goshawk, moose, grizzly bear, mule deer, northern caribou, marten, and fisher. The habitat suitability models for the selected species use the information from the TFEM to determine habitat ratings for the forest and, by applying the habitat suitability models over time, habitat supply for the species can be predicted.

The suitability models were developed using Netica©, a Bayesian Belief Network (BBN) software package. The Netica© software was chosen for the IFPA as a method for determining the rating of a habitat polygon rather than a traditional 'look-up' table method for a variety of reasons. One of the main advantages of BBN software is that in a traditional look-up table, decisions on habitat ratings are usually discrete without the ability to incorporate uncertainty. The Netica© BBN software allows uncertainties to be explicit and carried through to the final habitat rating. Other advantages of the Netica© software include:

- Easy to use, and models are rapidly developed once the software is learned.
- Provide visual representation of outcomes.
- Models can be developed with non-technical people to test their 'belief' of how a system works.
- Very easy to test 'what-if' scenarios during development by manipulating input variables.
- The software allows information from other data sources (e.g. GIS polygon data) to be incorporated into the models.
- Models can incorporate data uncertainties, missing data, learning from the data and decision making.
- Models can be very simple or very complex.
- Can incorporate data inputs from external sources and output them to spreadsheet, database or GIS software for visualization or further analysis.

Because of the large spatial scale—some 2.62 million hectares—of the Morice and Lakes Timber Supply Areas (TSAs) and the long temporal scale (250 years) over which these models are applied, there is little to no possibility of truly verifying the models. This is because true verification of the habitat models would require measuring stand and landscape patterns that are repeated and randomized over the study area and their effects on the species' population dynamics. To

reduce uncertainty in the habitat supply predictions care has been taken to use intelligent model design, thorough model evaluation (through internal and peer reviews), appropriate model application, and prudent interpretation of model outputs. As well, the models are updated with new information as it becomes available, and a program of verification of the model assumptions for selected species has been initiated within the M&L IFPA. During 2002 and 2003, suitability models were internally and peer reviewed and revised according to results from internal testing and from reviewer comments and advice.

The habitat suitability models are developed for critical times and/or important habitats identified for each selected species. Detailed habitat suitability/supply models are developed for the following species: marten (winter), northern caribou (winter, calving, and summer), moose (winter and summer), fisher (maternal and natal denning habitat, winter foraging), mule deer (winter), grizzly bear (spring, summer and fall), and northern goshawk (nesting).

This summary reviews activities during the 2003-04 fiscal year as related to the species-habitat modeling for the M&L IFPA and the model status for each species and season. Activities included finalizing draft versions of all models, external reviews of all draft models, processing the Morice TSA base case resultant file from the TFEM, and updating the documentation of all species-habitat models.

Objectives

The goal of this project is to develop detailed species-habitat suitability models for the M&L IFPA area to allow assessment of the effects of different management scenarios on wildlife habitat over time.

To achieve this goal, the following objectives will be met:

- Develop habitat suitability models for selected vertebrate species using Bayesian Belief Networks and document the models to ensure that the rationale and assumptions for decisions made during the model development are explicit.
- Develop user-defined layers and clearly characterize derived habitat variables for fine-filter models.
- Review the models with species and model experts and test the models to ensure that the model output is functioning as expected (validation).
- Complete sensitivity testing on each model to identify the influence of each habitat variable on the habitat suitability rating output and identify potential management levers.
- Assess the spatial distribution of resources (a factor in habitat supply) for individual species models.
- Provide recommendations of criteria for the wildlife scenario after other scenarios have been analysed.
- Identify potential research and adaptive management opportunities to resolve uncertainties.

It is anticipated that the results from this project will provide the M&L IFPA with information for management and conservation of wildlife species and important habitats.

Habitat Variable Development

The M&L IFPA identified attributes and ecological processes across the landscape that are to be monitored throughout the modeling process and are referred to as coarse filter elements. Habitat attributes used in the detailed species-specific models are referred to as habitat variables (see Table 1). A separate report outlines the background, assumptions and rationale of habitat element and

Table 1. Habitat variables developed and analysed for the species–habitat models

Summarized by site productivity and structural stage:
Total shrub cover
Fruit-bearing shrub cover
Shrub cover <2m
Shrub cover >2m
Willow cover
Shrub cover for moose forage
Shrub cover for ungulate forage
Herbaceous cover of Grizzly bear forage
Herbaceous cover of moose forage
Herbaceous cover of caribou forage
Herbaceous cover of mule deer forage
Large CWD volume
Density of large live trees
Density of large snags
Other Derived Habitat Variables:
Snow Depth by BEC subzone and landscape unit
Terrestrial lichen abundance (model)
Arboreal lichen abundance (model)
Adjacent Habitats
Structural Stage
Settlement/Recreation Buffer
Spatial Connectivity
User Defined Areas:
Motorized winter recreation intensity in the Telkwa caribou range
High Elevation caribou escape terrain
Low elevation escape terrain
Moose hunting intensity level

variable development (Roberts and Turney *in prep.*). Habitat variables not directly provided in the forest estate model output have been developed externally by Ardea using all available data, expert advice, and assumptions that are explicitly detailed.

As an example, the large coarse woody debris (CWD) look-up table was developed from locally collected data for the SBSmc2 and the ESSFmc (Lloyd 2001). The average volume (m^3/ha) for CWD greater than 20cm diameter was summarized for each site series and structural stage. Where there were sites or structural stages with no data, relative values were estimated based on a set of explicit assumptions. Large CWD is tracked at the coarse filter level as an indicator of ecosystem function as well as being used as a habitat variable in fine filter species-habitat models (e.g. in the marten winter habitat suitability model). Outputs of CWD volumes can be created based on the information obtained from the TFEM as tables or as maps (see Figure 1).

Habitat Suitability Model Development

The following section briefly outlines the status of each of the habitat suitability models for the selected species. Each species-habitat model is documented as a separate report that outlines the species account, assumptions, habitat variable relationships (explicitly described as an equation or in a conditional probability table), model sensitivity and testing, and recommendations for model verification.

Marten Winter Habitat Model

A marten winter habitat suitability model has been developed and has undergone review based on the output from a test area in the Morice Forest District. Internal review has been completed on the draft version and the Prince Rupert regional wildlife habitat ecologist has completed a working review.

A variety of habitat variables are evaluated, and in some cases assigned a suitability index. For example, coarse woody debris is an important factor in determining the availability of prey species, accessibility for marten to under-snow habitats, and in providing security from predators. Figure 2 illustrates how a CWD habitat rating is assigned based on the volume of CWD. The CWD rating is then brought into the BBN model and interpreted with respect to the other variables that are important to marten winter habitat value.

Coarse woody debris is predicated based on the ecosystem type and the structural stage of the habitat. Sensitivity testing has shown that the marten model is largely dependent on the physical attributes of the forest (such as the volume of large coarse woody debris). The output from the marten winter habitat suitability model will give a most probable rating of high, moderate, low, very low, or nil which can be presented as a summary table or mapped.

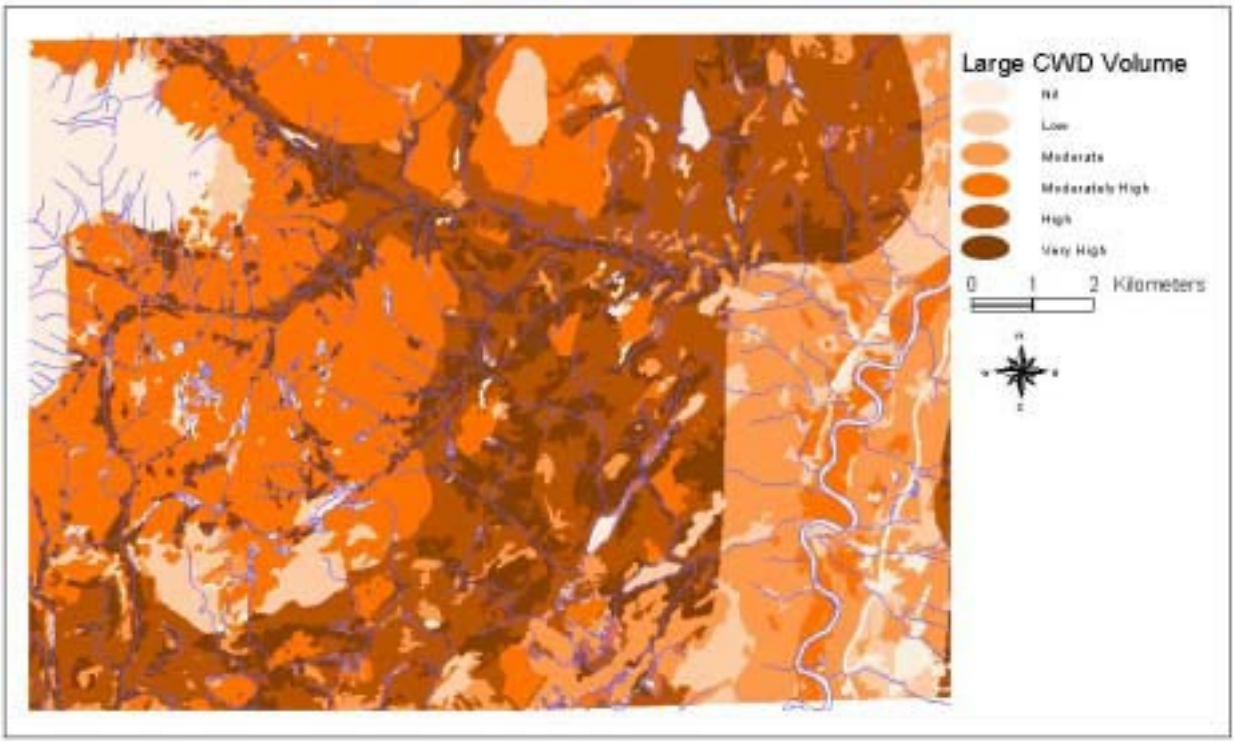

Figure 1. Predicted volume (m3/ha) of large (>20cm diameter) coarse woody debris in a test area in the Morice Forest District.

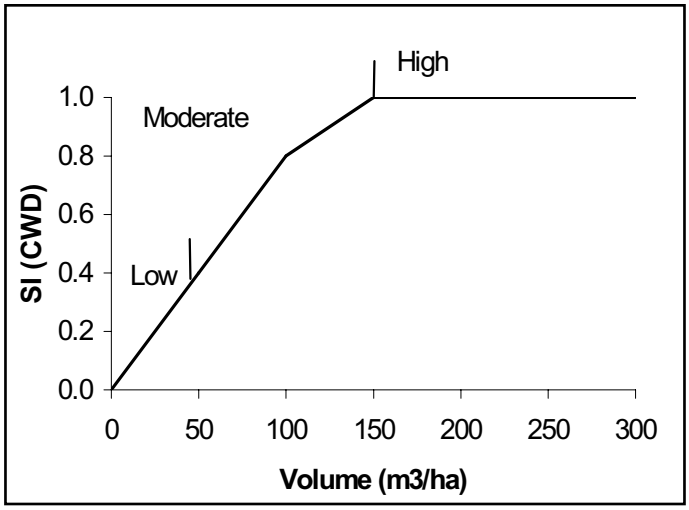

Figure 2. CWD volume (greater than 20cm diameter) and suitability index based on access by marten to the subnivean layer for foraging and resting sites during winter.

Evaluation of the marten winter habitat suitability model can be carried out at various levels. Assumptions that were made in the development of the look-up tables for site series/structural stage ratings can be tested in the field to reduce uncertainty. After marten winter habitat suitability values are assessed in the BBN model, the spatial pattern, or configuration, of the habitats should be assessed and the effect of the configuration on the value of the habitat for marten winter use determined.

Northern Caribou Winter Habitat Suitability Model

A caribou winter habitat suitability model has been developed and reviewed. External reviews were conducted with a wildlife ecologist from the Ministry of Water, Land and Air Protection and local experts in caribou biology. The development of the caribou winter habitat suitability model has been complex due to the number of habitat variables that had to be built such as: arboreal lichen abundance, terrestrial lichen abundance, predation risk, and motorized winter recreation use in the Telkwa range. Modeled predictions of terrestrial lichen abundance and arboreal lichen abundance were tested and the assumptions reviewed by a local lichenologist.

Northern caribou winter habitat suitability is reduced by both the risk of predation and the presence of motorized recreational users. Areas of high, moderate, low and nil use for winter motorized winter recreation in the area of the Telkwa range caribou herd were defined by regional biologists and mapped using ArcView© GIS. A caribou's risk to predation for all seasons was considered to be influenced by the density of wolves in close proximity to potential caribou habitat and the density of wolves directly within potential caribou habitat. The relative density of wolves was predicted based on the density of moose (Messier 1995), which will be modeled using the moose winter suitability model and the survey data collected by the Ministry of Water, Land, and Air Protection. Currently, the model was simplified to only predict suitability and not effectiveness due to time constraints, uncertainty in some assumptions, and complexity of modeling the effect of factors such as predation risk, habitat configuration, and disturbance on suitability. It is anticipated that these factors can be better evaluated and included in future iterations. For further explanation of the development of the caribou habitat models refer to: *Northern Caribou Habitat Models, ML-IFPA* (Roberts and Turney, 2004 - *draft*).

Northern Caribou Calving Habitat Suitability Model

A caribou calving habitat suitability model was developed and reviewed by a local caribou expert. During calving in the late spring, female caribou utilize specific habitat features in an effort to access food while also minimizing the risk of predation. This often results in calving caribou occupying remote and rugged terrain at high elevations in the alpine tundra whereas other female caribou may remain at lower elevations and some will utilize islands to space away from wolves and bears. The calving model predicts the value of the habitat to reproductive females for this specific time period. The main considerations in model development were the risk of predation by estimating the relative density of wolves, the value of terrain that could be used as escape terrain (e.g. islands or rugged, open tundra), with food resources considered as a secondary factor. The current output of the calving model is habitat suitability, which does not include evaluation of affects of factors such as predation risk or road distance on suitable habitat.

Northern Caribou Summer Habitat Suitability Model

The caribou summer habitat suitability model was reviewed with local caribou ecology experts, with government biologists, and against available telemetry locations. In the summer, caribou will often form small groups of animals that are spread out across the landscape. The risk of predation to caribou in the summer is more widespread due to greater mobility of all animals at all elevations; however, the intensity of predation is more dilute than in winter or spring. The caribou summer habitat suitability model is less complex than other seasons, and is mainly concerned with maximizing the foraging value while minimizing the risk of predation. The current output of this model was simplified to habitat suitability.

Moose Winter Habitat Suitability Model

The moose winter habitat suitability model (see Figure 3) was reviewed and revised based on comments and advice from regional biologists.

Moose habitat suitability is considered to be a function of both the abundance and availability of forage and the proximity to habitat that provides cover for security or thermal needs (see Figure 4).

Moose winter habitat suitability (see Figure 5) is evaluated spatially in ArcView GIS 3.2. This analysis evaluates the spatial relationship between feeding habitat and thermal cover value. Some habitats offer both thermal cover value and feeding value; however, many habitats do not supply both valuable foraging and thermal cover.

In a normal winter, moose use foraging habitats that are within a certain proximity to thermal cover. This distance has been reported differently for other study areas, however, after review and consultation with the Ministry of Water, Land and Air Protection (Smithers, BC), a distance of 100m was agreed upon as the maximum distance between foraging habitat and thermal cover in winter. Feeding habitat is not considered as valuable to moose if it is more than 100m from thermal/snow interception cover habitat. Habitat providing moderate to high value thermal cover is considered more valuable if it also provides high value feeding habitat (e.g. riparian forest, edge habitats). The general process used to evaluate moose winter habitat suitability is shown in Figure 6.

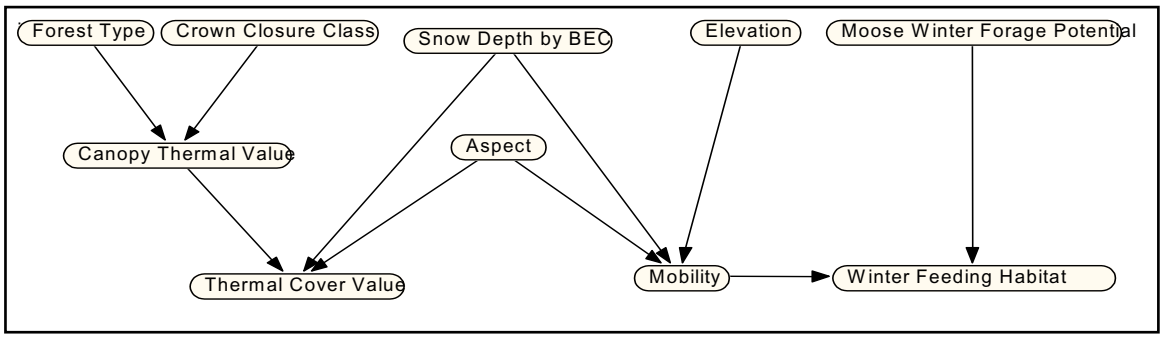

Figure 3. Netica© Bayesian Belief Network model predicting moose winter thermal and foraging suitability. The arrows indicate the direction of the influence of the variable

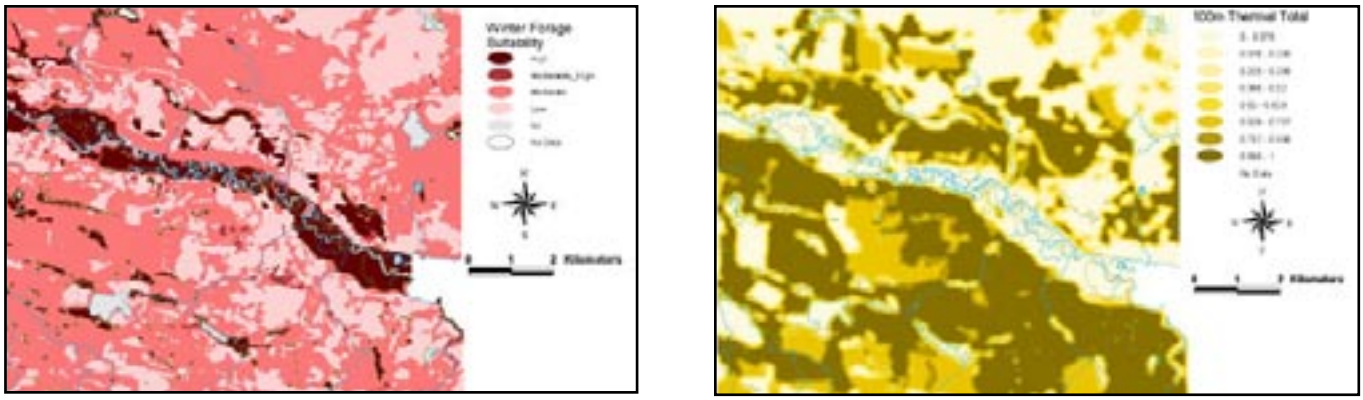

Figure 4. Mapped (25m grid) output of winter forage suitability and of the spatially calculated thermal value.

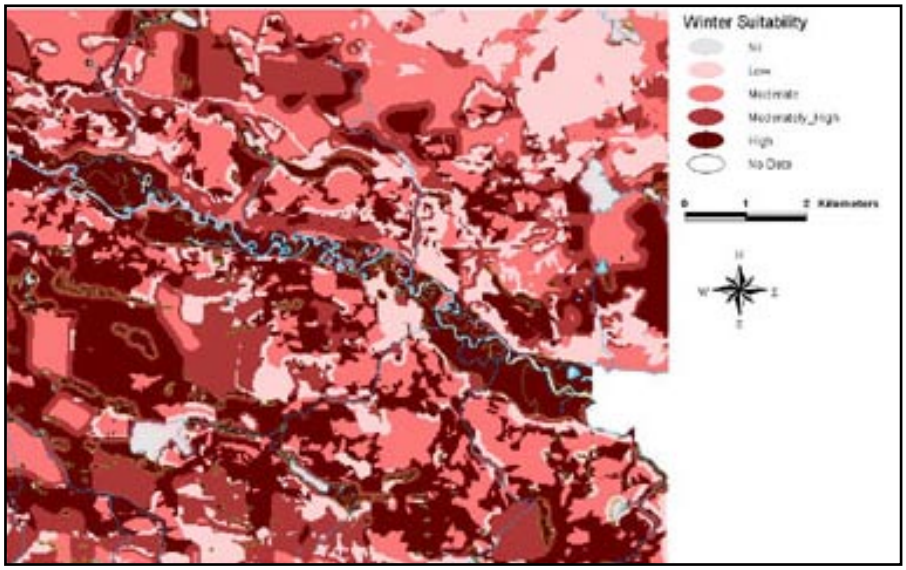

Figure 5. Moose winter habitat suitability in a portion of the Morice Timber Supply Area.

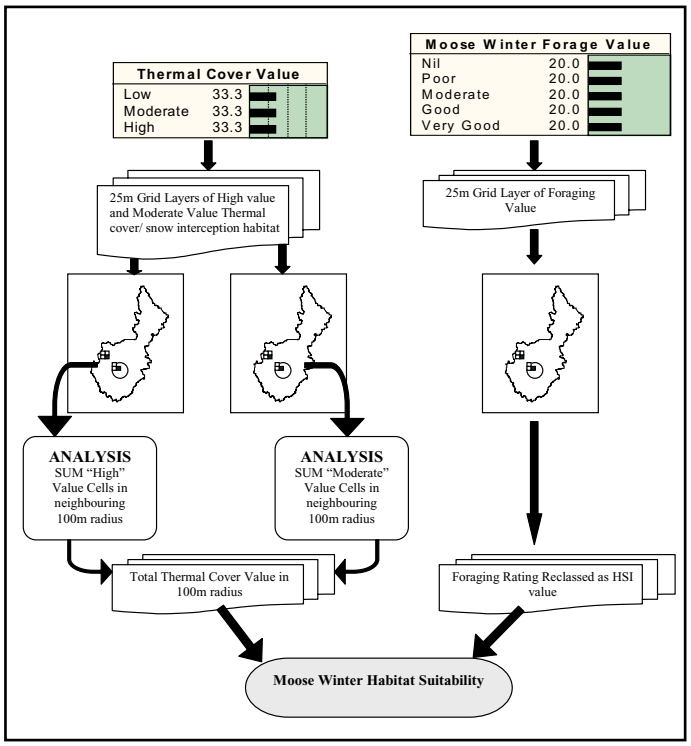

Figure 6. Process used in the evaluation of moose winter habitat suitability.

Moose Summer Habitat Suitability Model

A moose summer forage and thermal/ security suitability model was developed in Netica© and the evaluation of habitat suitability was developed in ArcView GIS 3.2. In summer, thermal cover requirements are often fulfilled from a water feature. Ponds and lakes also supply needed nutrients to moose in the summer. The general process to evaluate habitat suitability is the same as in Figure 6.

Fisher Maternal Denning and Winter Foraging Habitat Suitability Model

The fisher winter habitat model was initially developed as a composite of potential denning (natal and maternal) sites with foraging habitat. In the preliminary external review process of the winter habitat model, maternal and natal denning structure was identified as the critical factor for fisher in the study area and foraging habitat as not limiting. Therefore, we opted to restrict the current model to maternal and natal denning habitat until we had the time and information to incorporate a spatial evaluation of foraging habitat with respect to the location and value of denning structure. Maternal and natal denning habitat suitability was deemed the limiting habitat type for fisher in the study area.

Mule Deer Habitat Model

The mule deer winter habitat suitability model is developed as a Bayesian belief influence network using the Netica© program. The output of the mule deer winter habitat model predicts habitat suitability based on cover (thermal and snow interception) value and foraging value. Suitable winter range is assumed to be critical to mule deer. Winter range is highly defined by snow depth at both the landscape and the stand scale. Mule deer will often use edges or ecotones between areas that provide high cover values (thermal, security, and snow interception) and high forage values. Regional biologists reviewed this model and the mapped output based on the base case.

Grizzly Bear Habitat Model

A grizzly bear model has been developed that provides habitat ratings for spring, summer and fall habitat suitability. The model is based on assumptions of the ability of ecosystems to provide important forage plants for grizzly bears at a variety of structural stages and seasons. These assumptions use available information on forage plants for grizzly bears, data on the relative abundance of these forage plants within ecosystem/structural stage combinations in the Morice and Lakes TSAs and the authors' field assessments of grizzly bear habitats. Another component of the model uses available information on the location of spawning salmon within the rivers and streams of the Morice and Lakes TSAs to adjust the summer and fall habitat suitability ratings of habitats adjacent to these spawning areas.

Todd Mahon, WildFor Consultants Ltd., Telkwa, BC, reviewed early draft models for and provided input on foraging assumptions within ecosystems. Alan Edie, of A. Edie and Associates, Smithers, BC, provided comments that resulted in changes in the effects of salmon spawning, and slope and forest management practices on forage ratings within the model.

Northern Goshawk Nesting Habitat Model

The northern goshawk nesting habitat suitability model used in the M&L IFPA is the model developed by Todd Mahon and Frank Doyle, who have been studying northern goshawk in northwest BC since 1996 (Mahon and Doyle 2003 and *in prep.*). The model uses forest stand attributes such as tree species, canopy closure, tree height, stand age and distance from the forested edge and has been adapted to work with the outputs from the TFEM to provide ratings for nesting habitat suitability.

Model Runs

During the fall and winter of 2003, output from the TFEM for the Morice TSA base case scenario was used to provide habitat suitability outputs, based on the developed models. Models were run using time intervals of 0, 5, 20, 50, 100 and 250 years, generating habitat suitability rating outputs for each time period. Model runs involved preparing the output files from the TFEM, which were separate for each time period, by extracting the necessary input parameters and joining the time period files together. The resulting file was 11.7+ million records and was used as the base file for further processing of the individual species models. For example, for the Northern Caribou models, initial processing was required to obtain values for the terrestrial and arboreal models by processing the fragment file to obtain the inputs to the lichen models and then running them through their respective Netica© BBN models. Once the outputs were obtained from the lichen models they were then used, in conjunction with other parameters, to create the input files for the individual caribou seasonal models, which were then processed through their respective Netica© BBN models. The processing time to complete input files ranged from 3 to 5 hours, while the processing of the files through the BBN models ranged from 6 to 12 hours, depending on the complexity. Investigations into automation of the creation of input files and batch processing were undertaken, but require further work.

Next Steps

Model development, validation, review, and verification is an iterative, ongoing process that requires time and effort for the model to have effective predictive power (Brooks 1997). At this time, the species–habitat models are all suitability models. These models have all undergone some level of external review; however, uncertainty arising from several factors remain as outstanding influences on model output. These factors include: assumptions in the development of variable look-ups; predictions of variable relationships, habitat use, and population responses; resolution in the various data layers; and non-spatial evaluation of habitat. The next stage is to begin verification of selected model assumptions and data, followed by additional internal and external review. Models are dynamic and need to be improved as more ecological information is acquired, data layers are improved, variable relationships are better defined, and population responses are determined. Documentation has been compiled for each species–habitat model developed and within each report a listing of verification priorities is provided.

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