Morice Land & Resource Management Plan

Morice Land and Resource Management Plan

Environmental Risk Assessment:

Morice LRMP Table Final Land Use Recommendation

Prepared for:

Ministry of Sustainable Resource Management
Skeena Region

Prepared By:

A. Edie and Associates
10129 Horlings Rd.
Smithers, B.C.
V0J 2N2

June, 2004

BRITISH COLUMBIA

Acknowledgements

This report could not have been produced without the help of several people. I thank Laurence Turney and Ann-Marie Roberts for designing and running the marten, caribou, and grizzly bear models; Todd Mahon for designing and testing the goshawk model, and assisting with processing of goshawk model data; Andrew Fall for programming and running the SELES model, and for advice on landscape metrics; and William Elliot for GIS support. I would like to extend particular thanks to Geoff Recknell, my contract supervisor for his continuing support and assistance throughout this project. His care and thoroughness in reviewing material, and patience in dealing with sometimes complex and challenging issues made a major contribution to completion of this report and preceding ones; To these individuals and others who have provided their time and information goes much of the credit; the blame, however, is all mine.

Finally and especially, I thank my partner Julie Taugher for her patience and support during production of this document and the earlier LRMP documents which preceded it.

Summary

Item	Base Case Management	LRMP Management
Ecosystem representation	• < 0.1% of the Plan Area in Protected areas • 0.5% of the Plan Area in No Harvest areas *High Risk*	6.4 % of the Plan Area in Proposed Protected Areas 20.4% of the Plan Area in Proposed No Harvest Areas *Moderate to High Risk*
Coarse Filter Biodiversity	• no new Protected Areas • less old forest on managed landscape • 7.25% retention of Wildlife Tree Patches in logged blocks	• new Proposed Protected Areas or No Harvest Areas over 27% of the Plan Area. • High Biodiversity Areas over a further 6.2% of the Plan Area (8.9% of the forested area), • Wildlife Tree Patch Retention of an area equivalent to 7.25% of all logged blocks, plus temporary retention of additional unlogged forest on large cutblocks, • extended rotation on a portion of large cutblocks, • development and implementation of Best Management Practices for Coarse Woody debris. • retention of the deciduous component of managed forests • Development of Best Management Practices for management of tree species diversity • use of natural regeneration on a portion of logged land
	Overall Risk: High in areas developed for forestry.	Overall risk: Moderate-High in areas developed for forestry.

<table>
<tr><td rowspan="2">Grizzly Bear</td><td>No specific management of habitat availability or access-related mortality

Overall decline in suitability and value of seasonal habitats as a result of timber harvest.</td><td>• Checking for spring and salmon foraging sites during lower level planning
• Limitations to timber harvest near identified spring and salmon foraging sites
• Development and implementation of strategies for managing access related mortality
• Inclusion of some important grizzly bear habitat within Proposed Protected Areas or No Harvest Areas
• Overall decline in suitability and value of seasonal habitats as a result of timber harvest, but slightly less decline than under Base Case</td></tr>
<tr><td>Overall risk: High in roaded portions of Plan Area, Low-Moderate in remote unroaded portions.</td><td>Overall risk: High in roaded portions of Plan Area, Low-Moderate in remote unroaded portions; however, generally lower risk than under Base Case Management.</td></tr>
<tr><td rowspan="2">Northern Caribou</td><td>Limited timber harvest in Telkwa herd habitat.</td><td>• Limited timber harvest in Telkwa and Takla herd habitats.
• Checking for summer and calving habitats during lower level planning
• Limited timber harvest near identified summer and calving habitats</td></tr>
<tr><td>Overall risk: Uncertain as it will likely depend on long term predation trends.</td><td>Overall risk: Uncertain as it will likely depend on long term predation trends.</td></tr>
<tr><td rowspan="2">Fisher</td><td>No specific provisions.</td><td>• Protection of den trees.
• Inclusion of potentially important riparian habitats in Morice River No Harvest Areas.
• Better management of deciduous forests important to this species.</td></tr>
<tr><td>Overall Risk: Uncertain due to lack of information on local populations.</td><td>Overall Risk: Uncertain due to lack of information on local populations.</td></tr>
</table>

Northern Goshawk	Due to timber harvest, general reduction in habitat likely to be occupied.	• Due to timber harvest, general reduction in habitat likely to be occupied. • Protection of known nest/fledging sites • Inclusion of habitat in Protected and No Harvest Areas.
	Overall Risk: Moderate-High	Overall Risk: Moderate-High
Mountain Goat	No specific provisions.	• Access controls near isolated populations. • Limited timber harvest in important shelter habitats. • Inclusion of habitat in Protected and No Harvest Areas. • Reduced risk of disease transfer from domestic animals.
	Overall risk: Low for most populations, Moderate-High for small isolated populations near Morice and Nadina Mountains.	Overall Risk: Low for most populations, Moderate for small isolated populations near Morice and Nadina Mountains.
Moose	No specific provisions.	Development and implementation of Best Management Practices for management of habitats providing thermal cover, screening, and forage production.
	Overall risk: Low	Overall risk: Low
Marten	No specific provisions.	No specific provisions. Inclusion of habitat in Protected and No Harvest Areas. Greater amounts of old forest, and specific management of coarse woody debris should reduce risk to Marten relative to the Base Case.
	Overall risk: Low - Moderate	Overall risk: Low – Moderate, but slightly lower than Base Case due to management of forest age, and inclusion of habitat in Protected and No Harvest Areas.

Bull Trout	No specific provisions. Species benefits from general management of riparian areas.	• Management of special spawning areas, natal areas, and staging locations. • Species benefits from general management of riparian areas, aquatic ecosystems, and fish habitat. • Management of access to sensitive staging and spawning areas.
	Overall risk: Uncertain	Overall risk: Uncertain, but lower than under Base Case management.
Riparian Ecosystems	Assumed equivalent to Forest Practices Code	• Assumed equivalent to Forest Practices Code • Development of Best Management Practices for management of riparian areas. • Maintenance of function integrity of lakeshores and colluvial and alluvial fans.
	Overall risk: Uncertain	Overall risk: Low - Moderate
Rare Ecosystems	No specific provisions.	• Direction to reduce risk to Red and Blue Listed ecosystems. • Protection of large area of Red Listed Cottonwood-Red Osier ecosystem along Morice River.
	Overall risk: High	Overall risk: Moderate

<table>
<tr><td rowspan="2">Aquatic Ecosystems and Fish Habitat</td><td>Assumed to meet or exceed protection accomplished by the Forest Practices Code</td><td>Assumed to meet or exceed protection accomplished by the Forest Practices Code
Inclusion of portions of Morice, Nanika, and Nadina Rivers within No Harvest Areas.
Direction regarding:
water quality and temperature,
retention of functional integrity of streams, alluvial and colluvial fans, floodplains, riparian ecosystems, and lakeshore management areas,
rehabilitation of damaged fish habitat,
restoration of fish access impeded by land use,
maintenance of populations of lake resident fish that are sensitive to overfishing,
minimizing negative effects of water withdrawals.</td></tr>
<tr><td>Overall risk: Uncertain</td><td>Overall risk: Low-Moderate</td></tr>
</table>

Glossary

Acronyms:

BEC – Biogeoclimatic Ecosystem Classification. System includes zones, e.g. Sub-boreal Spruce (SBS), subzones, e.g. Sub-boreal Spruce, dry cool (SBSdk), and variants e.g. Sub-boreal Spruce, moist cool Babine variant (SBSmc2). See Section 2.2.1 for further information.

GPA – General Plan Area – This is the portion of the Plan area outside Protected Areas High Biodiversity Emphasis Areas, and areas managed under Area Specific Management.

HBEA – High Biodiversity Emphasis Area This is an area chosen by the LRMP table to receive special management to emphasize retention of natural biodiversity. For example, in HBEA's logging operations must ensure that a larger proportion of the land is left in old forest than is left in managed locations outside HBEA's.

NETICA – a computer program which uses a "Baysian belief" network to predict outcomes given a particular set of initial information. In this assessment, this program was used to predict habitat suitability given the state of the landscape predicted by SELES programming.

RNV – Range of Natural Variation. In this assessment, RNV was the range , for example, of forest age compositions observed in the 100 simulated landscapes produced during the Natural Case Simulation.

SELES – Spatially Explicit Landscape Event Simulator. This is a computer program which tracks the state of the landscape over time. See Appendix 3 for a description of how SELES was used in this assessment.

THLB – Timber Harvesting Land Base. This is the land base assumed available for logging and silviculture. In the Base Case assessment, the definition of THLB was the same as the one used during the last Timber Supply Review for the Morice TSA (TSR2). In the assessment of recommended LRMP management, the THLB was expanded to include the Agricultural Land Reserve which was excluded in TSR2 – this was done in order to simulate the specific agricultural development identified in the LRMP. Further, the THLB was reduced under LRMP management by removing recommended Protected Areas and No Harvest Areas.

Terms:

Base Case Management – Base Case Management is generally the resource management practices currently in use, and that would be used in the absence of LRMP implementation. More specifically, Base Case Management is the management practices assumed and analysed during the last Timber Supply Review undertaken in the Morice

Timber Supply Area (TSA). In the case of Forest Practices related to protection of riparian and aquatic ecosystems, practices that would be used in the absence of LRMP implementation are poorly defined due to transition from the Forest Practices Code to the as yet incomplete Forest and Range Practices Act and associated regulations. In this case, practices in the absence of LRMP implementation are assumed to meet or exceed the protection afforded by the Forest Practices Code.

Base Case Simulation – This was a simulation done with SELES for the next 250 years to examine impacts of continuing to use Base Case Management, i.e.., the impacts likely to occur in the absence of LRMP implementation.

biodiversity – "Biological diversity (or biodiversity) is the diversity of plants, animals and other living organisms in all their forms and levels of organization, and includes the diversity of genes, species and ecosystems, as well as the evolutionary and functional processes that link them"[1]

capability – habitat capability is the ability of habitat to support a particular species if the habitat is in an ideal seral state (age).

coarse filter biodiversity - refers to conservation of many species at once by conserving ecosystems they depend on.

fine filter biodiversity - refers to conservation of individual species by providing for their individual requirements. Usually, these species will have requirements which may not be met by the coarse filter approach.

Landscape Unit – The landscape units defined in the Morice LRMP background report are used in this assessment.

median – the middle value from a list. Similar to the average, but less affected by unusual values. The median of the list 5,9,12,50, and 80 is 12.

Natural Case Simulation – This was actually ten simulations of 3000 years each, from which sample landscapes were recorded every 300 years. That provided 100 landscapes from which median forest age composition could be calculated.

Range of Natural Variation – Also RNV, see above in acronym list.

reach – A reach on a stream is a stretch of the watercourse with more or less consistent characteristics.

[1] (Province of B.C., 1995)

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

Purpose and Scope

This report examines future implications of management provisions recommended by the Morice LRMP Table. The primary focus is to compare implications of management recommended by the LRMP ("LRMP management") with implications that I reported earlier for current management practices ("Base Case management"; Edie, 2004).

This report must be read as an extension and supplement to Edie (2004) because important literature review, background information and detailed computer simulation data presented in that report are not repeated here. My emphasis here is identification of differences in implications of LRMP and Base Case management. Where differences are small, my evaluation of environmental risks presented in Edie (2004) will not be repeated in detail in this report.

Assumptions Made

Analysis presented here incorporates important assumptions. Specifically, in making the inferences and suggestions contained in this report, I assume the following:

1. *The level of risk to general biodiversity values (Coarse Filter Biodiversity) increases as managed forests depart in characteristics from natural forests.* In other words, the more similar managed forests are to natural ones, the less risk is caused by management. This assumption is consistent with recent thinking on this issue ((Province of B.C., 1995); also see reviews by (Attiwill, 1994) and (Thompson and Harestad, 2003)). It also makes sense because organisms now occupying forest communities have through evolution become adapted to the forest ecosystems of which they are now part. Logically, if managed forests resemble the ones in which organisms evolved, risk to those organisms should be low.
2. *The level of risk to species of interest increases if availability of better quality habitat declines.* This assumption is obviously an oversimplification because the habitat we can measure, or perhaps the habitat elements of which we are aware, are not always limiting factors for a given wildlife species or population. However, this assumption will serve the purpose of facilitating comparison of habitat implications of Base Case and LRMP management. Where factors other than habitat are obviously also important, as for example is the case for grizzly bear, I will discuss this in the report.
3. *The SELES computer model used to track forest conditions over time in response to Base Case and LRMP management provides a reasonable approximation of forest characteristics which will result from management.* This assumption does not mean that I assume a high degree of precision and accuracy from the model, I just assume that the basic picture presented by model results is realistic. I believe that this assumption is reasonable because the model has undergone extensive sensitivity testing in the context of the Morice LRMP (Fall, 2004; Fall et. al.,

2003a), and the same programming language has been used for prediction of mountain pine beetle impacts in the Morice TSA (Fall et. al., 2003b). The Morice Landscape Model (MLM) and the simulation program were designed using SELES by Dr. Andrew Fall (Fall and Fall, 2001).

4. *The species models used to predict availability of habitat for marten, grizzly bear, caribou, and goshawk provide a reasonable index of habitat available under forest conditions predicted by the SELES landscape model.* Again, this does not mean that I assume high precision and accuracy, I just assume that the models produce a reasonable index of habitat availability. I believe that this assumption is reasonable because all models were constructed by local biologists after considerable effort at literature review, and all models incorporate knowledge developed during biological field work in the Morice Plan Area and nearby (Edie, 2004). Model output should be considered approximate, but I believe that it reasonably reflects what is currently known about the species in the Plan Area.

Analytical Tools Used

The primary analytical tool used here is the Morice Landscape Model, a computer model prepared specifically to support the LRMP process (Fall et. al, 2003). The model is written in a computer language called the Spatially Explicit Landscape Event Simulator (known as SELES; Fall and Fall (2001); Appendix 1). In essence the model keeps track over time of forest conditions on each individual hectare of the Plan Area. As the simulation progresses, the model chooses where to build roads, and where to log. Most importantly for this analysis, the model keeps track of forest age and related conditions which are then used to drive other computer models which evaluate habitat conditions for marten, caribou, grizzly bear, and northern goshawk.

Computer models for marten, caribou, and grizzly bear are written in another computer language called NETICA. NETICA is a Baysian Belief program which can use likelihoods of different possible outcomes rather than requiring that exact outcomes be known. For example, for a given set of habitat conditions, NETICA can be programmed to assume 80% probability of high forage value for grizzly bears, and 20% probability of moderate value. The NETICA species models use SELES output to track how much habitat is available over time in response to the management assumptions that SELES applies. Basically, SELES describes changes in forest age in each hectare of the Plan Area over time, and the NETICA models combine this age information with other data to determine how habitat suitability changes over time.

The final computer modelling tool used here is the habitat model for northern goshawk. It is written in Microsoft Access, and in essence is a table of all possible combinations of relevant habitat conditions, each combination with a habitat value assigned. The model is incorporated directly into SELES programming.

The last computer tool used here is area analysis, which is simply the use of either SELES spatial files or GIS analysis to determine, for example, how much of the plan area is recommended for a particular type of management, or what the distribution of protected area is between sub-units of the Plan Area such as Landscape Units or Ecosections.

Some aspects of LRMP management are not amenable to computer simulation. Where appropriate, implications of management which cannot be simulated are discussed subjectively.

Computer Simulations Undertaken

Three separate SELES simulations (each individually referred to as a “scenario”) form the basis for much of the analysis and discussion in this report:

- Base Case Scenario – This simulation applies current management practices. The intent is to determine what future impacts will likely be of continuing to manage land as it is currently managed. This simulation is described in Appendix 1; further details and results are reported in Edie (2004).
- Natural Case Scenario – This simulation applies a natural disturbance model to the Plan Area to determine what the natural state of forests would be in the absence of industrial forestry. This simulation is described in Appendix 1; further details and results are reported in Edie (2004). This simulation is used here and by Edie (2004) to establish the Range of Natural Variation, against which results of management may be compared.
- LRMP Management Scenario – This simulation applies the management provisions recommended by the LRMP Table, and is the main simulation presented and discussed in this document.

Risk Assessment Approach

In this report I use the following risk definition:

> Risk is the likelihood that serious adverse effects will occur to the species, habitat, or environmental value being considered.

Unless otherwise specified, risk is reported for the long term. The definition I use is similar to the one in the Biodiversity Guidebook (Province of B.C., 1995) except that my definition refers to risk of serious adverse impacts, not risk of any adverse impact no matter how small.

The risk classes used in this report vary depending on context (Tables 1 to 3):

Table 1. Risk Classes Relative to Range of Natural Variation

Relation to Range of Natural Variation	Risk Class
Within Range of Natural Variation	Low
Departure from natural median 1.0 – 2.0 times RNV	Moderate
Departure from natural median >2.0 times RNV	High

Table 2. Risk Classes Relative to Habitat Availability

Habitat Availability	Risk Class
>70% of currently available habitat	Low
40% to 70% of currently available habitat	Moderate
<40% of currently available habitat	High

Table 3. Risk Classes Relative to Population Outcome

Most Likely Population Outcome	Risk Class
> 70% of current population	Low
>40% to 70% of current population	Moderate
>10% to 40% of current population	High
0% to 10% of current population	Extremely High

Where possible, I use computer model predictions to assign risk categories; where no computer simulation data are available, I assign risk subjectively. Since no population models were available during the LRMP process, all risk assignments relative to population outcome are subjective, but I nonetheless intend them to fit criteria in Table 3 above.

I will also at times use relative risk classes "higher", "lower" and "similar".

It is critical to note here that none of the risk classes described above is, or can be, accurately measured. The risk classes in Tables 1 to 3 are as much conceptual as mathematical. Ultimately, the labels "High" "Moderate" "Low" or "Extremely Low" in this report boil down to an expression of my professional judgement or belief. That judgement is based on familiarity with relevant literature, some of which is reviewed in (Edie, 2004), discussions with other professionals during the LRMP process, examination of relevant data produced for the LRMP process, and 25 years of professional experience in the geographic area covered by the LRMP.

Structure of the remainder of the report

This remainder of this report covers two main topics:

- Ecosystem representation in Proposed Protected Areas and No Harvest Areas – In this section I describe the degree to which representation of particular ecosystems would be improved by recommendations of the LRMP Table.
- Environmental Implications of Recommended Management – In this section I examine predicted future trends in "coarse filter biodiversity" (Province of B.C., 1999) and status of identified wildlife species, special or rare ecosystems, and general fisheries values. Where available data warrant, trends are projected in time by use of computer simulation modelling; where not, trends are discussed subjectively.

2.0 Regional representation of ecosystems in protected areas

In this report, the term "regional representation" means, as it did in Edie (2004), representation on a broader geographic scale than just the Morice LRMP area itself. More specifically, it means representation of BEC zones, subzones and variants (SBS, SBSdk, an SBSmc2 for example) within the entirety of each Ecosection which overlaps the Morice LRMP area.

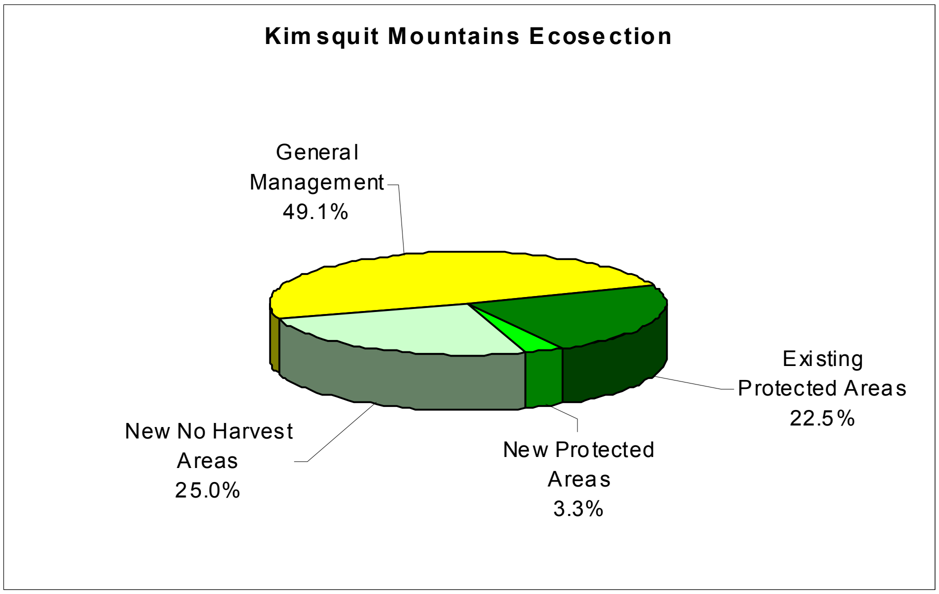
The LRMP recommends two means for ensuring long term representation of ecosystems:

- Protected Areas, proposed to receive status which would prevent mineral exploration and mining as well as timber harvest, and
- No Harvest Areas, proposed to receive status which would prevent timber harvest but permit exploration and mining.

No Harvest Areas are important to ecological representation. The only functional difference between them and Protected Areas is that No Harvest Areas allow exploration for and development of mines. Notwithstanding availability of mining activity, most if not all No Harvest Areas can be expected to contribute to ecosystem representation. This is because development of mines is a relatively infrequent occurrence, and in any case, ecosystem alteration would probably be localized and leave substantial areas which would still serve representation functions. Consequently, this section will present information on both Proposed Protected Areas and No Harvest Areas.

Changes in ecosystem representation are tabulated for all ecosections in Appendix 2. The LRMP Table recommends minor change (<1%) in the Babine Upland, Bulkley Basin, and Nechako Upland ecosections, and protection of an additional 27% and 28% respectively of the Bulkley Ranges and Kimsquit Mountains ecosections. Proposed changes in the Bulkley Ranges and Kimsquit Mountains ecosections are illustrated in Figures 1 and 2 below.

Figure 1. Proposed Changes in Ecosystem Representation in the Bulkley Ranges and Kimsquit Mountains Ecosections



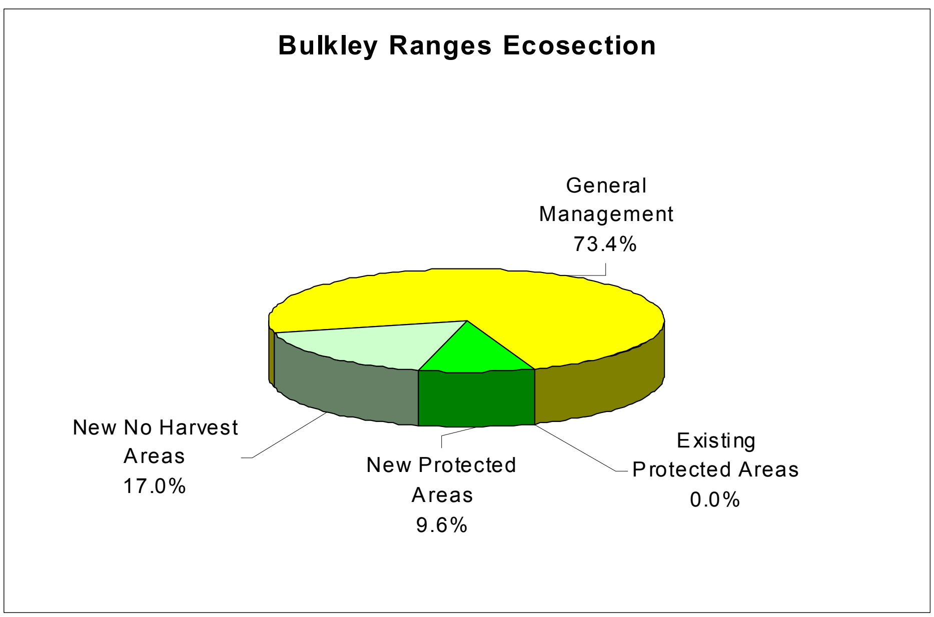
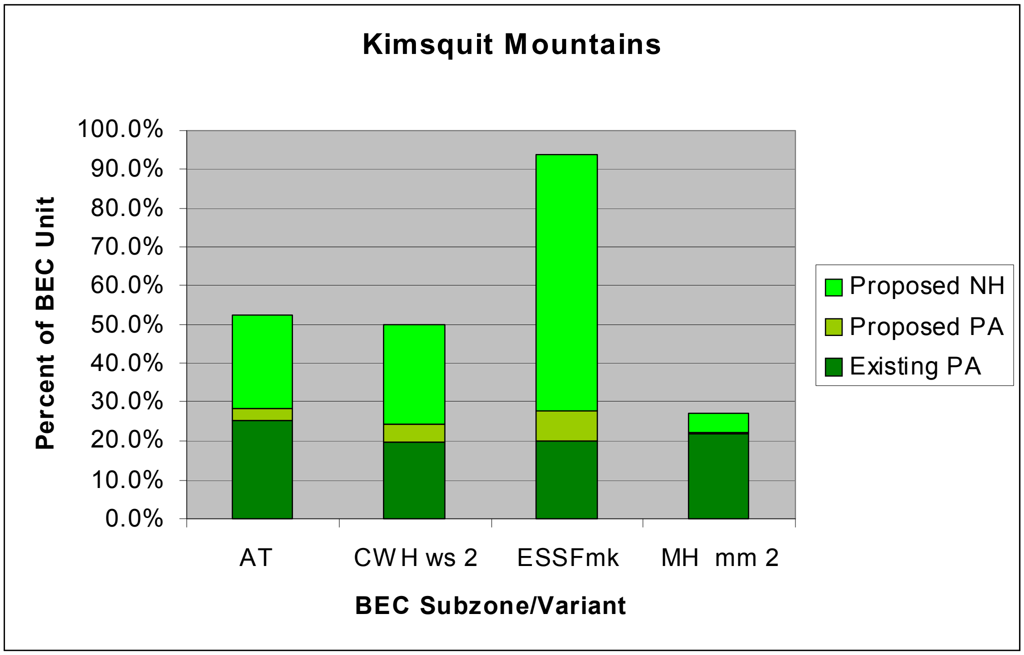
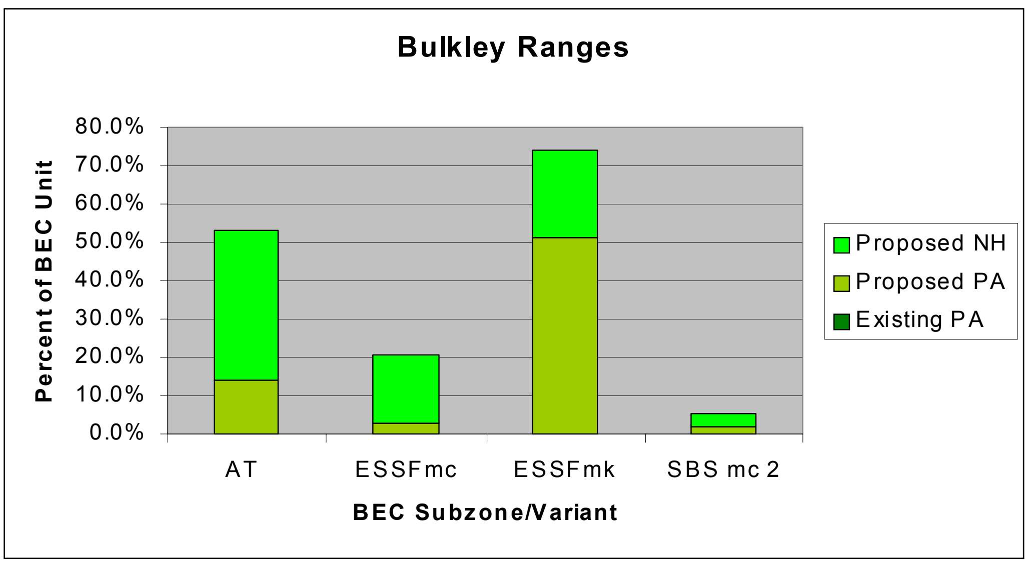


Figure 2 illustrates proposed changes in individual BEC subzones or variants within the Bulkley Ranges and Kimsquit Mountains ecosections.

Figure 2. Proposed Changes in Representation of BEC Subzones and Variants in the Bulkley Ranges and Kimsquit Mountains Ecosections





Note: AT includes all Alpine Tundra as well as all parkland forest types. Both figures refer to the entire Ecosections, including portions outside the LRMP area, and refer to proposed new protection afforded by the Morice LRMP only, not by other new LRMP's (eg North Coast or Central Coast).

Proposed changes are greatest in the Bulkley Ranges Ecosection. Overall, 27% of the Ecosection is proposed for protection. Of this 27%, 9.6% is included in the proposed Nanika-Kidprice and Burnie – Shea Lakes (Tazdli Wiyez Bin) Proposed Protected Areas, and the remaining 17% is included in No Harvest areas, mostly the Herd Dome, Morice

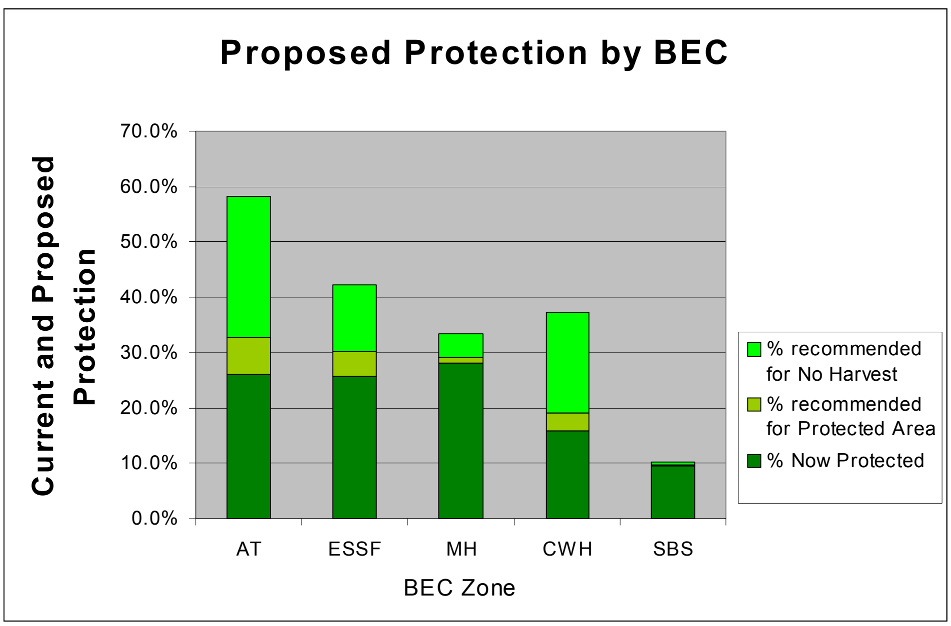
Lake, and Tahtsa - Troitsa units. The majority of the proposed protection is in the ESSF zone, particularly in the relatively warm ESSF mk which is found toward the coast, and the Alpine Tundra and parkland forests uphill from the ESSF.

Recommended changes are also significant in the Kimsquit Mountains ecosection, with 28% overall slated for protection. Of this 28%, 3.3% is included in the proposed Atna Lake Ecological Reserve, and the Nanika-Kidprice protected area, and 25% in the proposed Morice Lake and Tahtsa-Troitsa No Harvest Areas. Again, protection is concentrated in coastal and high elevation ecosystems: CWHws2, Alpine Tundra/ parkland forest, ESSFmk, and to a lesser degree, MHmm2.

Little protection is recommended for other Ecosections. This is of little importance for the Nechako Upland because protection in this ecosection is already very high at 70.5% overall, largely due to Tweedsmuir Park. However, Babine Upland and Bulkley Basin ecosections will be left at only 3.9% and 3.5% protection respectively, little changed from their current status.

Edie (2004) observed that Sub Boreal Spruce is currently the most poorly represented BEC zone in the Morice LRMP area. As Figure 3 illustrates, LRMP proposals will not change this significantly because little proposed protection lies within the SBS zone.

Figure 3. Proposed Protection by BEC Zone



Note: AT includes both Alpine Tundra and all parkland forest. Percent is of total BEC area within the entirety of all Ecosections which overlap the LRMP Area.

Table 4. shows the proposed change in protection within the subzones and variants of the SBS zone. Generally, little change is proposed, except that representation of SBSmc2 will increase from 0% to 5.6% in the Bulkley Ranges, and from 16.2 % to 17.4% overall.

Table 4. Proposed Increase in Protection in the Sub Boreal Spruce Zone

	SBSdk		SBSmc2		SBSwk3	
	Existing	Additional	Existing	Additional	Existing	ed Additional
Babine Upland	17.5	0.0	4.2	0.8	1.4	0.0
Bulkley Basin	3.0	0.7	2.7	0.1	NP	NP
Bulkley Ranges	0.0	0.0	0.0	5.6	NP	NP
Nechako Upland	30.7	0.0	60.1	0.1	NP	NP
All Ecosections combined	5.4	0.6	16.2	1.2	1.4	0.0

Note: Kimsquit Mountains is not included because it contains negligible amounts of SBS. Percent is of total BEC area within the entirety of all Ecosections which overlap the LRMP Area, and includes Morice LRMP proposed no harvest areas as well as Proposed Protected Areas.

Although overall protection within the Sub-Boreal Spruce zone does not change greatly under LRMP recommendations, the overall picture obscures one particularly significant proposal. The LRMP proposes a prohibition of timber harvest and settlement, and a near prohibition of new roads in the Morice River floodplain. This in effect would confirm and make more comprehensive the current practices under the Morice LRUP, zone A. The area covered by the floodplain is small relative to the entire Plan Area or SBS zone, but this arithmetic is deceiving. Floodplains never cover large proportions of the landscape. The Morice floodplain may be a small part of the Plan area, but protection of it covers a significant proportion of active, similarly-sized floodplains within the Plan Area, and further, it covers the majority of the active cottonwood – red osier floodplains still largely functioning in a natural way. The cottonwood - red osier forests on this floodplain are the best remaining examples of this red - listed ecosystem in the Plan Area, and have important fisheries and wildlife values. Protection of this floodplain is enhanced by recommended High Biodiversity Emphasis with extra retention of old forest in a 1000m buffer on both sides of the floodplain. The combination of no harvest, settlement, or new roads on floodplain, and enhanced management of forest age in adjacent forest will make a major contribution to ecological representation in the SBS zone regardless of the relatively small area involved.

2.1 Regional representation summary

The LRMP proposes two types of protection which will contribute to secure long term retention of ecological representation. Proposed Protected areas are intended to exclude both mining and forestry, and proposed No Harvest Areas to exclude forestry but not mining.

Proposed Protected and No Harvest Areas will protect an additional 27% and 28% respectively of the Bulkley Ranges and Kimsquit Mountains ecosections, and will protect only minor areas of the Babine Upland, Bulkley Basin, and Nechako Upland ecosections. Most proposed protection tends to be higher elevation ecosystems near the coastal end of the LRMP area. However, protection of SBSmc2 in the Bulkley Ranges will increase from 0% to 5.6%, and confirmation of LRUP protection of the Morice River floodplain will provide important retention of ecosystem representation in spite of the relatively small area involved.

3.0 Environmental Implications of Recommended Management

3.1 Role of Management Zonation in Conserving Biodiversity

One way that the LRMP conserves biodiversity is by applying higher management standards in more important locations. Protected Areas and No Harvest Areas provide the greatest restrictions on development, and the highest level of conservation. High Biodiversity Emphasis Areas provide less restrictions, but still high levels of conservation. The remainder of the Plan Area is subject to General Management which provides lower, but still significant conservation, especially under LRMP management. Table 5 summarizes the general risk levels that I believe exist in these zones under LRMP and Base Case management, and shows the proportion of the Plan Area in which the different levels of risk exist.

Table 5 shows that by its recommended Protected Areas, No Harvest Areas, and High Biodiversity Areas, LRMP management achieves low risk on 33% of the Plan Area. This compares to almost no achievement of low risk under Base Case Management. This comparison is partly misleading because the numbers include land covered by rock, ice, water, and other land without economically accessible timber. Nonetheless, the comparison shows that, regardless of the rock and ice included in the numbers, the Base Case includes virtually no long term, secure designations which either prevent development or which would be managed in a manner that I would consider low risk if development occurred. LRMP provisions dramatically increase the area in which low risk to biodiversity is reasonably assured in the long run.

Table 5. General Risk Levels Associated With Management Zones.

Management Zone	Proportion of Plan Area, Base Case	Base Case Risk Level	Proportion of Plan Area, LRMP	LRMP Risk Level
Protected Area	<0.1%	Low	6.4%	Low
No Harvest Area	0%	Not Applicable	20.4%	Low, but slightly higher than in Protected Area
High Biodiversity Emphasis Area	10%[2]	Moderate to High[3]	6.2%	Low, but higher than in No Harvest Area
Subtotal, Low Risk	0%		33%	
General Management	90%	High	67.0%	Moderate to High (varies with location and environmental value considered)

3.2 Coarse Filter Biodiversity

3.2.1 Seral stage distribution

Management of forest age across the landscape differs significantly under Base Case and LRMP management. First, as described above, the LRMP provides a substantial area of land on which timber harvest is not permitted, so forests there will be left to grow old, subject to potential influences of fire and insects. The LRMP also provides greater area held in older forest near facilities and features, and in Visual Quality Areas, and it applies more stringent levels of old forest retention in areas managed for timber production (Appendix 3).

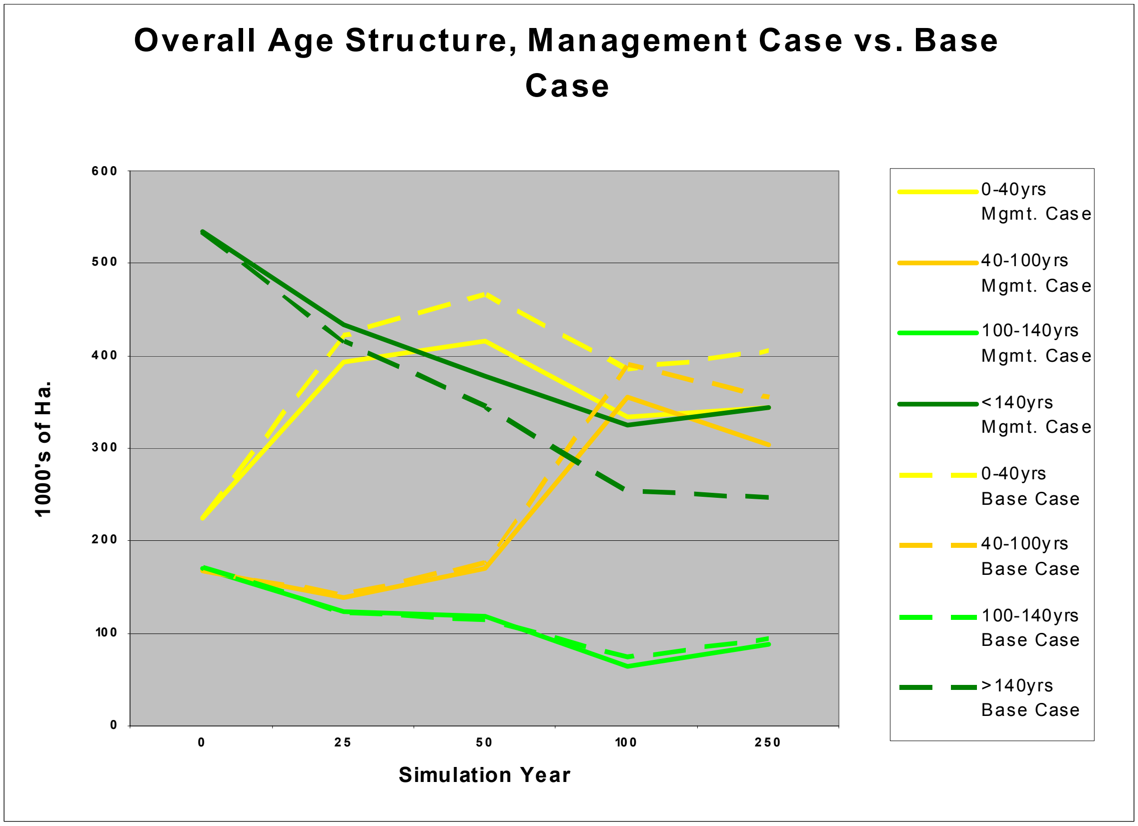
---

[2] Base Case management includes an averaged seral target which assumes that 10% of the Plan Area is High Biodiversity Emphasis. However, no specific locations are defined.

[3] The forest age standards assumed in Base Case management are considerably less stringent than in LRMP management, so risks will be higher.

SELES simulation results show the combined effect of these differences in Figure 4.

Figure 4. Overall Forest Age, Comparison between Base Case and Management Case.



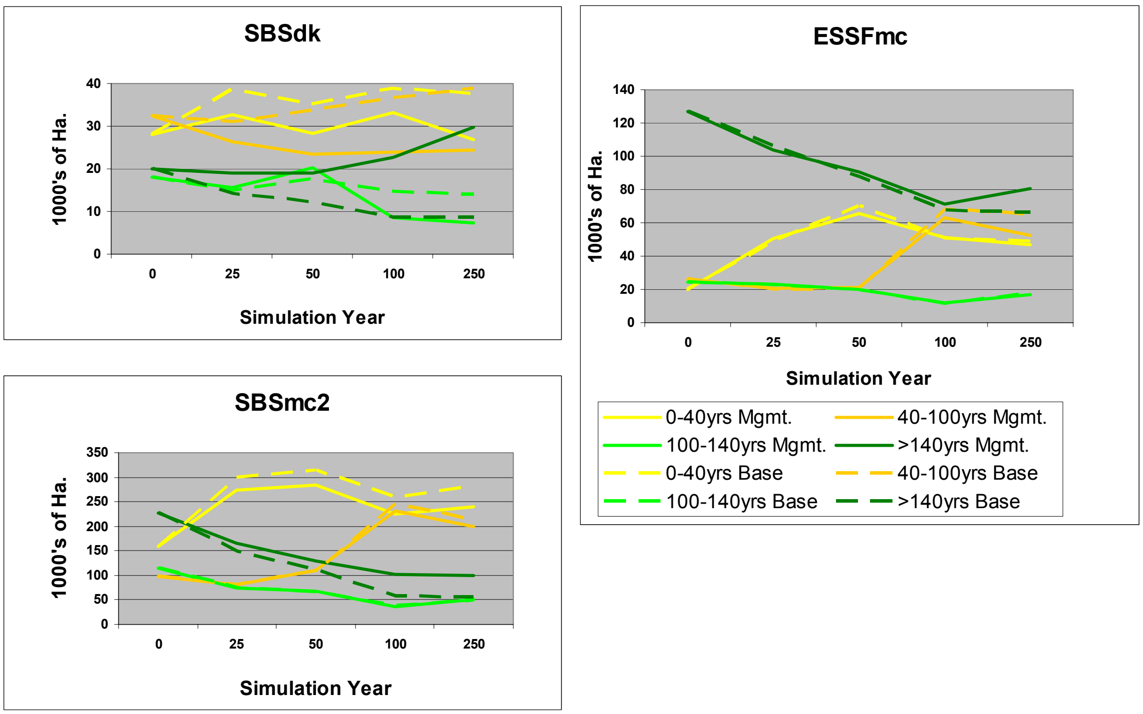
SELES simulations show that LRMP recommendations will result in more old and less young forest being present over time (Figure 4 and Appendix 4).

The same general pattern is apparent in individual BEC subzones/variants, although the strength of difference between Base Case and LRMP Management varies (Appendix 4). Figure 5 illustrates the trends in forest age for the BEC units in which most logging occurs under LRMP recommendations.

SBSdk shows the strongest response to LRMP recommendations, with more than three times the old forest present at the end of the simulation than was present in the Base Case. This strong difference is partly a result of forest age targets, but some of it probably arises because there is relatively little SBSdk in the Timber Harvesting Landbase, and a relatively high proportion of it happens to fall within areas recommended for protected or no timber harvest status.

Differences are also strong in the SBSmc subzone, with nearly twice the old forest present under LRMP Management Case than under Base Case Management at the end of the simulation.

Figure 5. Comparison of Trends in Forest Age under Base Case and Management Case.



Differences are small in the ESSF, which reflects the fact that a lower proportion of this high elevation type is in the Timber Harvesting Landbase.

Figure 6 presents comparative trends in percent of forest >140 years with reference to the Range of Natural Variation for the BEC units in which most logging occurs.

Figure 6. Trends in % of Forest >140 Years Old Relative to Range of Natural Variation

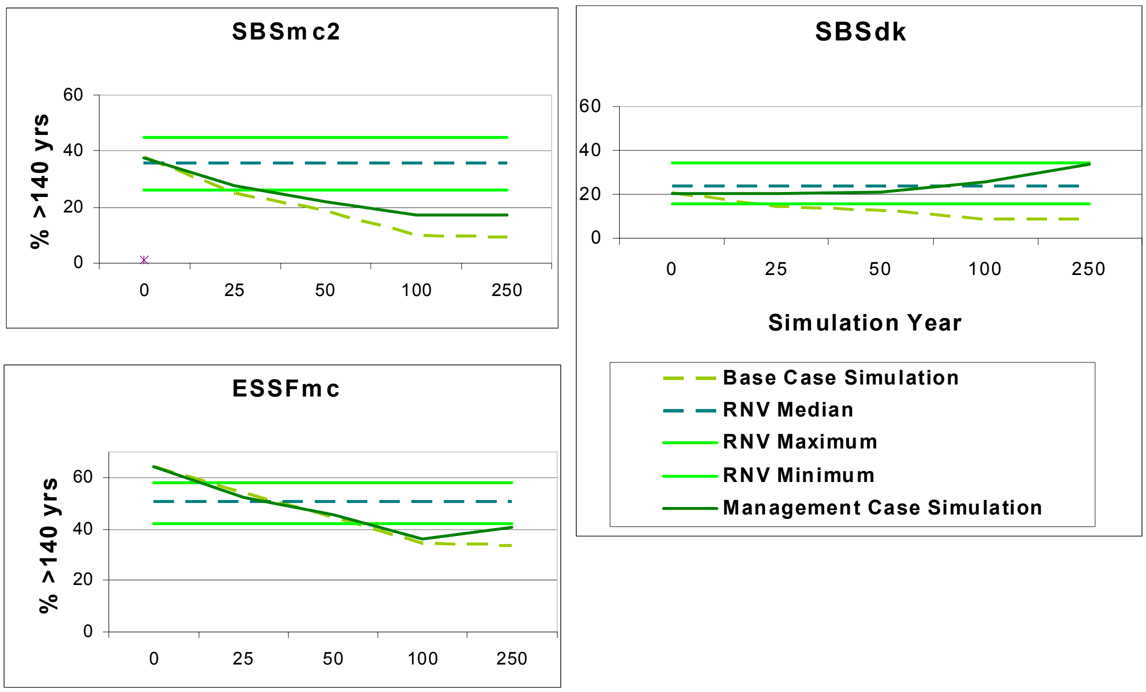


Figure 6 shows that, under LRMP management in SBSdk, the % of forest which is >140 years old remains within the Range of Natural Variation throughout the simulation. In ESSFmc, it departs slightly from RNV at 100 years, but returns almost to within RNV by the end of the simulation. In SBSmc2, it departs from RNV, but not as far as under Base Case management; by the end of the simulation, departure is about half what it was in the Base Case. Thus, in the BEC units in which most logging occurs, proposed LRMP provisions cause the age structure of forest to remain closer to RNV than was true in the Base Case. Put another way, the simulations show that LRMP provisions should result in a forest age structure closer to natural structure than Base Case Management would.

It is not possible to determine with precision what the differences in forest age structure between the Management Case and Base Case mean for coarse filter biodiversity. However, I believe it fair to suggest that the higher amount of old forest retained under LRMP management should result in a significant reduction in risk to biodiversity, especially in SBSdk and SBSmc2. Under Base Case Management the amount of old forest in both of these units declined to low levels well outside the Range of Natural Variation, to <10% in SBSdk, and <20% in SBSmc2. At these levels, the effects of fragmentation on any species which prefers connected old forest habitats can be expected to be significant because so little of the landscape is covered by the needed habitat. I believe that the risks to biodiversity under Base Case management in SBSdk and SBSmc2 would be high, and that under LRMP management risk would be reduced to at least moderate-high in SBSmc2 due to the doubling of old forest retained in that unit, and to low in SBSdk by the tripling of old forest retained there. The apparent benefits in the SBSdk must be tempered by the fact that much of this BEC unit is already heavily developed for settlement and agriculture, so biodiversity there is not as well retained as this comparison might suggest.

Another element of seral state management under the LRMP is the requirement to place 50% of required old forest into Old Growth Management Areas. This provision was not modelled in SELES so results are not reflected in the graphics presented above. The main consequence of this provision is to ensure that half of the forest maintained in an old seral state must meet the descriptive criteria for Old Growth Areas, namely, they must be representative, connected, unmanaged or natural, variably sized, and distributed in a representative fashion (see objective #1 in Biodiversity, Morice LRMP). They must also be specifically delineated, and would only be harvested when it is feasible and desirable to replace them in kind on another location. Clearly, if these criteria are met, the structure of the resulting forest mosaic will be closer to natural forest than if the targets for old forest are met by managed plantations without regard to characteristics other than age. This provision would strengthen the differences in risk discussed with regard to seral state, but in my estimation, would not change them substantially.

3.2.2 Patch size

Management of patch size also differs between Base Case and LRMP management (see Appendix 5) but difficulties arise in attempting to compare the two management designs. First, patch size provisions proved infeasible for computer simulation. An attempt was made to model patch size in the Base Case and Natural Case simulations, but difficulty with patch definitions resulted in data which were not usefully interpretable. Time limitations precluded further attempts to simulate patch characteristics in the Base Case and Natural Case simulations, and no attempt was made during Management Case simulation.

The second difficulty arises from potentially differing patch definitions between Base Case and the LRMP management. Base Case patch requirements arise from the Biodiversity Guidebook (Province of B.C., 1995). Unfortunately, the patch definition in that reference is ambiguous, and has apparently been interpreted in various ways by different forest regions (Steventon, 2004). Generally, the guidebook definition appears more focused on the size of cut blocks than on patch sizes in the forest matrix as a whole. Were this not the case, the criteria for ESSF, CWH, and MH would presumably have to consider patches over 250 ha, which they apparently do not; after all, most unlogged watersheds in these relatively wet units would likely have a considerable proportion of forest in patches larger than 250 ha. In any case, it is not safe to assume that the patch definition used in the biodiversity guidebook is the same or even similar to the one used in the LRMP recommendations, so estimating comparative results is not feasible.

Patch definitions notwithstanding, a few observations are possible:

- Provisions regarding CWH and MH are not important because neither of these BEC units will be logged under LRMP recommendations.
- Patch size criteria for SBS in the LRMP document are roughly similar to those in the Biodiversity Guidebook, but differences in definition might make this observation meaningless.
- The main apparent difference between the Base Case and Management Case Scenarios is in the criteria for ESSF. Regardless of patch definition, LRMP management will result in a substantially larger proportion of the forest landscape being covered by patches >250 ha.
- The patch size targets recommended by the Table are derived from data on the patch structure of unmanaged forest in the vicinity of the Plan Area (Steventon, 2002). Accordingly, LRMP patch provisions should, relative to the Base Case, result in managed forests closer in patch structure to natural forests in the Plan Area, and may therefore contribute positively to retention of biodiversity.
- Nonetheless, I am not convinced one way or the other whether LRMP management of patch size will make a significant change in risk to biodiversity. The literature on this topic does not clearly suggest predictable effects, and the task of designing and applying a patch definition in the field will, I think, prove challenging.

3.2.3 Forest structure at the stand scale.

Both Base Case and LRMP management include provisions intended to ensure that managed forest stands retain a degree of natural structure. Base Case management assumes a requirement to retain an area equivalent to 7.25% of logged areas as Wildlife Tree Patches, which is the overall average retention assumed in TSR2. LRMP management proposes retention ranging from 3%-18% depending on harvest intensity and history, and supplements this on cutblocks >250 ha by enhancing retention levels until the third pass, and applying a lengthened forest rotation on 5-10% of these large blocks. The LRMP also provides the strategic management direction that Best Management Practices should be developed and implemented for retention of coarse woody debris, snags and large live trees in managed forests.

SELES modeling was not able to clarify implications of these stand level provisions on coarse filter biodiversity or wildlife habitat, so only subjective comparison of Base Case and LRMP management is feasible.

There is less clarity regarding the benefits of provisions for Wildlife Tree Patch, Extended Rotation, and Coarse Woody Debris than there is regarding provisions for forest age. Standard forest inventory data can be used to assemble an accurate portrait of recent age structure of natural forest, and this has been done for the Plan Area by (Steventon, 2002). The targets used for forest age in the LRMP are derived directly from Steventon's analysis, so we know that they reasonably reflect the age structure of natural forest. We can be reasonably certain that following these targets will result in a more natural forest age structure than would result from Base Case management.

The same clear comparison is not possible regarding provisions for Wildlife Tree Patches, Extended Rotation, and Coarse Woody Debris. Part of the problem here is that we do not know what implementation of these provisions will actually produce on the ground. For example, we do not know exactly what forest tends to be retained now or will be retained in future as Wildlife Tree Patches. Although preliminary inventory within existing Wildlife Tree Patches has been done, no comprehensive sampling is available (Todd, 2004), so we don't know what Wildlife Tree Patches actually contain, so it is difficult to assess what influence they have in making managed forest more like natural forest. The same difficulty exists for Extended Rotation and Coarse Woody Debris provisions because neither has been implemented on the ground yet.

Another part of the problem is that, even if we knew what the provisions would produce on the ground, our understanding would still be limited by data currently available for natural forest. This is partly a problem of scale. As mentioned earlier, at the broader landscape scale natural conditions for forest age can be deduced using widely available forest inventory. The same is not true for structural characteristics of forest stands because comprehensive inventory does not exist for the more detailed information required to describe stand structure. Work on the design and implementation of such inventory has begun, especially for Coarse Woody Debris (Lloyd and Todd, 2003), but considerable work remains to be done before natural stand characteristics are sufficiently well understood in local forests to enable analysis of management alternatives.

For now, I believe that it is safe to assume that LRMP provisions regarding stand structure will provide benefits to coarse filter biodiversity. This is because cumulatively these provisions are almost certain to produce a more complex structure than would otherwise exist in managed forests. One of the main negative consequences of logging and silviculture systems is the simplification of stand structure (Thompson and Harestad, 2003), so the objective of producing structural complexity is in itself probably worthwhile. The LRMP's strategic direction to produce Best Management Practices for retention of Coarse Woody Debris structure should in particular provide benefits relative to the Base Case. Physical structure provided by woody debris near the forest floor is valuable for a variety of species, especially, for example, for American marten and its prey (Buskirk and Ruggiero, 1994). If Best Management Practices can be designed to provide long term availability of structure near the ground in managed forests, one of the major negative potential influences of silvicultural systems on forest structure would be reduced.

3.2.4 Tree species diversity and deciduous ecosystems

Base Case management includes no specific provisions regarding management of deciduous forest, but does exclude such forest from the Timber Harvesting Landbase. In contrast, LRMP management includes strong direction toward long term retention of deciduous forest on the managed landscape. Specifically, the LRMP directs that "disclimax" aspen stands (ones which tend to remain as aspen forest, usually with a vigorous herbaceous understory (Turney and Houwers, 1998)) be identified and retained as aspen, that there be no net loss of deciduous component in managed forest, and that

Best Management Practices be designed and implemented for management of tree species diversity.

Strategic direction surrounding management of tree species diversity, and especially deciduous forests should have important biodiversity benefits. Deciduous forests provide atypically productive foraging opportunities for a number of species. For example, the lush herbaceous cover in disclimax aspen stands provides important spring forage for bears and ungulates, and red osier and willow shrubs often associated with cottonwood forest provides important winter browse for moose and deer. Deciduous forest also provides excellent nesting opportunity for a variety of cavity nesting birds, and denning sites for both fisher and black bear. Overall, this forest contains atypically high biodiversity value, and LRMP direction to maintain it should provide significant benefit.

3.2.5 Natural Succession

The LRMP provides direction that 5% of harvested forest be permitted to regenerate through natural regeneration, and that between 1-15% of planted stands be permitted to regenerate without stand tending. These provisions would be replaced by development of best management practices by 2005. Base Case management includes no similar provisions.

The result of this LRMP provision will vary greatly among different forest sites. On some sites, the difference in forest structure achieved might be relatively minor in the long run, but on others where natural conifer seed sources are poor, or brush invasion vigorous, sites could remain in deciduous or other non-conifer cover for a long period of time (Lepage, 2004). Due to this uncertainty, no attempt was made to model this provision in SELES.

Understandably, managers will be reluctant to apply natural regeneration provisions to sites expected to regenerate into cover dramatically different from plantations; having sites re-grow into long term shrub, grass, or deciduous communities would imply a potentially significant loss of timber yield. This management issue, combined with the highly variable responses expected on different sites means that results of these provisions will be uncertain until the applicable Best Management Practices are finished, and the resulting management actions are implemented and monitored.

However, it is probably safe to assume that this provision will provide at least some diversification of forest structure and composition in comparison with Base Case management, because even on sites which tend to regenerate to conifer forest, the pattern and intensity of stocking will be different than would result from planting and stand tending. This greater diversity of forest structure should provide biodiversity benefits for the same reason that stand structure should – managed forest tends to be detrimentally simplified, so a greater variety in structure and composition is probably a good thing.

3.2.6 Summary of Coarse Filter Biodiversity.

Base Case Management – Relative to LRMP management, Base Case management provides:

- negligible Protected Area or other permanent status which prevents timber harvest, although some areas are unlikely to be developed for economic reasons,
- substantially less old forest on managed landscape than under LRMP management, particularly in the SBSdk subzone and SBSmc2 variant,
- 7.25% retention of Wildlife Tree Patches in logged blocks as the only provision regarding retention of stand level structure; no provision for Coarse Woody Debris or extended rotation on a portion of cutblocks,
- no specific management of deciduous forest or tree species diversity, and
- no provision for using natural regeneration to enhance forest diversity on a portion of cutblocks.

Overall, I believe that the cumulative result of Base Case management will be high risk to coarse filter biodiversity in many portions of the Plan Area, particularly in SBSdk and SBSmc2 in which the heaviest forest development occurs. I attribute most of this risk to the greatly reduced amount of old forest which will exist under Base Case management when compared to natural forest. However, I believe that this risk is exacerbated by each of the other characteristics listed above for Base Case management.

LRMP Management – Relative to Base Case Management, LRMP management provides:

- establishment of Protected Areas and No Harvest Areas over 27% of the Plan Area.
- establishment of High Biodiversity Areas which allow logging but apply enhanced management of forest age over a further 6.2% of the Plan Area (8.9% of the forested area),
- 3%-18% % retention of Wildlife Tree Patches plus additional temporary retention of unlogged forest on large cutblocks, extended rotation on a portion of large cutblocks, and specific management direction for development and implementation of Best Management Practices for coarse woody debris, snags, and large live trees.
- strong direction regarding retention of the deciduous component of managed forests, and development of Best Management Practices for management of tree species diversity
- use of natural regeneration on a portion of logged land in order to increase the diversity of regenerating forest.

Overall, I believe that the cumulative effect of these LRMP provisions will be to significantly reduce risk to biodiversity in all managed forests. In particular, I believe that, relative to Base Case management, risks in SBSdk will be reduced from High to Low, and in SBSmc2 from High to Moderate-High. This expectation mostly reflects the increased presence of old forest under LRMP management, an increase of 3x for SBSdk, and 2x for SBSmc2. Although the cumulative effect of other provisions listed above are likely to be significant as well, I think it only safe to assume that they strengthen the certainty of the expected benefit of better forest age structure, rather than making a large additional reduction in risk.

The reader may note that my estimate of overall risk here could be considered inconsistent with Table 5 in section 3.1 above. It could be argued from that table that if 33% of the Plan area is rendered low risk due to inclusion in Proposed Protected Areas, no harvest areas, and high biodiversity emphasis areas, and managed forest elsewhere is considered at moderate-high risk, then overall risk in the entire plan area should be lower than moderate-high. I have taken the view here that my overall risk estimate should reflect the most vulnerable components of biodiversity, so I have rated overall risk at moderate-high, mostly to reflect my impression of the consequences of forest age effects in the SBSmc2, arguably the BEC unit in which the influence of future forest operations will be the largest.

3.3 Focal Wildlife Species

3.3.1 Grizzly bear

Base case management includes no specific provisions regarding management for habitat for grizzly bears. In contrast, the LRMP provides direction for lower level planning to ensure that spring foraging locations and salmon feeding sites be checked for, and when found, afforded protection which ensures that no more than a third of nearby shelter habitats are logged at one time. Further, the LRMP provides direction for development and implementation of strategies designed to reduce bear mortality by managing human access.

None of the specific LRMP provisions regarding grizzly bears were amenable to computer simulation, so they were not included in SELES modelling.

Identification of spring and salmon foraging habitats will be useful because each is in limited supply, so protection of these two types of habitats should assist in ensuring food availability to bears. More important perhaps, these habitats are ones in which bears predictably, to experienced bear hunters, occur in vulnerable concentrations at particular seasons. Identification of these locations may assist in management of access so as to avoid excessive numbers of bears being shot.

The specific provisions described above are not the only means by which the LRMP will affect grizzly bears. Bears will also be affected greatly by the protection of 27% of the Plan Area from timber harvest, by enhanced management of forest age in High Biodiversity Areas, most of which are important bear habitat, by management of forest age in Visual Quality Areas, and by management of forest age in locations subject to general management. All of these aspects of LRMP management affect the age structure of managed forest, and consequently the ability of forest habitat to provide forage for bears.

The combined effects on bear habitat of the various LRMP provisions which affect forest age structure is explored by using a computer simulation model which evaluates grizzly bear habitat. The SELES model provides data describing the forested landscape over time in response to management, and the grizzly bear habitat model (see Appendix 6) combines SELES data with other information such as Biogeoclimatic Site Series to predict availability of bear food.

Figure 7 portrays trends in availability of high and moderate suitability habitats in the Base Case and Management Case Scenarios, as predicted by SELES data and the habitat model.

Figure 7. Trends in availability of grizzly bear habitat in Management Case and Base Case.

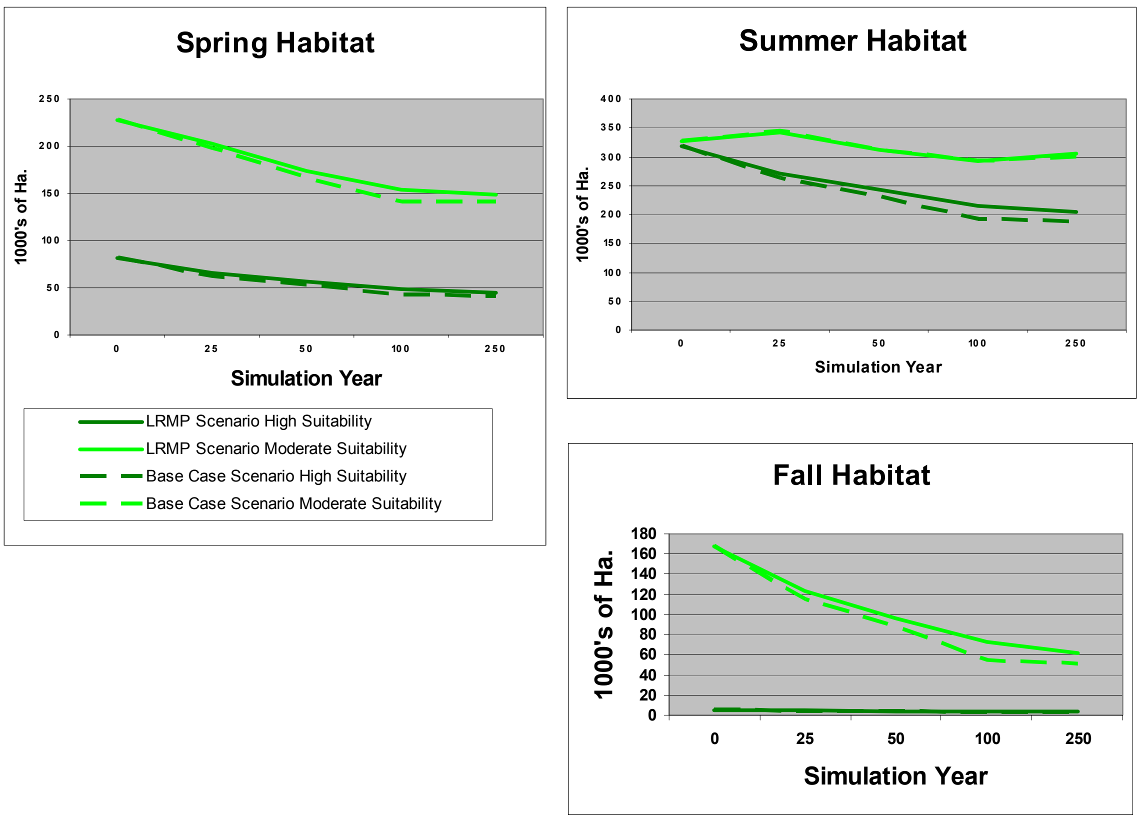
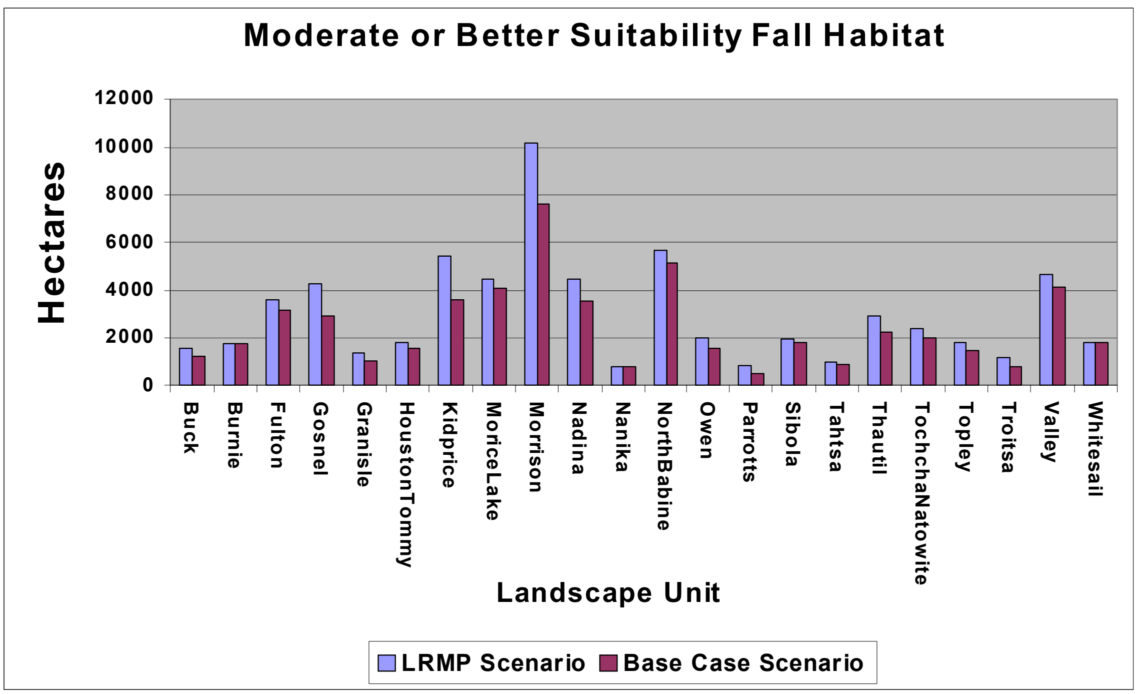


Figure 7 shows that trends in suitability of grizzly bear habitats vary little under Base Case and LRMP management. The general pattern of decline is similar in both management scenarios, but under LRMP recommendations, the decline in forage habitats is slightly less than under Base Case management. Trends in habitat value (considers the effects of roads on use of habitat – see (Edie, 2004)) are similar, except that overall declines in habitat are greater, and the improvement in habitat availability in the Management Case relative to the Base Case is slightly stronger. Detailed data for both suitability and value of habitats is presented in Appendix 7.

The influence of LRMP provisions relative to Base Case management varies among Landscape Units. Units with more Protected Area or No Harvest Area show greater improvement in habitat availability compared to the Base Case. Differences in habitat suitability trends between LRMP and Base Case management are strongest for fall habitats (Figure 8), but the same general trend is apparent in other seasons, and for habitat value as well as suitability (Appendices 8 and 9).

Overall then, LRMP management should result in slightly better forage conditions than Base Case management would. This difference is stronger in some Landscape Units than others, often as a result of larger amounts of land is included in Proposed Protected Areas and No Harvest Areas. However, differences between Base Case and LRMP management are small; in both, the availability of moderate or better suitability habitat declines in a similar manner over time.

Figure 8. Availability of Moderate or Better Fall Habitat in Landscape Units.



However, as discussed in (Edie, 2004), long term welfare of grizzly bears will likely be affected more by control of bear mortality than by availability of foraging habitats. Long term effects of the LRMP on grizzly bears will largely be determined by measures which affect bear mortality. The LRMP provision for retention of cover near salmon feeding locations and spring foraging sites may help somewhat by reducing vulnerability of bears to opportunistic shooting, but is unlikely to deter knowledgeable hunters. In my estimation, the main provision which will determine outcome of the LRMP for grizzly bears is the LRMP direction to develop strategies for reducing bear mortality by controlling human access. Such strategies could provide significant benefits to bear populations if they are successful in keeping people with firearms away from bears.

I hesitate to provide an overall risk estimate for grizzly bear. Actual risk varies greatly among different locations. Bears which take up residence in or near main settlement/agricultural areas such as Bulkley Valley and Francois Lake will, in my estimation, almost invariably end up in trouble with people and be killed or, less likely, translocated. Unfortunately, garbage, other attractants, or even excellent natural foraging habitats often attract bears to the vicinity of settlements. Unfortunately for bear populations, it is often mature females with family groups which move into settled areas, and they usually end up dead because it is very difficult to safely remove an entire family group of bears without shooting them. Settlement zones are extremely high risk locations for grizzly bears, and will remain so no matter what management is undertaken.

Risk elsewhere, away from farms and residences is certainly lower, but, I believe, still high wherever unrestricted road access exists. This means that, when settled and roaded areas are combined, I would consider most of the Plan Area as high risk for grizzly bears. The large Proposed Protected Areas and No Harvest Areas in the southwest portion of the Plan Area present the lowest risk to grizzly bears, but I would still rate risk there as Low-Moderate. Due to grizzly bears' large home ranges, few bears in these areas area likely to remain isolated from roads their entire lives.

3.3.2 Caribou

Both Base Case management and LRMP management include specific provisions regarding management of habitat for the Telkwa Caribou herd. LRMP management includes additional specific provisions for the Takla herd, plus provisions for protection of seasonal high value foraging and calving habitats of the Telkwa, Takla, and Tweedsmuir herds.

Base Case and LRMP management requires that 50% of specific identified key habitats within the Telkwa herd Management Area be >90 years old. Provisions for the Takla herd under LRMP management include harvest exclusion in identified high value habitats, and max 30% <80 yrs old in identified medium value habitats. The LRMP also provides direction that important foraging and calving habitat of all three herds be checked for, and when found, protected by ensuring that not more than 30% of nearby shelter habitats is logged at one time, and that disturbance be limited near calving areas during calving season.

SELES modelling and caribou habitat models (see Appendix 10) are used here to determine the effects of timber harvest restrictions on habitat used by the Telkwa and Takla caribou herds, and to assess the effects of other modelled LRMP provisions on habitat suitability. Caribou habitat models evaluate only the specific geographic areas used by the three herds in the Plan Area (Map Attachment 1).

Comparative trends in LRMP and Base Case simulations varied among herds and seasonal habitats.

Table 6. Proportion of Caribou Seasonal Habitats Within THLB.

Habitat Type	Suitability	Outside THLB	Within THLB
Calving	High	89.0%	11.0%
	Moderate	84.7%	15.3%
Summer	High	93.3%	6.7%
	Moderate	63.4%	36.6%
Winter	High	77.4%	22.6%
	Moderate	78.7%	21.3%

Trends for remaining herd/habitat combinations are summarized in Table 7.

Table 7. Comparative trends in Caribou Habitat under LRMP and Base Case Management.

Herd	Season	Suitability	Comparative Trend, LRMP vs. Base Case
Takla	Summer	High	Temporary loss of 1200 ha (17%); no significant change[4] long term
		Moderate	Increase of 3200 ha (9%) in long term
	Winter	High	Temporary loss of 300 ha (13%); no significant change long term
		Moderate	Increase of 900 ha (20%) in long term
Telkwa	Summer	High	No significant trend
		Moderate	Increase of 5500 ha (9%) in long term
	Winter	High	Increase of 900 ha (5%) in long term
		Moderate	Loss of 2000 ha (5%) in long term
Tweedsmuir	Summer	High	No significant trend
		Moderate	Increase of 2300 ha (5%) in long term

Table 7 shows that simulation results for other habitats are mixed. In the long term, little change occurs in high value habitat of any kind for any herd, presumably a reflection of how little high suitability habitat lies within the THLB (Table 6). Moderate value habitat increases from 5%-20%, in various herd/season combinations. Overall then, it seems that simulated forest harvest will have little or no negative effect on suitability of caribou habitat over the long term. The same is true for habitat value (Appendix 11).

Table 7 shows trends in the entire caribou management areas, including both THLB and non-THLB. Since so much habitat is outside THLB, the results in Table 7 are dominated by land which is never logged. Examination of trends specifically for habitats within the

[4] In this table, I have taken the view that anything less than a 5% difference is not significant.

THLB provides further information. Results within the THLB are similar to those listed in Table 7, but dramatically different for winter habitat. Figure 9 shows trends for suitability of winter habitats located within the THLB.

Figure 9. Winter Habitat of Takla and Telkwa Herds Within THLB.

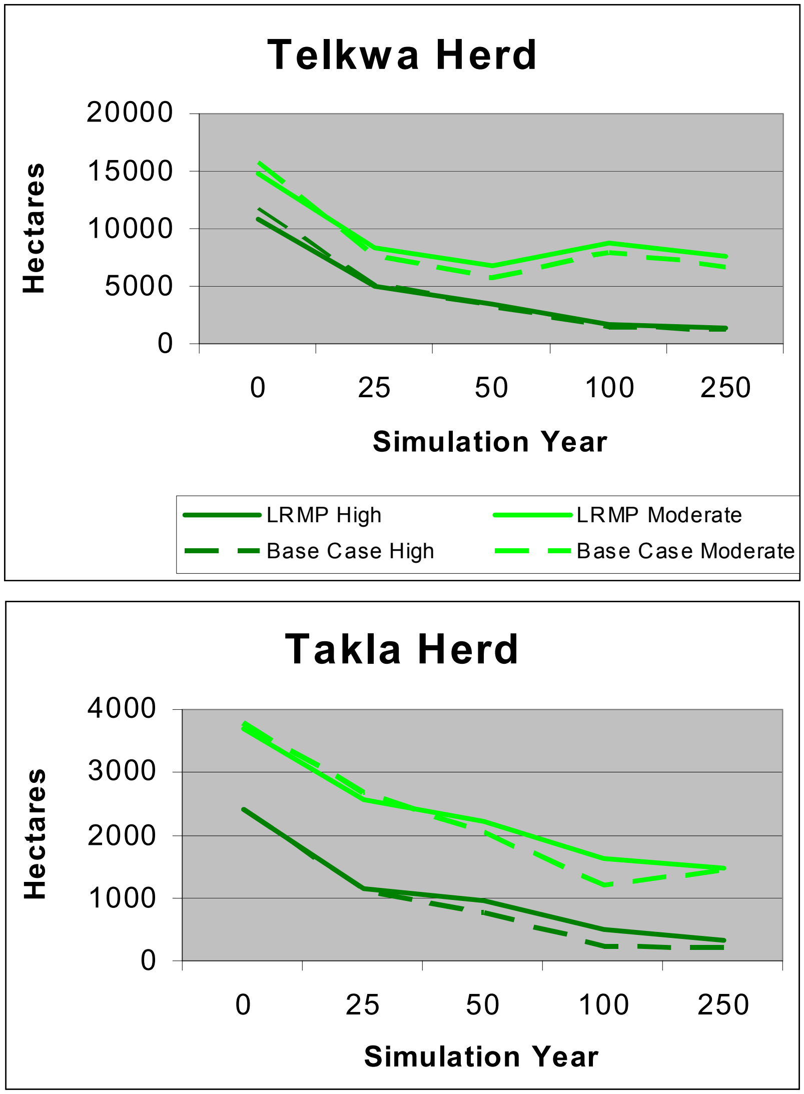


Figure 9 shows that, although winter habitat within the caribou management areas as a whole did not change much over the simulation, the amount of high and moderate suitability habitat within the THLB declined dramatically under both Base Case and LRMP management. LRMP management resulted in slightly less decline, but differences were small. The message here is that logging is harmful to winter habitat value. This is because availability of arboreal lichens, which is a major source of winter food for the Telkwa and Takla herds, is reduced in second growth and later rotations.

I think it important to note here that I believe that using SELES predictions at the local geographic scale involved in Table 7 and Figure 9 may be pushing the reliability of the tool somewhat. The placement of only a handful of simulated cutblocks could make a large difference in outcome for caribou habitat, and I do not think it reasonable to assume that SELES cutblocks are likely to accurately correspond to locations of actual cutblocks. When this sort of error is averaged over large geographic areas, the results will likely produce a reasonable overall summary of trends of interest. However, when applied to the small area of a particular habitat type for an individual caribou herd, the potential error is much larger. Consequently, I view the numbers in Table 7 and Figure 9 as only rough approximations of likely results of actual timber harvest on individual herds.

In any case, as discussed in (Edie, 2004) it appears likely that forest development is more likely to affect caribou by causing changes in mortality patterns, either through provision of access to hunters, or alterations of bear or wolf predation. The caribou habitat models incorporate simple consideration of this issue, but cannot be expected to deal effectively with it.

On balance, I believe that the main messages that should be taken from the modelling results are:

- overall damage to habitat by forest management is small due to the limited amount of high quality habitat likely to be logged, however,
- where winter habitat of the Takla and Telkwa herds is actually logged, loss of habitat usefulness on logged sites will be severe.

LRMP direction to check for important foraging habitats should allow refinement of the locations to which harvest exclusion or special management of forest age are applied.

I would rate overall risk to caribou as uncertain under both Base Case and LRMP management due to the great difficulty in predicting the long term outcome of predation. Risk caused by land management is more likely to arise from altered rates of caribou mortality than from habitat alteration *per se*. LRMP direction to check for and protect important forage habitats should nonetheless slightly reduce risk relative to Base Case Management.

3.3.3 Fisher

No specific provisions relative to Fisher were included in the Base Case Scenario. The LRMP management provides direction for protection of den trees and buffers around them. This management direction was not amenable to computer simulation.

It is important to note that fisher are probably not abundant even in the best habitats in the LRMP area, and in any case, there is little knowledge regarding their local patterns of habitat use and dependence. Consequently, only general commentary on LRMP influence is appropriate.

Several general biodiversity provisions recommended by the LRMP Table should incidentally benefit fisher relative to the Base Case, especially substantial protection of cottonwood dominated floodplain of the Morice River, ensuring a continuing deciduous component in managed forests, and retention of a higher proportion of older forest in lower elevation portions of SBSdk and SBSmc2.

Provisions regarding den trees and the beneficial change in forest composition will likely benefit fisher living in the LRMP area. However, the basic future picture presented by (Edie, 2004) will not be greatly altered by provisions of the LRMP. Fisher will still be vulnerable to loss of low elevation forest to agriculture or other permanent clearing, and the general reduction of old forest (see fig. 4 this document) in the SBSdk and SBCmc2 will likely be detrimental.

I would classify overall risks to this species in the Plan Area as uncertain due to the very limited data available on local fisher populations and habitat use.

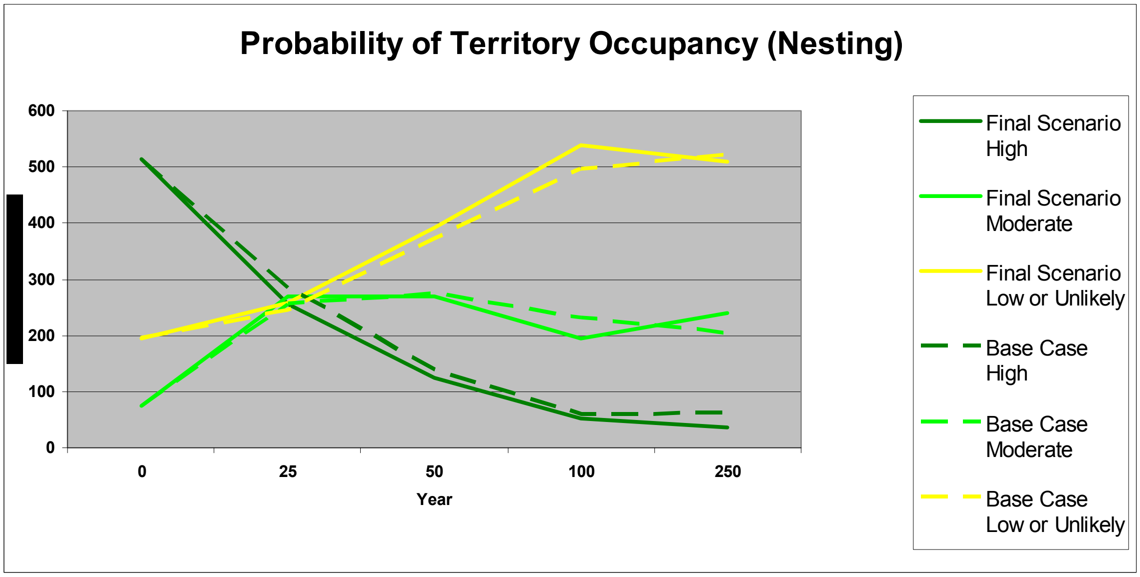
3.3.4 Northern goshawk

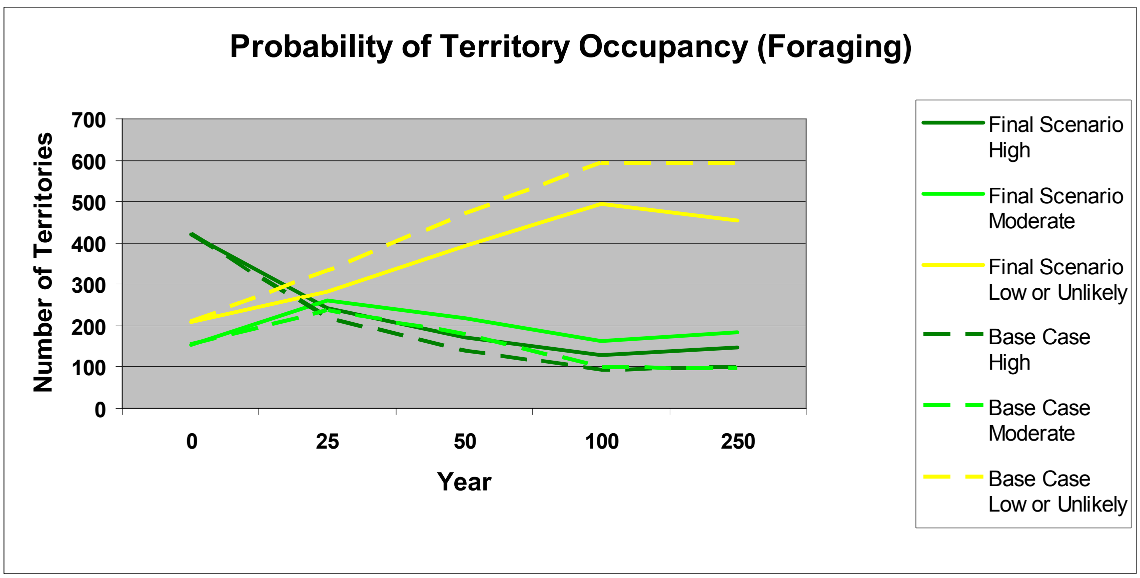
Base Case management does not include specific provisions for management of goshawk habitat, but LRMP management provides best management practices for protection of known nest sites. These practices include an approximately 24ha harvest exclusion zone with >=100m buffer around nest trees, and limitations on nearby industrial activities during the nesting and fledging seasons. Recommended protection of nest sites is not modeled in SELES.

However, SELES modelling tracks changes in forest structure caused by many other LRMP provisions, and, as is done for grizzly bear and caribou, implications of those other LRMP provisions for goshawk are evaluated by using a species habitat model (see Appendix 12) to assess the forest structures predicted by SELES.

Figure 10 shows trends in goshawk habitat over time under Base Case and LRMP management. The goshawk model differs from other habitat models in that it does not rate habitat according to suitability or value. Rather, the model evaluates hypothetical goshawk territories to determine the likelihood that habitat requirements within those territories are sufficient for goshawk occupation. For this analysis, the model arbitrarily divides the entire plan area into territories, and checks each one for the likelihood that it will be occupied. Likelihood of occupation is evaluated separately for nesting and foraging. The end result of this process is the number of territories with high, medium, and low or unlikely probability of occupation, and this is what Figure 10 shows.

Figure 10. Goshawk Territory Occupancy.



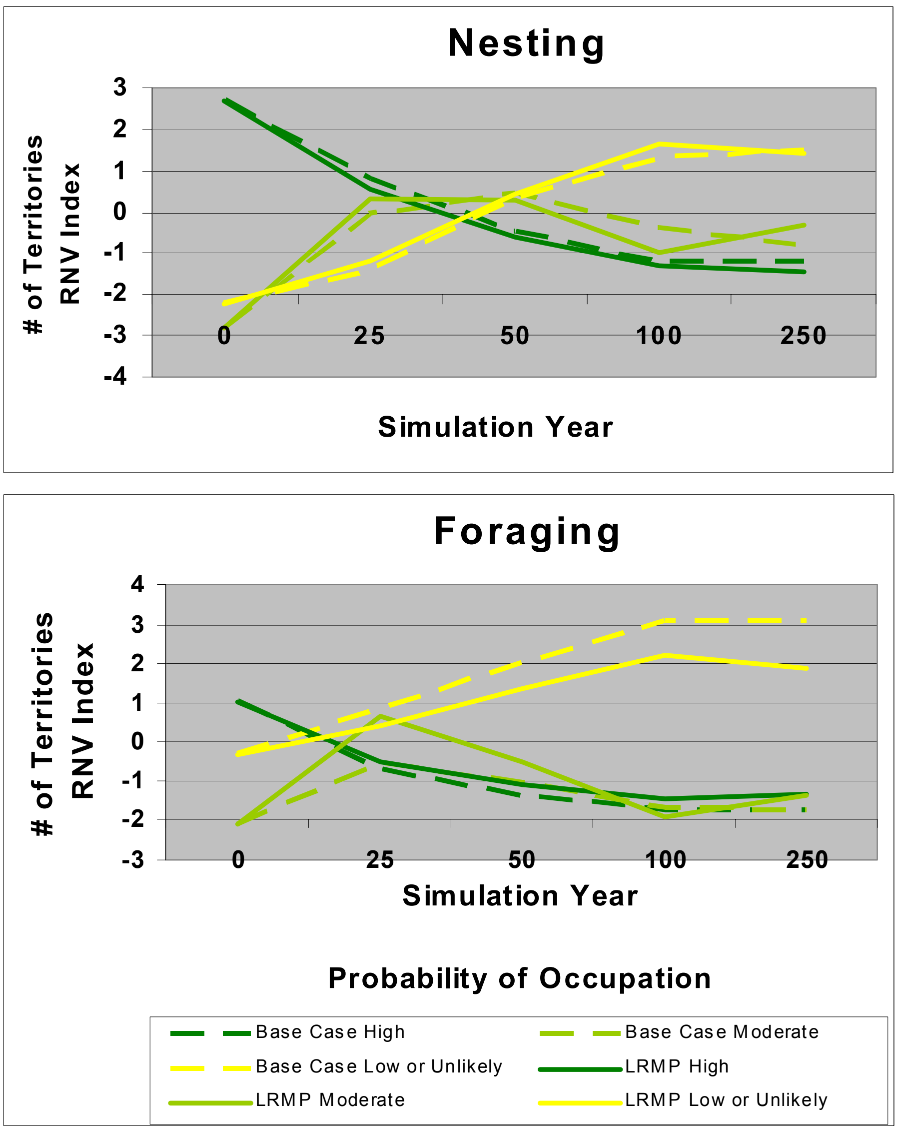


In Figure 10, the general pattern of change for nesting habitat is a major reduction in territories with high likelihood of nesting occupancy, and a corresponding increase in the number of territories with moderate or lower probability of occupancy. The pattern for foraging habitat is similar except that territories with moderate probability of occupancy at first increase, and then decline

The comparison between Base Case and LRMP management varies among habitat types. For nesting habitat, differences are slight, and in my estimation not significant. For foraging habitat, model results suggest that LRMP management has less impact than Base Case management. Under LRMP management, there are 50% more high likelihood territories, and almost twice as many moderate likelihood territories by the end of the simulation.

Because the Goshawk habitat model was incorporated directly into SELES, it was feasible to use the model to evaluate habitat conditions on all landscapes generated by the natural disturbance model during Natural Case simulations. Figure 11 shows how territory occupancy under Base Case and LRMP management compares with the Range of Natural Variation. In the figure, values above 1 are greater than the Range of Natural Variation, and values less than -1 are lower than the Range of Natural Variation.

Figure 11. Goshawk Territory Occupancy Relative to RNV.



As was true in Figure 10, nesting occupancy shows little difference between LRMP and Base Case management. Under both, the number of high probability territories drops to lower than the Range of Natural Variation by the end of the simulation. The number of moderate probability territories increases, and remains within RNV, and the number of low or unlikely probability territories rises until greater than RNV at the end of the simulation.

RNV results for foraging occupancy are mixed. Trends in high and moderate probability territories are similar under Base Case and LRMP management – both are lower than RNV by the end of the simulation. Low or Unlikely probability territories increased to higher than RNV, but departure from RNV was considerably greater under Base Case management than under LRMP management.

As discussed in (Edie, 2004), interpretation of these simulation results is difficult. On one hand, the results show a clear decline in high quality territories, especially for nesting over the simulation period. On the other hand, part of the reason for the large decline in nesting habitat is that the model judges current nesting suitability as considerably better than it would be in a natural landscape. It is not clear why the model evaluates current conditions so far outside RNV. On balance, it seems to me that there is something about forest structure as described by existing forest inventory that is different from forest simulated in the Natural Case simulations. Such a difference could be more a difference in the nature of the data than a real difference in forest structure, and still might cause the nesting model to evaluate current forest structures unreasonably higher than simulated ones. Such a problem could exaggerate differences between the Base Case and the Natural Case, at least in the initial period of the simulation when much of the forest structure is dependent on forest inventory rather than simulation results. By the end of the simulation, both the Natural Case and the management simulations are using simulated forest structures, so any errors in structure should be consistent, and the comparison reasonable. The foraging model is not based on the same forest structure criteria, and may not be affected by the same difficulty.

All this considered, I think that the basic message is probably accurate: projected forest development will have a detrimental effect on the usefulness of the forest landscape to goshawks, and a drop in goshawk populations could result from development under both LRMP and Base Case Management.

Overall risk to goshawks is not clear. Although the number of Low - Unlikely probability territories for foraging increases to above the high risk threshold of 3x RNV, the number of High and Moderate probability territories for foraging do not depart that far from RNV, and would indicate only moderate risk under the criteria set out earlier in this document. None of the results for nesting territories depart more than +-2 from RNV. On the other hand, the nesting model predicts a dramatic reduction in the number of high probability territories, but since initial ratings are high above RNV, the end results are only in the moderate risk category. Given these mixed results, I would rate risk as Moderate – High under both Base Case and LRMP management

3.3.5 Mountain goat

Base Case management includes no specific provisions for mountain goats or their habitat. LRMP management includes provisions and management direction intended to reduce potential transfer of disease from domestic livestock. It also includes provisions to ensure that important foraging, escape, and movement habitat are checked for in the field, and if found, that 70% of nearby shelter habitat be maintained in functional condition. It also includes several provisions intended to control access to occupied mountain goat habitat, as well as direction to design and implement Best Management Practices for access management near goat habitat. None of these LRMP provisions were specifically simulated in SELES.

As discussed in (Edie, 2004), access and the mortality risk it presents is probably the most important implication of forestry or other development for mountain goats in the Plan Area, and this is acutely the case with small isolated populations for which even very small excess mortality can cause serious population decline. Since SELES simulations of Base Case and LRMP management includes "building" roads to access timber, it is feasible to use SELES data to examine the general change in road locations relative to known goat habitat. Figure 12 shows the results of this analysis for Base Case and LRMP management.

Figure 12. Road access near mountain goat habitat.

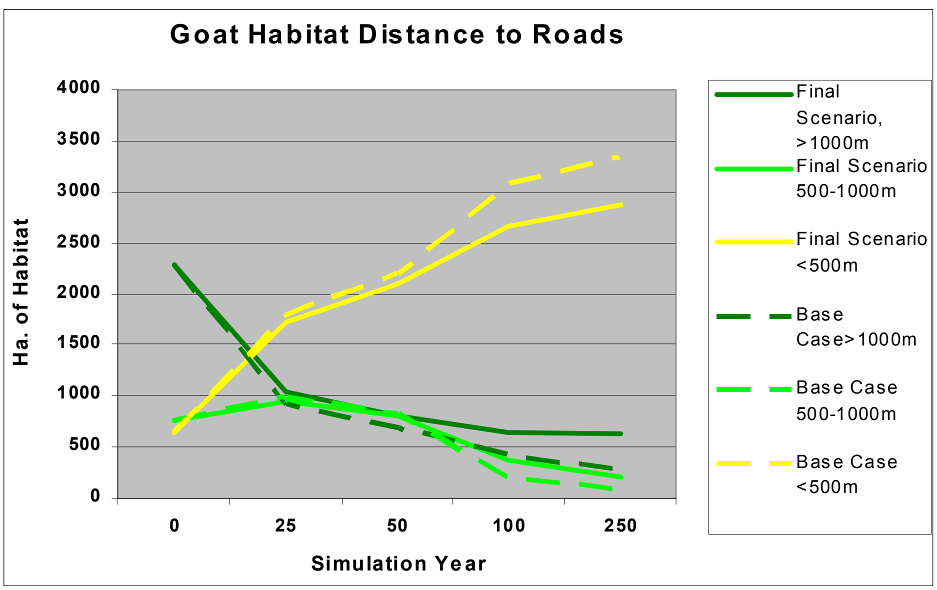


Figure 12 shows that, under Base Case management, future presence of roads near mountain goat habitat increases dramatically. Under LRMP management the same general pattern occurred, but the amount of habitat remaining >1000m from roads at the end of the simulation was twice as much as under Base Case management.

As mentioned above, LRMP management includes several specific provisions for management of goats or their habitat. These can be broadly separated into those dealing with access, thermal shelter habitat, and disease transfer. Each of these is discussed separately below.

Access Provisions:

Implications of access provisions recommended by the LRMP are difficult to determine, largely because they will depend on Best Management Practices yet to be designed and implemented. However, the LRMP provides specific management direction that such practices be designed and implemented for the purpose of controlling goat mortality. The existence of such management practices will be an improvement over Base Case management which includes no specific recognition of this issue, and no direction on how it should be dealt with. In order to ensure success, I believe that the Best Management Practices will need to accomplish effective physical barriers to motorized access, not merely specify the need for rules and signs. Mere rules and signs are unlikely in themselves to sufficiently deter poachers. If hunters are willing to hunt illegally, they will hardly care about access rules.

If Best Management Practices can accomplish significant access control around the small isolated goat populations in the Morice Mountain and Nadina Mountain area, risk to these populations will be reduced significantly.

Thermal Shelter Provisions:

In essence, provisions in the LRMP recommend that predictive information and field verification be used to identify summer thermal habitats, and that no more than 30% of the thermal habitat present at a given location can be logged at a time. Additional logging can be undertaken once habitat logged earlier regains thermal protection function.

This provision will limit change in both winter and summer shelter habitats because the definition of thermal habitat does not distinguish between winter and summer use by goats. The general cover criteria of 30% canopy cover and 8 m height seem likely to me to provide both shade for thermal purposes, as well as visual screening with regard to vulnerability to hunting. This approach to management of forested goat habitat can also incorporate important adaptive management opportunities. As mentioned in the Base Case Projection (Edie, 2004), it is possible that mountain goats in interior habitats might benefit from limited logging on winter range due to increased forage production. Permitting logging of some 30% of forest used for thermal shelter will permit observation on the degree to which new forage sources in cutblocks are used by goats, and subsequent management of block design near goat populations can be modified accordingly.

This LRMP provision will provide benefits to mountain goats in comparison to Base Case management, particularly if access management provisions are successful in controlling vulnerability of isolated goat populations to hunting mortality.

Disease transfer provisions:

The LRMP Table recommended that domestic llamas, sheep and goats be kept away from mountain goats to avoid transmission of disease. The risk of such transmission from these domestic species to mountain goats is important because[5]:

- all three species can harbour diseases or parasites which can readily infect mountain goats,
- mountain goats in the LRMP area have historically had extremely little contact with domestic livestock, and therefore are likely very susceptible to diseases carried by livestock,
- livestock can be infectious even in the absence of symptoms; a disease which is trivial to livestock may be lethal to wildlife.

Small isolated mountain goat populations such as the ones near Morice and Nadina may be particularly vulnerable to damage by disease outbreak.

Of the three domestic species mentioned in LRMP recommendations, sheep and goats present the greatest risk if contact with mountain goats occurs because of taxonomic affinity with goats, and the likely lower level of veterinary care than is typical for llamas (Schwantje, 2004). However, risk of transmission from llamas exists, and given the popularity of using llamas as pack animals in alpine areas, the possibility of direct or indirect (feces etc.) contact with mountain goats may be considerably higher than is the case with domestic sheep or goats.

In that context, implications of LRMP recommendations are variable. Risks regarding domestic sheep should be reduced by LRMP recommendations because there seems little likelihood of domestic sheep being grazed in alpine areas. The main risk is sheep used for silvicultural purposes, and that use should prove easily controllable under LRMP recommendations. The same is probably true for most domestic goats, but not all of them. Domestic goats or llamas used as pack animals in support of hikers traversing alpine areas present particular risks. The likelihood of contact between pack animals and mountain goats may be much higher than it is with other livestock. Many of the diseases which may be transferred can be transmitted through feces or urine, and some of them may persist for considerable periods of time under the right conditions. Consequently, presence of pack goats or llamas almost anywhere in alpine frequented by mountain goats could result in infection. Further, since at least some llamas are still being imported from other countries or continents, the risk of transmission and establishment of exotic

[5] (Schwantje, 2004;Schwantje and Stephen, 2003)

diseases or parasites exists. Outbreaks of exotic disease can have devastating consequences for wildlife which can be highly susceptible to new disease. Further, once introduced to the wild populations, exotic diseases are practically impossible to eradicate.

All this considered, the effect of LRMP recommendations on risks posed by pack llamas and goats will depend on the exact nature and effectiveness of implementation. If both llamas and domestic goats are kept out of alpine and other areas occupied by mountain goats, risks will be substantially reduced. If less drastic measures are taken, reduction of risks may be smaller.

3.3.5.1 Mountain goat summary

I believe that the most important risk caused by development in the LRMP area is the risk of mortality as a result of better access to goats, particularly to small isolated populations in the general vicinity of Nadina and Morice Mountains. The LRMP Table has recommended several provisions designed to reduce this risk in comparison to current management practice. These provisions should significantly reduce mortality risk to goats if and only if implementation results in effective physical barriers to motorized access.

Other recommended measures should reduce the potential for damage to shelter habitats, provide opportunity for adaptive management trials, and reduce the risk of disease transfer from domestic animals.

For the Base Case, I would rate overall risk to mountain goats as low for most populations, and moderate to high for the small isolated groups near Nadina and Morice Mountains. Successful implementation of LRMP provisions regarding access control would, I believe, reduce risk to these small groups to Moderate.

3.3.6 Moose

Base Case management does not include specific provisions regarding moose or their habitat, although Environmentally Sensitive Areas were removed from THLB, and some of those may have been designed to protect moose winter range. LRMP management includes direction to develop and implement Best Management Practices for management of habitats providing thermal cover, screening, and forage production, as well as direction to provide comparable priority for winter and summer forage production. None of the LRMP provisions were specifically simulated in SELES.

(Edie, 2004) concluded that, in general, availability of early seral forest increased or remained stable over the Base Case simulation, which indicates that availability of forage habitats should improve or at least not decline over time under Base Case management. Figure 4 earlier in this document shows that somewhat less early seral forest is available under LRMP management, but the general trend of increase over time is similar. However, as discussed by (Edie, 2004) the implication of this pattern for moose will depend on the quantity of forage actually available in young managed forests, which in turn will depend on the degree to which silvicultural practices permit shrub growth in managed plantations.

The Best Management Practices directed by the LRMP could produce significant benefits for moose if they enhance attention paid to moose habitat values during forestry planning and operations. For reasons discussed in (Edie, 2004), I believe that this is particularly true if means are found to incorporate enhanced levels of summer forage production in silvicultural management.

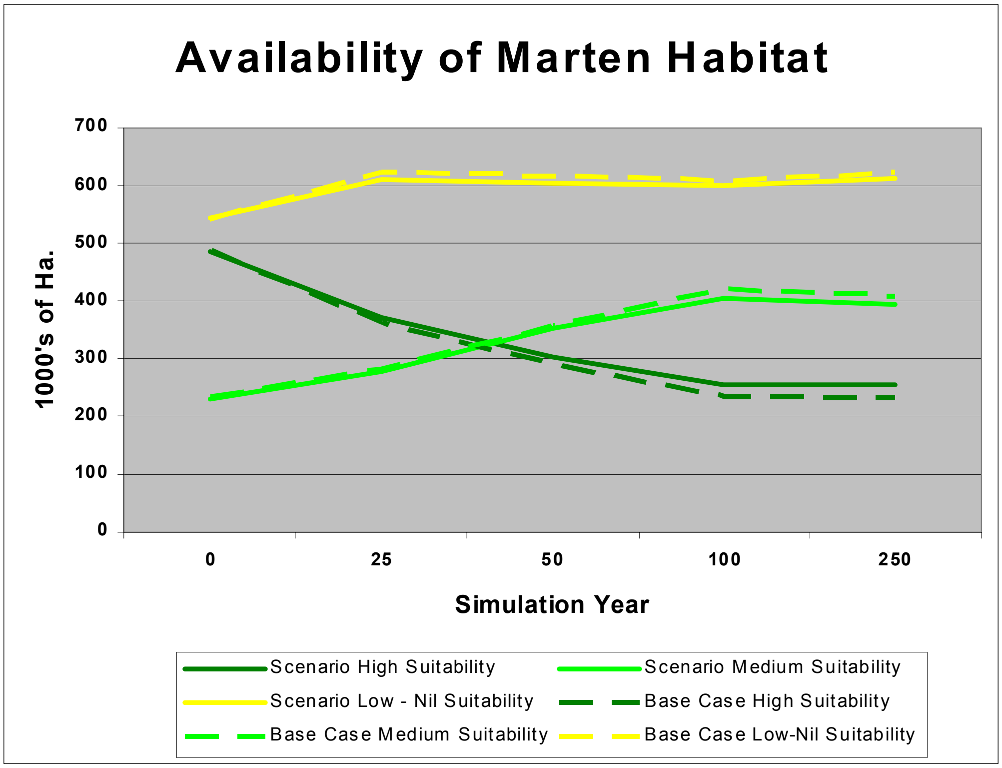
I would rate overall risk to moose as low under both Base Case and LRMP management. I believe that moose populations might benefit from enhancement of forage production in combination with management of nearby thermal shelter, but that population trends will to a greater degree be determined by management of hunting, and at times in some locations, predation.

3.3.7 American marten

Neither Base Case nor LRMP management includes specific provisions for marten, and none are included in SELES simulations. Under both management regimes, it is assumed that general biodiversity provisions, particularly those which provide for continued availability of old forest, provide intended protection for marten.

SELES predicts the forest landscape which will result from modelled LRMP provisions, and as done earlier in this document for grizzly bear, caribou, and goshawk, these SELES data are used to provide input to a species habitat model. The marten model (see Appendix 13) evaluates the habitats described by SELES, thereby predicting the combined influence of modelled LRMP provisions on marten habitat. Figure 13 shows simulation results under Base Case and LRMP management.

Figure 13. Projection of marten habitat under Base Case and Management Case scenarios.



Note: Results are confined to the SBS and ESSF Biogeoclimatic zones as virtually all logging occurs in them.

As Figure 13 shows, simulations predict little difference in habitat available under recommended LRMP management when compared with Base Case management. The extra amounts of old forest under LRMP management produce slightly more high suitability habitat in the long run, but the difference is small. Both simulations result in a loss of about half the high suitability habitat currently available.

As is discussed in (Edie, 2004), interpretation of these trends is difficult. The marten model is not yet calibrated to known marten densities, the assumed loss of coarse woody debris after the first rotation is uncertain, and potential spatial effects of early seral habitats on marten occupation of habitat are uncertain and not included in the model. These difficulties mean that model predictions have to be viewed as uncertain. If innovative management in managed stands is successful in maintaining forest structure that marten need, loss of high suitability habitat may not be as large as simulations suggest. On the other hand, if loss of forest structure is as bad as assumed, and spatial effects result in otherwise useful habitat not being used, loss of high suitability habitat may be worse than simulations suggest.

Overall, I would rate risk to marten as Low-Moderate. Although the loss of about 50% high suitability habitat might suggest a risk rating of Moderate under criteria listed earlier in this document, the amount of moderate suitability habitat increases by the same amount. Since the model is not calibrated for actual marten densities, implications of moving high habitat to moderate are very uncertain. As discussed in (Edie, 2004) such a change in ratings might correspond to complete loss of the habitat, or to negligible difference, depending on what the real differences between these habitat ratings mean to marten. If the difference means loss, the risk would be moderate, if it means little change, the risk would be low, hence my suggested rating of Low-Moderate.

3.3.8 Bull trout

Base Case management does not include specific provisions for protection of bull trout. However, under both the Base Case and LRMP management, this species benefits from riparian protection through application of riparian reserves and management zones. In simulations of both management regimes, riparian reserves and management zones are specifically identified and appropriate portions removed from the Timber Harvesting Landbase. Although treatment of these riparian areas is modelled in SELES, specific implications for bull trout were not modelled because no habitat model for this species is available.

In addition to the protection afforded through general provisions regarding riparian habitats, LRMP management includes direction to conserve special habitats for bull trout, including spawning areas, natal areas, and staging locations. The LRMP also includes direction to avoid providing easy angler access to staging areas where this species is vulnerable to over fishing, and to maintain temperatures used by this species below critical temperatures. LRMP direction regarding bull trout is clearly intended to recognize and act on the special habitat and population vulnerabilities of this species (see (Edie, 2004)), and should reduce risk to this species and its special habitats in comparison to Base Case management.

I believe that risk to this species is too uncertain to warrant a statement of overall risk. There is no doubt that bull trout have special vulnerabilities in both habitat requirements and susceptibility to overfishing. Nonetheless, I believe that the direction provided by the LRMP should reduce risks to bull trout. One of the reasons it is difficult to predict management outcomes for this species is that many of the important habitats are very localized in small streams. This very characteristic should permit LRMP direction greater likelihood of successful implementation because much can probably be accomplished in a relatively small portion of the landbase.

3.3.9 Additional wildlife provisions in the LRMP

The LRMP includes additional provisions intended to maintain or enhance deer winter range, maintain known fisher and black bear den sites, and develop and implement best management practices for several special wildlife habitat features, for habitats of species of interest, and for habitats of species at risk.

Implications of all these provisions will remain uncertain until they are implemented, but all should contribute positively to the species and habitats involved.

3.4 Special and Rare Ecosystems

3.4.1 Riparian ecosystems

In this section of this report, “riparian ecosystems” means ecosystems in their own right, as distinct from aquatic ecosystems and fish habitat which are discussed later.

As discussed in (Edie, 2004), it has been a challenge to define Base Case riparian management during this planning process because the rules for forestry operations in riparian areas are in a state of transition from the Forest Practices Code to the Forest and Range Practices Act. In the absence of better information, it is assumed here that the system of Riparian Reserve Zones, and Riparian Management Zones used under the Forest Practices Code, or similar retention near water bodies would be used.

The LRMP provides direction that Best Management Practices for management of riparian areas be developed by June 2005, and implemented soon thereafter. Until the new Best Management Practices are in place, the existing guidelines are to continue to apply. This general provision is supplemented by other LRMP direction which requires protection of the function and integrity of lakeshores and colluvial and alluvial fans.

SELES simulations were unable to provide useful comparisons between Base Case and LRMP management of riparian habitats.

It is difficult to speculate subjectively on LRMP impacts on riparian ecosystems because the primary instrument of the LRMP will be Best Management Practices which have yet to be developed. Further, it is as yet unclear what regulatory framework they will be implemented in.

Notwithstanding this uncertainty, I think that LRMP direction to maintain function and integrity of riparian ecosystems should result in improved management of these habitats. I believe that Best Management Practices should permit informed flexibility in design of riparian treatments, and that such flexibility should be able to accomplish more for both ecosystems and forestry operations than the current more or less rigid system of buffers does. LRMP direction to maintain functional integrity of lakeshores and colluvial and alluvial fans should add additional attention to these special features. All of these measures should be enhanced in effectiveness by input from the Watershed Advisory Committee which will include local persons with relevant knowledge and interests. Further, many high priority riparian ecosystems along Morice, Nadina, Nanika, Gosnell, Thautil, and Morrison and other systems will benefit from inclusion in Proposed Protected Areas, no harvest areas, or area specific management.

Overall, I have to rate risk to riparian ecosystems as uncertain under Base Case management due to changing legislation that will apply. I think LRMP management should result in reduced risk in comparison to Base Case management, probably to a level of Low-Moderate.

3.4.2 Rare ecosystems

Base Case management does not include provisions for management of rare ecosystems. LRMP management includes direction for conservation of red and blue listed ecosystems as defined by the Conservation Data Center. Specifically, LRMP direction is that there be no reduction in the area of undisturbed red listed ecosystems, and that risk to both red and blue listed ecosystems be decreased.

As discussed by (Edie, 2004), current red listed ecosytems in the Plan Area include Bluegrass - slender wheatgrass (SBSdk/82), Saskatoon - slender wheatgrass (SBSdk/81), Black cottonwood / red-osier dogwood - prairie rose (SBSdk/08) and Lodgepole pine - kinnikinnick (CWHws2/02).

The first two of these ecosystems are low elevation, grassland types mostly under threat from agricultural development, settlement, and grazing, not logging. Most examples of these types are on private land, mostly already developed for agriculture or settlement. LRMP direction will help status of these ecosystems in two ways. First, the Old Man Lake Protected Area proposal is specifically designed to incorporate examples of grassland ecosystems known to exist in the vicinity. Second, LRMP direction regarding rare ecosystems should be helpful by alerting government agencies so they can ensure that further alienation of crown land supporting these ecosystems is limited or avoided. As suggested in the LRMP management direction, long term health of these grassland systems might require use of prescribed fire and careful management or exclusion of grazing. LRMP direction may also help by providing impetus or priority to inventory effort, which is required because existing mapping is inadequate to identify locations of these ecosystems.

The third currently red-listed ecosystem, Black Cottonwood / red-osier dogwood – prairie rose, is often found along floodplains of larger rivers. LRMP recommendations would affect this ecosystem in two important ways. First, General Management Direction requires that the area of this ecosystem remaining undisturbed should not decrease, and that risks to it be reduced. These provisions should result in widespread examples of this ecosystem being treated with greater care than would be the case under Base Case Management. The second way the LRMP would affect this ecosystem is by including examples of it in No Harvest Areas placed over major floodplains. Protection of the Morice River floodplain in particular will be important because it contains what is probably the best remaining and most extensive example of this ecosystem in the Plan Area. As well as being protected from logging, the Morice floodplain would be retained in a naturally functioning state by largely preventing further infrastructure development or settlement. Maintenance of natural flooding processes is necessary to ensure renewal of cottonwood forests in this ecosystem in the long term.

The last currently red-listed ecosystem, Lodgepole pine / kinnikinnick, lies mostly outside the THLB, so very little of it would be logged under Base Case Management. None of it would be logged under recommended LRMP management because all examples of this ecosystem lie in No Harvest Areas in the south west portion of the Plan Area.

Overall, I would rate risk to rare ecosystems as high under Base Case management. I believe that successful implementation of LRMP direction will reduce this risk to low for the Cottonwood-Red Osier ecosystem, and moderate for other rare ecosystems.

3.5 Aquatic Ecosystems and Fish

Base Case management includes riparian protection discussed earlier in the section on riparian ecosystems: in the absence of more specific information, it is assumed that current Forest Practices Code rules or practices which achieve equal or better protection would continue under Base Case management.

LRMP management includes the riparian protection described earlier, and adds several additional means for ensuring protection of aquatic ecosystems: First, several high priority rivers (eg. Morice, Nanika, and Nadina Rivers) are included within no harvest areas and Proposed Protected Areas. Second, objectives and measures provide comprehensive direction regarding management of water quality and temperature; retention of functional integrity of streams, alluvial and colluvial fans, floodplains, riparian ecosystems, and lakeshore management areas; rehabilitation of damaged fish habitat; restoration of fish access impeded by land use; maintenance of populations of lake resident fish that are sensitive to overfishing; and minimizing negative effects of water withdrawals.

LRMP management includes development of Best Management Practices for management of riparian areas and stream temperature, development of a lakeshore management strategy, and development of a monitoring strategy for determining the impact of human activity on stream morphology. All LRMP provisions related to management of aquatic ecosystems will be monitored and assisted by a Watershed Advisory Committee established under LRMP provisions.

As discussed in Edie (2003) salmon are a particularly important feature of aquatic ecosystems in the LRMP area. Although the LRMP contains no specific management direction regarding salmon, much attention was directed toward salmon populations during the LRMP process. Protection of salmon habitat is achieved under LRMP management through the various provisions which protect aquatic ecosystems in general, and through area specific management which is often specifically intended to ensure special management of habitats of important salmon populations (eg. Morice, Nanika, and Nadina Rivers among others).

As was the case for Riparian Ecosystems, it is difficult to provide a clear comparison between the comparative results of Base Case and LRMP management. Although withdrawals of No Harvest Areas, Proposed Protected Areas, riparian reserves and management zones from THLB is done in SELES simulations, the impact of these actions on fish habitat and aquatic ecosystems is not in itself modeled, and none of the other specific provisions under LRMP management are simulated. Further, Base case management provisions are simply assumed in the absence of better information given the current transition from Forest Practices Code to the Forest and Range Practices Act. Finally, none of the specific provisions under LRMP management have yet been tried, so it is not possible to determine what results on the ground will be.

Notwithstanding this uncertainty, I think that LRMP direction should result in better management of aquatic ecosystems and fish habitat. As was true for Riparian Ecosystems, I believe that Best Management Practices should permit informed flexibility in design of management approaches, and that such flexibility should be able to accomplish more for both ecosystems and forestry operations than the current more or less rigid system of buffers does. LRMP direction to maintain functional integrity of lakeshores and colluvial and alluvial fans should add additional attention to these special features. Establishment of a local Watershed Advisory Committee will certainly ensure that difficulties in the field will be brought to the attention to managers, and should result in establishment of more informed targets and management practices. It is hard to imagine that these comprehensive measures included in the LRMP will not result in improved management in comparison to current management practices.

Overall, I have to rate risk to aquatic ecosystems as uncertain under Base Case management due to changing legislation that will apply. I think LRMP management should result in reduced risk in comparison to Base Case management, probably to a level of Low - Moderate.

4.0 Literature Cited

Attiwill, P.M. 1994. The disturbance of forest ecosystems: the ecological basis of conservative management. *Forest Ecology and Management* 63:247-300.

Bolster, L. 2003a. Personal Communication. Analyst, B.C. Ministry of Forests. Smithers, B.C.

Bolster, L. 2003b. In Prep. Decision Support System: Base Case Morice Landscape Model. *B.C. Ministry of Forests*. Smithers, B.C.

Buskirk, S.W. and L.F. Ruggiero. 1994. American Marten. pp. 7-37 In: Eds. L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon and W. J. Zielinski. The Scientific Basis for Conserving Forest Carnivores, American Marten, Fisher, Lynx and Wolverine in the Western United States. USDA Forest Service Gen. Tech. Rep. RM-254.

Edie, A.G. 2004. Environmental Risk Assessment: Base case Projection. *Ministry of Sustainable Resource Management*. Smithers, B.C. 87pp + append.pp.

Fall, A. 2004. Morice LRMP Final Plan Analysis. DRAFT Unpub. Report *B.C. Ministry of Forests*. Smithers, B.C. 13pp.

Fall, A. 2003. Morice Forest District timber supply review alignment using the SELES spatial timber supply model - DRAFT. Unpub. Report *B.C. Ministry of Forests*. Smithers, B.C. 13pp.

Fall, A, D. Morgan, and A. Edie. 2003a. Morice Landscape Model. Unpub. Report *B.C. Ministry of Forests*. Smithers, B.C. 41pp.

Fall, A., D. Sachs, T. Short, L. Safranyik, and B. Riel. 2003b. Application of the MPB SELES landscape scale mountain pine beetle model in the Morice TSA. Unpub. Report *B.C. Ministry of Forests*. Smithers, B.C. 27pp.

Fall, A. and J. Fall. 2001. A domain-specific language for models of landscape dynamics. *Ecological Modelling* 141:1-18.

Lepage, P. 2004. Personal Communication. Regional Research Silviculturist.

Lloyd, R. and M. Todd. 2003. Project Summary: A comparison of coarse woody debris in harvested and unharvested sites (2002). *Morice and Lakes Innovative Forest Practices Agreement*. Houston, B.C. 7pp.

Province of B.C. 1995. Forest Practices Code of British Columbia. Biodiversity Guidebook. *Ministry of Forests and B.C. Environment*. Victoria, B.C. 99pp.

Province of B.C. 1999. Forest Practices Code of British Columbia. Managing Identified Wildife: Procedures and Measures. Vol 1. *Ministry of Forests*.

Province of B.C. 2002. Morice Timber Supply Area Analysis Report. *Ministry of Forests*. Victoria, B.C. 124pp.

Province of B.C. 2000. Environmental Risk Assessment (ERA): An approach for Assessing and Reporting Environmental Conditions. *B.C. Environment*. Victoria, B.C. Technical Bulletin 170pp.

Schwantje, H. and C. Stephen. 2003. Communicable Disease Risks to Wildlife from Camelids in British Columbia. *Ministry of Water, Land and Air Protection, Province of B.C.*. Victoria, B.C. 54pp.

Schwantje, H. 2004. Personal Communication. Wildlife Veterinarian. Victoria

Steventon, D. 2002. Historic disturbance regimes of the Morice and Lakes Timber Supply Areas. Draft Discussion Report *Ministry of Forests, Government of B.C.*. Smithers, B.C.

Steventon, D. 2004. Personal Communication. Wildlife Research Biologist. Smithers, B.C.

Thompson, I. and A. Harestad. 2003. In Press. The ecological and theoretical basis of emulating natural disturbances in forest management: theory guiding practice. *Submitted to: Symposium on Emulating Natural Forest Landscape Disturbances: Concepts and Applications. Canadian Forest Service*. Saulte Ste. Marie, May 11-16, 2002

Todd, M. 2004. Personal Communication. Wildife Biologist. Houson, B.C.

Turney, L. and C. Houwers. 1998. Terrestrial ecosystem mapping within the Thautil River and Gosnell Creek drainages. Unpub. rep. prep. for the Wet'suwet'en Treaty Office and the Ministry of Forests Terrace, B.C. 51pp + appendicespp.

Turney, L. 2003. Grizzly bear species-habitat model (working draft). *Ardea Biological Consulting; Morice and Lakes Forest Districts IFPA*. Smithers, B.C. 36pp.

Appendices

Appendix 1 How SELES was used.

How SELES works

SELES divides the entire LRMP area into 1 ha cells or pixels, about 1.5 million of them, and keeps track of environmental conditions such as forest age in each cell over time. The model uses specified rules to determine, for example, where roads are built, where cutblocks are located, how big cutblocks can be, and how quickly forest re-grows in cut-over areas. Rules are programmed into the model so as to represent the land use practices being examined, and so as to reflect current understanding of how forests respond to logging, silviculture or natural disturbances such as insects and fire.

For each point in time, SELES constructs a data file which records the characteristics of each individual hectare in the LRMP area. As time progresses during simulation, a series of these files record the state of the landscape at each time of interest. The file for each point in time can be considered a "snapshot" of what the landscape looks like at that moment.

The data files for each snapshot can be used to produce maps to illustrate any of the recorded characteristics of the one hectare cells, such as for example, maps of forest age. The data files can also provide information to other computer models which determine habitat values for specific wildlife species. Species models examine the data for each one hectare cell, and decide how useful habitat in that cell would be for that species. By examining a series of snapshots over time, species models can track changes in habitat value over time. The snapshot data files can also be analyzed to examine landscape patterns such as patch size, age composition of the forest, or connectivity.

The Morice Landscape Model is described in further detail by Fall et. al. (2003a).

Base Case Simulation

SELES requires that all assumptions regarding management practices and forest growth be explicitly programmed into the model. For example, land available for timber harvest must be specifically defined, and the growth rates or yield curves of specific types of forest must be specified. The Base Case Simulation used the same assumptions made in the Morice Timber Supply Review completed in 2002, the so called "TSR2". (Province of B.C., 2002). TSR2 assumptions were adjusted as necessary to model events spatially, but the underlying intent was, with one exception, to apply management practices as closely as possible to those assumed in TSR2 (Fall, 2003). The exception was that the SELES simulation harvested the oldest available forest first, whereas the TSR2 assumed that harvest would first be directed to stands susceptible to beetle attack (Bolster, 2003a).

The Base Case Simulation defined the Timber Harvesting Land Base (THLB) as TSR2 did, which means that riparian reserve zones and all class 1 Environmentally Sensitive

Areas for soils, regeneration difficulty, avalanches, and wildlife were 100% removed from the THLB. Other removals included private land, parks, Agricultural Land Reserve, woodlot licenses, inoperable areas (including everything >1360m in elevation), non-commercial cover, non-merchantable forest types, sites with low timber growing potential, roads and landings, and areas uneconomic to harvest (Province of B.C., 2002).

Once THLB was defined, numerous assumptions were made regarding utilization levels, minimum harvest age, regeneration delay and so on. Notable here is the fact that the Base Case Simulation incorporates provisions for retention of old seral representation for landscape level biodiversity, for compliance with the Morice LRUP, for compliance with the Telkwa Caribou Herd recovery program, and for retention of wildlife tree patches. Details of these and all other management assumptions are described in (Province of B.C., 2002)(Fall, 2003)(Bolster, 2003b).

The Base Case simulation was run for 250 years, with "snapshots" recorded at 25, 50, 100, and 250 years.

Natural Case Simulation

In order to provide perspective to environmental conditions predicted under the Base Case Simulation, a separate Natural Case Simulation was undertaken to describe the forest landscape that would exist under "natural" conditions, i.e. in the absence of modern industrial forestry. Natural conditions were predicted by simulating stand replacement events such as fire and insect outbreaks at rates observed historically before industrial forestry began. The rates of disturbance used in the simulation were those developed from forest inventory data by (Steventon, 2002) for the Morice and Lakes TSA's.

The simulation "grew" disturbances over the landscape according to shape functions designed to produce natural disturbance shapes, and limited the final size of each disturbance according to probability rules designed to reflect the observed size of historical natural disturbances. In each BEC subzone/variant, the model generates sufficient numbers of disturbances to replace forests at historical rates observed by (Steventon, 2002)for that subzone within the Morice and Lakes TSA's. Disturbance rates were varied over time according to probability rules designed to reflect long term variation observed in historical disturbance rates.
In order to generate a sample of natural forest landscapes for the LRMP area, ten simulations were run, each for 3000 years, and resultant landscapes were recorded for analysis at each 300 years. The 300 year time period was chosen to ensure relative independence of sample landscapes, given that the oldest forest category considered was >250 years. After the 300 year simulation periods, every forest stand on the landscape must either have been altered by disturbance, or have been in the oldest defined age class for 50 years.

The ten simulations produced ten landscapes each, so 100 sample landscapes were available for analysis. These sample landscapes have been used to calculate the range of natural variability for measures such as forest age distribution and patch size. Results will be presented later in this report as comparisons between natural and managed forest structures.

LRMP Management Case Simulation

This simulation was the same as the Base Case simulation, except that the model was programmed to apply LRMP management instead of Base Case management. The main differences from simulation of Base Case management were different seral targets, removal of Proposed Protected Areas and No Harvest Areas from timber harvest, retention of additional old forest in several Area Specific Management areas, reduced harvest around many tourism and recreational facilities and features, and controlled harvest in additional Visual Quality Areas. Details of this simulation are reported in Fall (2004).

Appendix 2 Ecological Representation of Ecosections within Proposed Protected Areas and No Harvest Areas

Table 8. Representation in the Babine Upland Ecosection

Babine Upland	ESSF mc	ESSF mv 3	SBS dk	SBS mc 2	SBS wk 3	Other Variants	Total ha
To ha.	95.8	183.9	119.4	792.6	197.8	651.5	2041.0
%	0.0%	0.4%	17.3%	4.1%	1.3%	2.6%	3.6%
Hectares recommended for Protected Area Status (in 1000's of ha.):							
Bear Island	0.0	0.0	0.0	0.2	0.0	0.0	0.2
Long Island	0.0	0.0	0.0	1.1	0.0	0.0	1.1
Sanctuary Bay	0.0	0.0	0.0	0.8	0.0	0.0	0.8
Wilkinson Bay	0.0	0.0	0.0	3.5	0.0	0.0	3.5
% Protected after LRMP implementation	0.0%	0.4%	17.3%	4.8%	1.3%	2.6%	3.9%
Hectares recommended for No Harvest Status (in 1000's of ha.):							
GreaseTrailCore	0.0	0.0	0.0	0.5	0.0	0.0	0.5
% No Harvest after LRMP implementation	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Total % No Harvest and Protected	0.0%	0.4%	17.3%	4.9%	1.3%	2.6%	3.9%

Table 9. Representation in the Bulkley Basin Ecosection

Bulkley Basin	ESSF mc	SBS dk	SBS mc 2	Other Variants	Total ha
Total ha in BEC variant (in 1000's of ha.)	53.0	917.9	267.8	81.7	1320.3
% of Ecosection Currently Protected	0.1%	3.0%	2.7%	5.7%	3.0%
Hectares recommended for Protected Area Status (in 1000's of ha.):					
Old Man Lake	0.0	0.3	0.0	0.0	0.3
% Protected after LRMP implementation	0.1%	3.0%	2.7%	5.7%	3.0%
Hectares recommended for No Harvest Status (in 1000's of ha.):					
LowerMoriceCore	0.0	4.2	0.0	0.0	4.2
NadinaRiverCore	0.0	0.5	0.0	0.0	0.5
SwanLkChinaNose	0.1	1.7	0.3	0.0	2.1
% No Harvest after LRMP implementation	0.1%	0.7%	0.1%	0.0%	0.5%
Total % No Harvest and Protected	0.2%	3.7%	2.8%	5.7%	3.5%

Table 10. Representation in the Bulkley Ranges Ecosection

Bulkley Ranges	AT[6]	ESSF	ESSF mk	SBS mc 2	Other Variants	Total ha
Total ha in BEC variant (in 1000's of ha.)	138.8	153.8	58.3	231.3	26.2	608.3
% of Ecosection Currently Protected	0.0%	0.0%		0.0%	0.0%	0.0%
Hectares recommended for Protected Area Status (in 1000's of ha.):						
Nanika-Kidprice	6.0	2.4	15.2	3.4	0.0	27.0
Burnie – Shea Lakes (Tazdli Wiyez Bin)	13.4	2.2	14.6	1.0	0.0	31.2
% mentation	14.0%	3.0%	51.2%	1.9%	0.0%	9.6%
Hectares recommended for No Harvest Status (in 1000's of ha.):						
Herd Dome	8.2	2.6	3.3	0.1	0.0	14.2
Lower Morice Core	0.0	0.0	0.0	2.2	0.0	2.2
Morice Lake	12.8	5.3	2.1	3.8	0.0	24.0
Nadina River Core	0.0	0.0	0.0	0.1	0.0	0.1
Starr Creek	4.3	3.9	0.0	0.0	0.0	8.2
Tahtsa-Troitsa	29.3	15.3	7.9	0.6	0.0	53.1
Upper Morice Core	0.0	0.0	0.0	1.7	0.0	1.7
% No Harvest after LRMP implementation	39.3%	17.7%	22.8%	3.7%	0.0%	17.0%
Total % No Harvest and Protected	53	2	74.0%	5.6%	0.0%	26.6%

Table 11. Representation in the Kimsquit Mountains

Kimsquit Mountains	AT	CWH ws 2	m	MH mm	Other Variants	Total ha
Total ha in BEC v s of ha.)	27	1	12	1	7	763.1
% o	25	19	20	21.8	23	22.5%
Hectares recommended for Protected Area Status (in 1000's of ha.):						
Atna Lake Ecological Reserve	0.0	0.6	0.4	0.0	0.0	1.0
Nanika-Kidprice	9.1	5.9	8.7	0.8	0.0	24.5
% P	28	24	27	22.	23.	25.8%
Hectares recommended for No Harvest Status (in 1000's of ha.):						
Morice Lake	33.5	16.9	28.8	0.1	0.4	79.8
Tahtsa-Troitsa	33.7	20.0	50.9	6.6	0.0	111.2
% No Harvest after LRMP implementation	24	25.	66.0	4.9	0.5%	25.0%
Tot ted	52.3%	49.8%	93.7%	27.2%	23.9%	50.9%

[6] AT here includes all Alpine Tundra, and all alpine parkland types. This structure is necessary to accommodate different ecological mapping inside and outside the LRMP Area.

Table 12. Representation in the Nechako Upland Ecosection

Nechako Upland	A	ES mc	SBS d	SBS mc2	Oth Variants	Total
Total ha in BEC variant (in 1000's of ha.)	5	26	29.	383	2.3	740
% of Ecosection Currently Protected	1	0	0.3	0.6	1.0	0.
Hectares recommended for Protected Area Status (in 1000's of ha.):						
Nadina Mountain	0.9	1.5	0.0	0.0	0.0	2.4
% Protected after LRMP implementation	99	84.2	30.7	60.1%	99.9%	70.9
Hectares recommended for No Harvest Status (in 1000's of ha.):						
LowerMoriceCore	0.0	0.0	0.0	0.0	0.0	0.0
NadinaRiverCore	0.0	0.0	0.0	0.4	0.0	0.4
% No Harvest after LRM	0.0	0.0	0.0%	0.1%	0.0%	0.1%
Total % No Harvest and	99	84.2	30.7%	60.2%	99.9%	70.9

Appendix 3. Base Case and LRMP Requirements for Forest Age.

Table 13. Comparison of old forest requirement in Base Case and Management Case.

BEC Variant	Base Case Provision	Management Case Provision
ATp	N/A	N/A
CWH ws2	6.7 – 9.4[7]% >250 years old	62 – 70% >140 years old
MHmm2	14.2 – 19.9% >250 years old	62 – 70% >140 years old
ESSF mc and ESSF mv3	6.7 – 9.4% >250 years old	34 – 42% >140 years old
ESSF mk	6.7 – 9.4% >250 years old	82 – 84% >140 years old
SBS dk	8.2 – 11.5%. >140 years old	8 – 16% >140 years old
SBS mc2 and SBS wk3	8.2 – 11.5%. >140 years old	17 – 26% >140 years old

Second, in addition to the provision regarding minimum amounts of old forest, recommended provisions also impose limits on the maximum amount of young forest as well as the minimum combined amount of mature and old forest (Tables 4 and 5).

Table 14. Comparison of young (<40 yrs.) forest requirement in Base Case and Management Case.

BEC Variant	Base Case Provision	Management Case Provision in General Plan Area	Management Case Provision in High Biodiversity Areas
ATp	N/A	N/A	N/A
CWH ws2 and MHmm2	None	16%	27%
ESSF mc and ESSF mv3	None	28%	38%
ESSF mk	None	7%	9%
SBS dk	None	50%	64%
SBS mc2 and SBS wk3	None	37%	48%

[7] Higher figure is in High Biodiversity Areas, lower figure is for the rest of the Plan area exclusive of protected areas.

Table 15. Mature and Old (>100yrs.) forest requirements Under Base Case and LRMP Management.

BEC Variant	Base Case Provision	LRMP Provision in al Plan Area	LRMP Provision in High
ATp	N/A	N/A	N/A
CWH ws2 and MHmm2	None	64	71
ESSF mc and ESSF mv3	None	37	48
ESSF mk	None	83	86
SBS dk	None	10	21
SBS mc2 and SBS wk3	None	20	33

Appendix 4. Trends in Forest Age by BEC Unit

BEC	Age	Scenario	Year 0	Year 25	Year 50	Year 100	Year 250
CWHws2	0 to 40	Base	918	1036	1305	1748	1859
		Mgmt	918	964	1149	1204	1183
	>40 to 100	Base	80	80	80	467	737
		Mgmt	80	80	80	318	127
	>100 to 140	Base	479	452	447	447	1089
		Mgmt	479	463	463	463	470
	>140	Base	18977	18886	18622	17792	16769
		Mgmt	18977	18947	18762	18469	18674
ESSFmc	0 to 40	Base	19869	48477	70002	50796	48467
		Mgmt	19869	50448	65794	51317	47090
	>40 to 100	Base	26182	20045	20403	67833	65301
		Mgmt	26182	20409	21210	62984	52655
	>100 to 140	Base	24416	22655	19407	11551	17731
		Mgmt	24416	23194	20116	12149	17122
	>140	Base	127053	106343	87708	67340	66021
		Mgmt	127053	103469	90400	71070	80653
ESSFmk	0 to 40	Base	3925	6393	10305	12008	11296
		Mgmt	3925	5005	6010	4814	5025
	>40 to 100	Base	5615	4818	3770	9673	9864
		Mgmt	5615	5615	5665	7700	6891
	>100 to 140	Base	3452	3473	4425	2596	4250
		Mgmt	3452	3338	3305	3306	3421
	>140	Base	85285	83593	79777	74000	72867
		Mgmt	85285	84319	83297	82457	82940
ESSFmv3	0 to 40	Base	2003	6988	11118	7200	6628
		Mgmt	2003	8311	10563	7146	6628

BEC	Age	Scenario	Year 0	Year 25	Year 50	Year 100	Year 250
	>40 to 100	Base	1948	1457	1748	10474	10482
		Mgmt	1948	1460	1800	9773	7907
	>100 to 140	Base	2506	2117	1591	929	1545
		Mgmt	2506	2081	1654	937	1767
	>140	Base	17566	13461	9566	5420	5368
		Mgmt	17566	12171	10006	6167	7721
MHmm2	0 to 40	Base	98	98	98	98	98
		Mgmt	98	98	98	98	98
	>100 to 140	Base	25	25	25	25	26
		Mgmt	25	24	24	24	24
	>140	Base	2447	2447	2447	2447	2446
		Mgmt	2447	2448	2448	2448	2448

BEC	Age	Scenario	Year 0	Year 25	Year 50	Year 100	Year 250
SBSdk	0 to 40	Base	27987	38419	35050	38801	37480
		Mgmt	27987	32651	28187	33117	26933
	>40 to 100	Base	32453	31003	33678	36470	38704
		Mgmt	32453	26326	23375	24009	24410
	>100 to 140	Base	17971	14871	17612	14676	13794
		Mgmt	17971	15508	20214	8462	7292
	>140	Base	20032	14150	12103	8496	8465
		Mgmt	20032	19099	19134	22783	29736
SBSmc2	0 to 40	Base	159946	299089	314521	258172	282855
		Mgmt	159946	274109	283494	224076	240344
	>40 to 100	Base	98395	79592	109109	245275	211958
		Mgmt	98395	81511	110390	231362	198917
	>100 to 140	Base	114269	73269	65673	38157	49742
		Mgmt	114269	74125	68446	35040	51798
	>140	Base	226907	147567	110214	57913	54962
		Mgmt	226907	164698	129714	101024	100443
SBSwk3	0 to 40	Base	9076	20640	22166	13709	14879
		Mgmt	9076	19481	20204	11459	14691
	>40 to 100	Base	1228	1508	5647	17543	14899
		Mgmt	1228	1715	6034	17305	11860
	>100 to 140	Base	6736	2875	1728	2116	3803
		Mgmt	6736	2973	1783	2066	4129
	>140	Base	20173	12190	7672	3845	3632
		Mgmt	20173	13044	9192	6383	6533

Appendix 5. Patch Size Requirements under Base Case and LRMP Management

Table 16. Patch size Requirements

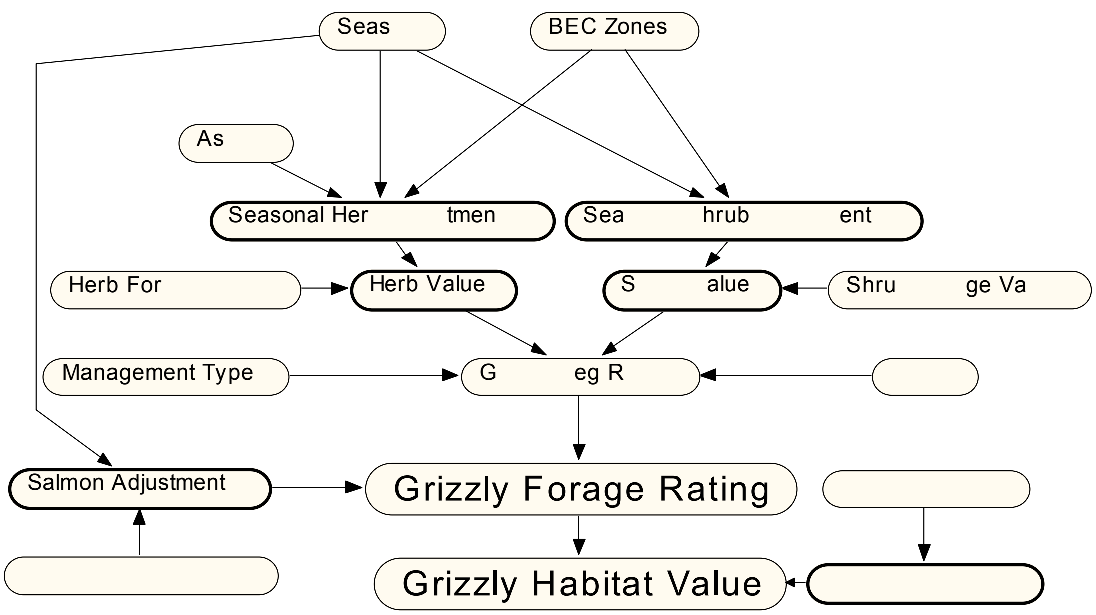
BEC Variant	Base Case Provision	Management Case Provision
ATp	N/A	N/A
All SBS	10-20% <40 ha; 60-80% > 250 ha	20-30% <40 ha; 50-60% >250 ha
All ESSF, CWH, and MH.	30-40% <40 ha; 20-40% 80-250 ha; 0% or unspecified >250 ha .	15-25% <40 ha; 50-60% >250 ha

Appendix 6. The Grizzly Bear Model

The computer model which is used to predict habitat suitability and value for grizzly bears is written in NETICA, a Baysian Belief Network program. Put simply, a Baysian Belief Network assigns likelihoods of different possible outcomes rather than deciding exact outcomes. For example, in evaluating a particular piece of habitat, given a certain site series and a given seral state, NETICA might assign an 80% probability of high forage value for grizzly bears, and a 20% probability of moderate value. This sort of probability assignment is common throughout the structure of a NETICA model.

The NETICA model prepared for grizzly bear habitat provides three different habitat evaluations, one for spring, another for summer, and one for fall habitats. Schematics of the model and a brief explanation of how it works is provided below. Further detail on the structure and function of the model is provided by (Turney, 2003).

Grizzly bear habitat model:



7494

The model determines herb forage value and shrub forage value from the site series and seral state of the habitat being considered. The initial value for both forbs and shrubs is modified to reflect the state of plant growth in the season and BEC Zone the habitat is in. For example, Alpine Tundra would have no forb food available in spring because it is covered with snow, but would have forb food available in summer and fall after the snow melts, while Engelmann Spruce Subalpine Fir would have a high shrub value for berries in the fall but not the spring.

Herb and shrub values are combined and further adjusted according to slope steepness and management state (managed forests are rated approximately one class lower than natural forests) and steepness of slope (slopes greater than 70% are lowered two classes because bears do not like to forage on them). Finally, the vegetation rating is modified to reflect access to salmon to produce the Grizzly Forage Rating. The Grizzly Forage Rating (same as "forage suitability rating") in essence reflects how much food is available for grizzly bears on the site being evaluated during the season considered.

The last output of the model is Grizzly Habitat Value which is produced by reducing habitat availability in response to road disturbance. Habitat within 100m of roads is reduced by 0.7, that between 100 and 200m by 0.4, and that between 200 and 500m by 0.1. Habitat more than 500 m from roads is not adjusted.

Thus, forage suitability reflects food supply only, whereas habitat value reflects both food supply and road disturbance.

Appendix 7. Grizzly Bear Habitat Trends Under LRMP and Base Case Management.

Table 17. Grizzly Bear Habitat Suitability Under LRMP and Base Case.

Season	Forage Suitability	Mgmt	Simulation Year 0	25	50	100	250
	High	LRMP	82	66	57	49	45
Spring	High	Base	82	62	52	42	40
Spring	Moderate	LRMP	227	202	174	154	149
Spring	Moderate	Base	227	197	166	141	141
Spring	Low	LRMP	387	389	364	375	385
Spring	Low	Base	387	395	367	377	382
Spring	Nil	LRMP	803	841	903	921	919
Spring	Nil	Base	803	845	912	939	935
Spring	Low or Nil	LRMP	1189	1230	1268	1296	1304
Spring	Low or Nil	Base	1189	1239	1280	1316	1317
Summer	High	LRMP	319	272	243	215	204
Summer	High	Base	319	262	231	192	187
Summer	Moderate	LRMP	327	341	312	293	306
Summer	Moderate	Base	327	345	311	294	300
Summer	Low	LRMP	537	558	569	595	601
Summer	Low	Base	537	566	576	607	614
Summer	Nil	LRMP	315	328	376	395	387
Summer	Nil	Base	315	326	380	406	398
Summer	Low or Nil	LRMP	853	886	944	990	988
Summer	Low or Nil	Base	853	892	957	1013	1011
Fall	High	LRMP	5	5	4	4	4
Fall	High	Base	5	4	4	3	3
Fall	Moderate	LRMP	168	123	97	72	62
Fall	Moderate	Base	168	114	87	55	51
Fall	Low	LRMP	684	651	597	592	599
Fall	Low	Base	684	655	593	584	586
Fall	Nil	LRMP	642	720	801	831	834
Fall	Nil	Base	642	725	814	857	859
Fall	Low or Nil	LRMP	1326	1371	1398	1422	1433
Fall	Low or Nil	Base	1326	1380	1408	1441	1445

Table 18. Grizzly Bear Habitat Value Under LRMP and Base Case.

Season	Habitat Value	Mgmt	Simulation Year				
			0	25	50	100	250
Spring	High	LRMP	63	38	31	24	19
Spring	High	Base	63	34	27	16	13
Spring	Moderate	LRMP	172	126	109	86	77
Spring	Moderate	Base	172	120	101	72	61
Spring	Low	LRMP	187	182	164	146	142
Spring	Low	Base	187	180	160	137	129
Spring	Nil	LRMP	1076	1152	1194	1243	1261
Spring	Nil	Base	1076	1164	1210	1274	1296
Spring	Low or Nil	LRMP	2152	2316	2404	2517	2557
Spring	Low or Nil	Base	3228	3480	3614	3791	3853
Summer	High	LRMP	261	193	172	146	131
Summer	High	Base	261	182	159	121	105
Summer	Moderate	LRMP	276	255	238	207	202
Summer	Moderate	Base	276	250	229	189	174
Summer	Low	LRMP	291	254	229	227	221
Summer	Low	Base	291	256	229	227	221
Summer	Nil	LRMP	671	796	858	919	944
Summer	Nil	Base	671	810	881	962	998
Summer	Low or Nil	LRMP	1342	1607	1740	1881	1942
Summer	Low or Nil	Base	2013	2417	2621	2842	2941
Fall	High	LRMP	4	3	2	2	2
Fall	High	Base	4	2	2	1	1
Fall	Moderate	LRMP	133	76	60	43	36
Fall	Moderate	Base	133	69	51	30	24
Fall	Low	LRMP	278	263	246	213	204
Fall	Low	Base	278	260	238	190	171
Fall	Nil	LRMP	1084	1156	1190	1241	1257
Fall	Nil	Base	1084	1167	1207	1277	1302
Fall	Low or Nil	LRMP	2167	2324	2398	2518	2559
Fall	Low or Nil	Base	3251	3491	3605	3794	3861

Appendix 8. Grizzly Bear Habitat Suitability Among Landscape Units

Landscape Unit	Spring LRMP	Spring Base	Summer LRMP	Summer Base	Fall LRMP	Fall Ba
Buck	10.29	9.66	22.08	21.11	1.52	1.22
Burnie	2.25	2.24	19.21	19.22	1.76	1.76
Fulton	19.11	19.32	33.67	33.46	3.59	3.17
Gosnel	5.82	4.70	22.40	18.80	4.24	2.92
Granisle	2.07	1.74	6.87	6.88	1.33	1.04
HoustonTommy	4.60	4.02	14.96	14.24	1.78	1.58
Kidprice	9.57	7.80	33.66	29.35	5.42	3.64
MoriceLake	6.22	5.73	37.08	35.69	4.45	4.07
Morrison	22.53	19.99	33.73	32.28	10.17	7.61
Nadina	15.44	14.27	35.52	34.74	4.44	3.54
Nanika	2.37	2.37	18.90	18.90	0.76	0.76
NorthBabine	12.56	12.28	17.27	17.02	5.68	5.18
Owen	8.78	7.74	17.86	16.05	2.00	1.54
Parrotts	7.01	6.88	8.96	8.80	0.81	0.52
Sibola	3.58	3.43	27.00	26.46	1.93	1.78
Tahtsa	11.17	11.36	23.49	24.18	1.00	0.94
Thautil	6.62	5.77	18.60	17.24	2.92	2.24
TochchaNatowite	9.43	8.56	23.74	22.19	2.41	1.97
Topley	3.14	2.66	9.52	9.35	1.82	1.46
Troitsa	2.70	2.32	26.37	22.96	1.18	0.76
Valley	22.99	21.76	42.23	41.35	4.64	4.12
Whitesail	6.35	6.45	17.13	16.87	1.82	1.82

Note: Body of Table contains the area of moderate or better habitat left in each Landscape Unit at the end of model simulations (year 250). Units are 1000's of ha.

Appendix 9. Grizzly Bear Habitat Value Among Landscape Units

Landscape Unit	Spring		Summer		Fall	
	LRMP	Base	LRMP	Base	LRMP	Base
Buck	4194	2982	9830	8036	554	394
Burnie	2247	2213	19205	19044	1761	1729
Fulton	8053	6296	15159	12623	1236	792
Gosnel	3576	1784	17605	11888	2566	982
Granisle	664	397	2383	1678	416	238
HoustonTommy	2005	1451	9855	8495	933	661
Kidprice	4890	2381	23941	14644	3199	1279
MoriceLake	5572	4573	35957	33108	3972	3288
Morrison	12182	8406	17843	13401	6050	3598
Nadina	6841	5037	18848	15525	2004	1283
Nanika	2373	2226	18897	17757	755	723
NorthBabine	6069	4990	8028	6586	3311	2440
Owen	3833	3090	8877	6909	796	511
Parrotts	2454	2478	3354	3539	267	142
Sibola	3159	2822	26196	24738	1893	1685
Tahtsa	4360	3432	11300	9502	414	268
Thautil	3710	2685	13585	11033	1627	982
TochchaNatowite	3704	2759	10505	8301	1096	750
Topley	1239	938	4885	4213	682	623
Troitsa	2438	1713	25873	20341	1052	642
Valley	8872	7899	20106	18648	2083	1696
Whitesail	3278	2716	10754	9542	968	797

Note: Body of Table contains the area of moderate or better habitat left in each Landscape Unit at the end of model simulations (year 250). Units are 1000's of ha.

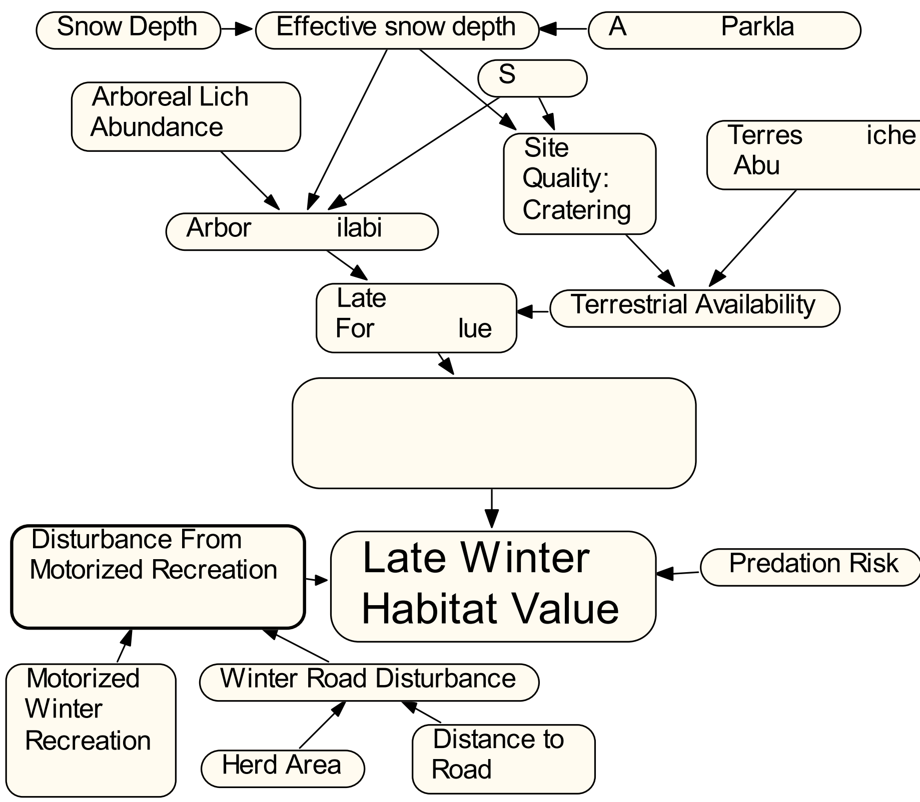
Appendix 10. Caribou models.

The basic function of the caribou models is similar to the grizzly bear models described above. Three models are used, one for winter habitat, another for summer habitat, and the final one for calving habitat. Schematics of each model and a brief description of how it works is provided below.

Winter Habitat Model

A schematic of the Netica winter habitat model is shown below.

Caribou winter habitat model:



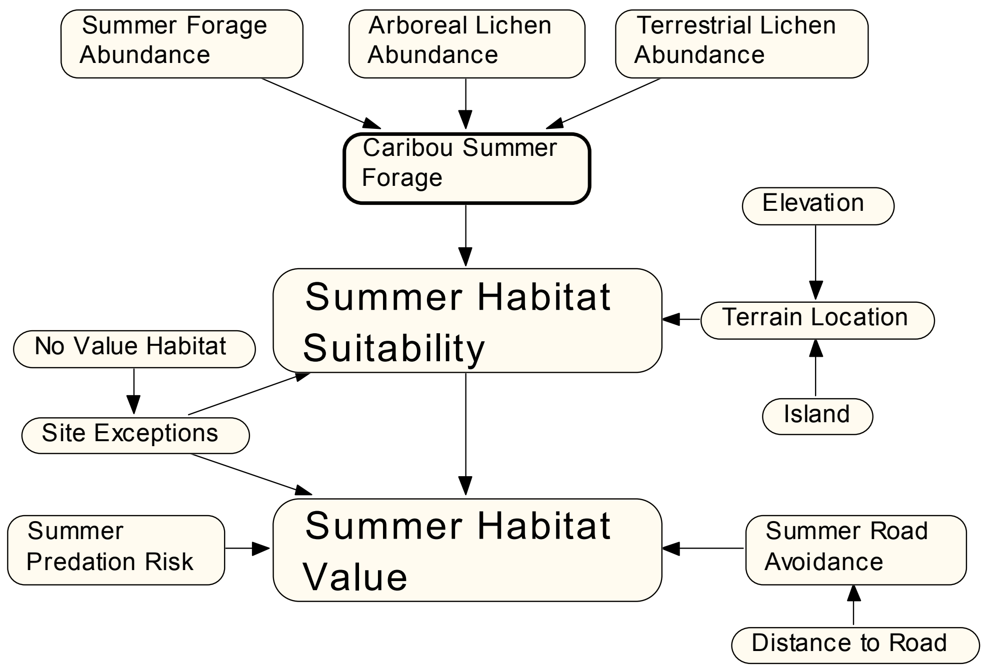
The model produces two outputs, late winter habitat suitability, and late winter habitat value. Suitability is derived from abundance and availability of terrestrial lichens (those that grow on the ground) and/or aboreal lichens (those that grow on trees), which are in turn predicted on the basis of forest stand characteristics predicted by SELES, and snow conditions predicted on the basis of biogeoclimatic zone. In essence, habitat suitability is a reflection of the abundance and availability of lichens used as winter food.

Habitat value downgrades habitat suitability according to the degree of expected disturbance from roads and snowmobiles, and the extra predation expected due to presence of moose and wolves. In the winter model, presence of moose and wolves is predicted by a simple relationship with BEC Zones, with zones such as SBSdk where moose wintering is common receiving higher predation risk, and zones with little moose wintering such as ESSF receiving less risk. In essence, habitat value is the effectiveness of habitat after the effects of disturbance and predation are taken into account.

Summer Habitat Model

A schematic of the Netica summer habitat model is shown below

Caribou summer habitat model:



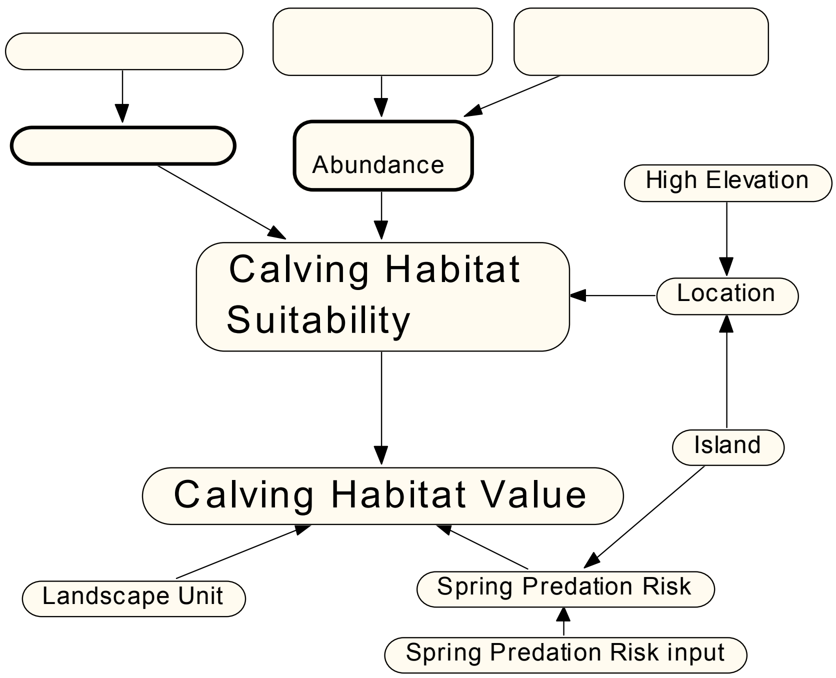
As the winter model did, the summer model produces two outputs, habitat suitability and habitat value. Habitat suitability is derived from abundance of terrestrial lichens, arboreal lichens, and other forage species, as modified by terrain (higher elevations and islands are better) or by special habitat types which are not useful to caribou (eg. lakes, rivers, glaciers etc.).

Habitat value is derived from habitat suitability by reducing it according to expected predation risk and road disturbance. In the summer model, predation risk from wolves supported by moose is predicted by both BEC Zone and seral state, with early seral states which produce moose food receiving higher risk ratings.

Calving Habitat Model

A schematic of the Netica calving habitat model is shown below.

Caribou calving habitat model:



As the other two caribou models did, the calving model produces two outputs, habitat suitability and habitat value. Habitat suitability is derived from abundance of terrestrial lichens and other forage species, as modified by terrain location, and as corrected in specific habitat types which are not useful (rivers, lakes, glaciers, etc.).

Calving habitat value is derived by reducing habitat suitability to account for predation risk. In the calving model, predation risk is predicted based on BEC and seral state as it was in the summer model. However, it is also modified by applying a risk in the Whitesail and Troitsa Landscape Units to reflect believed lower density of wolves in these areas.

Appendix 11. Caribou Habitat under Base Case and LRMP Management.

Table 19. Caribou Calving Suitability

Herd	Calving Suitability	Management	Simulation Year 0	25	50	100	250
Takla	High	Base	21.0	21.0	21.0	21.0	21.0
		LRMP	21.0	21.0	21.0	21.0	21.0
	Moderate	Base	5.3	5.4	5.4	5.3	5.3
		LRMP	5.3	5.4	5.4	5.3	5.3
	Low	Base	103.7	103.7	103.7	103.7	103.7
		LRMP	103.7	103.7	103.7	103.7	103.7
	Very_Low	Base	33.3	33.3	33.3	33.3	33.3
		LRMP	33.3	33.3	33.3	33.3	33.3
Telkwa	High	Base	57.5	57.5	57.5	57.5	57.5
		LRMP	57.5	57.5	57.5	57.5	57.5
	Moderate	Base	15.9	19.6	19.8	17.0	16.7
		LRMP	15.9	19.4	19.4	17.2	17.1
	Low	Base	252.5	248.7	248.6	251.4	251.7
		LRMP	252.5	249.0	249.0	251.2	251.2
	Very_Low	Base	7.1	7.1	7.1	7.1	7.1
		LRMP	7.1	7.1	7.1	7.1	7.1
Tweedsmuir	High	Base	52.7	52.7	52.7	52.7	52.7
		LRMP	52.7	52.7	52.7	52.7	52.7
	Moderate	Base	13.2	13.6	13.1	12.7	13.1
		LRMP	13.2	14.2	13.7	13.0	13.1
	Low	Base	188.6	188.3	188.7	189.2	188.7
		LRMP	188.6	187.6	188.2	188.8	188.7
	Very_Low	Base	46.4	46.4	46.4	46.4	46.4
		LRMP	46.4	46.4	46.4	46.4	46.4

Table 20. Caribou Calving Value

Herd	Calving Value	Mgmt	Year 0	25	50	100	250
Takla	Good	Base	2.9	2.9	2.8	2.8	2.8
		LRMP	2.9	2.9	2.8	2.8	2.8
	Poor	Base	160.4	160.4	160.4	160.5	160.5
		LRMP	160.4	160.4	160.5	160.5	160.5
Telkwa	Good	Base	57.5	57.5	57.5	57.5	57.5
		LRMP	57.5	57.5	57.5	57.5	57.5
	Medium	Base	3.0	3.0	3.0	3.0	3.0
		LRMP	3.0	3.0	3.0	3.0	3.0
	Poor	Base	272.5	272.5	272.5	272.5	272.5
		LRMP	272.5	272.5	272.5	272.5	272.5
Tweedsmuir	Good	Base	52.7	52.7	52.7	52.7	52.7
		LRMP	52.7	52.7	52.7	52.7	52.7
	Medium	Base	6.4	6.5	6.5	6.3	6.6
		LRMP	6.4	7.0	7.0	6.6	6.7
	Poor	Base	241.8	241.7	241.7	241.9	241.6
		LRMP	241.8	241.2	241.2	241.6	241.5

Table 21. Caribou Summer and Winter Habitat Suitability.

Habitat Type	Herd	Suitability	Management	Simulation Year				
				0	25	50	100	250
Summer	Takla	H		4.9	6.4	7.4	5.5	5.5
			LRMP	4.9	7.0	6.1	5.7	5.6
		M	Base	54.5	39.8	32.5	34.6	35.8
			LRMP	54.5	41.0	36.0	38.9	39.0
		L	Base	104.0	117.0	123.4	123.2	122.0
			LRMP	104.0	115.3	121.2	118.8	118.7
	Telkwa	H	Base	62.1	66.3	67.3	64.5	64.2
			LRMP	62.1	65.7	65.8	63.5	63.7
		M	Base	73.7	65.1	60.0	61.3	60.5
			LRMP	73.7	65.7	61.6	67.2	66.0
		L	Base	197.1	201.6	205.7	207.1	208.3
			LRMP	197.1	201.6	205.5	202.2	203.3
	Tweedsmuir	H	Base	74.7	75.6	75.7	75.9	75.8
			LRMP	74.7	75.8	75.7	75.1	75.0
		M	Base	57.7	51.3	46.5	43.7	44.7
			LRMP	57.7	51.5	46.6	45.4	47.0
		L	Base	168.6	174.0	178.7	181.2	180.4
			LRMP	168.6	173.5	178.6	180.5	178.9
Winter	Takla	H	Base	4.0	2.7	2.3	1.8	1.8
			LRMP	4.0	2.3	2.2	1.8	1.8
		M	Base	6.9	5.9	5.2	4.4	4.6
			LRMP	6.9	6.4	6.1	5.6	5.5
		L	Base	152.4	154.8	155.8	157.1	156.9
			LRMP	152.4	154.5	155.0	155.8	156.0
	Telkwa	H	Base	27.9	21.2	19.3	17.5	17.3
			LRMP	27.9	20.7	19.4	18.2	18.2
		Moderate	Base	47.4	39.2	37.2	39.5	38.2
			LRMP	47.4	36.2	34.8	37.2	36.2
		Low	Base	257.7	272.6	276.5	275.9	277.5
			LRMP	257.7	276.0	278.8	277.5	278.5

Table 22. Caribou Summer and Winter Habitat Value.

Season	Her	Value	Management	Simulation Year				
				0	2	50	100	250
	Tak	Good	Ba	1.8	3.9	5.0	2.6	2.5
			LR	1.8	4.5	3.7	2.8	2.6
		Medium	Base	52.3	39.2	32.7	28.6	25.4
			LRMP	52.3	40.3	35.0	32.5	30.3
		Poor	Base	109.2	120.1	125.6	132.1	135.4
			L	109.2	118.5	124.6	128.0	130.3
	Tel		Base	46.3	46.3	46.2	45.4	44.9
			LR	46.3	46.3	46.2	45.5	45.2
		Medium	Base	88.0	84.8	80.3	71.4	65.3
			LRMP	88.0	85.0	80.8	78.5	74.2
		Poor	Base	198.7	201.9	206.5	216.2	222.7
			L	198.7	201.7	205.9	208.9	213.6
	Tweedsmuir		Base	55.1	53.7	53.7	53.5	52.8
			LR	55.1	53.9	53.8	53.6	53.6
		Medium	Base	80.7	72.5	70.7	63.9	62.7
			LRMP	80.7	74.0	71.8	66.3	66.4
		Poor	Base	165.1	174.7	176.5	183.5	185.4
			LRMP	165.1	173.0	175.2	180.9	180.8
Winter	Takla	Good	Base	0.4	0.4	0.3	0.2	0.2
			LRMP	0.4	0.4	0.4	0.4	0.4
		Medium	Base	8.6	6.5	5.8	4.8	4.8
			LRMP	8.6	6.7	6.4	5.6	5.6
		Poor	Base	154.3	156.4	157.1	158.2	158.2
			LRMP	154.3	156.2	156.5	157.3	157.3
	Telkwa	Good	Base	13.9	11.7	10.9	10.2	9.8
			LRMP	13.9	11.1	10.5	10.0	10.0
		Medium	Base	41.0	34.6	33.4	32.1	32.0
			LRMP	41.0	30.9	30.0	29.2	29.2
		Poor	Base	278.1	286.7	288.7	290.7	291.2
			LRMP	278.1	291.1	292.5	293.8	293.8

Appendix 12. Goshawk models

The following description of the goshawk models was prepared by Todd Mahon of Wildfor Consultants Ltd.:

Nest Area Model

Nest Area Habitat Suitability Model Variables

Forest Composition

Suitability ratings in the following table are based on the associations of tree species observed at nest areas. Suitability depends on the form and structure of the trees and the stands they make up, and can therefore vary substantially among sites. Most known nest areas in the SBS zone in the Lakes and Morice Forest Districts are in pine leading stands. Pine seems to be preferred because it often forms even-aged stands with closed canopies and open understories. Other species such as spruce and fir tend to have more broken canopies, greater vertical stand structure (with less open understories) and poorer branch structures for nests.

Tree Species	Condition	Rating
Cottonwood		0.5
Aspen	>20%	0.6
Aspen	<20%	1.0
Sub-alpine Fir		0.6
Birch		0.5
Douglas Fir		0.8
Pine		1.0
Spruce		0.8
Black Spruce		0.5
Western Hemlock	>30%	1
Western Hemlock	<30%	0.6
Amabilis Fir		0.6
Any others (Dr, Hm, Yc, etc)		0.5

Overall stand forest type suitability ratings are calculated by multiplying the species rating by its percentage composition (0-1) and summing the individual species ratings for all types in the stand.

E.g.: $P_{70}S_{20}AT_{10}$=0.7(1.0)+0.2(0.8)+0.1(1.0)=0.96

Stand Age

The structural maturity of a stand, and trees within a stand, form the fundamental basis for nesting suitability for goshawks. As a surrogate to structural stage we use stand age, and stand height as detailed in the next section.

In the SBS of the Morice and Lakes Forest Districts suitable nesting habitat for goshawks consists of forest that is 120-200 years old that has gone through the self thinning phase, but has not yet entered the gap-phase dynamics associated with the old growth stands. Forests in these age classes also tend to have more nest support structures than younger stands. This structural stage generally has high canopy closure and an open understory which creates open flyways under the main canopy that are used by goshawks for nest access and hunting. The vast majority of nests found in the Lakes and Morice Districts are located in forest stands that are between 121 and 250 years old (age classes 7 and 8). Age class 9 (>250 years) forests in the SBS are reduced in rating because they have variable canopy structure and more developed understories.

Age Class	Age (yrs)	Rating
0 to 3	0-60	0.00
4	61-80	0.10
5	81-100	0.30
6	101-120	0.50
7	121-140	0.90
8	141-250	1.00
9	>250	0.80

Stand Height

Stand height is strongly correlated to stand age. Although we generally avoid using correlated variables in the HSI model, there are certain circumstances where relatively young stands on good growing sites provide moderate nest area suitability. To account for these circumstances we use the average suitability ratings for stand height and age in the model.

The height suitability function we used is described in the table below.

Height (m)	**Rating**
< 3	0.00
3 to 8.99	(H - 3) x 0.016667
9 to 19.99	0.1 + (H - 9) x 0.0818182
20 +	1.00

Canopy Closure

After the fundamental requirement of a ‘mature’ forest stage, canopy closure is probably the single most important structural variable relating to nest area suitability. Virtually every study examining goshawk nest areas identifies canopy closure as a key attribute (Cooper and Stevens 2000). Stands <30% canopy closure are generally too open for nesting. Optimal values, as represented from our observed sample of nest areas, are between 46% and 75%. Corresponding suitability ratings for the canopy closure classes available in the forest cover database are provided below.

Canopy Closure Class	Canopy Closure %	Rating
0-2	0-25	0
3	26-35	0.3
4	36-45	0.6
5-7	46-75	1.0
8-9	>75	0.8

Edges

Data from a sample of > 60 nest areas in the Lakes, Morice and Kispiox Forest Districts indicates that goshawks tend to avoid locating nests near forest edges. Avoidance was relatively weak 50-100m from an edge but strong 0-50m from an edge. This behaviour is represented in the ratings table below. This pattern of selection was noted for what we defined as 'hard' edges. Hard edges occurred where mature forest met non-forested or early seral habitats and the difference in height was >10m. Hard edges occur around regenerating cutblocks, roads, human settlement/development, swamps, swamp forest, wetlands, brush patches, lakes, rivers and ocean.

Edge Distance (m)	Rating
0-50	0.4
50-100	0.8
>100	1
0-100 blended*	0.7
Road edges**	0.4

*Due to computational limitations, the digital resolution of the GIS analysis may only be done at 100m pixel size. If this occurs a blended rating of 0.7 should be used in the model.

**Road edges present a similar problem at 100m pixel resolution. In all cases where a pixel has a road in it apply a rating of 0.4.

Nest Area Habitat Suitability Model

This nest area model follows a limiting factor, non-compensatory approach. From an ecological perspective this means that when the suitability rating of one variable decreases below its optimal range it decreases the overall suitability by that amount. Further, suboptimal ratings in two or more variables are combined, through a multiplicative function, to decrease the overall value. The function is non-compensatory in that the value of one variable cannot compensate for a deficiency in another. The equation used to calculate the suitability ratings is:

Nest Area Suitability = Tree Spp Rating x **Can. Cl.** Rating x **(Age Cl.** Rating **+ Stand Ht.** Rating **/ 2)** x **Edge** Rating

Ratings can be categorized within a 4-class system for map themeing:

Ratings	Class
0-.249	Nil
.25-.499	Low
.5-.749	Moderate
>=.75	High

Foraging Area Model

Unlike the nest area habitat model, which combines rating from 5 variables to produce a final rating, the foraging model is based on categorically defined habitat units. The habitat suitability ratings are driven primarily by preference indices developed from observed habitat selection of radio-tagged goshawks, with professional judgement used to rate habitats not available within the telemetry study. The criteria used to define each habitat type and the suitability rating are provided in the table below. This table includes similar habitat types with equivalent ratings. We have explicitly decided not to lump these habitat types at this point because additional data may become available over the summer that would allow us to refine ratings among these habitats. To determine appropriate habitat classifications the table should be read as : (Age **AND** Leading Forest Cover) **OR** NP types **OR** NF Types. The table criteria are supposed to be comprehensive (i.e. include all possible combinations) and mutually exclusive (i.e. input combinations can only result in one classification).

Table 1. Foraging area habitat classification and suitability ratings

Broad Habitat Type	**Age (years)**	**Leading Forest Cover**	**NP types**	**NF types**	Rating
Herb/Low Shrub	0-15	any			0.1
Shrub-deciduous	15-40	Any deciduous	NPBR	NCBR	0.4
Shrub-conifer	15-40	Any coniferous	NPBU[1]	NSR[1]	0.5
Young Forest - dec	41-80	Any deciduous			0.4
Young Forest - con	41-80	Any coniferous			0.3
Mature Forest - dec	81-120	Any deciduous			0.6
Mature Forest - con	81-120	Any coniferous			0.6
Old Forest - dec	>120	Any deciduous			0.7
Old Forest - Pl	>120	Pl			1
Old Forest - S	>120	Spruce, any except Sb			1
Old Forest - B	>120	Bl and Ba			1
Old Forest – other conifer	>120	H, Hw, Hm, Cw, Yc, Fd, Sb			0.8

Non-Forested	Blank		A, AF, S, C, M, P, OR, SWAMP		0.3
Not Suitable			ICE, R, GR, SAND, CL, L, RIV, MUD, U, NA		0

1. Classify preferentially using age and FC; NPBU and NSR should only be used to classify type if age and/or FC are absent

Similar to the nest area ratings, foraging area ratings can be categorized within a 4-class system for map themeing:

Ratings	Class
0-.249	Nil
.25-.499	Low
.5-.749	Moderate
>=.75	High

Theoretical Territory Analysis Units

Goshawk pairs are spaced relatively regularly through suitable habitat within a landscape. Habitat supply analysis is required at the territory scale in order to evaluate the distribution of habitat with respect to spacing pattern of the species.

To address this issue theoretical territory analysis units (TAUs) will be systematically located across the district. Each unit will be assessed at each time period to determine whether it meets minimum requirements for nesting and foraging habitats. Analysis units will be located using a systematic hexagonal grid with a random first seeding and using a 2765m radius (centre to corner). This spacing distance corresponds to the average ~5km spacing observed among adjacent goshawk territories in the Morice and Lakes. For analysis we will consider a circular area using the 2765m radius, which will result in some of overlap of TAUs. (The hexagonal grid is only used to systematically locate the centre of each TAU).

Habitat Thresholds for Theoretical Territory Analysis Units

As indicated above, each TAU will be assessed at each time period of interest, for each scenario, to determine whether habitat within each TAU meets minimum requirements for nesting and foraging habitats. It is important to emphasize that neither the goshawk literature nor our local research confidently quantifies minimum habitat thresholds for goshawks. In reality minimum habitat requirements will change depending on several factors, especially prey abundance for foraging habitat. To address this uncertainty and variance we have identified 4 potential occupancy thresholds for both nesting and foraging habitat. Again it is important to emphasize the relative nature of these thresholds. We do not have the data to correlate whether these habitat thresholds correspond to actual goshawk densities. The primary value in using this information is in relative comparisons of the number of TAUs in each potential occupancy class between scenarios and over time. A summary of the habitat thresholds is provided in Table 2. A more detailed description of the criteria and rationales used to develop the thresholds are provided in the following sections.

Table 2. Threshold limits for potential occupancy of theoretical goshawk territory analysis units.

Potential Occupancy	Nest Area	Foraging Area
High	240 ha of High NA	960 ha of High FA
Moderate	120 ha of High NA	600 ha of High FA
Low	**50 HA OF HIGH NA**	240 ha of High FA
Unlikely	**<50 HA OF HIGH NA**	240 ha of High FA

Criteria and Rationale for Nest Area Thresholds

The nest area is smallest component of a goshawks territory and is the activity centre for a goshawk pair throughout the breeding season. In the SBS the typical nest area size is 24 ha, however, most known nest areas have been contiguous with larger stands of mature forest. Other literature indicates that goshawks require alternate nest area habitat, in addition to currently used areas. Based on our observations and information from the literature we predict that a territory with at least 240ha of high value nest area habitat (10% of the territory) has a high probability of being occupied by goshawks. Rationales for the other occupancy classes are outlined in Table 3. Moderate value nest area habitat is estimated to have an approximate equivalency of 0.5 to high value habitat.

Table 3. Rationale for thresholds limits for potential occupancy of theoretical goshawk territories for nest area habitat suitability.

Potential Occupancy	Condition*	Rationale
High	≥240 ha of High NA + 0.5 x Moderate NA	Corresponds to 10% of 2400ha breeding home range
Moderate	≥120 ha of High NA + 0.5 x Moderate NA	Corresponds to 5% of 2400ha breeding home range
Low	≥50 ha of High NA + 0.5 x Moderate NA	Meets basic requirement of 1 used and 1 alternate nest area, however occupation at this theoretical minimum requirement is rarely observed
Unlikely	<50 ha of High NA + 0.5 x Moderate NA	Does not meet minimum nesting habitat requirement

*The rationale for this approach is that many moderate rated stands contain patches of high value habitat. We estimate that moderate habitat has approximately equivalency of 0.5 to high value habitat, hence the multiplication of moderate habitat by 0.5 in the threshold condition.

Criteria and Rationale for Foraging Area Thresholds

As a predator, the ability of goshawks to survive and reproduce is primarily driven by the abundance and availability of prey. As a fairly generalist predators goshawks feed on a range of prey including red squirrels, medium sized birds (jays, thrushes, woodpeckers), snowshoe hares and grouse, all of whose abundance varies with habitat, season and year. Not only must these prey be in sufficient abundance, they must also be in habitats where they are available for goshawks to hunt them. For example, snowshoe hares may be abundant in regenerating clearcuts, but the regen is too thick for goshawks to successfully locate and capture them. Based on detailed telemetry tracking of two goshawks in the Lakes District, goshawks in the SBS strongly select old forest for hunting and avoid all other habitats relative to their proportional occurrence. Based on the habitat composition of the territories of our two radio tagged birds, and other studies, if appears that territories with at least 40% old forest have a high probability of occupancy[8]. Areas with less than 10% mature forest are unlikely to be used. Twenty-five percent was chosen as an intermediate value for the moderate probability threshold (Table 4).

Ultimately, obtaining suitable foraging habitat will likely be the primary requisite in determining whether goshawks occupy an area or not. If there is suitable foraging habitat, it is likely the birds will be able to find a place to nest. In that context it may be adequate to only consider foraging area habitat for habitat supply. The problem in doing that, however, is the complexity and variation associated with all of the factors that affect foraging area suitability (prey abundance and availability, scale effects, prey and habitat switching). Given this uncertainty we recommend that both foraging and nest area habitat suitability be considered.

Table 4. Rationale for thresholds limits for potential occupancy of theoretical goshawk territories for foraging area habitat suitability

Potential Occupancy	**Condition**	**Rationale**
High	960 ha of High FA	Corresponds to 40% of 2400ha breeding HR*
Moderate	600 ha of High FA	Corresponds to 25% of 2400ha breeding HR
Low	240 ha of High FA	Corresponds to 10% of 2400ha breeding HR
Unlikely	**<240 HA OF HIGH FA**	Does not meet minimum foraging habitat requirement

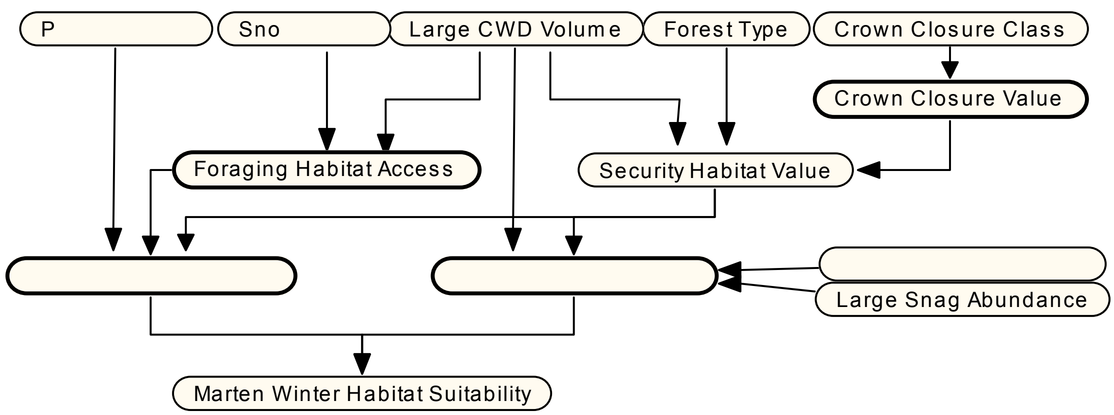
[8] Habitats with a suitability rating other than high are used to some extent by goshawks and definitely contribute to prey at the territory scale, however, because local telemetry data indicates that these habitats are used so little by goshawks we have chosen to only consider high value habitat.

Appendix 13. The marten model

Basic function was similar to the grizzly and caribou models described above.

A schematic of the NETICA model is shown below.

Netica model of marten winter habitat suitability



The NETICA model combines suitability for foraging with suitability for denning in order to produce an overall rating for winter habitat suitability.

Suitability for denning is determined partly by availability of potential den sites in the form of large trees, large snags, and large coarse woody debris, and partly by security value as determined by crown closure, forest structure, and large coarse woody debris. Canopy closure is provided directly from SELES, and the other variables are predicted primarily on the basis of site series and forest age.

Suitability for foraging is determined partly by prey biomass which is predicted on the basis of forest age and site series provided by SELES, partly by snow depth which is predicted on the basis of Biogeoclimatic Zone provided by SELES, and partly by large coarse woody debris, which is predicted on the basis of forest age and site series provided by SELES.

Morice Land and Resource Management Plan

MAP 1. CARIBOU MANAGEMENT AREAS