Morice Land & Resource Management Plan

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Environmental Risk Assessment: Base case Projection

Prepared for:

Ministry of Sustainable Resource Management
Skeena Region

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Executive Summary

This risk assessment examines the degree to which different ecosystems are represented within protected areas, and examines the likely future effects of the current management regime on coarse filter biodiversity, several specific wildlife species, aquatic ecosystems and fish, and special or rare ecosystems.

The Morice LRMP area has a continental climate which is moderated by coastal moisture and warmth which penetrate past the Kimsquit Mountains. Winters are cold, with persistent snowpack at all elevations in most winters, and summers are cool or warm, with a short growing season. Forests in the area are mostly coniferous, but aspen and black cottonwood forests occur in some locations at lower elevations.

The LRMP area includes significant portions of the Babine Upland, Bulkley Basin, Bulkley Ranges, Kimsquit Mountains, and Nechako Upland Ecosections. Representation of these ecosections within existing protected areas varies, with Bulkley Ranges currently not represented, and Nechako Upland over 70% protected. The main Biogeoclimatic Zones in the LRMP area include Sub-boreal Spruce, Englemann Spruce-Subalpine Fir, Coastal Western Hemlock, and Alpine Tundra. Regional representation of these units within protected areas varies from less than 10% for Sub-boreal Spruce to over 30% for Alpine Tundra/parkland.

Future impacts of current management practices were examined by using computer simulation to predict where logging will occur, and keep track of how logged areas re-grow over time. Computer simulation was also used to determine the Range of Natural Variation of forest structure in the absence of industrial forestry.

Potential risk to coarse filter biodiversity was examined by comparing the age structure of managed forests with the Range of Natural Variation. Over the 250 year Base Case Simulation which applied current management practices, forest age composition changed substantially in areas subjected to logging. Generally, the proportion of forest >140 years old declined over time in all areas managed for forestry. Departures from the Range of Natural Variation, and presumed risk for biodiversity, were greatest for ESSFmk, ESSFwv3, and SBSmc2 forests, and for the North Babine, Kidprice, and Thautil Landscape Units.

An attempt to examine implications of forest patch size and connectivity to coarse filter biodiversity failed due to problems with patch definition in the computer model.

Future consequences of current management practices were examined for grizzly bear, caribou, fisher, northern goshawk, mountain goat, moose, American marten, and bull trout.

Computer projections predict a decline in availability of higher quality habitat for grizzly bears during spring, summer and fall. Declines are predicted to occur both as a result of changes in vegetation communities, and as a result of disturbance from roads. Predicted reductions in forage due to changes in vegetation communities are probably reasonably

accurate, and suggest losses on the order of 30-50% of high and moderate suitability habitat. Predicted habitat "loss" due to disturbance by roads may be less accurate. However, the grizzly bear model does not deal with the important issue of bear mortality caused by new access provided by roads. In light of this limitation, the accuracy of assumed disturbance effects is probably not important. Overall, impacts on bears will likely be at least as serious or possibly more serious than is suggested by predicted habitat changes.

Computer projections for caribou suggest that winter and summer range will decline in quality, both in response to changes in forest habitats caused by logging, as well as in response to changes in predation and disturbance. Although modelling results are difficult to interpret, the basic message that caribou will suffer in the face of forest development is probably correct. It appears possible that the impacts of increased mortality from predators and poachers could be serious, especially for the Telkwa and Takla herds.

Computer projections for goshawk predict a substantial decrease in the number of goshawk territories able to provide high quality nesting and foraging habitat. By the end of the Base Case Simulation, territories with a high or moderate probability of being occupied according to foraging criteria are well below levels observed during Natural Case Simulations. On balance, it seems safe to assume that projected forest development will be substantially detrimental to goshawks, and may cause population decline.

Subjective analysis suggests that predicted trends in forest age will be somewhat detrimental to fisher, but how detrimental is uncertain. Impacts on mountain goat will arise more from access and consequent hunting mortality than from direct alteration of habitat, and may be serious for small isolated groups of goats which live at low elevations near Nadina and Morice Mountains. Impacts on moose, if any occur, will be due to silvicultural activities which prevent or limit the production of moose foods in logged areas. Food production on logged sites may become increasingly important as other habitats age and are not replaced by wildfire. American marten will lose habitat, primarily due to loss of older forest. Overall, it is unlikely that marten populations will be reduced by more than a third to a half, although intensity of impacts will vary locally, and long term impacts are uncertain. Impacts on bull trout are not predictable, first because they will occur on a geographic scale too local for this analysis, and second because much will be determined by rules which may change regarding forestry operations near streams.

Several plant communities in the LRMP area are considered to be at conservation risk, and are Provincially listed as red or blue. The one community which stands out as particularly important for the LRMP table is Cottonwood/Red Osier Dogwood forest, the best remaining examples of which are now found on the Morice River floodplain. In addition to being red-listed this forest makes unique and important contribution to both wildlife and aquatic habitats along the Morice River.

Human activities and industrial development affect aquatic ecosystems and fish in many ways, the most important being alteration of the physical structure of stream channels, increased peak flows in streams, increased temperature in streams, and siltation of streams.

Future trends in these impacts are difficult to predict because they will to a great degree be determined by rules and practices governing logging, road building, and development activities, which rules are now in a state of transition and potential change. Particularly important are practices in and around the smallest streams with fish, and those without fish (S4, S5, and S6) as these streams may have the potential to cause cumulative downstream effects on streams with important fish populations.

Several locations particularly sensitive to future development include the upper Morice River, the upper Thautil River, the Morice River between Gosnell and Owen Creek, and the Nadina River. Fish passage through drainage structures is also a significant concern, especially for juvenile coho salmon and cutthroat trout.

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.

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 this assessment, the definition of THLB was the same as the one used during the last Timber Supply Review for the Morice TSA.

Terms:

Base Case Simulation – This was a simulation done with SELES for the next 250 years to examine impacts of continuing with the current management regime.

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).

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

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.

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1 Introduction

This report presents an Environmental Risk Assessment of the Base Case Scenario for the Morice LRMP Table. This Base Case assessment examines the future implications for environmental risk if management practices used today continue to be used without change in future.

This document will describe the environmental setting of the plan area, provide baseline information to support the development of the LRMP, and examine risks associated with continuing with the current management regime. The risk assessment presented here is intended to allow a risk comparison between the Base Case scenario and other scenarios which will be examined later in the LRMP process (Province of B.C., 2000; Province of B.C., 2001).

This assessment incorporates two general approaches.

First, it examines the degree to which different ecosystems are represented within the boundaries of existing protected areas. In this assessment, representation at a broad regional scale only is discussed.

Second, this assessment examines predicted future trends for several environmental variables. Measures intended to track "coarse filter biodiversity" (Province of B.C., 1999), and others intended to track status of identified wildlife species, special or rare ecosystems, and general fisheries values are examined. Where available data warrant, trends are projected in time by use of computer simulation modelling; where not, trends are discussed subjectively.

The remainder of this report consists of three sections:

- Description of the environmental setting of the Morice LRMP area.
- Discussion of representation of ecosystems in protected areas.
- Discussion of predicted trends in coarse filter biodiversity, status of several wildlife species, status of rare or important ecosystems, and status of fisheries.

The first two sections provide context, the third section presents the analysis of future environmental risks.

2 Environmental Setting

2.1 Climate

Thompson (1981) and Demarchi et al. (1990) describe the climatic processes which influence the Morice LRMP area. Several continental-scale patterns influence climate in the LRMP area. One is the generally eastward movement of moist Pacific air onto the coast of B.C., and subsequently across the LRMP area and the province. Although the direction of air movement varies during individual weather systems, Pacific air tends overall to move eastward over the coast, into the LRMP area, and beyond. During summer, the North Pacific High causes generally northwest winds; during winter, the Aleutian Low causes a winter-long series of frontal systems which often deliver Pacific air onto the coast from the south-west.

Movement of coastal air into the LRMP area is impeded by mountains in the Kimsquit Mountains Ecosection. As moist coastal air moves eastward and lifts over these mountains, it cools and much of its water content condenses and falls as rain or snow. Condensation and precipitation continue somewhat east of the mountains, so there is a general gradient of decreasing rain and snow toward the interior of the LRMP area. Because of the rain and snow "removed" by coastal mountains, climate in the LRMP area is drier than it is on the coast. The Kimsquit Mountains also partially isolate the LRMP area from the Pacific Ocean's warming influence on winter temperatures. The LRMP has colder average temperatures and colder extreme temperatures during winter (Banner et al., 1993) than nearby coastal areas do. The coldest winter temperatures occur during arctic outbreaks when the LRMP area can be blanketed by very cold, heavy air from more northern latitudes.

The relatively low elevation of the Kimsquit Mountains results in a climate somewhat warmer in winter and moister year round than would exist in the LRMP area if the coastal mountains were higher. Higher coastal mountains south of Bella Coola and north of Prince Rupert form a stronger barrier, with correspondingly greater contrasts in moisture and temperature between coastal and interior locations.

The above general patterns produce a continental climate in the LRMP area, but one that is moderated by coastal influences which penetrate past the Kimsquit Mountains. Winters are cold, with persistent snowpack at all elevations in most winters, and summers are cool or warm, with a short growing season.

2.2 Ecological description of the LRMP area

2.2.1 Ecological classifications

The general climatic picture described above, combined with the effects of local topography, results in a diversity of local climatic conditions and vegetation communities in the LRMP area. Two classification systems have been devised in British Columbia to subdivide this diversity into useful ecological units: Ecoregion Classification designed by the then Ministry of Environment, Lands and Parks (Demarchi et al., 1990); and Biogeoclimatic Ecosystem Classification (BEC) developed by the Ministry of Forests (Banner et al., 1993).

Ecoregion Classification subdivides the landscape on the basis of climatic and physiographic[2] characteristics. The most detailed subdivision, and the only one which will be referred to here, is the Ecosection. Portions of seven different ecosections occur in the Morice LRMP area (Map Attachment 1).

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[2] physical shape of the earth's surface

Biogeoclimatic Ecosystem Classification (BEC) subdivides the landscape on the basis of vegetation characteristics, which integrate the influences of climate, soils, and topography. The most general subdivision is the Biogeoclimatic Zone, of which Sub Boreal Spruce is an example. Zones are intended to reflect broad climatic conditions, and are named for climax tree species which occupy "zonal" sites, i.e. sites with moderate characteristics of slope, moisture, microclimate and soils. Zone names sometimes also include climatic or geographic modifiers (eg. "Sub-Boreal" in Sub-Boreal Spruce, and "Coastal" in Coastal Western Hemlock).

Zones in turn are subdivided into sub-zones (eg. Sub Boreal Spruce, dry cool, or SBSdk) and variants (eg. Sub-Boreal Spruce, moist cold, Babine variant, or SBSmc2), both named for their relative climatic characteristics. Nine sub-zones/variants are found in the LRMP area (Map Attachment 1).

The most detailed BEC subdivision referred to in this report is the site series, which is a site upon which a particular plant community will develop in the long run. Site series are named for their dominant trees and understory plants. For example, in the Sub-Boreal Spruce, dry cool (SBSdk) subzone in which the town of Houston lies, the most common site series is called Hybrid Spruce-Spirea-Purple Peavine (Banner et al., 1993). This site series is widespread on moderately sloped locations. Mature forests are dominated by hybrid spruce, and often contain lodgepole pine and trembling aspen. The shrub layer is diverse and contains prickly rose[3], birch-leaved spirea, soopolallie, and young hybrid spruce. The herb layer contains purple peavine, showy aster, bunchberry, and fireweed. The moss layer is relatively undeveloped due to the lush shrub and herb layer.

One way in which the BEC and Ecoregion systems differ is that BEC zones change with differences in elevation, whereas Ecosections do not. For example, Morice Mountain, the town of Houston, and the landscape between them, all lie in the Bulkley Basin Ecosection. However, as elevation increases from Houston to the top of Morice Mountain, Biogeoclimatic Classification changes from Sub-Boreal Spruce, dry cool, through Sub-Boreal Spruce, moist cold and Englemann Spruce, moist cold, to Alpine Tundra (Map Attachment 1).

Another difference is that the BEC system includes more detailed classifications (eg. Site Series) which can be mapped to a relatively fine level of local detail, whereas the most detailed subdivision provided by the Ecoregion Classification is the Ecosection, which is useful only for broad landscape interpretations.

2.2.2 Ecological description

The southwest portion of the LRMP area is mountainous (Map Attachment 1). Terrain elsewhere is a plateau on which fewer and smaller mountains are found. The mountainous

[3] Plant names throughout this report follow (Mackinnon et al., 1992)

portion of the LRMP area includes portions of the Bulkley, Nass[4], Kitimat Ranges[5] and Kimsquit Mountains Ecosections, and is dominated by alpine and subalpine ecosystems. The remaining plateau includes the Nechako Upland, Bulkley Basin, Babine Upland, and Manson Plateau[6] Ecosections, and is dominated by sub-boreal forests of spruce and pine with scattered blocks of subalpine fir forest and alpine tundra. Table 1 provides a summary of the Ecosections and BEC classifications found in the LRMP area.

Table 1. Ecological composition of the Morice LRMP area.

	Babine Upland	Bulkley Basin	Bulkley Ranges	Kimsquit Mountains	Nechako upland	Total[7]
Alpine Tundra	0	0	50	39	1	91
Coastal Western Hemlock	0	0	0	45	0	45
Englemann Spruce Sub-Alpine Fir	60	39	207	124	26	456
Mountain Hemlock	0	0	0	13	0	13
Sub-Boreal Spruce dry cool	1	124	0	0	3	128
Sub-Boreal Spruce moist cold	312	88	188	0	118	707
Sub-Boreal Spruce wet cool	41	0	0	0	0	41
Total	416	251	445	222	147	1481

Note: Units in the table are 1000's of ha.

More detailed ecological description of the LRMP area is presented below, organised by BEC Zones, subzones, or variants as appropriate. All descriptions are based on Banner et al. (1993) unless otherwise referenced.

Alpine Tundra Zone

The Alpine Tundra (AT) zone is treeless except for stunted trees at its lowest elevations, and occurs from 1350 – 1800m at its lowest elevations, to 2700m at its highest. Most AT in the LRMP area is found in the Bulkley, Nass, and Kimsquit Mountains Ecosections, but less prominent examples also occur on scattered mountaintops elsewhere (Map Attachment 1).

Although the AT zone has not been subdivided into sub-zones, a significant gradient exists from the Kimsquit Mountains to the scattered mountain tops further inland. Snowpack data (Province of B.C., 2003e) from sites not far downhill from AT suggest that accumulations in AT in the Kimsquit Mountains may exceed 3 meters in an average winter, whereas in AT further inland, accumulations are probably a half or third of that. One consequence of this variable snowpack is that plant communities in the AT vary over the LRMP area. In high

[4] Only a small area of the Nass Ranges Ecosection is present on the north-western boundary of the LRMP area.
[5] Only a small area of the Kitimat Ranges Ecosection is present on the north -western boundary of the LRMP area.
[6] Only a small area of the Manson Plateau Ecosection is present on the northern boundary of the LRMP area.
[7] Manson Plateau, Nass Mountains, and Kitimat Ranges are excluded due to their small areas of overlap (12,000ha, 5,000ha, and 3,000ha respectively). A more detailed tabulation is available in Appendix 1.

snow locations nearer the coast, dwarf evergreen shrubs such as heathers and crowberry are widespread. In drier more inland AT, these evergreen shrubs occur on sites with unusually high snow accumulation, but in other locations, deciduous dwarf willow, grasses and lichens are widespread.

Englemann Spruce Sub-Alpine Fir Zone

The Englemann Spruce Sub-Alpine Fir (ESSF) zone occurs immediately downhill from the AT zone, from 900-1400m at its lowest elevations, to 1350-1800m at its highest. This wide range in elevational position is caused by differences in snow accumulation. Where snowpack is deeper, ESSF is "driven" downhill by the more challenging growing conditions. Snowpack probably ranges from depths of more than 3 meters in portions of the Kimsquit Mountains, to a third or so of that depth further inland. Most ESSF in the LRMP area occurs in the mountainous Kimsquit Mountains, Bulkley Ranges, and Nass Ranges Ecosections, but it also occurs on scattered areas of high elevation elsewhere (Map Attachment 1).

As plant communities did in AT, those in ESSF vary along the coast-interior gradient through the LRMP area. Three sub-zones have been classified along this gradient: ESSF moist, cool (ESSFmk), ESSF moist cold (ESSFmc), and ESSF moist, very cold (ESSFmv). The relatively warm ESSFmk is found in the Kimsquit Mountains and the western portion of the Bulkley Ranges where coastal influence is strongest, the ESSFmc in most of the rest of the LRMP area, and the ESSFmv in the most continental climate in the area northeast of Babine Lake (Map Attachment 1).

Subalpine fir is the dominant tree species throughout the ESSF zone. However, mountain hemlock and amabilis fir are common where coastal influence is strong, and hybrid spruce and lodgepole pine are common in drier interior areas, especially above the Sub-Boreal Spruce zone where fire influence is more common. Whitebark pine and western hemlock are also common locally.

ESSF forests are continuous at lower elevations, and grade into subalpine parkland in the transition to AT. Parkland forest is considered a separate variant of each of the three ESSF subzones (ESSFmkp, ESSFmcp, ESSFwkp; Map Attachment 1). Parklands form in the transition between continuous forest and AT because the more severe environment there prevents the establishment of continuous forest.

Avalanche tracks vegetated with Sitka alder and herbs such as cow parsnip and Indian hellebore are common on steep mountainsides, especially in higher snowpack areas nearest the coast.

Although not described specifically here, small areas of the Mountain Hemlock Zone (MH) occur along the south-westernmost boundary of the LRMP area. This zone replaces ESSF on the coast. It has generally warmer temperatures and deeper snow than the ESSF zone does, and is dominated by mountain hemlock and amabilis fir rather than subalpine fir.

Coastal Western Hemlock zone

The Coastal Western Hemlock (CWH) zone is widespread at low elevations on the north coast. However, it only penetrates into the LRMP area in the Kimsquit Mountains , and only in a few locations near some of the major lakes (Map Attachment 1). In locations where it occurs, it is immediately downhill from either MH or ESSFmk. Only the CWH wet, submaritime subzone, montane variant (CWHws2) occurs in the LRMP area. Forests in the CWHws2 are dominated by western hemlock and amabilis fir with smaller components of western red cedar and Sitka spruce. Snowpack is probably variable due to coastal influence, and intermediate between the 3 or so meters observed in ESSF at higher elevations and the one meter or less observed further inland.

Sub-boreal Spruce zone

The Sub-boreal Spruce (SBS) zone is the most widespread zone in the LRMP area. Three subzones occur: SBSmc (moist, cold) and SBSdk (dry, cool) and SBSwk (wet, cool).

The moist cold subzone, SBSmc, lies downhill of the ESSF inland of the Kimsquit Mountains . Only the Babine variant, SBSmc2 is present in the LRMP area. SBSmc2 occurs at elevations ranging from 500-850 meters at its lower boundary to 1050-1350 at its highest. SBSmc2 covers almost half of the LRMP area (Map Attachment 1; Table 1).

Mature forests in this variant are dominated by lodgepole pine, hybrid spruce, and subalpine fir. Trembling aspen and black cottonwood form minor components of mature forests. Snowpack is up to one meter in depth.

The dry, cool subzone, SBSdk, replaces SBSmc2 at lower elevations in all or portions of the Bulkley, Morice, Owen/Nadina, and Buck/Parrot valley bottoms (Map Attachment 1). It has the driest, warmest climate in the LRMP area, and most settlement and agriculture are located in this subzone. Snowpack is typically less than 50 cm deep.

Mature forests are relatively infrequent in SBSdk due to the high degree of development in the subzone, but where they occur, they are dominated by lodgepole pine and hybrid spruce, sometimes with a small component of trembling aspen. Forests on active floodplains of major rivers, active alluvial fans, and some seepage areas are often dominated by black cottonwood.

SBSwk is found only in a small area east of Babine Lake on the edge of the LRMP area. Vegetation and climate in this area is transitional between SBSmc2 described above and SBSwk, most of which is found outside the LRMP area. For the purposes of this report, this small area of SBSwk can be considered similar to SBSmc2.

3 Regional representation in protected areas

The term "regional representation" here means 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.

Table 2 summarizes regional representation of Biogeoclimatic Zones within the five Ecosections which significantly[8] overlap the Morice LRMP area[9].

Table 2. Regional representation of Ecosections and Biogeoclimatic Zones.

	AT/ SubAlpine Parkland[10]	ESSF	MH	CWH	SBS	Overall % or Total
Babine Upland	1.4	3.2	NP	NP	3.8	3.7
Bulkley Basin	0.0	1.2	NP	NP	3.1	3.0
Bulkley Ranges	0.0	0.0	0.0	0.0	0.0	0.0
Kimsquit Mountains	29.1	19.5	28.3	16.2	1.1	22.5
Nechako Upland	98.6	83.8	NP	NP	58.0	70.5
% Protected all Ecosections	33.9	25.8	28.2	15.9	9.5	14.8

Note: Units in table are % protected within each Ecosection or, in the total row, % protected in all Ecosections combined.

The degree of representation in current protected areas varies among these five Ecosections. Bulkley Ranges currently has no representation, Bulkley Basin and Babine Upland currently have low representation at 3-4%, and Kimsquit Mountains and Nechako Upland have high representation at >20% and >70% respectively. At a regional scale, the highest priority ecosections for additional protection appear to be Bulkley Ranges, Bulkley Basin, and Babine Upland. Representation of Biogeoclimatic units is also part of the intent of the Protected Areas Strategy (Province of B.C., 1993). Examined from that point of view, Table 2 shows that current representation is concentrated in high elevation zones, including Alpine Tundra/Parkland, Englemann Spruce Sub-Alpine Fir, and Mountain Hemlock Zones. The least represented BEC Zone is Sub-boreal Spruce, which is examined in more detail in Table 3 below.

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[8] Manson Plateau, Nass Mountains, and Kitimat Ranges are excluded due to their small areas of overlap (12,000ha, 5,000ha, and 3,000ha respectively)

[9] Representation was examined by the Prince Rupert Regional Protected Areas Team in 1996 (Columbia, 1996). Since that work was completed, the boundaries of several Ecosections have changed. The analysis here is based on the new boundaries.

[10] This category combines parkland categorized as Alpine Tundra parkland, all ESSF parkland, and all Mountain Hemlock parkland. This aggregation was done in order to combine two types of BEC mapping which used different parkland classification.

Table 3. Regional representation of the Sub-Boreal Spruce Zone

	SBSdk	SBSmc2	SBSwk3
Babine Upland	17.5	4.2	1.4
Bulkley Basin	3.0	2.7	NP
Bulkley Ranges	0	0	NP
Kimsquit Mountains	NP	NP	NP
Nechako Upland	30.7	60.1	NP
All Ecosections combined	5.4	16.2	1.4

Note: Units in table are % representation within each ecosection, and , in the total row, % representation within all ecosections combined. NP = not present in Ecosection

Table 3 shows that, within the three Sub-Boreal Spruce subzone/variants which occur in the LRMP area, most currently protected area is found in the SBSmc2, but representation is distributed unevenly; most representation is in Nechako Upland, and none in Bulkley Ranges. SBSwk3 and SBSdk have less representation at about 5% and 1% respectively. Of these two variants, SBSdk is probably the more important for the Morice LRMP because there is considerably more of it in the LRMP area.

More detailed tabular summaries of regional representation are presented in Appendix 2.

3.1 Summary of regional representation

Bulkley Ranges, Bulkley Basin, and Babine Upland are the least represented Ecosections, and Sub-Boreal Spruce is the least represented Biogeoclimatic Zone. Of the three SBS variants/subzones found in the LRMP area, SBSdk and SBSwk3 are the least represented, particularly in Bulkley Ranges and Bulkley Basin.

4 Base Case Projection

4.1 What is the base case projection, and how will it be done?

This base case projection describes likely future consequences of current land use practices. The intent is to provide a baseline against which alternative land use may be compared later in the LRMP process.

Computer simulation tools have been used to explore what future landscapes will look like. Specifically, a computer model called the Spatially Explicit Landscape Event Simulator (SELES, Fall and Fall, 2001) was used to model changes in the forest environment over time.

SELES was used in this projection exercise to predict future landscapes, and these landscapes were then analyzed for patterns or values of interest. Two simulations were done:

- Base Case Simulation – this simulation describes landscapes which occur over the next 250 years if the current management regime continues.
- Natural Case Simulation – this simulation determines the Range of Natural Variation by describing conditions on 100 sample landscapes in which forests are affected only by natural fire and insect regimes.

Appendix 3 provides further information on how SELES works, and how the Base Case and Natural Case Simulations were done.

Several approaches are used in this assessment for interpreting implications of the landscapes predicted by SELES:

- Implications for biodiversity are examined by tracking forest age structure over the 250 year Base Case Simulation. Age structure in the Base Case simulation is compared with the Range of Natural Variation (RNV) generated by the Natural Case Simulation.
- Implications for goshawk are examined by incorporating a goshawk habitat model into SELES. Habitat values are tracked over the 250 year Base Case simulation, and compared with the RNV for natural forests.
- Implications for habitat values of marten, grizzly bear, and caribou are examined by applying habitat models to forest landscapes generated by SELES in the Base Case Simulation. The habitat models used were constructed in NETICA by Ardea Biological Consulting. Habitat value for these species is examined as trends over time during the 250 year Base Case Simulation.
- Implications for moose, mountain goat, fisher and bull trout are examined subjectively because no habitat models for these species are currently available for the LRMP area. Subjective discussion attempts to determine likely consequences for these species given the changes predicted by the Base Case Simulation in the forest environment.
- Implications for rare ecosystems, riparian ecosystems, and general fisheries values are also examined subjectively.

The results of these evaluations are presented below.

4.2 Coarse Filter Biodiversity

4.2.1 What is coarse filter biodiversity, and how will it be examined?

Put simply, biodiversity is the diversity of living organisms. The Biodiversity Guidebook (Province of B.C., 1995a) provides a more comprehensive definition:

> "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."

The term "coarse filter" refers to conservation of multiple species by conserving ecosystems they depend on; "fine filter" refers to conserving individual species whose requirements may not be met by the coarse filter approach (Province of B.C., 1995a). Coarse filter biodiversity will be discussed in this section, fine filter will be discussed later in the sections on individual species.

One major reason why a "coarse filter" approach is necessary is because not enough is known about organisms, their habitats, and their interactions to protect biodiversity by dealing with one species at a time. While we have at least a basic understanding of many plants and animals, our understanding of some groups of organisms such as freshwater algae, invertebrates, and fungi is poor. Exceedingly little is known about freshwater algae in the LRMP area, and many species of fungi and possibly thousands of species of invertebrates have yet to be described scientifically, let alone studied to determine specific habitat requirements or ecological linkages with other species (MacKinnon, 1998). Further, even for relatively well studied plants and animals found in the LRMP area, our understanding of subtle ecological requirements and species interactions is limited.

Another major reason for using a coarse filter approach is that, even if we understood all organisms, trying to deal with thousands of individual species would be unreasonably complex.

The inherent complexity of biodiversity, coupled with our relative ignorance about it, makes predicting impacts a challenge. The Biodiversity Guidebook (Province of B.C., 1995a), suggests that this challenge can best be met by making two general assumptions:

- biodiversity can be more effectively retained by managing ecosystems than it can by trying to manage all individual species, and
- the likelihood that biodiversity will be retained will be greater if managed forests resemble those produced by natural disturbance agents such as fire[11], wind, insects and disease.

These assumptions drive the analysis undertaken here. More specifically, this projection assumes that relative risk[12] to biodiversity will be reflected by comparative forest age structure[13]. How age structure is likely to change, and how it varies between managed forests and natural ones will be discussed below.

However, important context must be provided first. Analysis of forest age structure, or of other landscape descriptors, cannot provide accurate quantitative trends or comparisons of

[11] It is assumed here that fires set historically by First Nations were a natural agent of forest change.
[12] Risk here means the likelihood that elements of biodiversity being considered will be lost over time. High risk mean high probability of loss, low risk low probability of loss.
[13] An attempt was made to analyze both patch size and connectivity as additional forest descriptors. However, results were inconclusive due to difficulties with patch definition, so no analysis of these descriptors was possible for this report.

biodiversity values. No tight quantitative linkage between forest age structures and biodiversity has been proven or is being assumed here. This descriptor is used here simply as a tool to *describe similarity of forests*: similarity of managed forests compared over time, and similarity of managed forests to natural forests. This report assumes generally that, as measured by forest age structure, greater similarity means less risk to biodiversity, and lesser similarity greater risk. This conceptual framework is consistent with recommendations in the Biodiversity Guidebook (Province of B.C., 1995a), with recent thinking regarding strategies for retaining biodiversity values during forest management (see reviews by Attiwill, 1994; Thompson and Harestad, 2003), and with the approach being taken in the North Coast LRMP process (Holt and Sutherland, 2003).

The analyses presented regarding these descriptors cannot provide clear, quantitative reasons for particular land use decisions, and they are not presented for that purpose. Rather, they are intended to assist the Table in considering priorities for application of available options for management and protection. The sort of questions that the analyses are intended to help answer are:

- Are there particular forest types or geographic areas in which current management practices will result in relatively lower or higher risks to biodiversity? In lower risk locations, the Table may wish to apply a forestry management emphasis; in higher risk areas or forest types, the Table may wish to more carefully consider options for protection or special management techniques.
- Which forest types or geographic areas are likely to change most dramatically in the near future, and which are likely to change the least? The former are probably at greater immediate risk of impacts on biodiversity, and so may deserve more careful attention and effort than the latter.

4.2.2 Forest age structure

4.2.2.1 Range of Natural Variation

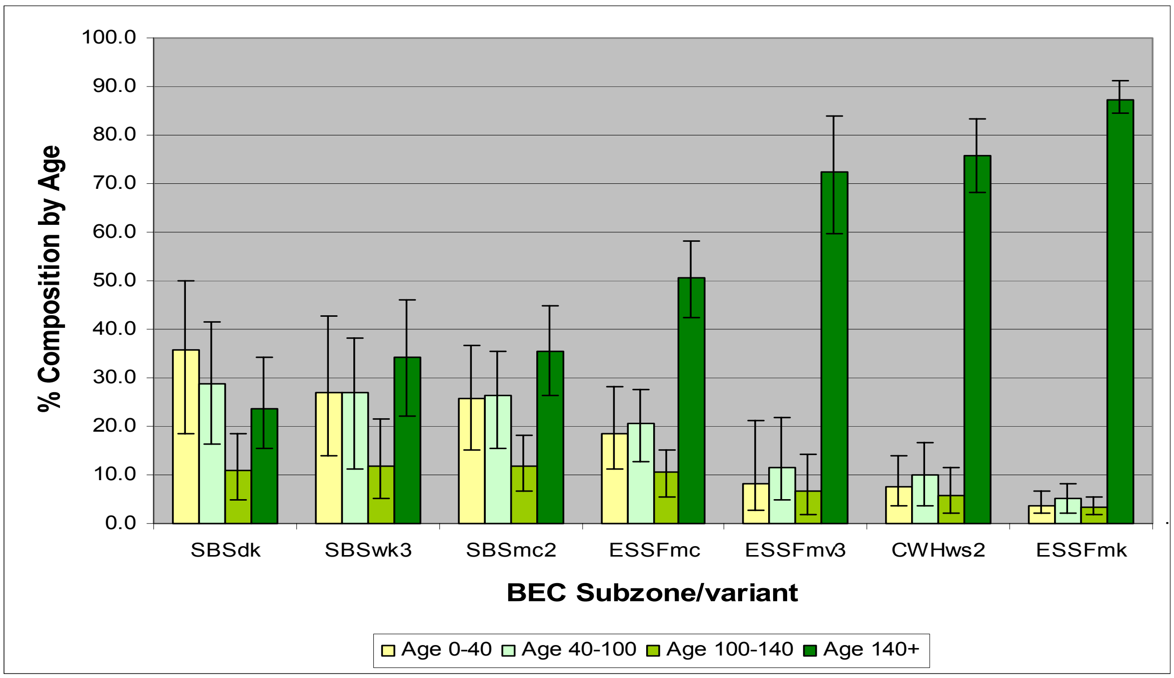
Forest age is analysed here only within BEC subzone/variants. While this analysis can identify departures from natural age structure at this relatively coarse geographic and ecological scale, it could fail to identify departures from natural age structure at more detailed scales. Even though overall age structure in a particular BEC variant is within the Range of Natural Variation, age structure in a particular site series within that variant could be well outside the Range of Natural Variation. Comprehensive analysis at the sites series level of detail has not proven feasible in this evaluation. Consequently, the Table may wish to keep in mind that particular site series, perhaps the ones of greatest interest for forestry, may experience larger departures from natural states than predicted for BEC subzones and variants.

As mentioned earlier, and explained in more detail in Appendix 3, SELES was used to run two different simulations, the Natural Case Simulation, and the Base Case Simulation. The Natural Case simulation used a forest disturbance model to determine the Range of Natural

Variation in forest age composition for each BEC subzone/variant and Landscape Unit in the LRMP area. It was important to determine Range of Natural Variation because many of the forest types found in the LRMP area are naturally subject to repeated fire and insect kill. Consequently, evaluating the results of Base Case Management would be difficult without understanding what the natural age structure would be in the absence of industrial forestry.

Figure 1 shows the Ranges of Natural Variation observed during the Natural Case Simulation for major BEC subzones/variants in the LRMP area.

Figure 1. Age Composition of Natural Forests by BEC subzone/variant[14].



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Note: The height of coloured bars shows the median percentage of forest observed within each age class in the 100 natural landscapes produced by the Natural Case Simulation. The error bars show the maximum and minimum percentages observed, and define the Range of Natural Variation observed in the Natural Case Simulation.

Figure 1 shows that the natural balance between young and old forest varies dramatically between the driest subzone SBSdk (this is the valley bottom unit in the Bulkley Valley and other low elevation areas), and the much wetter ESSFmk. (this is subalpine forest near the coast). A median of 65% of SBSdk forest is naturally <100 years old, while only 9% of

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[14] BEC subzones/variants in which little or no THLB exists are not included in the Table. RNV for all BEC subzones/variants are tabulated in Appendix 4.

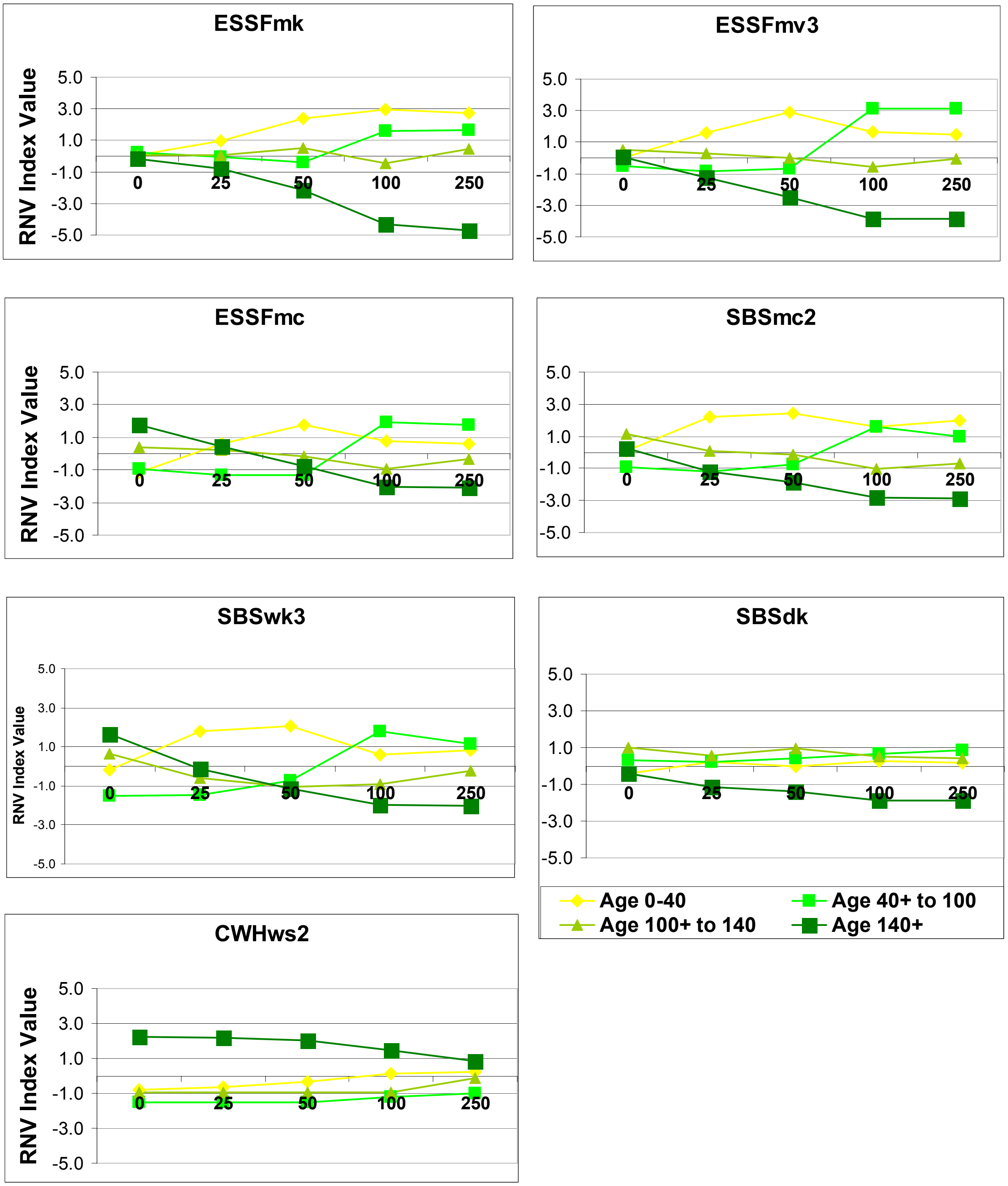
ESSFmk is naturally <100 years old. Another pattern worth noting is that age composition is naturally more variable for SBS units than it is for ESSF and CWH.

4.2.2.2 Forest age distribution in BEC subzones/variants

Figure 2 on the next page shows how forest age composition varied among BEC subzones/variants over time during the Base Case Simulation.

Figure 2 shows strong shifts in age structure of forests over time relative to the Range of Natural Variation. By 100 years into the simulation, all BEC units except CWHws2, in which very little logging took place had less forest >140 years old, and most had more forest <40 years old than occurred in the natural simulation. ESSFmv3, ESSFmk, and SBSmc2 departed furthest from the natural case, with the two ESSF units attaining an index value of around -4 for forest >140 years old.

Figure 2. Managed forest age structure relative to RNV by BEC units[15].



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[15] BEC subzone/variants not included in the figure were omitted because they had little or no area in the THLB, and therefore would not be affected by logging over the simulation. Data for all BEC subzones/variants is tabulated in Appendix 4.

Note: An RNV index of greater than 1 means that, in that year of the Base Case Simulation, more than the natural amount of that forest age was present. An RNV index of less than minus one means that less than the natural amount of that forest age was present. An RNV Index anywhere between minus 1 and plus 1 means that the amount of forest present during the Base Case Simulation was within the Range of Natural Variation[16].

Figure 3 on the next page examines changes specifically in the amount of old forest present in BEC subzones/variants over the Base Case Simulation.

Figure 3 shows that by year 100, ESSFmv3 had about one third the amount of old forest present at the lower end of the natural range. For perspective, under the analysis used in the North Coast LRMP, this age departure would rate as high risk in a five step scale from very low to very high.[17] ESSFmk, given the very similar pattern in Figure 2, would have a similar level of risk..

By year 100, SBSmc2 also had about one third the amount of old forest present at the lower end of the natural range. Again, for perspective, under the analysis used in the North Coast LRMP, this age departure would rate as high risk.

SBSdk, was the subzone with the smallest departure from natural forest other than CWHws2. Again, by year 100, old forest is reduced to about half of the amount found at the lower end of the natural range. And again, calculations used by the North Coast LRMP suggest a high risk rating. Given that the natural variability of age structure is probably higher in SBSdk than in higher elevation forests (Figure 1), and that most species in SBSmc2 can be expected to be more adapted to disturbance, one might assume that the risk would be lower in SBSdk than in SBSmc2, ESSFmv3, and ESSFmk.. However, for species dependent on old SBSdk forest, the fact that only 10% of the landscape still supports such forest after 100 years may present a high risk irrespective of any arithmetic regarding the natural median. At only 10% coverage, the risk of fragmentation and connectivity effects is bound to be high simply because there is so little old forest left. Risk for SBSwk3 and ESSFmc should be similar to SBSdk according to median calculations. However, ESSF may not be at quite as high a risk as the two SBS units are, because the amount of old forest in ESSFmc does not go below 33%.

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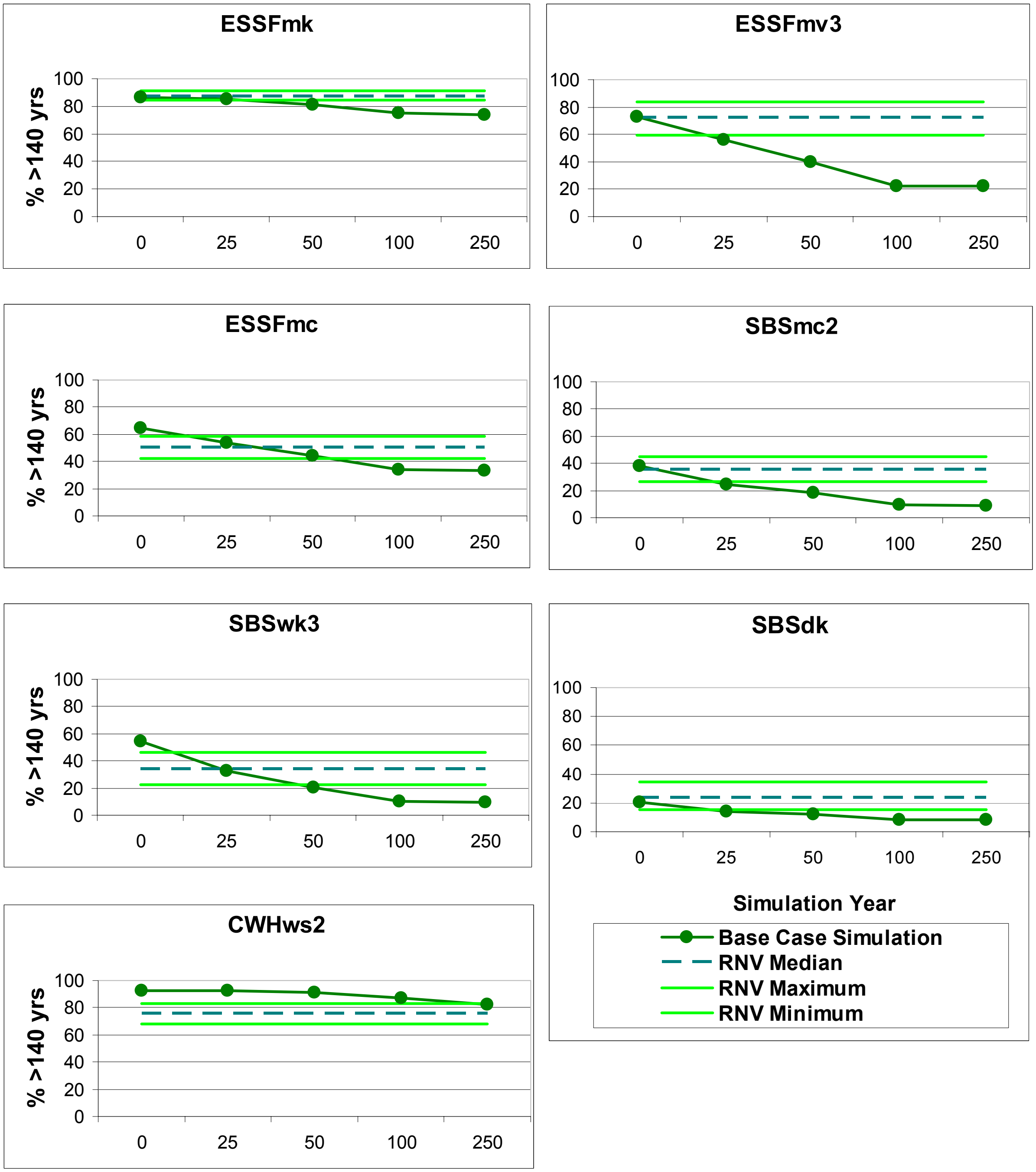
[16] If RNV Index = 2, this means that the % observed is twice as far from the natural median as the maximum natural percentage was in the 100 sample landscapes produced by the Natural Case Simulation. For example if the natural median is 40% and the maximum natural value is 50%, an observed percentage of 60% would generate a value of 2 because 60 is twice as far from 40 as 50 is. Put another way, the calculation in this case would be RNV index = (60-40)/(50-40)=2

[17] Calculation is ((Natural Median%-observed %)/Natural Median%)*100; this is the percent deviation from the median (North Coast used mean, but median should suffice). This works out to ((72.5%-22.3%)/72.5%)*100 = 69%, which rates as high risk. In the North Coast process, this base risk was adjusted, usually upwards or no change, according to other risk factors including trends in patch distribution, amount in protected area, and ecosystem conservation value (Holt and Sutherland, 2003).

Figure 3. Forest >140 years old relative to RNV by BEC units.



4.2.2.3 Summary of age distribution in BEC subzones/variants

In summary, the Base Case simulation showed substantial departures from natural age compositions in all BEC subzones/variants in which substantial logging occurred. A simple index based on departure from the natural median suggests that risk to biodiversity is highest for ESSFmv3, ESSFmk, and SBSmc2, somewhat lower for ESSF mc, SBSwk3, and SBSdk, and, at levels of development assumed in the simulation, very low for CWHws2. However, all ESSF and SBS units would have a high base risk under North Coast LRMP criteria. Further, the very small amount (<10%) of landscape left covered in old forest in all the SBS units suggests that risks of fragmentation or connectivity problems may be high in spite of arithmetic regarding the median natural proportion of old forest. On balance, risks to coarse filter biodiversity appear significant in all ESSF and SBS units, and the real ranking of risk between them is not clear.

4.2.2.4 Forest age distribution in Landscape Units

Patterns of forest age among selected Landscape Units (LU's) are illustrated in Figure 4. The LU's included were chosen to illustrate the range of results among all LU's Details for all LU's are shown in Appendix 5.

Patterns in forest age composition among Landscape Units were variable. Kidprice and Thautil (Appendix 5) exhibited the greatest departure from RNV for old forest. Most other LU's in which logging occurred exhibited the same general pattern of declining old forest and increasing young forest, but the strength of the pattern varied. In many LU's, the proportion of young forest peaked at the 50 year point in the simulation.

Figure 4. Managed forest age structure relative to RNV by Landscape Units.

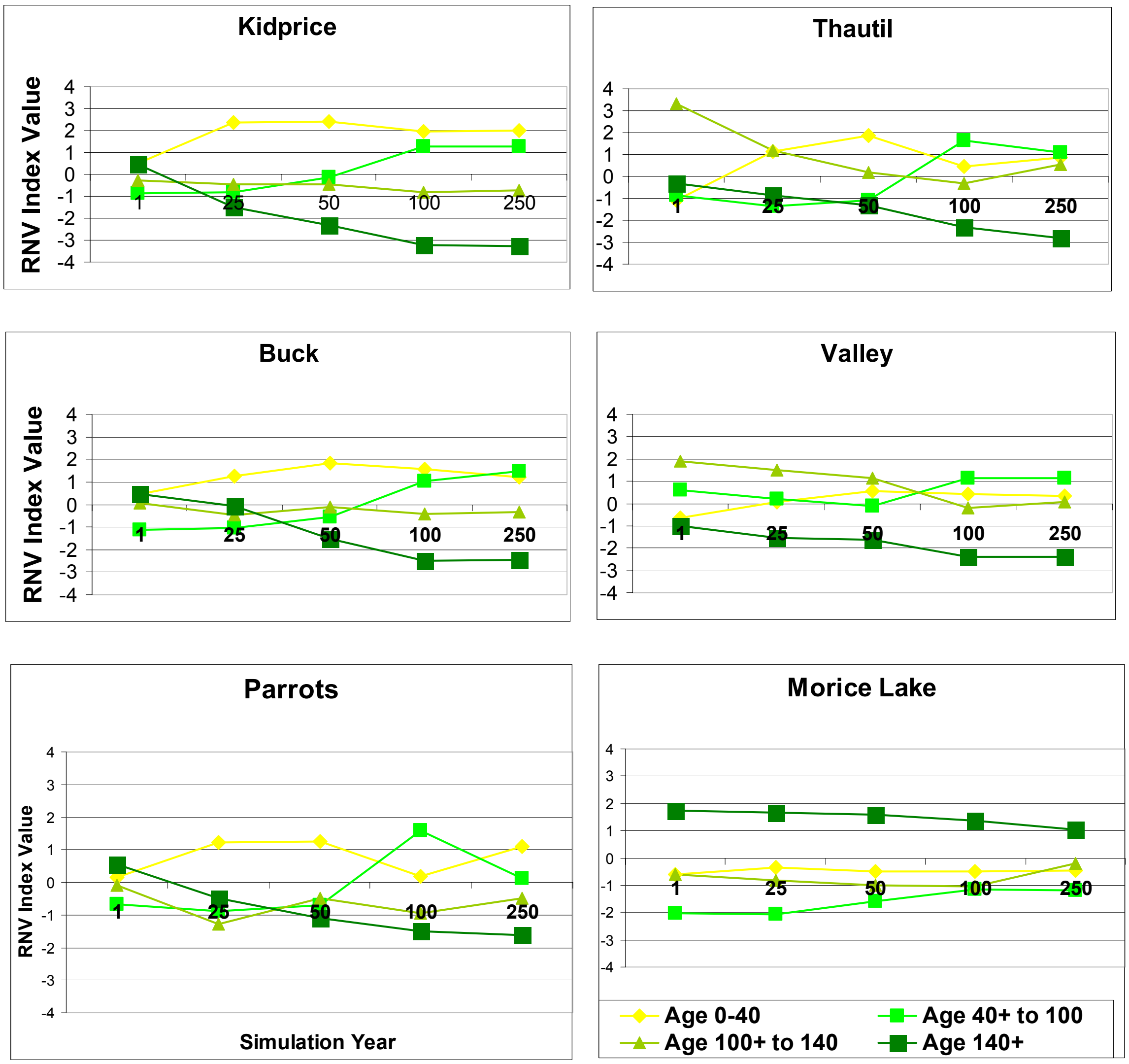
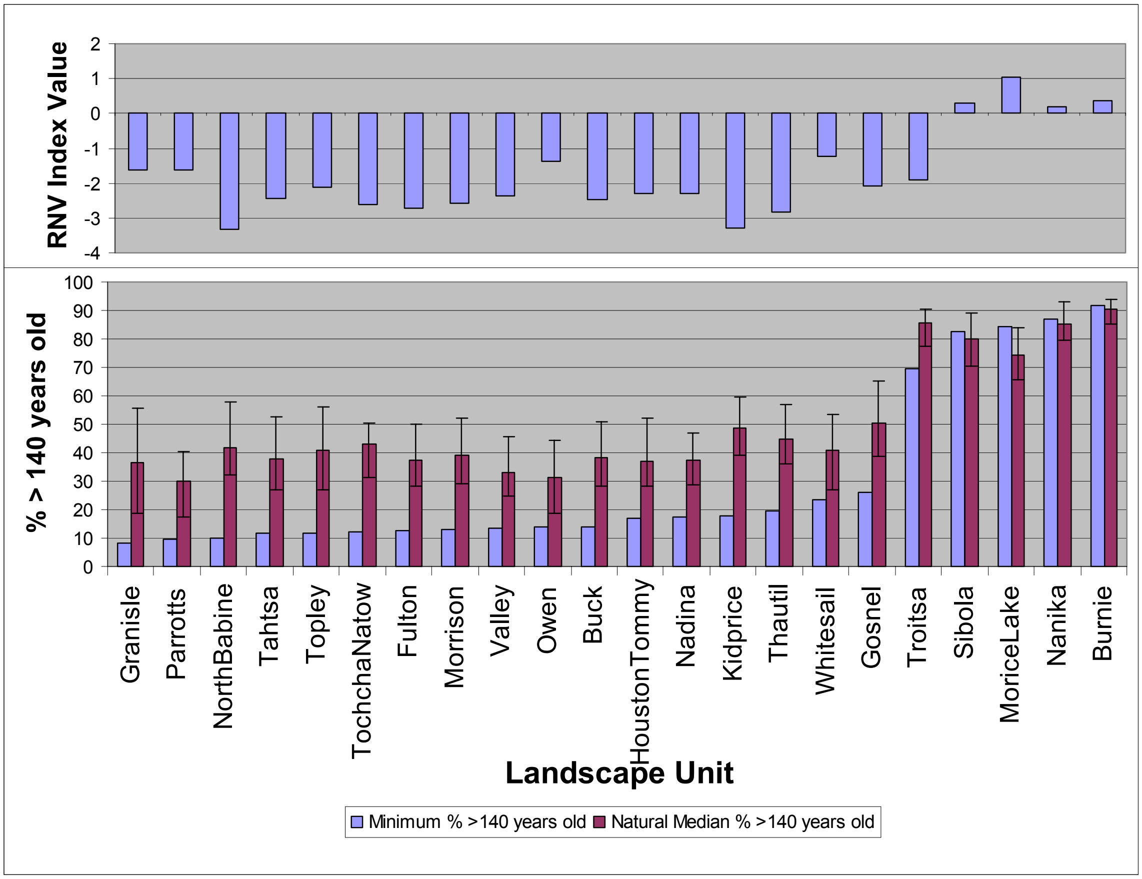


Figure 5 on the next page shows patterns regarding forest >140 years old for all Landscape Units.

Figure 5. Forest >140 years old relative to RNV by BEC units.



Note: The upper section of the figure shows the maximum departure from the Range of Natural Variation expressed as RNV Index. The bottom section shows the minimum % of forest >140 years old observed during the Base Case Simulation. Landscape Units in the figure are ranked according to the minimum % of old forest observed during the Base Case Simulation.

Figure 5 shows that Landscape Units fall into two groups, Troitsa, Sibola, Morice Lake, Nanika and Burnie, in all of which logging was minimal or absent during the simulation, and in all of which, dominance of wetter, more coastal BEC units resulted in high natural percentages of forest >140 years old. The remainder of the LU's had substantially less old forest both naturally and as a result of Base Case Management. In terms of relative risk regarding old forest, North Babine stands out by both having only 10% old forest left, and also by declining to an RNV index of -3.3. Kidprice and Thautil also reach RNV Indices of -3.3 and -2.8 respectively, although they retain greater absolute proportions of older forest. The remainder of the LU's are more or less similar except that Granisle, Parrots, Owen and Whitesail are probably at lower risk by the RNV Index criterion because their RNV Indices only lie just outside the RNV.

4.2.2.5 Summary of forest age in Landscape Units

North Babine, Kidprice and Thautil depart the furthest from the Range of Natural Variation, and therefore are presumed at the highest risk to Biodiversity. Troitsa, Sibola, Morice Lake, Nanika, Burnie, Granisle, Parrots, Owen and Whitesail remained within or close to their Ranges of Natural Variation. Other Landscape Units departed less than North Babine, Kidprice and Thautil, but did so in the same direction, i.e. forests in the Base Case Simulation contained less old forest, and more young forest than was observed in the Natural Case Simulation.

4.2.3 Fragmentation/connectivity

An attempt was made to analyze both fragmentation and connectivity over the 250 year Base Case Simulation. Fragmentation was examined by tracking Expected Patch Size for each of three patch ages over the Base Case Simulation, and comparing results with RNV obtained in the Natural Case Simulation. Mathematically, Expected Patch Size is the area weighted mean patch size. Conceptually, it is the patch size you would find yourself in if you were randomly placed somewhere within the area being considered. Connectivity was examined by tracking Centroid Connectivity Index (CCE, Steventon, 2002) and comparing with RNV. Analyses were undertaken by BEC subzone/variant, Landscape Unit, and for the LRMP as a whole.

Unfortunately, results were inconclusive, apparently due to a problem with patch definition. Time was insufficient to re-program and re-run the simulation prior to this report, so it remains uncertain whether additional analysis will permit useful interpretation of fragmentation and connectivity.

4.3 Focal Wildlife Species

This section will examine predicted forest changes from the “fine filter” approach, i.e. with regard to implications to selected individual wildlife species, namely grizzly bear, caribou, fisher, goshawk, mountain goat, moose, marten, and bull trout. These species were chosen due to their status as existing or proposed Identified Wildlife under the Forest Practices Code, or due to expressed interest by the LMRP Table.

The methods used to examine species differ depending on the type of information available. For some species, the value of habitats in future will be predicted by use of computer modelling (grizzly bear, caribou, goshawk, and marten); for others, future values will be evaluated by subjective consideration of the forest structures predicted by SELES (fisher, bull trout, moose, mountain goat). For all species, discussion will attempt to portray the likely consequences of the forest structures predicted by the SELES simulations for the next 250 years.

It is important to note that the computer models used to predict habitat values for individual species can at best only roughly predict actual habitat values. While all the models used here endeavour to incorporate the best information available, the predictions of relative habitat value over time, and comparisons between habitats, must be taken only as approximations.

4.3.1 Grizzly bear

4.3.1.1 Status and biology in the LRMP area

Unless otherwise indicated, the following summary relies on Pasitschniak-Arts (1993), Pasitschniak-Arts and Messier (2000) for general biological information, and on Blume and Turney (2002b) and Turney et al. (2001) for information specific to B. C. and the Morice LRMP area.

In B.C., grizzly bear is blue listed, and an identified wildlife species. Blue listing means the species is of special concern but not under immediate threat (Province of B.C., 2002c;Province of B.C., 2003b). Population size and trend in the LRMP area is unknown. Generally, most geographic vicinities in the LRMP area can be assumed to be used at least intermittently by grizzly bears.

Grizzly bears are highly adaptable opportunists with a special problem – they must find enough food in about six months to last another six months in hibernation. This challenge is especially acute for pregnant females due to the nutritional demands of gestation and lactation, both of which occur during hibernation[18]. In meeting their nutritional challenge, grizzly bears exploit a wide array of foods and habitats, and large variation exists between years in response to changes in availability of foods, and between individual bears which make different choices for a variety of reasons.

Patterns of habitat use in the LRMP area will generally resemble those observed elsewhere, with variations determined by what specific foods are available, and when they are available. Generally, bears can be expected to use habitats that provide the best food source available at a given time, and to move to new locations as better alternatives become available.

In spring in the LRMP area, grizzly bears will use lower elevation locations which lose snow early and provide new growth of grasses and herbs. The best spring habitat may be found in the SBSdk, but much of it is not generally used by grizzly bears. Bears that choose to use habitats in the settled or agricultural portions of the SBSdk often get into trouble with people, and are killed or translocated as a result (A. Edie pers. obs.). Much spring habitat used by grizzly bears probably occurs in lower elevations of the SBSmc2, especially on open south facing slopes and along riparian areas. Grizzly bears may exploit spawning suckers and squawfish from about late May until early July near lakes in outlet or inlet streams (Schultze, 2003). During summer, habitat use in the LRMP area will likely be variable. Habitats used will probably include locations from the Alpine Tundra to valley bottoms (with the exception mentioned earlier re. SBSdk). Summer foods will include green vegetation similar to what was eaten in spring, berries when and where available, and the larvae of ants, wasps and bees,

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[18] Implantation is delayed until about November, so almost all foetus growth occurs during hibernation. Lactation begins in the den, and continues for up to 2.5 years.

as well as other items. During fall, habitat will often be in berry producing areas or salmon spawning areas. The best berry areas will often be found in the lower elevations of the ESSF where blue and oval-leaved huckleberries are sometimes abundant, especially after fires. Some bears may move out of the LRMP area to exploit salmon sources elsewhere such as at Pinkut Creek, or below the Babine fence on Babine River.

Throughout the active season, grizzly bears will use carrion whenever they find it. In early summer, individual bears may be proficient predators on young moose or caribou. Grizzly bears may also prey on marmots and at least occasionally on other small mammals including chipmunks, voles and mice. Carrion may be particularly important in spring because winter moose range is often good spring bear habitat, so bears can simultaneously exploit newly emerging vegetation as well as carrion from moose.

While food is arguably the main criterion for selecting habitat, it is not the only one. Large males are dominant, and sometimes take over good habitat and force other bears into less favourable locations. Large males also sometimes kill and eat cubs and females. Consequently, females with young sometimes choose habitats with less food in order to avoid large males. When food supplies are concentrated in space, bears sometimes feed in dense aggregations.

The grizzly bear has one of the lowest reproductive rates of any terrestrial mammal. Females typically do not breed until around 5 years old, sometimes not until twice that age, and time between litters is from 2 to 4 years. This low reproductive rate means that grizzly bear populations are sensitive to increases in mortality. Relatively small numbers of animals killed, especially of mature females, can result in population decline.

Mortality caused by people is a major influence on grizzly bear populations. In a compilation of results from 13 radio collar studies in the Rocky and Columbia Mountains of southern B.C. and adjacent U.S.A. and Alberta, McLellan et al. (1999) found that between 77% and 85% of mortality among adult grizzly bears was caused by people, nearly always by shooting. Less than half of observed mortality was hunting, and the rest was problem bear control, self defence, and malicious killing. The bottom line is that new road access into inaccessible grizzly habitat will result in more bears being killed if people with firearms are permitted to enter newly accessible areas.

Increased road access can also affect bears by causing them to abandon habitats near roads. Although some studies have failed to show abandonment in response to activity near roads, others have documented daytime abandonment of up to 16% of available habitat (McLellan, 1990). However, given the variation in response to road disturbance, the fact that animals often habituate to disturbance, and the fact that areas abandoned during day are sometimes used during night, the greatest impact of new roads is increased mortality, not loss of habitat.

4.3.1.2 Projection

Projected consequences of base case management on grizzly bear have been assessed with the assistance of computerized habitat suitability models. The models were designed by Ardea Biological Consulting, and the details of their structure are provided by Turney (2003a). Separate models for summer, winter, and fall habitat were written in NETICA, a Baysian Belief Network program. The models are described briefly in Appendix 6.

The models produce two different types of habitat ratings. The first rating is for forage suitability. This rating depends only on the amount of food present on a site; it ignores whether that food is actually available to bears. The second rating is for habitat value. Habitat value can be considered the same as habitat effectiveness, and is derived in the model by reducing the forage suitability rating to account for bears avoidance of roads. In summary then, forage suitability measures the amount of food, and habitat value measures how much of that food is actually available because of the effects of disturbance.

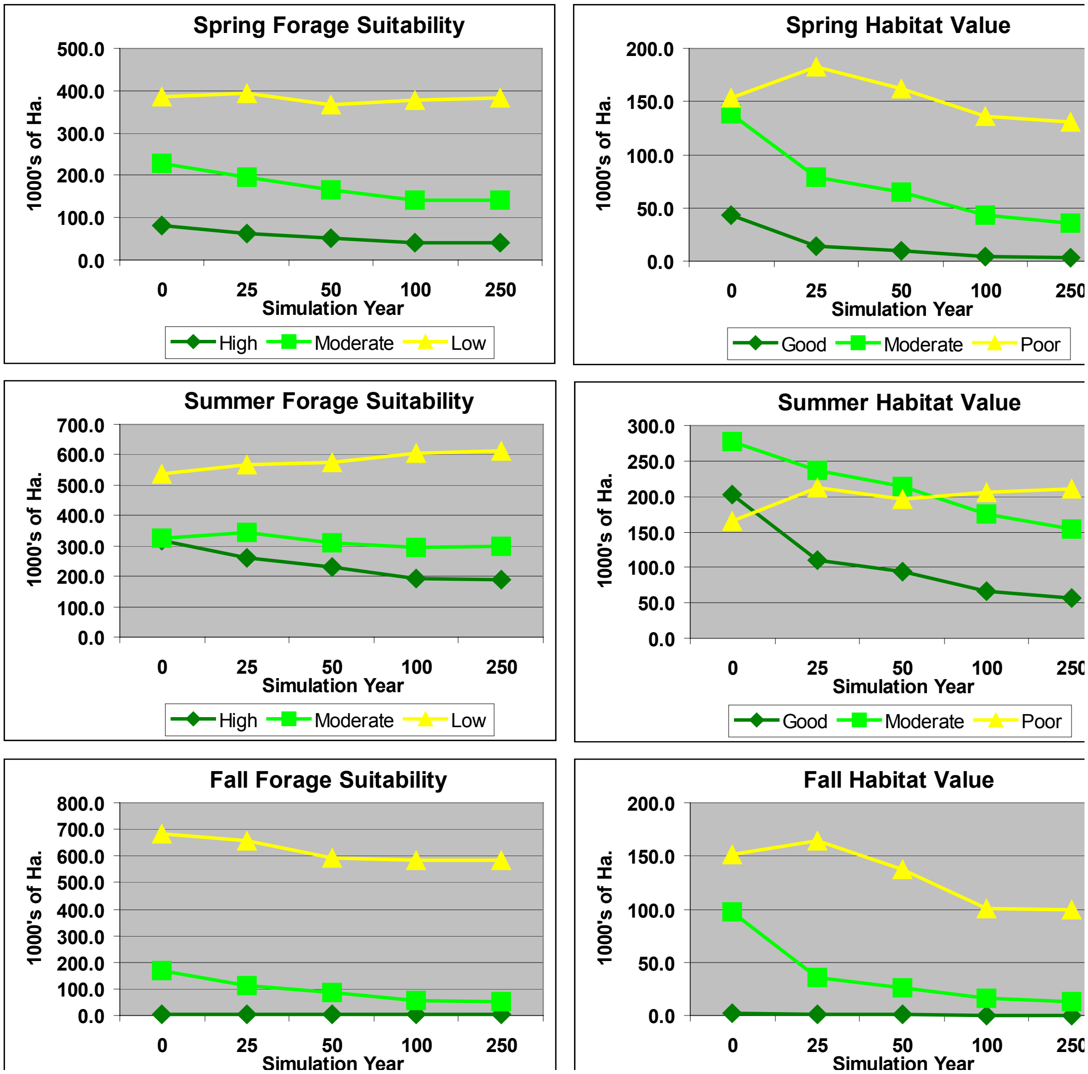
Summarized tabular results from all models are presented in Appendix 7. Figure 6 below summarizes trends for the LRMP area as a whole.

For the LRMP as a whole, the models predict moderate to strong declines in both forage suitability and habitat value in all three seasons. The amount of habitat with moderate or better suitability drops to as low as 1/3 of the amount presently available, and the amount with moderate or better habitat value drops as low as <1/10 of the amount presently available.

Declines are strongest in Landscape Units in which substantial logging and road building occurs. Space limitations do not permit graphic projections for all Landscape Units. However, Appendix 7 provides a summary of trends in availability of moderate or better habitats in all Landscape Units.

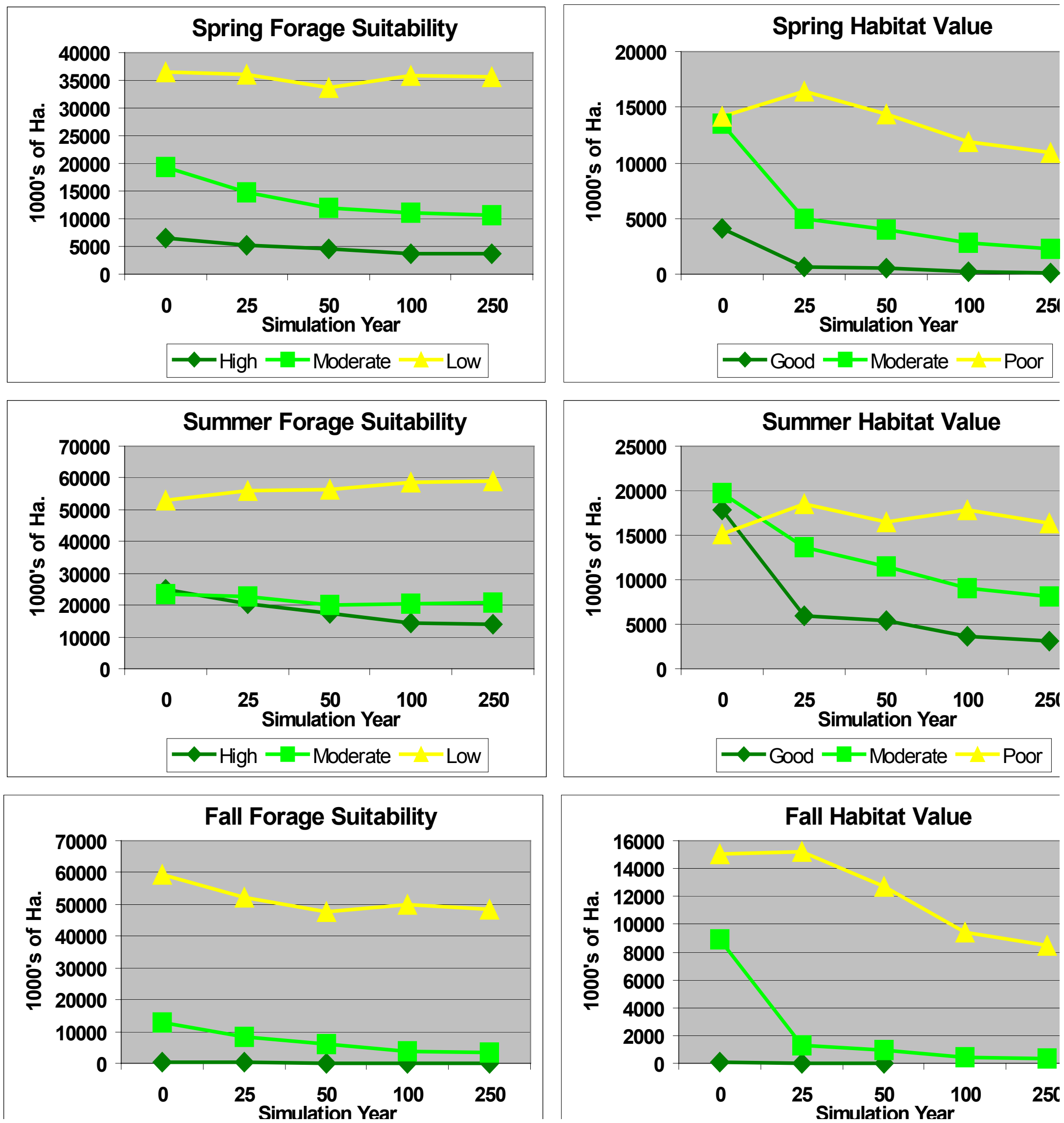
Figure 7 provides an illustration of trends in the Nadina LU which is among those most severely affected during the simulation.

Figure 6. Grizzly bear habitat projections for the Morice LRMP Area[19]



19 Graphs omit the Nil and None ratings in order to avoid excessive compression of the scale of higher ratings.

Figure 7. Grizzly bear habitat projections for the Nadina Landscape Unit[20]



Predicted trends in forage suitability are probably reasonable. Grizzly bear food habits are reasonably well understood, and predicted forage availability depends on simple extrapolation from seral state and site series (see Appendix 6). These predictions are unlikely to be seriously in error.

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[20] Graphs omit the Nil and None ratings in order to avoid excessive compression of the scale of higher ratings.

The accuracy of habitat value predictions are less certain. These values are produced by reducing forage availability to correct for assumed avoidance of roads by bears. The reductions applied are modest, only a 0.7 reduction within 100m of roads, 0.4 reduction between 100m and 200m, 0.1 reduction between 200m and 500m, and no reduction greater than 500m. However, the model did not distinguish between busy roads and roads which are barely used. Consequently, the assumed loss of habitat may be excessive in some circumstances, and perhaps insufficient others. It is not possible to be certain in which direction the real error may lie.

However, the real limitation in the models' predictions probably overshadows potential errors regarding abandonment of habitat near roads. The model does not assess the impact of mortality caused by people using new roads into previously inaccessible bear habitat. As discussed earlier, this is a serious issue for grizzly bears because of their very low reproductive rates. If new roads are used by persons with firearms, bears will be shot as a result. On balance, I believe that this impact will greatly outweigh any effect of disturbance, and in this light, the declines portrayed by the habitat value data may underestimate the effects of projected development on grizzly bears.

4.3.1.3 Summary

Simulation results predict a decline in availability of higher quality habitat during all three seasons. Declines are predicted to occur both as a result of changes in vegetation communities, and as a result of disturbance from roads. Predicted reductions in forage due to changes in vegetation communities are probably reasonably accurate, and suggest losses on the order of 30-50% of high and moderate suitability habitat. Predicted habitat "loss" due to disturbance by roads may be less accurate, but suggest even more severe declines in habitat availability. However, the main limitation of the modeling is that it does not deal with the important issue of bear mortality caused by new access provided by roads. In light of this limitation, the amount of habitat assumed to be disturbed by roads is probably not important. The most important impact will be the increase in mortality caused by new access. Overall, impacts on bears will likely be as serious as suggested by predicted habitat losses.

4.3.2 Caribou

4.3.2.1 Status and biology in the LRMP area

Caribou are widely distributed in mountainous terrain in B.C., and all but northern populations are considered to be at one degree or another of conservation risk. Two separate types of risk classification are important for caribou in B.C., the provincial system in which species are designated as red, blue, or yellow, and the system used by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), under which species are classified as endangered, threatened, special concern, or not at risk.

Under the Provincial system, all caribou in the Morice LRMP area are blue listed which means that the population is considered a conservation concern, but is not under immediate threat. (Province of B.C., 2002c; Province of B.C., 2003b).

Under the COSEWIC system, three so called "ecotypes" of caribou are recognized in B.C., mountain caribou found in south central B.C., boreal caribou found in the northeast corner of the province, and northern caribou, which includes the three herds in the LRMP area, plus numerous other herds to the north, south and east of the LRMP area. Some Northern ecotype herds, including all three in the LRMP area are classified as threatened, and these populations are designated under Schedule 1 under the Species at Risk Act of Canada. This designation means that a recovery strategy must be completed by December, 2006.

Caribou populations have lower reproductive rates than populations of other North American members of the deer family such as moose and deer. This is primarily because female caribou do not bear twins, and do not become pregnant until they are at least 1.5 years old (Bergerud, 2000). The low productivity of caribou populations means that any source of extra mortality has the potential to cause population declines. Caribou in B.C. are believed to have suffered dramatic population declines during the early to mid 1900's as a result of the combination of hunting and predation (Seip and Cichowski, 1996). Until the early 1970's, hunting regulations allowed harvest of female caribou, and excessive harvest occurred in many herds near road access. Also during the early 1900's, moose populations in B.C. grew substantially, wolves became more abundant, and predation of caribou is believed to have increased as a result. In their review of population ecology of B.C. caribou, (Seip and Cichowski, 1996) found that most caribou populations were declining; the only exceptions were the few populations whose habitat is not typically used by moose and wolves. Since Seip and Cichowski's review, (Kinley and Apps, 2001) have confirmed that the caribou population they studied in the Purcell mountains in southern B.C. is declining, apparently due to cougar predation which has increased as a result of logging and consequent increases in deer populations.

The risk of harm or extirpation due to increases in mortality is particularly high for small populations like the Telkwa and Takla caribou herds. Population simulation shows that even very small increases in mortality, especially of adult females, can result in extirpation of small populations in the long run (Hatter, 2003).

Caribou populations are often highly mobile and use extensive habitat over large geographic areas. The most famous examples of this characteristic are the extended annual migrations of some arctic populations, but less dramatic movements are common in many woodland populations as well. Among the three herds in the LRMP area, the Tweedsmuir herd has the most pronounced and predictable migratory habits. The entire herd winters in a relatively confined area near Entiako Lake east of Tweedsmuir Park, and every year migrates west and north to summer range, some individual animals as far away as the crest of the coast mountains. The Telkwa and Takla herds exhibit no such major, consistent migratory behaviour. In most years, most animals in both herds remain at relatively high elevation throughout the year, but year to year variation is sometimes high, and individual animals sometimes exhibit atypical movements.

High mobility of caribou is thought to be an adaptation both to avoid predators by spacing away from them, and to disperse use of relatively unproductive food sources so that they are not damaged by over-exploitation (Bergerud, 2000).

Caribou can be displaced by disturbance by snowmobiles. Such displacement could potentially result in animals being forced into habitat with poorer food supplies, and in the Revelstoke area, is believed by researchers to result in animals being forced into steeper, more avalanche prone terrain, and being killed more often in avalanches as a result (Seip and Cichowski, 1996). Predators are also believed to use both snowmobile tracks and roads as access routes during otherwise difficult snow conditions, thereby potentially increasing winter predation as a result.

Three caribou herds use habitats within the LRMP area. Map Attachment 2 shows the range assumed in the habitat simulation model for each of the three herds.

Each of the three herds is discussed below.

Takla Herd

The Takla caribou herd includes approximately 100 animals (Poole et al., 1999). Most of this herd's currently occupied range lies north the LRMP area. However, roughly 20% of the habitat used by the 50 or so animals using the Mount Sidney Williams area is inside the LRMP boundary. As a result of recommendations of the Ft. St. James LRMP process, the 25,000 ha. Mount Blanchet Provincial Park was established in 2001, largely to protect habitat of this herd.

During the study conducted by (Poole et al., 1999), elevational migration of caribou was variable, although in two of three springs monitored, animals migrated to elevations as low as ~1100-1200m. In the third spring, mean elevation was about 1400m. Overall, most habitat use throughout the year was at elevations of 1200m or higher. Although specific analyses of forage were not done, the authors believed on the basis of habitat selection that winter foods included arboreal lichens in high elevation forest, and terrestrial lichens in the alpine. Terrestrial lichens were not used in forested habitats, apparently because little or none of this habitat is available in the area.

Tweedsmuir Herd

The Tweedsmuir-Entiako caribou herd currently includes about 300 animals, but the population appears to be declining (Marshall, 2003a). Only roughly the northernmost 10% of the range used by this herd is inside the LRMP area (Cichowski, 1993). However, ongoing studies on this herd suggest that the habitat inside the LRMP area is important because caribou using it have higher survival and calf production than do caribou elsewhere in the herd's range (Cichowski, 2003).

The Tweedsmuir-Entiako herd is migratory, and winters in the Entiako Lake area east of Tweedsmuir Park. In late winter and spring the herd migrates west and north to widely scattered habitats, both forested and alpine. Caribou that use habitat in the LRMP area migrate across Ootsa Lake in the general vicinity of Whitesail Reach. Some remain in the vicinity of Ootsa Lake the whole summer, and others continue on to habitats further west and north. Important calving habitats are found on islands in Whitesail Reach, in highlands surrounding Troitsa Lake, and in the eastern portion of the Sibola Range north of Tahtsa Lake (Cichowski, 1993; Cichowski, 2003).

Telkwa Herd

The Telkwa herd currently includes about 65 animals, and appears to be increasing in number(Schultze, 2003). In 1997, 10 caribou, and in 1998, 22 more, were transferred into the Telkwa herd from the Sustut-Chase herd located northwest of Takla Lake (Schultze, 2003) Roughly half of the range of the Telkwa herd lies inside the LRMP boundary. Since the introductions, the Telkwa herd has been tracked using both VHF and GPS radio telemetry (Schultze, 2003; Vik Stronen, 2000; Roberts et al., 2003). The herd is not generally migratory, although some animals in some years move to low elevations for part of the year (Roberts et al., 2003). Most animals remain in Alpine Tundra or Englemann Spruce parkland all year, and except for the 1997-98 winter and following spring, these habitats were statistically selected for during all seasons in all years by radio collared cows reported on by (Roberts et al., 2003). However, although these general patterns in elevation use were strong, habits of individual animals varied, and some individuals moved as far as the Boulder/Corya Creek area north of Moricetown (Roberts et al., 2003), and as far south as the Sibola Range (Schultze, 2003).

Although winter forage has not been studied for the Telkwa herd, investigators believe that winter food consists of mostly arboreal lichens in high elevation forests, and terrestrial lichens in alpine or sub-alpine locations (Vik Stronen, 2000; van Drimmelen, 1986b; Roberts et al., 2003). Summer forage has not been studied either, but data from the Tweedsmuir area (Cichowski, 1993) suggest that summer food likely includes significant amounts of grass, forbs, and sedges, as well as substantial amounts of lichen.

4.3.2.2 Projection

Projected consequences of base case management on caribou have been assessed with the assistance of computerized habitat suitability models. The models were designed by Ardea Biological Consulting, and the details of their structure are provided by (Roberts, 2003). The models were written in NETICA, a Baysian Belief Network program. Separate models for summer, winter, and calving habitat were written, and they are described briefly in Appendix 8. The models were applied only to the landscape areas used by each of the three caribou herds present in the LRMP area (See Map Attachment 2).

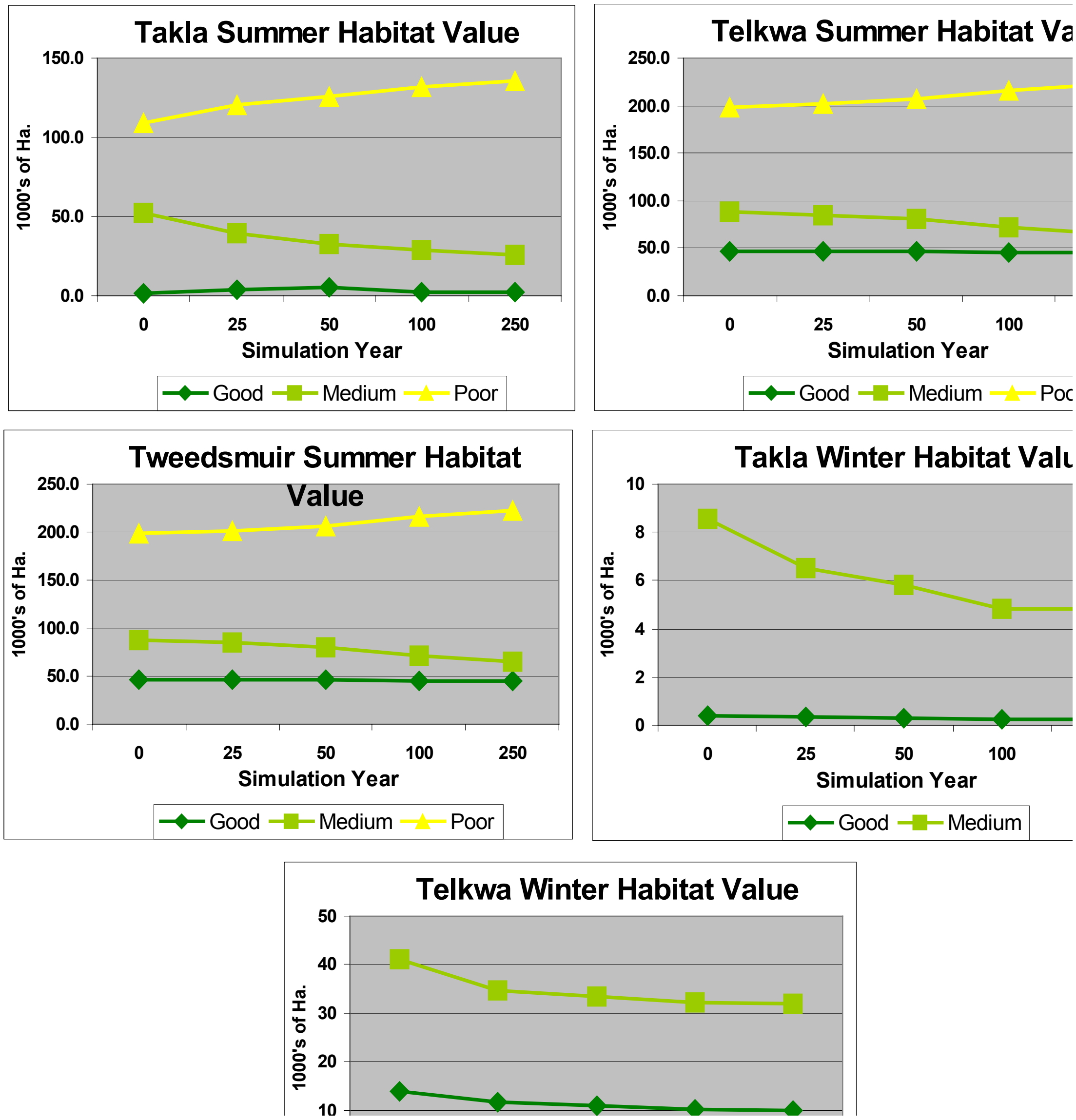
Detailed tabular results from all models are presented in Appendix 9. Figure 8 on the next page summarizes the trends apparent in the modelling output for the three caribou herds in the LRMP area.

The only obvious trend in summer habitat was a reduction in habitat rated as medium value over time, coupled with a corresponding increase in habitat rated as poor (Figure 8; Appendix 9). This change was largely attributable to changes in habitat in BEC Subzones in which logging and road building activity was high (SBSdk and SBSmc2 for example). Little change occurred in the amount of good value habitat, presumably because most habitat rated as good was at higher elevations where little logging occurred.

The trend for winter habitat was a reduction in habitat rated as good or medium, and a corresponding increase in habitat rated as poor (Figure 8; Appendix 9). Again, the strongest changes were in BEC subzones in which logging and road building activity was high.

Little change occurred in the rating of calving habitat (Appendix 9).

Figure 8. Caribou Habitat Projections



Notes: Trends in calving habitat were negligible, so graphs are not presented. Winter habitat graphs omit poor habitat in order to avoid excessive compression of the scale for medium and good habitats. A winter graph for the Tweedsmuir herd is not presented because all current winter range of the herd is outside the LRMP area. See Appendix 9 for detailed data.

Interpretation of these trends is difficult. The caribou habitat models are complex, and they are works in progress. They have as yet not been tested against real field data with regard to many of the assumptions and relationships included in their structures. Quite aside from the nature of the model structures themselves, caribou relationships with their habitat are unusually complex and difficult to make detailed predictions about. Caribou are highly mobile and use a great variety of widely distributed habitats. The factors driving their use of particular habitats are complex and, for example, appear to include such influences as distribution of predators, and detailed patterns of accumulation and wind scouring of snow. Individual animals also vary greatly in the habitat choices they make.

An important issue with the models is how they deal with the influence of predation. As mentioned earlier, research shows that caribou are vulnerable to predation, and, in B.C., caribou suffer population declines whenever their habitat use overlaps strongly with moose and wolves. The models attempt to reflect this by reducing habitat ratings according to predation risk predicted on the basis of BEC classifications and seral states (see Appendix 8 for details). However, the ability of the models to accurately reflect predation risk is very limited because of the complexity of habitat relationships with moose and wolves. At best, the predicted predation risks over time can be considered only very rough guesses at what might actually happen.

The real question is whether increased predation would pose a risk of population decline, and at this stage of development, the model cannot answer this question.

All this considered, the caribou models can only be assumed to provide a general description of strong patterns; they cannot be expected to accurately reflect small changes. They especially cannot be expected to accurately describe the consequences of changes in predation.

The main message provided by the caribou models is that in areas developed for logging, caribou habitat will be detrimentally affected both through changes in forest structure and composition, and through changes in predation (or other mortality) and disturbance. This message can be assumed to be generally correct. Whether the magnitude of change suggested by the models is appropriate is impossible to say. Certainly, I believe that the models cannot be assumed to accurately portray consequences of increased mortality through predation or poaching. It remains possible that projected development could tip the balance toward population decline in at least the Telkwa and Takla herds if not the Tweedsmuir herd as well. It is exceedingly unlikely in my estimation that computer modelling effort will be able to accurately predict the long term unfolding of this issue for caribou. The bottom line is that new roads and new logging in caribou habitat constitute a mortality risk to caribou, and this species is very sensitive to increased mortality. It is not possible to accurately predict exactly what level of development could tip a population into decline.

4.3.2.3 Summary

Computer simulation suggests that winter and summer range will decline in quality over the period of projection. The decline is predicted to occur in response to changes in forest habitats caused by logging, as well as in response to changes in predation and disturbance. Although modelling results are difficult to interpret, the basic message that caribou will suffer in the face of forest development is probably correct. It appears possible that the impacts of increased mortality from predators and poachers could be more serious than predicted changes in habitat ratings would suggest.

4.3.3 Fisher

4.3.3.1 Status and biology in the LRMP area

The biology and status of fisher in British Columbia has been recently reviewed by Weir (2003a), and general reviews of this species' biology are provided by Powell (1993) and Powell and Zielinski (1994). Habitat suitability ratings for the Morice LRMP area are provided by Turney et al. (2001), and habitat requirements of fisher in the LRMP area were reviewed by Blume and Turney (2002b). Unless stated otherwise, Weir's review and the reports by Turney and Blume are the source of information presented here regarding biology and status of fisher in B.C., and all five references are sources regarding more general information.

In B.C. fisher are red listed, which means that the species is considered to be under immediate threat, and is a candidate for designation as Threatened or Endangered under the Wildlife Act (Province of B.C., 2002c; Province of B.C., 2003b). The size and trend of the fisher population in the Morice LRMP area is unknown. The provincial population is also unknown, although rough estimates based on relative habitat capability of BEC units, combined with local density estimates in the Williston area, suggest a provincial population of something like 1000 - 3000 animals. Densities in B.C. appear substantially lower than those in eastern North America; some eastern locations have densities 4-8 times those observed in B.C. No one knows why western populations are smaller. Western populations also appear to be more reliant on old conifer forests than fisher in eastern North America, again for unknown reasons. However, (Powell, 1993) hypothesizes that western forests may provide structural attributes similar in some poorly understood way to eastern deciduous forests, and/or that they modify snow conditions in a way which facilitates hunting under the specifics of western climate.

Extrapolation of specific density estimates to the BEC zones found in the Morice LRMP area could, in theory at least, provide a rough estimate of the number of animals that may be present in the area. However, this will not be done here because prediction of specific population numbers seems unjustified given the imprecise nature of capability classifications, the limited data available to calibrate population densities in different capability habitats, and the somewhat peripheral, and therefore perhaps atypical, nature of fisher populations here.

It is perhaps safer to use expected densities to indicate relative importance of the different BEC units to fisher populations. Table 4 shows the current estimates of habitat capability of BEC units in the LRMP area, and the rough percentage of fisher likely to be found in those units.

Table 4. Habitat capability and distribution of fisher in the LRMP area.

Habitat capability[21]	BEC units	1000's of ha	%of LRMP	%of fisher living in Plan Area[22]
High	SBSdk	128	9	30
Med	SBSwk	42	3	7
Low	SBSmc2	710	47	55
Rare	ESSF, MH, CWH	524	35	8
Nil	AT	98	7	0

The highest capability habitat is in the SBSdk subzone which comprises 9% of the LRMP area. Only the Sub-boreal Spruce dry, warm (SBSdw) subzone found in the area around Prince George and Quesnel is thought to have higher habitat capability. Density estimates suggest that something like 30% of fisher in the LRMP live in SBSdk, but this 30% figure is probably optimistic because much of the SBSdk is developed for agriculture and settlement, particularly in riparian areas observed to be favoured by fisher elsewhere in B.C.

The SBSwk has medium capability, but probably makes a small contribution to total populations given the small area of habitat included in this subzone. In any case, the small area of this unit in the LRMP area is transitional, and not likely substantially different from nearby SBSmc2.

The SBSmc2 variant covers nearly half of the LRMP area, so, in spite of its low capability rating, it probably contributes more to fisher populations in the LRMP area than the other BEC units combined do. This is especially true given the probable overestimate of the contribution by SBSdk. Other BEC units outside the SBS zone probably contribute little to fisher populations in the LRMP area.

Overall, habitat capability for fisher is considered low, rare, or nil in nearly 90% of the LRMP area. Fisher are probably rare in all high elevation habitats and in habitats subject to strong coastal influence.

Specific habitat preferences of fisher have not been studied in the Morice LRMP area. Studies elsewhere have demonstrated repeatedly that fisher strongly prefer areas with

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[21] Capability is the maximum ability of land to support fisher under ideal habitat conditions. Actual suitability may be lower if habitat conditions are less than ideal. Capabilities used here are those provided by (Weir, 2003a;Weir, 2003b). They are approximately consistent with more detailed suitability ratings developed by (Turney et al., 2001)

[22] From BEC-specific densities provided by (Weir, 2003b).

overhead cover, and avoid areas without it. Overhead cover does not have to be mature or old forest, it can be shrubs or other vegetation.

A potentially important habitat element required by female fisher is secure dens in which young can be borne and raised. In B.C., 19 such dens have been found by following radio-tagged fisher. All nineteen dens were in black cottonwood or balsam poplar trees averaging >1meter in diameter and all were over 15 meters above the ground. Researchers believe that such inaccessible den locations may protect young fishers from predators, perhaps especially male fishers, while their mother is hunting away from the den. Fisher elsewhere in North America are known to use dens in other deciduous species, so it is possible that, in time, use of other tree species may be observed in B.C. For now however, it would be prudent to assume that black cottonwood trees are important and may be critical to breeding female fisher in the Morice LRMP area.

Fisher in B.C. use a variety of resting sites which are often associated with older forest. Such structures include tree branches (especially branches of large spruce and sub-alpine fir infected with rust broom), tree cavities, coarse woody debris, and cavities in the ground. In winter during temperatures below about -15C, only use rest sites beneath the snowpack because such sites are warmer. Fisher will avoid areas of deep soft snow, and are less effective than American marten are at hunting beneath the snowpack. Researchers believe that the inability of fisher to hunt effectively in deep snow is the main reason for the large difference in geographic distribution between fisher and American marten.

Fisher will forage in most habitats with sufficient overhead cover and available prey. They are opportunists, and will kill and eat more or less any animal that they can catch and subdue. Among other things, they are known to eat numerous species of small and medium sized mammals, as well as carrion, birds, snakes, fish, insects, and berries and other plant material. Fisher is the only predator which regularly kills and eats porcupines. In the one major diet study in B.C., snowshoe hares, squirrels, voles and porcupines were the most common food items, but numerous other items were consumed as well.

4.3.3.2 Projection

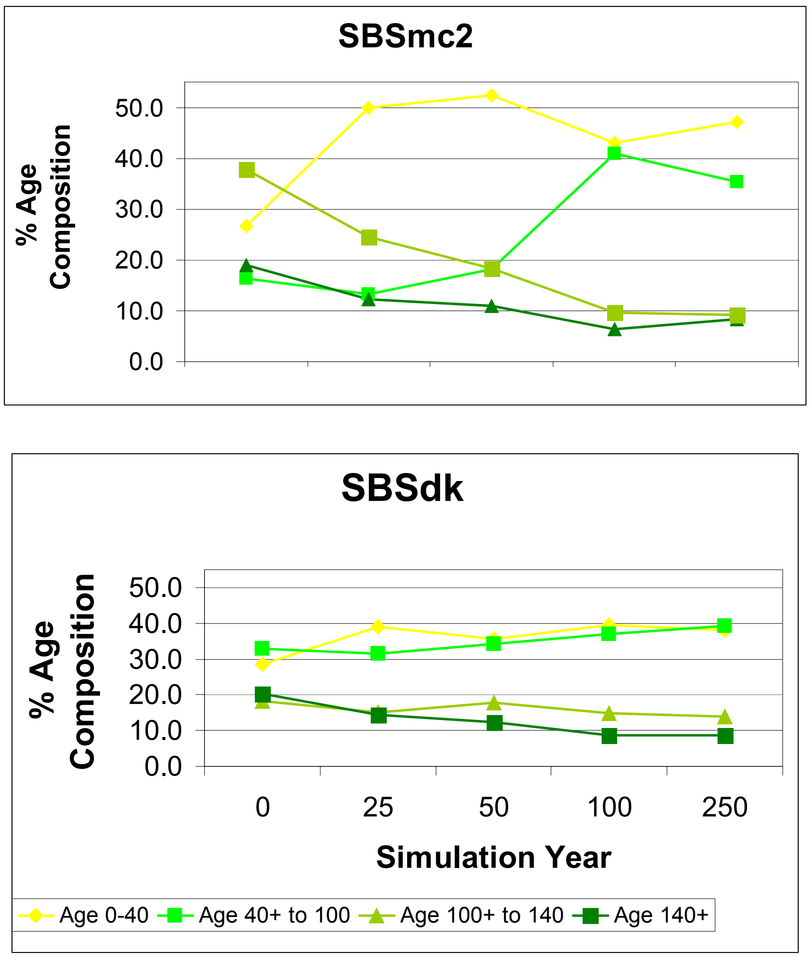
No habitat simulation model is available for fisher. Consequently, likely changes in fisher habitat will be subjectively evaluated.

As discussed earlier, habitats in the SBS zone are likely the only ones in the LRMP area used to a significant degree by fisher. Of those, SBSdk has the highest habitat capability, and SBSmc2 the largest quantity of habitat.

Within the SBSdk much habitat is already compromised by settlement, transportation corridors, and agriculture. If these land uses in the SBSdk expand into areas now occupied by warm, low elevation forest, some of the best fisher habitat in the LRMP will be lost. This is particularly true for the few LU’s which still have significant areas of undeveloped SBSdk habitat left: Buck, Parrots, Houston Tommy, and Nadina.

Likely impacts from forestry operations are less straightforward. Figure 9 shows the changes in forest age predicted by SELES simulation in SBSdk and SBSmc2. Age composition in the SBSdk is predicted to change modestly, with the largest change being a 50% drop in the amount of forest >140 years old. Proportional changes in other age classes of forest are smaller, with a slight decrease in forest 100-140 years old, and a similar increase in younger forest. Age composition in SBSmc2 changes to a greater degree, with a decline similar to SBSdk in forest >140 years old, but stronger declines in forest 100-140 years old, and stronger increases in younger age classes.

Figure 9. Forest age composition in SBSdk and SBSmc2.



Understanding of fisher habitat requirements in B.C. is limited, and this species has not been studied in the LRMP area, so it is difficult to determine what these trends in forest age composition may mean for fisher. Habitat preferences elsewhere are believed to reflect complex interactions between the need for overhead cover, the availability of prey which can be caught, the structural complexity of forest, especially near the ground, and the effects of snow on the ability of fisher to hunt. Predicting how these various influences may interact with one another in the LRMP is very difficult. I think it fair to assume that the best habitat for this species is in the SBSdk in complexes of old lowland conifer forest mixed with younger seral states which support prey species such as hare and porcupine. To the degree that there is any of this left undeveloped, the main trend which may be important in the SBSdk is probably the 50% loss of forest >140 years old. The same is likely true regarding SBSmc2 forest. However, the real impacts of this loss of old forest for fisher are very difficult to assess, because it is not at all clear how much of it they need in combination with foraging habitats in younger seral states, and there is no information available about how the old forest left in the simulation is distributed with respect to foraging habitats. It is a fair bet that little of the remaining old forest in the SBSdk will be in the lowest elevation bottomlands favoured by fisher. It is also a fair bet that the lowland conifer forests at lower elevations in the SBSmc2 were the first ones to be logged in the simulation, and that much of this forest is already logged today. On balance, I think it fair to assume that loss of old forest to the degree predicted in the SBSdk and SBSmc2 will be detrimental for fisher habitat, but exactly how detrimental is difficult to say. In the SBSdk, I think that further development for settlement and agriculture will have impacts at least as great if not considerably greater than forestry will.

It should be mentioned again here that riparian habitats are preferentially used by fisher in B.C., and large cottonwood trees may be critical for secure den sites for female fishers with young offspring (Weir, 2003a). Consequently, on a per hectare basis, the mixed cottonwood/conifer forests along the Morice River may be some of the most valuable fisher habitat in the LRMP area.

The welfare of fisher in the LRMP area will also depend on trapping. The primary reason this species has been recently red listed is due to managers' concerns regarding its vulnerability to trapping, particularly incidental capture in traps set for marten. It is impossible to know what influence trapping has had or will have on fisher in the LRMP area, but it is reasonable to assume that fisher in the LRMP area are vulnerable to trapping, and that long term fisher densities may be influenced by trapping mortality.

4.3.3.3 Summary

Fisher are rare in high elevations of the LRMP area. Most useful habitat for fisher is found in the SBS zone, and the best habitat is in the SBSdk. Riparian habitats are particularly important, and large cottonwood trees may be critical as den sites for females with young. The largest risk to fisher in the LRMP area may be permanent clearing of low elevation forest for settlement, agriculture, or transportation corridors. Predicted trends in age composition of forest in response to forestry operations in the SBSdk and SBCmc2 will likely be detrimental due the loss of older forest, but exactly how detrimental is impossible to assess.

4.3.4 Northern goshawk

4.3.4.1 Status and biology in the LRMP area

Status and biology of northern goshawk in B.C. has been recently reviewed by Doyle (2002). Since 1998, this species has been studied intensively in the Morice LRMP area by T. Mahon and F. Doyle, and results to date from this work are presented in Mahon and Doyle (2003) . Unless otherwise specified, the following summary relies on both of these two papers for general information, and on Mahon and Doyle (2003) for information pertaining specifically to the Morice LRMP area.

Northern goshawks are widely distributed in British Columbia, and have been confirmed as occupying, and breeding in, almost all forested Biogeoclimatic zones inventoried to date, including in all zones present in the Morice LRMP area except Alpine Tundra. Two subspecies are present in B.C., *Accipiter gentilis atricapillus* on the mainland, and *A. g. laingi* on Vancouver Island and the Queen Charlotte Islands. The coastal *A. g. laingi* is blue listed, which means that it is considered to be of management concern, but not under immediate threat. The interior *A. g .atricapillus* is yellow listed, which usually means that the species' welfare is not of immediate conservation concern. However, *A. g. atricapillus* is classed as S4 which means that it is considered to be of long term conservation concern (Province of B.C., 2002c; Province of B.C., 2003b).

Northern goshawk is generally considered to be resident all year, although tagged individuals have been recorded as moving from Minnesota to the Peace River region of B.C. (Campbell et al., 1990a). Historical observations suggest that, in occasional winters, substantial numbers of northern goshawks move south during winter, perhaps in response to prey scarcity (Campbell et al., 1990a).

Northern goshawks are found throughout the Morice LRMP area wherever forests have appropriate structure. Population numbers in the LRMP area are unknown. However, territory spacing in the Taltapin area suggests that less than roughly 450[23] breeding pairs are likely to be present. Field observations during 5 years of study by T. Mahon and F. Doyle suggest that the goshawk population in the LRMP area is stable.

Goshawk researchers have usually considered three classes of habitat used by this species: nesting areas, post-fledging areas, and foraging areas. Nesting areas form the core of activities during the nesting season, and are aggressively defended by the adult pair. Usually more than one nest site is present in a nest area. Breeding pairs often return year after year to the same nest areas. Nest areas also form the cores of fledgling activity once the young birds leave the nest, although over time activity centers shift gradually away from the nests, usually in the direction from which adults bring food. In the Morice LRMP area, adults begin to occupy nest areas in mid-February, and the young hatch near the end of May and are independent by mid-August.

Mahon and Doyle (2003) conclude that nesting and post-fledging activities are typically confined to an area of about 24ha, and recommended protection measures accordingly. Recent data from the Morice, Lakes and Kispiox TSA's indicates that northern goshawks are

[23] This guess assumes full occupation of all forested land in the LRMP ~1,096,000 ha. at minimum spacing observed by Mahon and Doyle (2400 ha./pair). The actual number is almost certain to be substantially lower than 450 because not all areas classified as forest will be occupied.

probably more tolerant of disturbance to nesting/post-fledging areas than previous studies suggest. Mahon and Doyle have to date observed the influence of logging on nest area re-occupation and breeding success 73 times, 7 of which were in nest areas more than one half logged. To date, there has been no significant difference in nest area re-occupation or in breeding success between nest areas affected by logging, and nest areas not affected. Mahon and Doyle point out that continued monitoring over the next few years will be required before a delayed response to disturbance can be ruled out.

Given the relatively modest size of areas apparently needed for nesting and fledging, and, at least so far, breeding birds' greater than anticipated degree of tolerance to disturbance, it now seems that nesting habitat may not be the most limiting factor for this species. Mahon and Doyle now expect that availability of effective foraging habitat will be the decisive factor in determining how many goshawks will persist in the face of development (Doyle, 2003). Important research remains to be done, but the main question now appears to be the point at which incremental loss of foraging habitat will result in territory abandonment.

Goshawk requirements regarding foraging habitat are still poorly understood, but these birds are widely considered to be forest specialists. Their short rounded wings and long tail are considered to be adaptations to manoeuvring through trees in forested habitat. They are ambush predators which perch low in the tree canopy awaiting the appearance of prey. If prey appears within range, they attack with a short explosive flight which sometimes includes plunging through tangled branches in pursuit of prey (Kaufman, 1996). Several researchers have observed that summer hunting occurs disproportionately in mature forest habitats, that kill sites are located disproportionately in mature forest habitats, and that birds selectively choose mature forest over adjacent younger seral stages with greater densities of prey (Doyle, 2002 and references therein).

Another aspect of goshawk preference for mature forest is competition with other hawks, red-tailed hawks in particular. Red-tailed hawks have been observed to harass goshawks and steal prey from them in open areas (Doyle, 2003), so preference by goshawks for forested habitat may be in part a reflection of the need to avoid competitors, not simply an inability or inefficiency at catching prey in open habitats.

The bulk of prey by weight for northern goshawks in the LRMP area consists of red squirrels, grouse, and snowshoe hares, but many other species including other small mammals, forest birds, and ducks are taken as well.

4.3.4.2 Projection

Projected consequences of base case management on goshawk have been assessed with the assistance of computerized habitat suitability models. The models were designed by Wildfor Consultants Ltd., and Wildfor's summary description of the model is included here as Appendix 10. Separate models for nesting habitat and foraging habitat were written, both in Microsoft Access.

Goshawk modelling examined the effects of spatial distribution of habitat. The models divided the LRMP area into artificial goshawk territories, and SELES was programmed to determine how many of the artificial territories contained acceptable amounts of nesting and foraging habitat. Although the boundaries of the artificial territories were arbitrary, the results serve as an effective index of the usefulness of the landscape for goshawks.

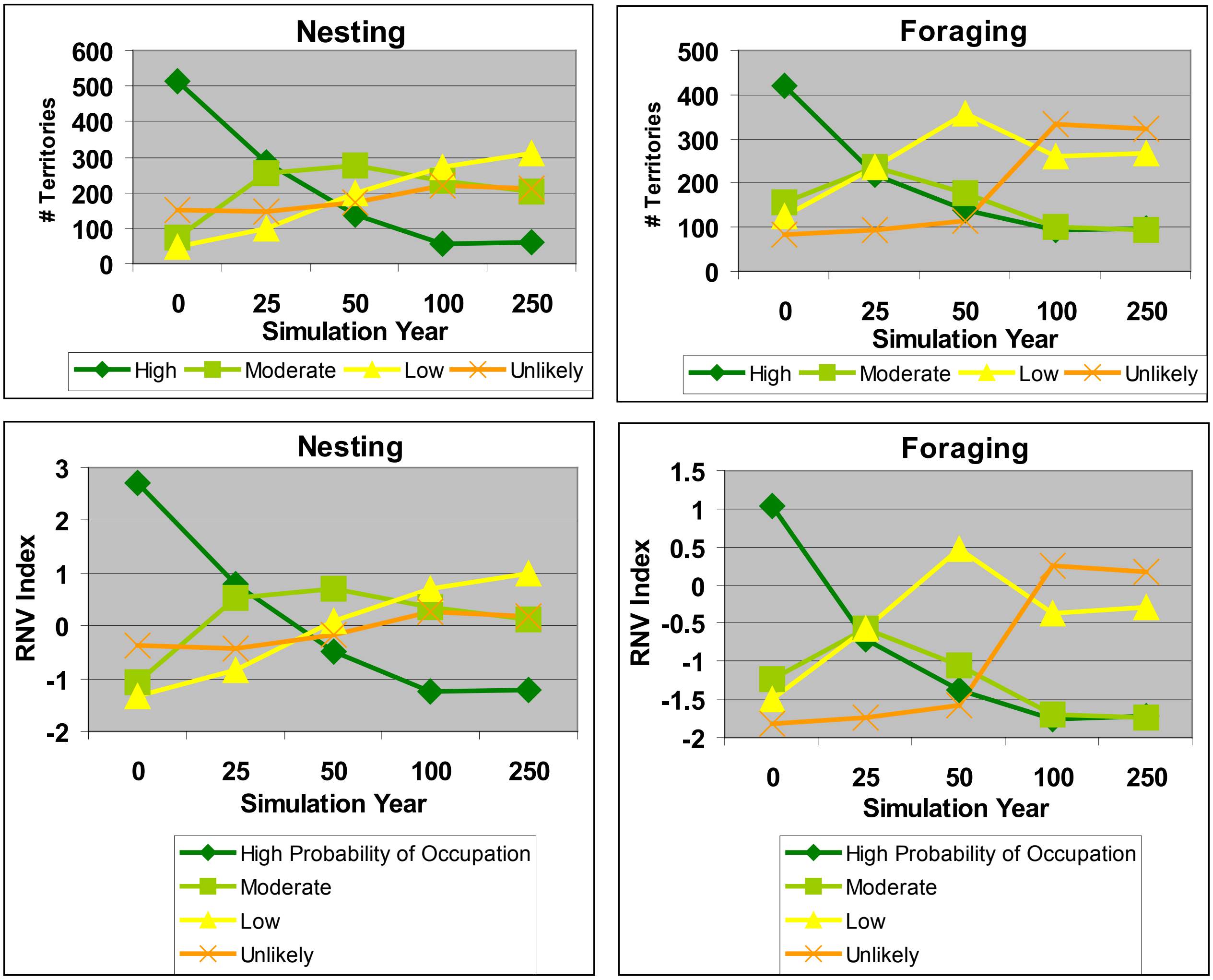
Goshawk modelling also determined a range of natural variability by analysing artificial territories in the 100 natural landscapes produced in SELES (See Appendix 3).

Modelling evaluated the probability of occupancy according to two different sets of criteria, one regarding availability of nesting habitat, and the other regarding the availability of foraging habitat. The first two graphs in Figure 10 show trends in the numbers of goshawk territories with high, moderate, low, or unlikely probability of occupancy by goshawks according to nesting and foraging criteria. The last two graphs show the same trends, except territory numbers are converted into Range of Natural Variation Indices to illustrate how trends compare with what was observed in the Natural Case landscapes.

Simulation predicts a dramatic reduction in the number of territories with high probability of occupation. This is true whether occupancy is predicted on the basis of nesting or foraging criteria. Trends for territories with a moderate probability of occupancy are more variable, and show slight increases in numbers based on nesting criteria, and a decline based on foraging criteria. Territories with low or unlikely probabilities of occupancy increase in numbers under both nesting and foraging criteria.

Relative to the Range of Natural Variation, the simulation suggests that there are currently more territories with high probability of occupancy than were observed in Natural Case simulations, and that the number of these territories declines strongly over the Base Case Simulation. By the end of the Base Case simulation, the number of territories with high probability of occupation was slightly less than was observed during Natural Case Simulations. Territories with moderate probability of occupation declined to below the Range Natural of Variation under foraging criteria. Other results were within the Range of Natural Variation by the end of the simulation.

Figure 10. Projection of Goshawk Territory Occupancy



<u>Note:</u> An RNV index of greater than 1 means that, in that year of the Base Case Simulation, more than the natural number of territories of that probability of occupation were present. An RNV index of less than minus one means that less than the natural number of territories of that probability of occupancy was present. An RNV Index anywhere between minus 1 and plus 1 means that the territories present during the Base Case Simulation was within the Range of Natural Variation[24].

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[24] If RNV Index = 2, this means that the number of territories observed is twice as far from the natural median as the maximum number of territories was in the 100 sample landscapes produced by the Natural Case Simulation. For example if the natural median is 40 territories and the maximum natural number of territories is 50, an observed number of 60 would generate a value of 2 because 60 is twice as far from 40 as 50 is. Put another way, the calculation in this case would be RNV index = (60-40)/(50-40)=2

Interpretation of these simulation results is difficult. On one hand, the results show a dramatic decline in high quality territories over the simulation period. On the other, part of the reason for the large decline is that the model judges current nesting suitability as considerably better than it would be in a natural landscape. . On balance, it seems to me that the simulated forest structures may be somewhat different than actually occur, so the nesting model may be evaluating current forest structures higher than simulated ones as a result. If this is true, simulation results for nesting may exaggerate differences between the Base Case and the Natural Case, at least in the initial period of the simulation. By the end of the simulation, both the Natural Case and the Base Case 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 would 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 substantial detrimental effect on the usefulness of the forest landscape to goshawks, and a substantial drop in goshawk populations may result from base case development.

4.3.4.3 Summary

Computer simulation predicts a substantial decrease in the number of goshawk territories able to provide high quality nesting and foraging habitat. By the end of the Base Case Simulation, territories with a high or moderate probability of being occupied according to foraging criteria are well below levels observed during Natural Case Simulations. On balance, it seems safe to assume that projected forest development will be substantially detrimental to goshawks, and may cause population decline.

4.3.5 Mountain Goat

4.3.5.1 Status and biology in the LRMP area

The status and biology of mountain goats in North America has been reviewed by Peek (2000), and in B.C. by Province of B.C. (2003d) and Shackleton (1999). Considerable work has been done on this species in or near the LRMP area (Turney et al., 2001; Blume and Turney, 2002a; Mahon et al., 2003). Unless otherwise specified, the following summary relies on all these references for general information, and on the latter three for information pertaining specifically to the Morice LRMP area.

In B.C., mountain goat is yellow listed, and it is an identified wildlife species (Province of B.C., 2002c; Province of B.C., 2003b). Yellow listing usually means that the species' welfare is not of immediate conservation concern. However, mountain goat is classed as S4 which means that it is considered to be of long term conservation concern (Province of B.C., 2002c; Province of B.C., 2003b). The B.C. population is roughly estimated at 30,000 to 60,000 goats.

Mountain goat distribution in the LRMP Area and elsewhere is powerfully limited by the availability of steep rocky terrain used as refuge from predators. Goats spend little time more than about 500 meters away from such terrain. Goats will intermittently use distant mineral licks, and will move across valleys between cliff habitats. However, the great majority of goats' lives all year round is spent in or near cliff systems which are used as refuge from predators. They will not, at least not in the presence of predators, continuously inhabit locations remote from cliffs no matter how abundant the food supply is in such locations. Study after study has shown that the most useful predictor of habitat use by goats is presence of cliffs. Other habitat variables are weak by comparison.

Not surprisingly then, goats in the LRMP area are found only where they have access to cliffs. Few goats are found within the LRMP Area north and east of the Bulkley River. Goat population estimates elsewhere in the LRMP Area are summarised in Table 5.

Table 5. Mountain goat populations of the Morice LRMP Area[25].

General Area	Approximate Number
Mountainous terrain between Burnie Lakes area and Whitesail Lake	800
Morice LRMP portion of Telkwa Range	90
Nadina Mountain	75
Morice Mountain	65
Forested habitats in general vicinity of Nadina and Morice Mtns.	100
Total	1130

Summer habitat for most goats, both in the LRMP Area and elsewhere, consists of alpine ridges and meadows with nearby cliffs. The cliffs provide the obligatory escape terrain, and the high elevation typically produces more nutritious forage than nearby areas at lower elevations.

Many goat populations move to lower elevations to spend the winter. In coastal locations with severe snow accumulations, this movement can be all the way from alpine to sea level. In drier interior climates, elevational migrations are less pronounced. Generally, goats can be expected to move about as far from summer range as is dictated by snow conditions. However, even in the absence of significant influence from snow, wintering goats have been observed to contract habitat use to smaller areas in an apparent mechanism to reduce energy expenditures during relative food scarcity.

In the more interior portions of the LRMP Area, such as in the Telkwa Ranges, Nadina Mountain, and Morice Mountain, goats which use alpine habitats in summer will usually winter in subalpine areas nearby, often on southerly aspects, but will remain in or occasionally return to alpine locations if wind scouring permits foraging in alpine locations.

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[25] Data from (Province of B.C., 2003a)(Mahon et al., 2003)

In portions of the LRMP Area closer to the coast and consequently with generally deeper alpine snowpack, there will likely be a greater tendency for goats to migrate to forested winter range at lower elevations (A. Edie, Pers. Obs.) Limited radio telemetry results from elsewhere in the Skeena region suggest that forested habitat as far as 5km or so away from summer range may be used in winter (Turney, 2003b). Movements observed elsewhere in North America have been up to 24km.

Whether or not, or to what degree, wintering goats are dependent on forest canopy probably varies. Interior populations often winter in habitats with open or no forest canopy, but coastal populations often appear to choose, and perhaps require, dense mature canopy which is thought to intercept snow and permit access to forage.

While most goats in B.C. and elsewhere follow the general pattern of summering in alpine areas with cliffs, and wintering nearby or downhill as dictated by snow, this pattern is not universal. Some goat populations also inhabit lower elevation areas all year round, so long as escape terrain is available.

In the LRMP area at least 100 animals in the general vicinity of Nadina and Morice Mountains use lower elevation cliff systems surrounded by forested terrain all year round. The main populations living at lower elevations are described in Table 6.

Table 6. Low elevation goat populations in the Morice LRMP Area[26]

General Area	Min. # Mtn. Goats	Comments
Bob Creek	12-20	Extensive canyon and cliff system on east side of Buck Cr.
Klo Creek	12-20	Includes several large bluffs and moderately developed canyons
Dungate	12-20	Large system of bluffs and cliffs immediately east of Bob Cr.
Mosquito Hills	12-20	Large system of bluffs and a few small canyons. Sighting of 17 goats reported in 1999. 2-6 generally observed while flying over area. Very well defined trails currently have low use suggesting goat densities may have been higher in past.
Shelford Hills	12-20	Use is concentrated in 2 canyons on north and northwest side of area

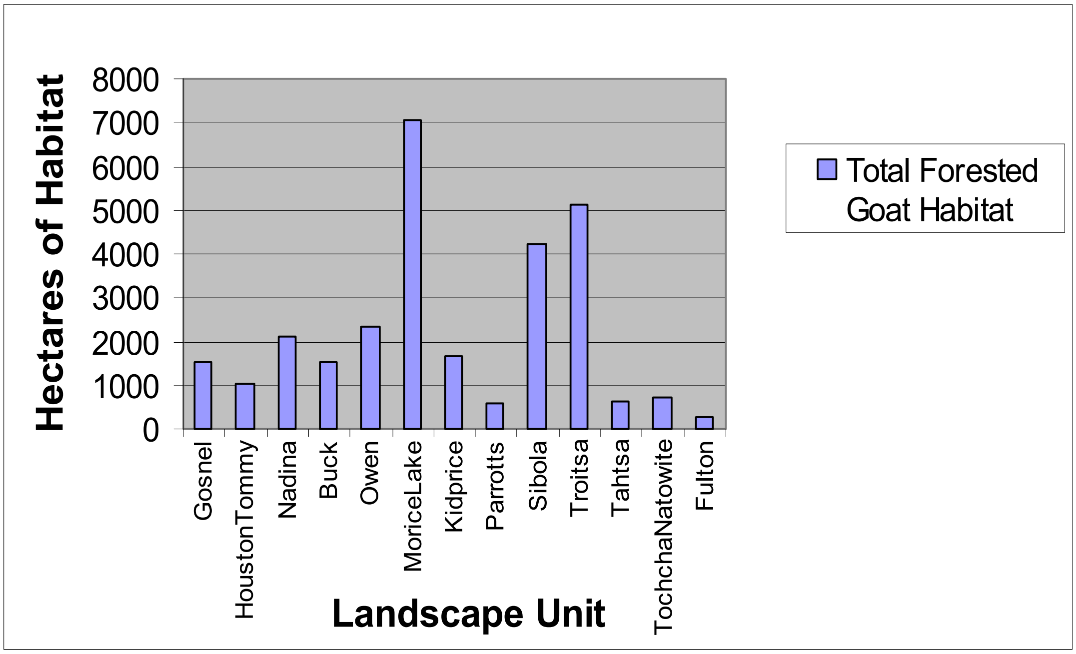
The distribution of all identified forested goat range by Landscape Unit is shown in Appendix 11. The distribution of forested goat range among Landscape Units with more than 100ha of habitat within the THLB is shown in Figure 11.

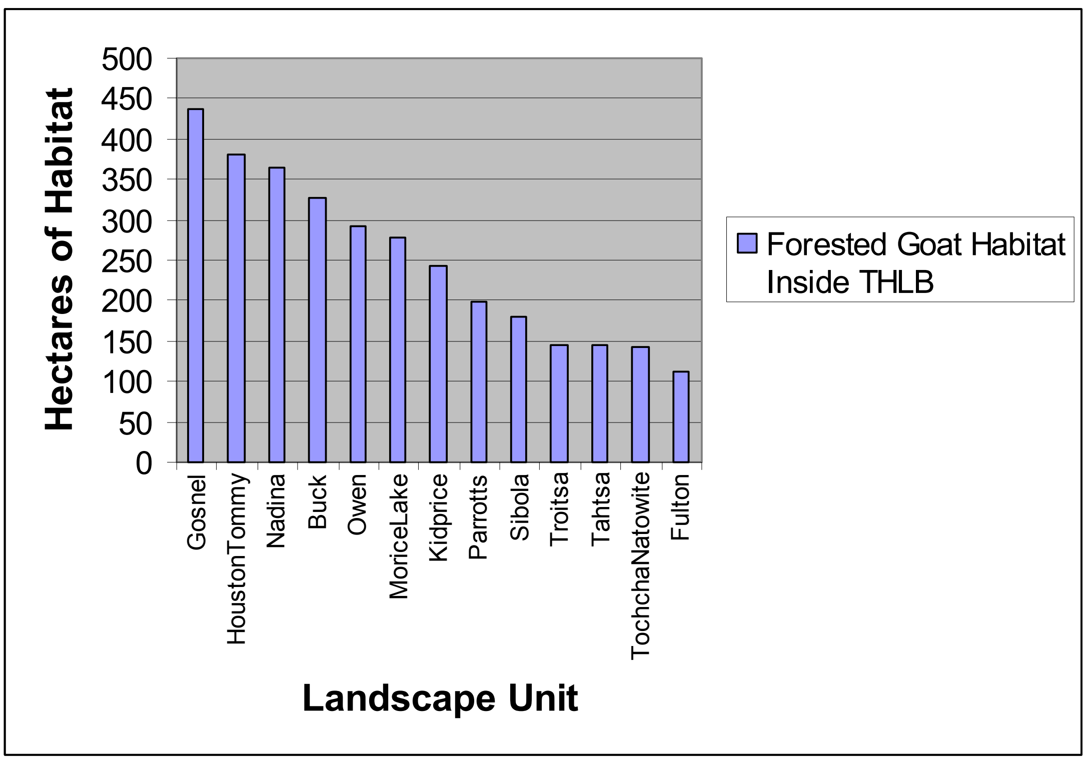
[26] Table information from (Mahon et al., 2003). The population numbers listed are the beliefs of (Mahon et al., 2003) based on field work done during their study.

These small populations may be particularly vulnerable to the impacts of forestry activity for two reasons, first they use habitats which are low in elevation and therefore more likely to be directly or indirectly affected by logging activity, and second, they are small, potentially isolated populations which may be more likely to be harmed by excessive hunting mortality.

Goats have the broadest tolerance for different foods of any ungulate (hoofed mammal) native to B.C. They are one of the few native species which will eat Soopolallie and western hemlock (Cowan, 1965). This characteristic, coupled with an ability to tolerate deep snow temporarily, probably explains why they can occupy coastal areas in which snow conditions are generally too severe for other native ungulates. The specific diet chosen by goats is dictated by what is available locally. In B.C. and elsewhere, winter diets vary significantly between interior areas in which grasses and sedges predominate, and coastal areas where browse from shrubs and conifers predominate. Summer diets vary with local plant availability, but can be expected to emphasize the most nutritious plant material available. Often this will mean a summer mixture of succulent herbs, newly growing grass and sedges, and browse.

Figure 11. Distribution of forested goat habitat among selected Landscape Units.





Goats are vulnerable to hunting mortality. In the Kootenay region of B.C. in the 1960's, increasing access to goat populations resulted in a severe decline which eventually resulted in closure of the hunting season, but only after considerable damage had been done (Phelps et al., 1983). The decline went unnoticed for years because, as local mountain blocks were depleted, new ones were made available by new roads. Consequently, overall harvest remained more or less constant in spite of the sequential depletion of local herds. Goat density data in the Skeena region suggests that current populations may reflect historical damage similar to that experienced in the Kootenay region. Goat densities are consistently lower on mountain blocks with existing or recent road access to alpine habitats than on blocks which have never had such access (Province of B.C., 2003a).

4.3.5.2 Projection

There are two general impacts which may arise as a result of Base Case management, impacts on habitat, and impacts on access to goat populations. The main potential impact on habitat itself is logging of pockets of low elevation forested habitat. While rugged topography would sometimes make logging unlikely, subjective evaluation suggests that the majority of forested sites used by goats would be vulnerable to logging immediately below the cliff habitat, and about a third would be vulnerable to logging adjacent to the tops of cliffs (Turney, 2003b).

Two difficulties arise in evaluating the likely seriousness of this problem. First, the pockets of goat habitat being considered are very local in geographic scale. Predicting whether or not these particular sites may be logged is not an appropriate use of the landscape scale SELES simulation undertaken during this Base Case analysis. Outcomes for individual pockets of habitat will be determined by details of exactly where blocks are located in lower level plans, not by the broad landscape management options explored here.

Second, it is not clear what the impact on goats might be of logging, or partial logging, of these interior winter ranges. On one hand, goats in high snow areas appear to use forest canopy to permit mobility through snow. On the other hand, these interior ranges, especially the lower elevation ones, do not have snowpack as deep as the coastal habitats in which goats are presumed to need forest canopy. Further, goats are known to forage in clearcuts even in coastal habitats with more snow than the LRMP area (Gilbert and Raedeke, 1992), so it is possible that limited logging in forested winter range could be beneficial by producing forage.

On balance, access seems more amenable to analysis and more important, so the remainder of this projection will deal with that issue.

Changes in the accessibility of goat habitats was examined using SELES by tracking the number of hectares of habitat found within particular distances from roads. Figure 12 shows the number of hectares of habitat within four distances of roads. The figure includes only habitat within the THLB since that is primarily the habitat which will be most affected by forest development. Only logging roads projected by the SELES model are included in the analysis behind Figure 12. Although access provided by mining exploration roads can cause similar impacts, there is no way to predict future locations of such roads, so they could not be included in the analysis.

Figure 12. Projection of accessibility of forested goat habitat within the THLB.

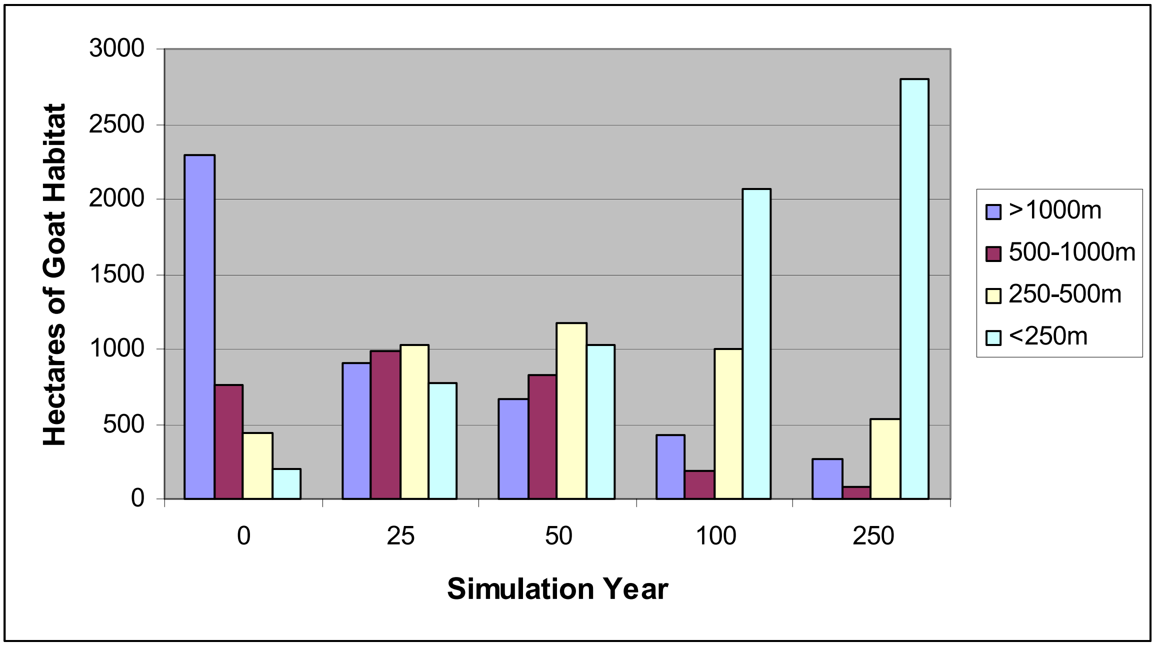


Figure 12 portrays a dramatic shift in accessibility of forested goat habitat within the THLB. At present, over 60% of forested habitat is more than a kilometre from roads. Twenty five years into the simulation, only 25% is that far from roads, and by year 250, <10%. The trend for habitat less than 250 meters from roads is opposite, rising from 5% at present to over 75% by the end of the simulation. Clearly, if access patterns in future develop roughly as predicted by SELES, access to the small goat populations using forested range will be dramatically improved, and risk to these populations of hunting mortality, legal or otherwise, will be increased substantially. Some of this risk can be reduced through design of hunting regulations and implementation of harvesting agreements with First Nations communities. However, for small isolated groups of goats, the potential consequence of even a few goats being taken under First Nations hunting rights or illegally could be serious. Recent computer modelling efforts suggest a population of 75 goats is necessary to withstand hunting of just one female goat per year and still have a 90% chance of not being extirpated in 50 years (Hatter, 2003). Taking one female per year from a group of only 25 goats would produce a 50% chance of extirpation in only 15 years.

4.3.5.3 Summary

Mountain goats are common inhabitants of typical alpine and subalpine goat habitat throughout the mountainous portions of the LRMP area. In addition to the goats which live in alpine and nearby habitats, approximately 100 goats are also found on low elevation forested sites with cliff habitat. These small populations may be particularly vulnerable to the potential for increased hunting mortality as a result of improved road access. The Base Case simulation predicts a dramatic improvement in access to goat habitats in the THLB, which could result in a significant increase in risk of excessive hunting mortality. It is not clear what the impact of logging low elevation winter ranges might be for goats. It is possible that limited logging within or near goat habitat could improve food production. Adaptive management trials to test this issue may be worthwhile, provided that the challenge presented by access can be dealt with.

4.3.6 Moose

4.3.6.1 Status and biology in the LRMP area

In B.C., moose is yellow listed, and it is not an identified wildlife species (Province of B.C., 2002c; Province of B.C., 2003b). Yellow listing means that the species' welfare is not of immediate conservation concern. Moose are managed primarily as a hunted species in B.C. The provincial population is believed to be stable or declining in most areas (Hatter, 1998).

Aerial census of moose has been undertaken periodically in the Bulkley-Lakes area since 1983 (Marshall, 1998). Population estimates since 1988, when the current survey area was delineated, have ranged from about 9000 in 1988, 14,000 in 1992, to 11,000 in 1997 . Although the estimate for 1997 appears to signal a recent population decline, personnel who did the survey believe that the low estimate was the result of poor sightability during the survey, and that the general population trend has remained positive since monitoring began in 1983 (Marshall, 2003b). Roughly 3,000[27] of the 11,000 moose estimated in 1997 were probably in the Morice LRMP area.

Selection of habitats by moose is a complex process in which animals balance multiple life requirements. Priorities vary over time and between animals. During winter, an overriding priority for most moose appears to be avoidance of snow too deep to permit efficient access to food. For cows in spring, a high priority during calving may be isolation from potential predators. For all moose, avoidance of overheating will be a priority regularly in summer, and intermittently during winter. The varying tradeoffs made by animals in selecting habitats make generalizations difficult. However, evidence to date suggests that moose select habitat primarily for the most abundant and highest quality of forage, and this underlying selection is modified as and when factors other than food assume importance in a particular circumstance (Peek, 1998). Winter and summer habitats are discussed below.

Winter Habitat

The general pattern of winter habitat use by moose in the LRMP area is well known as a result of observations during census efforts since 1983. During fall and early winter, moose usually move to lower elevations in response to snow accumulation. During winters with heavy snow accumulation, most moose move to the SBSdk and lower elevations of the SBSmc2. During winters with less snow, moose remain scattered widely, some at high

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[27] A population estimate specifically for the Morice LRMP area is not available. This guess assumed that 75% of the estimate for the surveyed portions of MU's 6-8 and 6-9 (0.75*3784), plus 10% of the estimate for the surveyed portions of MU's 6-4, 6-5, 6-6 (0.1*3944) (Marshall, 1998)belongs to the LRMP area.

elevation. The winter of 2002-03 is a good example of a low snow winter. The Ministry of Water, Land and Air Protection had planned a stratified random block survey of moose populations for February-March of 2003, but abandoned plans because moose were too widely distributed, some at elevations up to 1500 meters (Marshall, 2003b).

During winters with high snow, shrub dominated wetlands such as those in the Owen-Nadina area support high densities of wintering moose. For example up to 400 moose have been counted in the 20 km of riparian and nearby habitats between Owen and Francois Lakes (van Drimmelen, 1986a).

Although moose concentrations such as the one in the Owen Nadina complex are impressive, winter census efforts show that most moose winter at lower densities in more widely distributed locations (Table 7).

Table 7. Moose distribution during the 1997 aerial survey[28].

Density class	Area (sq. km.)	% Area	Moose	% Moose
Low	3806	44	1240	23
Medium	3373	39	2551	47
High	1128	13	1093	20
Super High	271	3	594	11
Total	8578	100	5478	100

Only 31% of moose counted in the 1997 winter census were found in habitat blocks rated as high or super high density. Sixty-nine percent of moose were in blocks rated as moderate or low density. The 1997 winter had relatively high snow accumulation (Marshall, 1998). Consequently, in many winters, even fewer moose would be located on the core winter ranges than were located there in 1997. The implication for moose management is that winter habitat for moose cannot be adequately managed by considering only the most obvious concentrations of wintering moose. The long term welfare of moose will also depend greatly on the cumulative contributions of much habitat which is more widely distributed and less densely populated.

Quantitative analysis of selection of specific winter habitats in the LRMP area is not available. However, subjective impressions (A. Edie, pers. observation) during several aerial surveys suggests that moose are usually found in locations with an obvious nearby source of deciduous browse, and that such locations usually fall into one of the following categories:

- Shrub-dominated wetlands such as found in the Owen-Nadina complex. Often these habitats are smaller in scale than the Owen-Nadina complex,
- Aspen or Black Cottonwood dominated forest,
- logged or burned areas in which shrub regeneration is significant.

[28] Data from (Marshall, 1998). Nil stratum excluded (12,872 sq. km.)

- conifer forest with a broken, open canopy and/or a substantial deciduous component, and a significant shrub understory.

The role of cover in moose winter range has been much discussed in the literature. There is no doubt that, at least during late winter, moose use conifer cover (Peek, 1998). Exactly why they do so is less certain. Various functions have been hypothesized, the main ones are thermal shelter from heat and cold, predator avoidance, and favourable snow conditions.

While in their winter coats, moose require access to thermal shelter to reduce overheating at temperatures above 0°C. As temperature rises above about 0°C, moose seek shade, expend energy by panting and raising heart rate, and reduce or cease feeding, which causes a food deficit which cannot be made up later (Schwartz and Renecker, 1998; Renecker and Hudson, 1992). It seems likely that any conifer forest dense enough to provide winter shade would suffice for thermal shelter. Some authors have suggested that moose also require thermal shelter during cold weather (Blume and Turney, 2002b). However the low critical temperature for calf moose is -30°C, and the critical temperature for adults is probably less than -40°C (Karns, 1998), but has not yet been measured because sufficiently cold temperatures have not yet been available for testing (Schwartz and Renecker, 1998). Further, other moose populations such as those on the Seward Peninsula and the north slope in Alaska apparently manage without access to conifer cover in climates colder than that of the LRMP Area (Balsom et al., 1996). Cold is not likely a large issue for moose in the LRMP area.

Cover has also been hypothesized to assist moose by reducing snow depth or increasing its density thereby making it easier for moose to move. The degree to which this effect may operate in the LRMP area is uncertain, and potentially variable. In the SBSdk, snow depths are generally less than 50cm (Banner et al., 1993), which is less than the 70 cm or so thought to definitely impede moose movement (Balsom et al., 1996; Peek, 1998). Consequently, conifer cover may not often be needed in the SBSdk for the purpose of assisting mobility in snow. Snow depths in the SBSmc will vary with elevation, and with proximity to the Coast range. In higher snow depth locations, it is possible that conifer cover provides a benefit by altering snow depth or density, but there is no local information available on the issue.

Logically, visual cover may also reduce predation or hunting risks to moose, but little definitive analysis has been accomplished.

Food habit studies elsewhere suggest that wintering moose will preferentially eat willow browse wherever preferred species are available, and that they will also eat fallen aspen leaves and a wide variety of other shrubs as well (Renecker and Schwartz, 1998). In the LRMP area, moose use several species of willow, as well as red osier dogwood, saskatoon, Douglas maple, paper birch, highbush cranberry, red elderberry, Sitka mountain ash, trembling aspen (Roberts, 1986), subalpine fir (A. Edie, pers. obs.) and possibly false box (Blume and Turney, 2002b). Moose are selective in their use of willow species, with Scouler's and Bebb's willows being particularly important. Scouler's willow is an upland species seldom found near watercourses. It is heavily or severely browsed wherever new growth is accessible to moose, and frequently becomes very abundant in logged areas or burns (Roberts, 1986). It is probably a key winter food for many if not most moose wintering in the LRMP area, and may be the primary reason for many moose wintering on widely distributed upland sites. Bebb's willow is also found in upland sites, and also occurs in lowland cottonwood forests and wetlands. Other heavily used wetland species include Drummond's, Barclay's, and pussy willows (Roberts, 1986). In late winter and early spring moose will also strip bark from aspen trees (A. Edie pers. obs; Renecker and Schwartz, 1998).

Summer range

In summer, moose in the LRMP area are more widely distributed, and at higher elevation than they are in winter. Moose fitted with radio collars during the winter in the Owen-Nadina winter range summered as far south as Ootsa and Tahtsa Lakes, as far west as the lee side of the Coast Range, and almost as far north as Burnie Lakes (van Drimmelen, 1986a). Bulls summered up to 80 km from winter range, and cows up to 65km from summer range. Bulls tended to wander most of the summer, while cows tended to move directly to the location where calves were born, and remain in that vicinity for the summer.

Specific habitat preferences during summer in the LRMP area have not been studied, but can be expected to be highly variable, ranging from various aquatic habitats such as beaver ponds, lakes, and river side channels, to high elevation meadows or shrub fields. Two common ingredients will likely be universal, a relative abundance of summer foods, and thermal shelter. Heat stress is an important issue for moose in summer (Renecker and Hudson, 1992), and access to shade and/or water is likely a very important component of effective summer range. The need to avoid overheating may also result in moose choosing cooler topographic locations such as high elevation, north facing valleys during summer.

Summer food habits of moose have not been studied in the LRMP area. Work elsewhere suggests that as spring advances and moose disperse from winter ranges, food habits will shift from browse and bark stripping to newly growing herbs, new shoots and leaves on shrubs, especially willow, and an assortment of aquatic plants which grow in lakes, ponds, and other small water bodies (Blume and Turney, 2002b).

Relative importance of summer and winter range

Winter range is often considered the critical influence on moose populations because food availability is at its worst for moose then, and moose obviously suffer weight loss and condition over the winter period. Reality is more complex. Even on high quality winter range, moose exist in a negative energy budget, and a marginal or worse protein supply (Schwartz and Renecker, 1998). Moose on winter range are starving, the main variable is how quickly they are doing so.

In a sense, the contribution of winter range to nutritional status of moose is small: it mostly determines the rate at which reserves accumulated in summer are depleted. It is high quality summer food, not winter food, that supports growth, lactation, and reproduction in moose.

This issue of course presents the risk of a “chicken first vs. egg first” debate. However, the point here is that both summer range and winter range are important; winter range is not the only factor driving moose populations in the LRMP area, and it may not be the most important one.

4.3.6.2 Projection

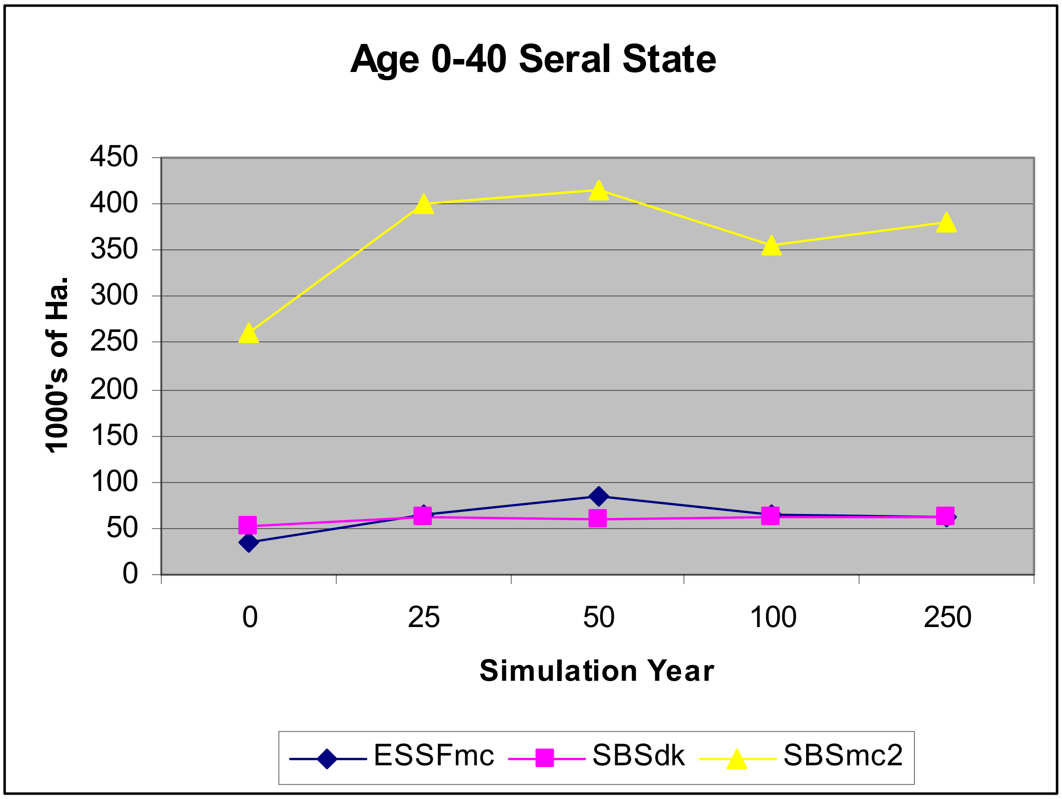
A computerised habitat model was not used in this assessment, rather, general implications of base case management was inferred from predicted changes in seral states over the SELES simulation.

The forestry activities anticipated in this projection will probably influence moose habitat in a number of ways. Most obviously, and perhaps most importantly, logging and subsequent growth of replacement forest will alter the distribution and availability of young seral habitat over the landscape. Young seral habitat provides important food all year round, whether as deciduous browse in winter, or as herbs or deciduous leaves in summer. Continuing availability of young seral habitats is important to moose in both summer and winter.

Projected availability in SBSdk, SBSmc2, and ESSFmc of habitat from 0-40 years old over the 250 year SELES simulation is shown in Figure 13. Trends in the SBSdk and SBSmc2 show implications for winter range, and trends in SBSmc2 and ESSFmc show implications for summer range. The simulation predicts a roughly 50% increase in age 0-40 forest in the first 25 years in SBSmc2, and minor change thereafter. Little change is predicted in SBSdk over the simulation. In ESSFmc, age 0-40 habitat doubles over the first 50 years, and declines slightly after that. Examination of trends within individual Landscape Units shows similar results; some units show initial or long term increases in age class 0, others show little change, and none show a significant decrease over the entire 250 years (Appendix 12).

Overall then, there appears little reason to expect that base case management will cause general reductions availability of early seral habitats for moose in the LRMP area. Availability of early seral summer habitats should increase for the next fifty years or so, and remain considerably higher than at present thereafter. Trends in availability of early seral winter habitat will vary somewhat, but will usually change little or increase on the order of 25% over the next 25-50 years, and decline slightly or remain stable thereafter.

Figure 13. Projected availability of young forest in SBSdk SBSmc2 and ESSFmc.



The predicted trends are not necessarily benign for moose. Much of the existing upland winter range consists of aspen or mixed forest (A. Edie, pers. obs.) which is probably the result of fires, and in which the availability of willow and other browse is probably declining over time. Due to fire prevention, or perhaps to climate cycles, this habitat is not generally being replaced by fire in recent years, although insect kill of trees may produce replacement habitat. In any case, it is possible that unless "natural" stand replacement increases to levels more representative of recent history, moose in the LRMP area will become gradually more dependent on early seral habitats provided by logging. If silvicultural activities such as herbicide treatments or early planting at high stocking rates reduce the utility of logged landscape for production of moose foods, the actual amount of high suitability habitat for moose could decline in spite of the implications of Figure 13. The outcome for moose will depend on specific silvicultural objectives and activities determined in lower level plans.

Useful comment on potential trends in the availability of cover is difficult, partly because the usefulness of such cover will depend on its specific location relative to moose food, and partly because the nature of cover required depends on the assumed function. Thermal and security cover would likely be provided as soon as conifer growth was sufficient to provide shade and perhaps break the wind. In Alberta, moose began to use logged areas as cover after about 20-25 years after logging (Thompson and Stewart, 1998), so thermal and security purposes seem likely to be satisfied here after something like that length of time.

Considerably older forest would likely be required for purposes of modifying snow characteristics in the SBSmc2, but no specific information is available.

Reproductive rates of moose in the Bulkley Valley/Lakes area suggest tentatively that the quality of existing habitat may be relatively low, or that the population is about as large as the habitat can support. Among other fecundity indicators, twinning rate in moose is thought to sensitively reflect the quality of habitat available to moose populations (Boer, 1992; Schwartz, 1998). When populations are below, near, and above carrying capacity, observed twinning rates have been 25 – 80%, 15 – 40%, and ~5% respectively (Boer, 1992). Twinning rates in the Bulkley Valley/Lakes area are around 11% (Marshall, 1998), which is consistent with a population at or above carrying capacity. From an LRMP standpoint, this suggests that continued production of early seral stages with abundant moose food, and retention of cover in the vicinity of food, will be important to moose populations in the LRMP area.

4.3.6.3 Summary

Moose are distributed widely in the LRMP area. Moose use a broad variety of habitats during summer, ranging from low elevation aquatic habitats, to high elevation forest and meadows near the treeline. During winters they move to low elevations to the degree dictated by snow depth. Moose in the LRMP winter in dense concentrations in some shrub dominated wetlands such as the ones found in the Owen-Nadina area, but cumulatively, most moose winter at lower densities in widely scattered locations, usually in either the SBSdk or lower elevations of the SBSmc2. Moose depend year round on early seral states which provide browse in winter, and herbs, leaves, and new stem growth of various food plants in summer. The amount of early seral state habitat available over the simulation increased in both summering and wintering portions of the LRMP area, so general impacts on moose should be positive, provided that silvicultural activities do not prevent growth of food plants on cutblocks, and that cover remains available near food supplies.

4.3.7 American Marten

4.3.7.1 Status and biology in the LRMP area

General reviews of the biology and status of American marten (hereafter "marten") in North America are provided by (Buskirk and Powell, 1994; Buskirk and Ruggiero, 1994), information pertinent to the LRMP area has been reviewed by (Blume and Turney, 2002b), and the results of a study on marten in the LRMP area are provided by (Lofroth, 1993). Unless otherwise stated, the following summary uses all these references for general information, and the latter two for information specific to the LRMP area.

In B.C. marten is yellow listed, which means that the species' welfare is not of immediate conservation concern (Province of B.C., 2002c; Province of B.C., 2003b). Marten is managed as a furbearer in B.C, and is the most important individual species to the trapping industry. Annual marten harvests in M.U.'s 6-4, 6-8, and 6-9 which cover most of the LRMP area have ranged from about 500 to 3500 since 1985 (Province of B.C., 2003a).

The marten is broadly distributed in forested habitats of North America and British Columbia. In the LRMP area, marten probably occupy most forests with a significant conifer component, and populations reach their densest in older conifer forests. The population size in the LRMP area is unknown, but densities observed elsewhere range from 0.4/km^2 in logged habitats to over 2/km^2 in older forest habitats. Consequently, given the roughly 400,000 ha of forest in the LRMP area, the marten population may be roughly 4,000 - 8000.

American marten occupy forest habitats nearly exclusively, and in particular appear to prefer mature and old growth conifer forests, especially those with complex physical structure near the ground. Physical structure near the ground is believed to provide marten with three particular life requisites: access beneath the snowpack for hunting prey in winter, access to thermal shelter from cold, and protection from predators. Structure near the ground may also provide a greater abundance of prey, and more effective hunting for marten. On the infrequent occasions where marten have been found exploiting non-forest habitats, other physical elements of those habitats, such as talus fields, have apparently substituted for structure normally provided in forest habitat by trees and coarse woody debris. Baker (1992) found extensive use of second growth forest by marten. However, she suggested that marten were able to use this habitat because of the legacy of large woody debris left after logging.

The marten study undertaken at Emerson Creek near the confluence of the Bulkley and Morice Rivers found that marten populations were higher in the conifer forests of the SBSmc2 than they were in the drier mixed conifer/deciduous forests of the SBSdk. Within their home ranges, studied marten preferentially used sites with more coarse woody debris, larger conifer trees, more snags, larger snags, and low to moderate shrub abundance in comparison with available sites. Marten selected forest sites with moderate tree abundance and canopy closure.

Marten are generally considered reluctant to cross openings without overhead cover, perhaps especially in winter, but this reluctance varies geographically and seasonally. Marten are known to use non-forested habitats at high elevation in summer, and forage in herbaceous and shrub habitats if prey density is high. Lofroth (1993) reported that marten cross openings of 100m wide in winter.

Marten eat a wide variety of foods including voles, mice, shrews, squirrels, pocket gophers, snowshoe hares, ungulate carrion, fish, birds, eggs, insects, and fruit. Generally, they are an opportunistic predator, and will kill and eat nearly any appropriately sized prey. They also eat carrion, and are known to eat human provided food.

4.3.7.2 Projection

Projected consequences of base case management on marten have been predicted with the assistance of a computerized habitat suitability model. The model was designed by Ardea Biological Consulting, and the details of its structure are provided by Roberts (2003). The model was written in NETICA, a Baysian Belief Network program. The model evaluates winter suitability only. Winter is believed to be the most limiting season for Marten in the

LRMP area, primarily because of lower availability of food to marten at this time of year. A description of the model is presented in Appendix 13.

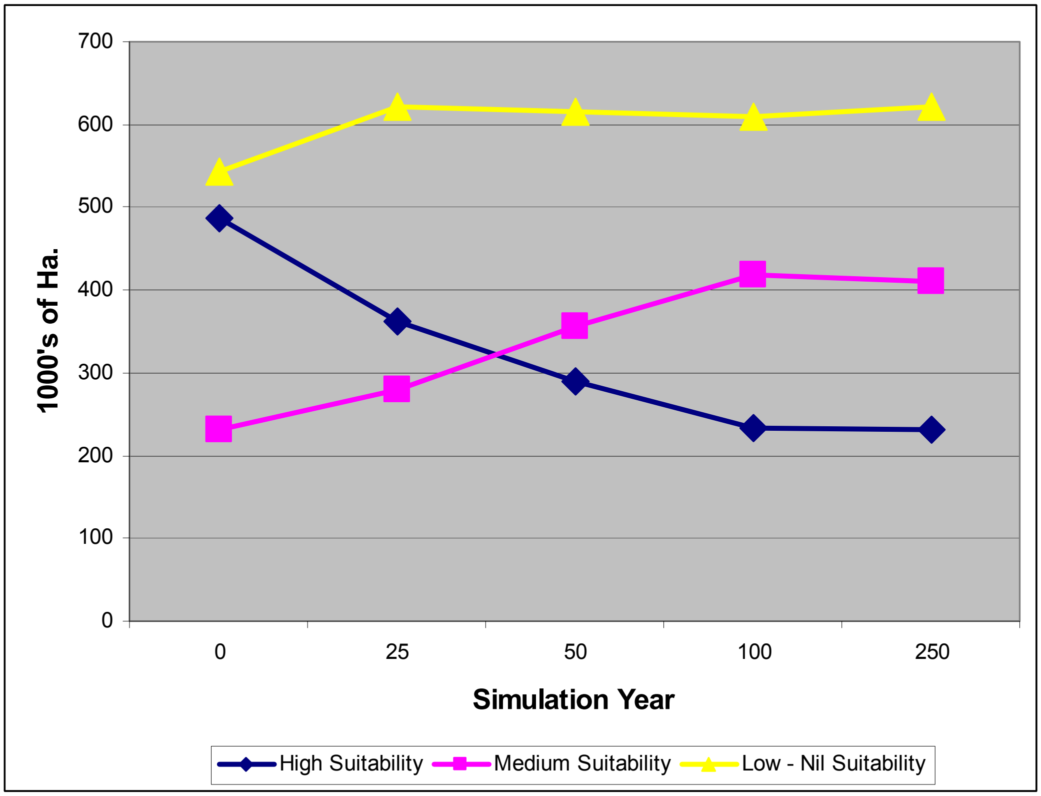
Tabular summaries of simulation results are presented in Appendices 14, 15, and 16. These appendices document details regarding which BEC subzones/variants provide the majority of high quality habitat, and predicted trends over time in the availability of different suitability classes in each BEC subzone/variant and Landscape Unit.

Modelling shows that, at present, 98% of high and medium suitability habitat for Marten is found in the SBS and ESSF zones. Other BEC zones contribute little, either due to small area in the LRMP area, or poor suitability for marten (Appendices 9 and 10).

Predicted trends in availability of high, medium, and low-nil suitability habitat in the SBS and ESSF zones are shown in Figure 14.

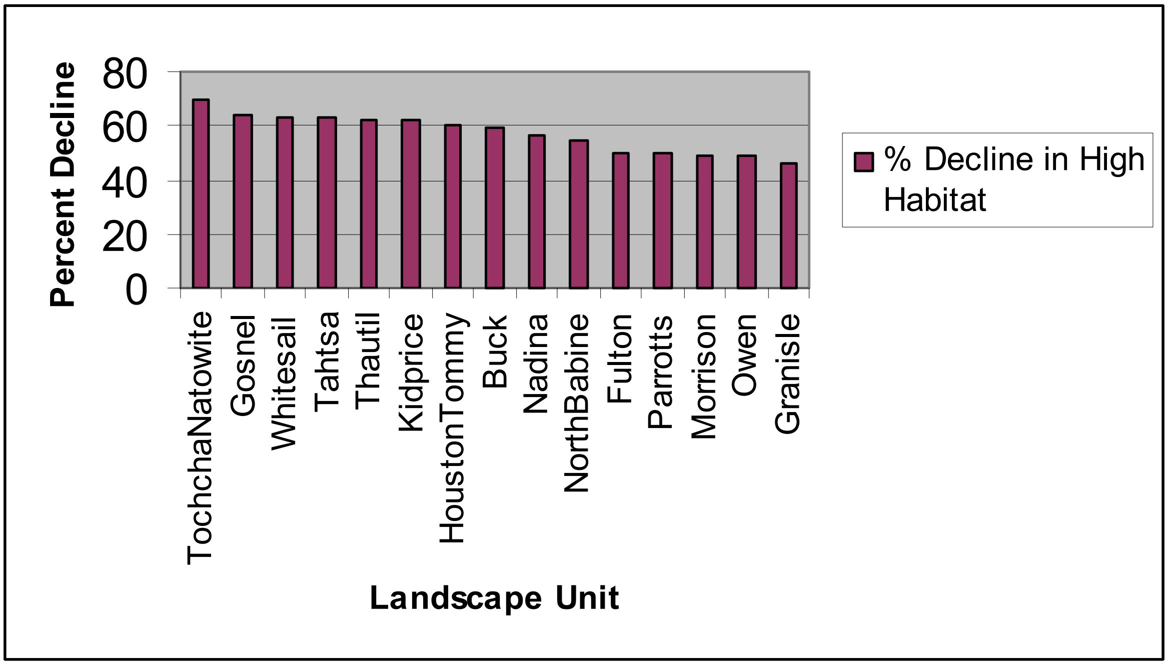
Figure 14 shows that, over the first 100 years of the simulation, the area of high suitability habitat drops by 52%, and the area of medium habitat increases by 76%, and the area of low-nil habitat increases by 17%. Most of this change occurs in SBSmc2, SBSmk3, ESSFmc, and ESSFmv3. Changes in the remainder of the SBS and ESSF zones are minor (See Appendix 14).

Figure 14. Marten habitat suitability projection.



When trends are examined at the Landscape Unit scale, a similar general pattern of decline in high suitability habitat is apparent (Appendix 16), but the decline in some Landscape units ranges as high as 70%. Figure 15 shows the percent declines in high suitability habitat in Landscape Units with greater than 40% loss of high suitability habitat.

Figure 15. Percent decline in high suitability marten habitat in selected Landscape Units.



Interpretation of these trends is complex, and hinges on at least three potentially significant issues.

The first issue is whether suitability ratings produced by the model adequately calibrated to reflect the real value of rated habitats to marten. The suitability model has not yet been verified to determine what densities of marten are found on habitats rated at particular suitabilities (Roberts, 2003). If real value to marten is not reasonably reflected by suitability ratings, errors in interpretation are possible. For one extreme example, the model might rate more or less all habitat useful to marten as high, and little or none of it as medium or lower. In this case, the predicted trends might mean a 50% or worse reduction in marten populations. At the other extreme, if the habitats rated as high and medium suitability are equally useful to marten, the predicted trends would mean considerably less. However, at least over the first forest rotation, neither of these two extremes seems likely. The suitability model incorporates a substantial body of information from the literature on marten (Roberts, 2003), including information gathered in a study in the LRMP area (Lofroth, 1993). Further, suitability in the model is driven mostly by availability of coarse woody debris, which has been the subject of considerable fieldwork in and near the LRMP area (Turney, 2003b). On balance, it is probably safe to assume that the overall trends in availability of different habitat classes are roughly representative of reality, at least for the first forest rotation.

The second issue is whether the model's assumptions about availability of coarse woody debris after the first rotation is realistic. It is possible that the amount and quality of woody debris on the ground may be considerably less in later rotations because fewer trees may die and provide woody debris input in managed stands. The model assumes a reduction in availability of woody debris after the first harvest, but no further reduction is made in subsequent rotations. Good information on long term trends in woody debris in managed forests is not available for interior forests, so the size of this problem remains uncertain. If loss of woody debris is in fact a problem in the long term, marten populations will be reduced more than predicted by simulation results presented here.

The last question is whether changes in the spatial distribution of habitat might cause difficulty in interpretation. The model does not, for example, consider whether a given patch of habitat is big enough to support a marten, or whether it is sufficiently connected to other marten habitat to likely be colonized. There is no way of knowing with available information what the influence of spatial distribution of habitats might be as a result of predicted changes under Base Case Management. However, research elsewhere suggests that marten may be sensitive to habitat fragmentation. In studies in Maine, Utah, and Quebec, marten infrequently established home ranges in habitat complexes containing more than 20-30% open areas (Chapin et al., 1998;Hargis et al., 1998; Potvin et al., 2000). Results are not directly applicable here due to differences in forest types and harvest techniques. However, these studies nonetheless suggest that landscapes may be rendered unsuitable for marten if, at the scale of individual potential home ranges, >20-30% of the landscape is transformed into open or early seral habitat. If this effect is present in the Morice LRMP area, the future decline in marten habitat suitability may be worse than suggested by the computer projection presented here.

4.3.7.3 Summary

Marten are widely distributed in forested portions of the LRMP area, especially in older conifer forests. This species makes limited use of non-forest habitats, or young forest. Projected consequences of base case management to marten were evaluated using a computerized habitat suitability model. Simulation indicated a roughly 50% reduction in high suitability habitat in the first 100 years of the Base Case Simulation, and little change thereafter. Somewhat larger losses were predicted for some individual Landscape Units.

The implications of the predicted change in habitat suitability are somewhat unclear because the model has not been calibrated to marten density, the long term consequences of forest management on availability of coarse woody debris remain uncertain and the model does not consider spatial distribution of habitats. If simulation results are assumed to be reasonably accurate in spite of these limitations, it appears unlikely that the predicted change in suitability could cause more than roughly a one third to one half reduction in marten numbers in the LRMP area as a whole. Impacts in some individual Landscape Units could be somewhat higher.

4.3.8 Bull trout

4.3.8.1 Status and biology in the LRMP area

Status and biology of the bull trout in B.C. has been summarized by Province of B.C. (1997), and general biology and habitat requirements by Baxter and McPhail (1996). Bull trout have also been studied intensively using radio telemetry in the Morice River watershed by Bahr (2002), and status in the Morice watershed has been reviewed by Bustard and Schell (2002). Unless otherwise stated, the following summary uses all these references for general information, and Bahr (2002) and Bustard and Schell (2002) for specific information on the Morice watershed.

In B.C., bull trout is blue listed, and it is an identified wildlife species (Province of B.C., 2003b). Blue listing means the species is of special concern but not under immediate threat . Population numbers in the LRMP area are unknown. Although reliable population estimates are not available, Bustard and Schell (2002) suggest that the spawning population in the Morice watershed may be less than 1000 fish. The population in the Bulkley/Morice watershed is believed by regional fisheries biologists to be in decline, and populations in Morice and Babine are believed to be at risk (Giroux, 2003). Within the LRMP area, bull trout are known to be present in all watersheds except Nechako Reservoir system where no information is available (Province of B.C., 2002a) and the Burnie/Clore system. Although bull trout populations are present in much of the LRMP area, the largest concentration is in the Morice watershed.

Bull trout exhibit a variety of life history strategies. Non-migratory populations are generally smaller fish which live their whole lives in small headwater streams. They often mature earlier than migratory populations do. Adults of migratory populations live in lakes or large streams, and migrate to small streams to spawn. Not all fish spawn every year. All life strategies may exist in the LRMP area, but specific information is lacking except for the Morice watershed. In the Morice watershed, stream resident populations which do not migrate are known from upper Thautil and Starr Creeks. The main population in the Morice watershed live in the main river and migrate to tributaries to spawn. It is possible but still uncertain whether a population exists which is resident in Morice Lake.

Most adult bull trout monitored with radio tags in the Morice watershed live most of the year in the main Morice River, and migrate into several smaller tributaries to spawn. Most monitored fish spawned in upper Gosnell Creek, but spawning was also recorded in Glacier Creek[29], Houston Tommy Creek, Denys Creek, and Gold Creek. Migration to spawning locations occurred gradually during June, July and August, and spawning occurred in the last week of August and first two weeks of September. Some bull trout moved over 60km to their spawning locations in the Gosnell/Thautil watershed. After spawning, fish moved quickly out of tributaries, often to locations where they could forage on eggs from spawning salmon. Mortality among spawning adults in the Morice study was high. Over 40% of monitored fish in the Morice Study disappeared while in tributaries used for spawning, some of them

[29] Named and mapped as Redslide Creek in (Bahr, 2002).

apparently as a result of predation. However, this mortality rate among spawning adults appears high relative to observations elsewhere (Bustard and Schell, 2002).

Few if any bull trout in the Morice watershed spawn before they are 4 years old, and the bulk of the spawning population is 6, 7, and 8 years old (Bahr, 2002;Bustard and Schell, 2002).

Bull trout have long been noted as selective in their preference regarding spawning locations, and have often been observed to use only a small portion of apparently suitable habitat. Recent research suggests that bull trout spawn preferentially in locations influenced by ground water. Baxter and Hauer (2000) found that bull trout preferentially selected tributaries with specific topographic structures which caused water to upwell through stream gravels. Within these tributaries, bull trout spawned in the nearby vicinity of the strongest upwelling. Surprisingly, the trout chose actual redd sites in which water direction was into the gravel rather than up through it. The authors suggest that bull trout may choose spawning areas affected by groundwater because the warmer groundwater (in winter) may prevent freezing of redds in the small tributaries used for spawning.

Bull trout sometimes stage (gather together and wait) in pools for as long as a month prior to spawning. Groups of adult fish in pools used for staging are vulnerable to over-fishing by anglers. As McPhail and Baxter (1996) put it, "they are large, conspicuously coloured, good to eat, and will take almost any lure". Over-fishing is thought to have resulted in declines in several populations in western North America. The idea that over-fishing has contributed to observed declines is strengthened by the fact that regulatory controls which reduced fishing pressure resulted in increased spawner numbers in Line Creek and higher proportion of repeat spawners in Kananaskis Lake.

Habitat requirements and diet vary over the life cycle of bull trout. All bull trout populations appear to spend at least their first two or three years in small streams, even if adults later live in large rivers or lakes. During their first summer after hatching, fry use locations with relatively low water velocity, and abundant cover. Cover can include in-stream wood debris, cut banks, or overhead vegetation. However, it often consists of coarse gravel and cobble substrate into which the small fish can retreat to hide from predators. Loss of these interstitial spaces due to siltation could have serious impacts on the ability of small streams to support bull trout fry. During their second and third summers, juvenile bull trout remain in small streams, but gradually use deeper and faster water, and larger cover structure. Fry and juvenile bull trout leave cover at night to forage more widely, presumably due to reduced risk of predation by birds. Fry and juvenile bull trout eat aquatic insects. As juveniles grow, they shift to eating fish. By the time they reach 100-200mm in length, juveniles often shift completely to fish.

Distribution of fry and juvenile bull trout may be strongly influenced by a combination of temperature and competition with other salmon and trout species. Juvenile bull trout rear in tributaries cold by local standards, for instance they do not occupy any lake headed tributaries in the Morice Watershed. Evidence suggests that one reason for this preference may be that in warmer water, young bull trout cannot compete with other salmon and trout species (Haas, 2001).

Habitats used by adult bull trout are variable. Stream resident forms continue to use the same small streams in which spawning and rearing as juveniles occurred and often continue to eat mostly aquatic insects. When not spawning or migrating to spawning locations, migratory adults generally live in larger rivers or lakes. Most of the monitored adults in the Morice study used the upper river for about 2-3 km downstream from Morice Lake. Adults in the Morice study wintered in deep pools in Morice River, and possibly Morice Lake. Adults in migratory populations are aggressive fish eaters (piscivores), and will eat a wide variety of species. Their vulnerability to lures suggests that they will attack more or less any fish of appropriate size. Apparently, salmon eggs can also be an important food source.

4.3.8.2 Projection

Bull trout in the LRMP area are resident year round, so they could be affected by any influence which causes a general decline in the productivity and health of the aquatic ecosystems in which they live. Excessive siltation, detrimental temperature change, and damage to structure or stability of stream channels would harm bull trout, as they would many other aquatic organisms. These general impacts on aquatic systems will be discussed later in Section 4.5.

However, bull trout appear to have special vulnerabilities. Four in particular deserve mention here:

- Bull trout are adapted to colder water than other species in the LRMP area, and consequently, may suffer more in response to elevated temperatures. This issue may be particularly important for juvenile bull trout which rear in small streams for the first three years of life. The potential for elevated temperatures will be discussed in Section 4.5 below.
- Although spawning by bull trout in large rivers cannot be ruled out completely yet, available information suggests that bull trout preferentially use smaller streams for spawning, and preferentially spawn in very limited, particular locations (Bahr, 2002; Baxter and Hauer, 2000). Consequently, very small geographic locations could be crucial to the welfare of spawning bull trout populations, both in terms of potential damage to the special local habitat, and in terms of the potential impacts of angler access and consequent over-fishing. One such area in the LRMP area is upper Gosnell Creek, where 75% of the spawning redds identified in the Morice study were located (Bahr, 2002). Other potentially sensitive locations exist in both the Thautil and Nanika drainages (Bahr, 2002). Given the apparent importance of groundwater in bull trout spawning habitat, this species may be particularly sensitive to interference with ground water by roads. Since most or all spawning and rearing happens in small streams, bull trout may also be particularly vulnerable to spawning areas being lost, and movements of juveniles being blocked, as a result of barriers to fish passage.

- Bull trout fry use spaces among gravel and cobbles as cover to a greater degree than other species do, and once again, they do this in small streams, not large ones. Consequently, bull trout may be more vulnerable to siltation and changes in bedload movement than other species are. This greater vulnerability could arise both from fry's dependence on spaces in the streambed, and from the relative ease with which such habitat could be damaged in small streams.
- Due to their long lives and relatively low productivity, bull trout are very vulnerable to over-fishing. This vulnerability will be acute when adult fish stage during the gradual migration to spawning locations, at the spawning areas themselves, and in locations where fish gather after spawning. Some tagged fish in the Morice study held in pools in Gosnell Creek for up to a month prior to spawning. There is little doubt that the LRMP Area includes other currently unknown locations where bull trout are vulnerable to over-fishing. Access to local areas where bull trout congregate could result in serious damage to local populations due to increasing fishing pressure.

The special vulnerabilities of bull trout boil down to the possibility of habitat damage to the small streams used for spawning and rearing, and the potential for detrimental angling pressure as a result of access to staging or spawning locations. It is difficult to predict what impacts might occur in future in the LRMP area as a result of these special vulnerabilities. Part of this difficulty arises due to uncertainties surrounding what forestry practices will be permitted under "results based" rules near streams, which will be discussed later. Further, many of the impacts to this species will be determined by the exact locations of roads and cutblocks. The main contribution possible at the LRMP level of planning will be provision of strategic directions on how lower level planning should take into account the localized needs of bull trout.

The welfare of bull trout in future will probably vary according to the information available about the small streams used for spawning and rearing, and the special locations used for spawning and staging. The Morice River population is fortunate because work done there has identified a number of locations where bull trout are known to be vulnerable at staging or spawning locations. Little is known about such vulnerable locations elsewhere in the LRMP area. Bull trout elsewhere in the LRMP Area may fare better in future if more information is gathered on this issue.

4.3.8.3 Summary

Bull trout are widely distributed in the LRMP area. The species has been studied in the Morice River watershed, but little detailed information exists elsewhere. Bull trout share with many other aquatic organisms vulnerability to stream destabilization, excessive sedimentation, and elevated water temperature. However, bull trout may be particularly sensitive to all these influences because of the specie's unusual reliance on small streams for spawning and rearing, it's high degree of selectivity in choosing spawning sites, it's juveniles' reliance on interstitial spaces in the streambed for cover, and its adaptation to colder water than other fish living in the LRMP area. Bull trout are also vulnerable to over fishing at spawning locations and locations where migrating adults stage before spawning.

Due to the very local geographic scale at which these special vulnerabilities operate, and the changing rules regarding forestry operations around streams, this projection is not able to predict specific outcomes for bull trout as a result of the Base Case Simulation.

The welfare of bull trout in future will depend on the nature of protection afforded to small streams under the new “results based” rules, and on whether lower level planning takes appropriate steps to protect specific locations at which bull trout are especially vulnerable. The most important contribution the LRMP process can make for this species may be provision of strategic guidance to lower level planning on how planning and operations should deal with specific local sites where bull trout are vulnerable.

Finally, future welfare of bull trout will also depend on the availability of information regarding the specific locations at which bull trout are vulnerable. Information is reasonable in the Morice River watershed but very limited elsewhere.

4.4 Special and Rare Ecosystems

4.4.1 Riparian ecosystems

Riparian ecosystems have long been recognized as having special significance and value, not only because of their influence on adjacent aquatic ecosystems, but also as terrestrial systems in their own right. Riparian forests have strong and critical influences on stream ecosystems in particular, providing shade for temperature control, coarse woody debris for cover and channel structure, and leaf and needle fall for energy input to benthic invertebrate communities which provide food for fish (Murphy and Meehan, 1991). They also provide habitat to a varied community of wildlife, some of which is found nowhere else, and some of which exhibits preference for riparian habitats (Voller, 1998).

Riparian cottonwood forests along the Morice provide an outstanding example of important riparian habitat in the LRMP area. These forests and the large downed trees they provide to the river are a key influence on the physical structure of the floodplain and the fish habitat found there. They also provide potential denning habitat for fisher (Weir, 2003a), nest sites for pileated woodpeckers and several species of cavity nesting ducks (Campbell et al., 1990a; Campbell et al., 1990b), as well as excellent winter range for moose (A. Edie, pers. obs.). Given the large size of trees used by black bears for hibernation dens (Davis, 1996), I expect that the large cottonwood trees in this riparian habitat probably also offer the best trees available for hibernation dens in the LRMP area.

Floodplain forests along the Morice on other active floodplains in the LRMP area are highly important both as a critical influence on adjacent aquatic habitat, and also as special terrestrial habitats different from upland areas nearby. However, the same is not necessarily true for all other riparian habitats in the LRMP area. While most small streams will be profoundly affected by adjacent riparian forest for reasons which will be discussed later, not all riparian forests will be different from or more valuable than nearby upland habitats. Much of the literature suggesting that riparian habitats are uniquely valuable as terrestrial ecosystems comes from arid climates where riparian habitats are profoundly different from nearby upland areas (McGarigle and McComb, 1992). Investigations in other areas including coastal forest of the Pacific Northwest (McGarigle and McComb, 1992), deciduous forests of eastern North America (Murray and Stauffer, 1995), and boreal mixed wood forest in Alberta (Hannon et al., 2002) do not support the notion that all riparian areas are uniquely valuable as terrestrial habitats in comparison with upland areas.

Arguably perhaps, the work most applicable to the LRMP area on this issue is the study by (Hannon et al., 2002) in boreal forest of Alberta. In this study, the researchers found little difference in amphibian, mammal, or bird communities, and little difference in forest composition, between riparian and upland areas. The authors concluded that in their study area, riparian forests were not unique, and protection of old forests need not be located near water bodies. This study examined only riparian areas surrounding lakes and wetlands, so it is clearly not applicable to active floodplains of larger rivers. However, I would argue that it is applicable to riparian habitats along many smaller streams, wetlands and lakes of the LRMP area. Along many of these wetlands and water bodies, the influence of water processes is extremely limited in an uphill direction, and forest more than a few meters away appears little or not affected by its "riparian" status (A. Edie, pers. obs). In his study on fire history of forests, (Steventon, 2002) found no difference in fire history between forests in and out of riparian areas.

As will be discussed at greater length later, riparian forest along smaller streams in the LRMP will often warrant protection due to the strong influence such forest has on streams. However, the separate issue of whether such forests warrant protection on the basis of value *as a special terrestrial habitat per se* is, I think, less clear. There is an implication here for the LRMP process. If extra riparian forest is proposed for protection on the assumption that it is more valuable than other uphill sites, and this assumption is incorrect in many circumstances, options for protecting other forests which really do warrant special protection may be reduced unnecessarily.

Consequences for riparian habitats under Base Case Management are difficult to predict. This is primarily because the rules covering forestry operations in riparian areas are in a state of change, and partly because the landscape scale of analysis undertaken here is incapable of determining specific consequences at the scale that riparian effects would need to be evaluated. Further discussion of riparian habitats is provided in section 4.5 regarding aquatic ecosystems and fish.

4.4.2 Rare ecosystems

A total of 11 plant communities found in the LRMP area are currently listed as red or blue in B.C. A list of these communities, and a brief summary of their status in the LRMP area is provided in Table 8 below.

Table 8. Rare plant communities found in the Morice LRMP area.[30]

Name	Biogeoclimatic Site Unit(s)	Provincial Rank	Provincial List	Status In the Morice LRMP Area[31]
Bluegrass - slender wheatgrass	SBSdk/82	S1	Red	Rare grassland originally found on warm aspects in Bulkley Valley and Ootsa Lake areas. Now mostly converted to hay pasture.
Saskatoon / slender wheatgrass	SBSdk/81	S2	Red	Rare, found on dry rocky sites with warm exposure and base-rich parent materials.
Black cottonwood / red-osier dogwood - prairie rose	SBSdk/08	S2	Red	Limited to floodplains of large rivers, mostly the Bulkley and Morice within the LRMP area. Usually subject to repeated flooding.
Lodgepole pine / kinnikinnick	CWHws2/02	S2	Red	Rare dry forest found only on dry upper slopes.
Hybrid white spruce/ twinberry - coltsfoot	SBSdk/06 SBSmc2/05	S3	Blue	Widespread in LRMP area on sites slightly moister and richer than zonal. Rated blue because most examples have been logged.
Douglas-fir / feathermoss - stepmoss	SBSdk/04	S3	Blue	Mainly found on dry rocky sites along eastern ends of Francois and Babine Lakes.
Lodgepole pine / juniper / ricegrass	SBSdk/02	S3	Blue	Restricted to very dry, rocky nutrient poor sites. Poorly growing open pine stands with reindeer lichens.
Black cottonwood / red-osier dogwood	CWHws2/08	S3	Blue	Limited to active floodplains on large rivers.
Sitka spruce / salmonberry Wet Submaritime 2	CWHws2/07	S3	Blue	Limited to active floodplains on large rivers, on higher bench and flooded less often than Black Cottonwood community above.

[30] All ratings information is from (Province of B.C., 2003b)

[31] Unless otherwise indicated, status information is from (Banner et al., 1993)

Name	Biogeoclimatic Site Unit(s)	Provincial Rank	Provincial List	Status In the Morice LRMP Area[31]
Amabilis fir - western redcedar / devil's club Wet Submaritime	**CWHws2/06**	**S3**	**Blue**	**Common on small areas of seepage on lower slopes. Large fir trees. Rated blue because few sites are left unlogged.**
Amabilis fir - western redcedar / oak fern	**CWHws2/04**	**S3**	**Blue**	**Common on richer moist sites. Larger than average trees.**

Two plant communities found on dry sites in the SBSdk are red listed. The first, bluegrass-slender wheatgrass is listed as red, and is also ranked as S1 which means that it is considered to be critically imperilled within B.C.. S1 is the most seriously imperilled rating available provincially. The second, Saskatoon/slender wheat grass, is listed as red, and rated as S2, which means that it is imperilled, but not as critically as S1. Both of these plant communities occur at low elevations within the settlement and agricultural zone of the SBSdk, often on private land. Most of the bluegrass – slender wheatgrass sites are already converted into hayfields. Although PEM mapping suggests that some 600 ha each of these remains undeveloped, this estimate is likely too high. PEM mapping cannot be trusted to identify these types accurately. PEM will sometime err by missing sites, and more often will predict sites where they do not exist (Banner, 2003). Neither of these two communities is likely to be logged because they do not support forests. The main risks to these communities will be agricultural development to bluegrass – slender wheatgrass community, and housing development to both communities. Agricultural impacts to bluegrass-slender wheatgrass communities can arise both as a result of intense agricultural development such as cultivation, and also as a result of grazing by livestock. Impacts from grazing are probably more widespread due to the extensive nature of grazing tenures.

The other red listed community in the SBSdk is Black cottonwood / red-osier dogwood - prairie rose, which is rated as S2. This community is found along the Bulkley and Morice Rivers, but sites along the Bulkley are in poor or marginal condition due to impacts of settlement and agriculture, and are threatened in the long term by erosion control measures. Sites along the Morice River are in excellent condition (Haeussler, 1998). PEM indicates that around 5500 ha of this community exists in the LRMP area, all but about 1000 ha of which is excluded from the THLB due to proximity to rivers or because black cottonwood is the leading species. In the SELES simulation done for this risk assessment, the 1000 ha within the THLB was logged, presumably because the leading species was spruce. Risks to long term welfare of this community include development for settlement or agriculture, logging (to whatever degree may be permitted under new rules for riparian areas), and changes in succession caused by erosion and flood control measures. This community will continue to thrive along the Morice River provided that natural flood processes are permitted to continue, and that cottonwood forest is protected from logging.

The only red listed community in the CWHws2 is Lodgepole pine / juniper / ricegrass, which is rated as S2. PEM mapping should be reasonably accurate for this type given the distinctive landscape position it is found on, and the presence of lodgepole pine as a leading species. This type is only found along the western ends of Morice, Nanika, Tahtsa, , and Ootsa Lakes, likely on southern exposures. PEM indicates that around 2000 ha of this type exists there, but less than 100 ha is included in the THLB. Risk to this community is uncertain, but will presumably be determined by whether logging activities occur along the large lakes where this type is found, and whether the forests are economic to log. This community is fire dependent, and long term fire suppression could result in its replacement by hemlock dominated forest (Haeussler, 1998)

Hybrid white spruce/ twinberry – coltsfoot is found in both SBSdk and SBSmc2, and it listed as blue, and rated as S3 which means that the community is considered vulnerable, but not under as immediate a threat as S2. This community is widespread in both BEC units. It is found on sites which are moister and more nutrient rich than zonal sites, and tree growth is consequently attractive for harvest. PEM indicates that about 26,000 ha exists in the SBSdk, and 12,000 of that is in the THLB. PEM does not differentiate this type from SBSmc2/06, so no separate estimate for the blue listed community is available for SBSmc2. SBSmc2/06 combined with hybrid white spruce/ twinberry – coltsfoot is found on about 175,000 ha, about 140,000 of which are in the THLB. Hybrid white spruce/ twinberry – coltsfoot was extensively logged in the SELES simulation, resulting in a substantial reduction in prevalence of older aged stands. However, because the trend is driven by SBSmc2 data in which hybrid white spruce/ twinberry – coltsfoot is combined with another type, predicted changes for blue listed type itself are not available. It is probably safe to assume that the main risk to this plant community will be logging, and that many or most accessible examples will be logged unless contrary decisions are made.

Two more dry plant communities are blue listed in the SBSdk subzone, Douglas-fir / feathermoss – stepmoss, which is according to PEM not found in the LRMP area, and Lodgepole pine / juniper / ricegrass, of which about 1000 ha exists in the LRMP area. The latter type is a low productivity pine forest. Only about 260 ha of the 1000 ha in the LRMP was within the THLB for the simulation, but enough of it was logged in the simulation to shift the age structure toward younger age classes. Risks to this type are likely smaller than those to white spruce/ twinberry – coltsfoot because timber values are smaller.

Two flood plain communities in the CWHws2 are blue rated, Black cottonwood / red-osier dogwood, and Sitka spruce / salmonberry Wet Submaritime 2. Only 100 ha of the former and 360 of the latter are predicted by PEM to be present in the LRMP area. Two other blue listed communities are found in the CWHws2 variant, Amabilis fir - western redcedar / devil's club Wet Submaritime, and Amabilis fir - western redcedar / oak fern. Both are found on local areas of seepage and rich soils. All of these last four sites in the CWH are very limited in their distribution, and simulation results provide no useful information. The two floodplain sites may receive protection due to their riparian location and/or deciduous type. The two Amabilis fir – western red cedar types would most likely be logged if nearby locations are because they are rich sites which produce attractive timber. Risk to all these four types will depend on how much development occurs along the western ends of Morice, Nanika, Tahtsa, and Whitesail Lakes. If development occurs there, the Amabilis fir communities will be most at risk because they would not be afforded protection by riparian or deciduous status.

4.4.2.1 A note of perspective

It should be noted here that existing information on rare plant communities has important limitations. First, PEM mapping does not adequately document the location and extent of ecosystems currently recognized as rare. Neither the forest inventory nor subsequent use of it under PEM was specifically intended to document rare ecosystems. Particular attention to rare ecosystems could improve reliability of mapping (Haeussler, 2003), but by nature of their rarity, accurate mapping of these systems requires specific effort in the field.

Second, and more fundamentally, the list of plant communities (Site Series and Site Associations) described to date under the BEC classification system does not identify all rare plant communities which may deserve consideration. The intent of the current list was not to separate out and describe rare communities. In the words of (Banner et al., 1993), “No guide can encompass all the complexity and diversity in the landscape. The recognized site units cover relatively common ecosystems sampled…” A recent study in the SBSdk (Haeussler, 1998) found several communities which had not previously been described, but in Haeussler’s opinion deserved listing as red or blue.

In order for rare ecosystems to be recognized, considered, and where appropriate, protected, work like that done by (Haeussler, 1998) will have to be extended to other areas. Until such work is completed, understanding of risks to rare ecosystems will remain incomplete.

4.4.2.2 Summary

Of the three red listed communities in the SBSdk, Saskatoon/slender wheat grass and Bluegrass-slender wheatgrass are found on dry low elevation sites which are at risk more from housing and agricultural development than forestry. The third red listed SBSdk site, Black cottonwood / red-osier dogwood - prairie rose is confined to floodplains of the Bulkley and Morice Rivers. Bulkley examples of Black cottonwood/red osier dogwood are generally in poor condition due to housing development, flood control works, and agricultural activity, and will likely continue to be at risk from all these influences due to the degree of development in the Bulkley Valley. Morice examples of this community are still in excellent condition, and will remain so, provided that normal flood processes are allowed to continue, and the forest is not logged.

The one red listed community in the CWHws2, Lodgepole pine / juniper / ricegrass, is predicted to occur along the western ends of Morice, Nanika, Tahtsa, , and Ootsa Lakes, likely on southern exposures. Risk to this community is uncertain, but will presumably depend on whether logging activities occur in this area, and whether the forests prove economic to log. This community is fire dependent, and long term fire suppression could result in its replacement by hemlock dominated forest.

Strategic direction from the LRMP Table may reduce risk to rare ecosystems which are currently recognized under the BEC classification system. However, the success of strategic direction will be limited because existing inventory is not accurate, and in any case, the BEC system does not recognize all plant communities which may deserve consideration. Field inventory will be required in order to properly identify rare ecosystems and improve decisions about their protection and management.

4.5 Aquatic ecosystems and fish.

Fish populations in the LRMP area are diverse and important. Babine sockeye runs support a regionally important commercial fishing industry out of Prince Rupert and elsewhere, and support a number of First Nations fisheries on the Skeena and Babine Rivers. Nanika sockeye also provide fish both to Wet'suwet'en fishery at Moricetown, as well as to other downstream fisheries undertaken by other First Nations. Coho salmon, chinook salmon, and especially steelhead in the Babine and Morice/Bulkley systems host a fish guiding industry known internationally for its exceptional angling opportunities, and provide unguided anglers with world class fishing opportunity. Other lakes and streams also provide numerous local fisheries for resident rainbow trout, cutthroat trout, lake trout, or burbot. Other fish species present in the LRMP area include blue listed (Province of B.C., 2003b) cutthroat, dolly varden , and bull trout , as well as kokanee, mountain whitefish, lake whitefish, pygmy whitefish, lake chub, long-nose sucker, large scale sucker, long nose dace, redside shiner, prickly sculpin, and Pacific lamprey (Bustard and Schell, 2002; Schell, 2003a).

Habitat requirements and living strategies of these species are very diverse, as are conservation issues presented by them. Some of this diversity is summarized briefly in Table 9.

Table 9. Life history and conservation concerns for selected fish species.[32]

Species	Major life history characteristics	Main conservation concerns
Sockeye salmon	- spawn in fall in streams, or sometimes on lakeshores, rear in lakes for 1-2 years. - fall spawning means eggs are vulnerable to scouring during high water during fall storms, and freezing during winter. - juveniles in lakes, so not subject to freezing during winter in rivers.	- native populations depressed by commercial fishery focused on enhanced stocks. - some local stocks (Maxan, Bulkley Lakes) near extirpation due to combination of fishery, recent years of very low flows in upper Bulkley, and water quality problems in the upper Bulkley.
Pink salmon	- spawn in fall in streams, immediately migrate to sea after hatching, so juveniles not subject to winter risks in fresh water habitat.	- no major problems, current populations are high by historical standards.
Coho salmon	- spawn in fall in streams, sometimes very small ones, rear 1-2 years in river side channels, low gradient tributaries, and off channel habitats such as beaver ponds. - overwintering juveniles subject to several risks including freezing during low water.	- populations seriously depressed due in part to sockeye fishery; perhaps recovering since fishery curtailed. - sensitive to damage to small streams, and to low flows which do not permit access upstream of good rearing habitat.
Chinook salmon	- spawn in fall and rear 1- 2 years in mainstems of larger rivers. - juveniles generally in deeper water and less likely to freeze during winter.	- recent spawning runs in Morice are large by historical standards. - both spawning and rearing habitats may be fully utilized at current run sizes.
Steelhead	- spawn in spring in streams, sometimes very small ones, sometimes large. - rear in streams similar to those used by chinook. - spring spawning means eggs vulnerable to high spring runoff, but not freezing.	- current population status debated, but adult escapement at least in the Morice River seems too small to result in all juvenile habitat being occupied. - sensitive to damage to small streams.
Bull trout	- spawn in fall in particular locations in small streams. - juveniles rear in small streams, adults sometimes remain in small streams, sometimes live in lakes, and sometimes in larger rivers.	- current population status relative to historical levels unknown. - unusually susceptible to angling while enroute to spawning locations. - vulnerable to damage to small streams, unusually vulnerable to increased temperature.
Lake trout	- spawn, rear, and live as adults in larger lakes.	- populations often slow growing and easily over-exploited by angling.
Cutthroat trout	- spawn and sometimes rear in small streams, usually live as adults in small lakes.	- current status of populations probably variable locally, but uncertain. - sensitive to alteration of small streams, particularly barriers to migration between small streams and the lakes to which juveniles migrate.

Table 9 illustrates that, even among salmon and trout, there is tremendous variability in life history, habitat use, population status, and conservation problems.

[32] Information in Table from (Bustard and Schell, 2002;Schell, 2003a)

The complexity of aquatic systems doesn't stop with life histories and interactions among fish species. The physical processes and characteristics of the aquatic ecosystems used by fish are deeply complex and diverse. Lakes are different from rivers, large rivers from small streams, steep streams from low gradient ones, streams with much bedload from streams with little, streams cooled all summer by snowmelt from those warmed by lakewater, streams with stable flows from streams with dramatically variable ones, and so on.

This complexity makes generalizations regarding risks a challenge. However, several general risks are apparent, and will be discussed in the next section below.

4.5.1 Projection, and summary of risks to aquatic ecosystems.

Projection of the likely consequences of Base Case Management for fish and aquatic ecosystems is difficult because the rules which govern logging and other forestry activities near streams are in transition. If transition to the new Forest and Range Practices Act (Province of B.C., 2003c) results in changes in practices near streams, it will take time before sufficient experience has been accumulated to judge the effects of these changes. In the meantime until the nature of changes, if any, are determined and their effects observed, potential consequences of future forest development for fish and aquatic ecosystems will remain uncertain.

In face of this uncertainty, this section of this report will do two things:

- describe selected risks to aquatic ecosystems, and provide examples within the LRMP area. This will in part be a summary of work presented to the LRMP Table already by (Schell, 2003a), and of other recent reviews by (Bustard and Schell, 2002) and (Gottesfeld et al., 2002).
- offer my thoughts on how these risks may be affected by changes in the current rules regarding relevant forest practices.

Among the various risks identified by Schell (2003a) Bustard and Schell (2002) and Gottesfeld et al. (2002) to fish and aquatic ecosystems, I believe four general categories are the most important: alteration of stream channel structure, change in stream flow regime, change in stream temperature, and stream siltation. Each of these is discussed briefly below.

4.5.1.1 Stream channel structure

The physical structure of streams, and the availability and organization of fish habitat in them, is a dynamic equilibrium between hydraulic forces of moving water, and the resistance to those forces provided by streambed and streambank materials, riparian vegetation and its roots, and woody debris in or near stream channels. Woody debris plays a key role, particularly in small streams. It stores bedload material, including at times, high quality spawning gravels. By breaking stream gradient into steps, it provides a greater diversity of habitats, particularly low gradient ones, in the stream channel. By causing localized scour during high water, it provides pool structures for fish and other organisms which prefer pool habitats. It also provides cover for fish, and a stable substrate for other organisms (see reviews by Swanston, 1991).

The interaction between forestry operations and stream channel structure is extremely complex (see reviews by Swanston, 1991). Very broadly speaking, any major change in:

- flow regime, particularly peak flows,
- amount of sediment and bedload delivered to or moving through a stream channel,
- stability of existing, and delivery of new, large woody debris, or
- stability of streambanks

can be expected to alter channel structure. Interactions among different types of influences is common. For example, increased peak flows can destabilize woody debris, which causes stored sediment and bedload to be released for transport, which can cause channel aggradation (filling in) and bank erosion, which in turn adds more bedload, and so on. Streambank damage by logging, and direct damage to woody debris in the channel, can make it easier for altered peak flows to cause structural change. Any given influence on flow, bedload functioning, or bank stability has the potential to cascade through other secondary effects to cause more change than was initially obvious.

On the other hand, organisms must to some degree be adapted to dealing with structural change. Periodic high flows which move bedload, add, remove, and re-position woody debris, and cause bank erosion and lateral channel movement are normal processes in many if not most stream channels used by fish. Many of the channel structures which provide important stream habitat are constructed during and dependent on such high flows. Were it not for the deep scouring which occurs around channel obstructions during high flows, pools would not be formed and kept in place. Periodic high flows also sort and flush gravel used for spawning. Even spectacular changes in stream structure sometimes result in only temporary reductions in fish populations (Swanston, 1991).

Whether a given impact on a particular stream will result in structural change important to fish, and for how long, will depend on numerous details including the fish species and life stage being considered, and especially how the contemplated impact compares in magnitude with the natural channel processes at the site of the disturbance and downstream. Some streams and reaches will be far more tolerant to disturbance than others are.

(Bustard and Schell, 2002;Schell, 2003a) identified the following specific issues or locations which they judged as important with regard to channel structure:

Morice River from Gosnell Creek to Owen Creek – this reach of the main Morice River includes major spawning areas for pink salmon (90% of Morice run), coho salmon, and steelhead, especially in side channels, plus significant spawning areas for chinook salmon in the main river as far downstream as Lamprey Creek . It also includes very important rearing habitat for juvenile chinook salmon, coho, and steelhead.

Side channels in this reach are particularly important, and are potentially vulnerable to alteration by construction or logging on the floodplain. Supply of water to side channels is usually dependent on structural controls which direct water away from the main channel. These structural controls are often tree root systems (Chamberlin et al., 1991) at least on small and moderate sized rivers, but on larger rivers, rooting depth may be insufficient to control erosion (Province of B.C., 1995b). Logging or road construction which removes or interferes with control structures at the heads of side channels, be these tree roots, log jams or other influences, could destabilize water flow to side channels from the main river, and damage important fish habitat as a result. Side channels are sometimes dependent on groundwater input from adjacent valley walls, and road construction could intercept and re-direct such water to the detriment of fish habitat in the side channel.

In addition to the issue with side channels along this reach, another stability issue arises as a result of logging moving into steeper tributaries on the west side of the Morice River along this reach. Because of their gradient and size, several of these tributaries may be capable of moving considerable extra bedload and sediment into the Morice River as a result of logging and road building impacts. Increases in sedimentation may damage the extensive spawning habitats in this reach, and could alter stream channel structure to the detriment of fish habitat.

Small streams/fish passage – One structural attribute of streams is the ability of fish to move upstream in them. Culvert and bridge installation on small streams can completely block access to important habitat, and this impact can last as long as the offending structure does. This potential problem can arise anywhere in the LRMP area for a number of species, but two species in particular deserve mention here. Juvenile coho are particularly susceptible to culvert placements on river floodplains. In spring during the high water period, juveniles move from the main river and side channels into off channel habitats, often in, or accessed by, very small tributaries. These small streams are easily blocked by culverts, thereby making it impossible for juvenile coho to reach important off-channel habitat. Providing upstream passage for coho fry during spring high water is difficult because these small fish can only achieve sustained velocities of less than 0.4 meters per second (Furniss et al., 1991). The second species which is particularly vulnerable to culvert installations is cutthroat trout. The problem is similar to the one regarding coho, namely providing upstream passage for juvenile trout. This species sometimes spawns in small streams downstream from the lake used by adults. Culvert installation between spawning locations and lakes could isolate juveniles from lake habitat. Fish passage issues arise for other species as well, perhaps especially bull trout, rainbow trout, and Dolly Varden.

A key aspect of this problem is that, if a drainage structure blocks fish passage, that impact is permanent unless the structure is replaced. Numerous locations along Highway 16 and the CNR railway near the upper Bulkley River are good examples of this problem. The impacts of some of these structures (or absence of structures where side channels have been isolated without installing even a culvert) have now persisted for a half century.

Sites at which fish passage problems may occur, especially where passage of juvenile fish may be required, are not necessarily be obvious to forestry staff, and if they are not recognized, damage may be done without anyone realizing that a problem with fish passage existed.

An aquatic and riparian habitat assessment on the lower Nadina Watershed (Oikos Ecological Services Ltd., 1999, 1999; SKR Consultants Ltd. and Oikos Ecological Services Ltd., 1999) found that logging had destabilized alluvial fans in the Cliff, Shelford, and Poplar North Sub-basins, and recommended evaluation for potential restorative work. The study also identified a more widespread long term impact on stream channel stability. Considerable lengths of tributary streams were logged to the streambank prior to implementation of 30-50 meter buffers, and this has left many small streams without a supply of large organic debris. Recovery of large organic debris inputs will take something like another 50-70 years on most sites.

4.5.1.2 Stream flow

Stream flow in the LRMP area is affected by land use in primarily two ways. The first is removal of water from streams for domestic or irrigation use, an issue which is unlikely to be significant anywhere other than the upper Bulkley system (Schell, 2003a). The second issue is the effects of forestry operations on stream flow.

Forest harvest and road development affect stream flow in several ways (see review by Chamberlin et al. (1991). First, the removal of forest means that more snow and rain will reach the ground rather than being intercepted by trees and returned to the atmosphere by evaporation. Second, the removal of trees means less water pumped out of the soil and lost as evaporation from leaves or needles. The combination of these two effects means more water in the soil, and more water reaching streams after logging. Increased water yield after logging has been observed in several studies.

The second way forest harvest affects stream flow is by altering snow accumulation and melt patterns. Clearings develop deeper snowpack than forest does, partly because snow is intercepted by trees and evaporated, and partly because wind tends to deposit snow in clearings. In addition to accumulating more snow, clearings lose it quicker during spring snowmelt. However, the change in the rate of melt depends on exposure of the clearing to sun and wind, so actual results for individual small watersheds can vary. In any event, the overall effect of alteration in snow processes in most areas of the LRMP will likely be an increase in peak flow during spring snowmelt. In the nearby Stuart-Takla Fisheries/Forestry Interaction Project just north-east of the LRMP, peak spring runoff from two partially logged watersheds increase by up to more than 100% due to alterations in snow accumulation and melt patterns.

Finally, the third way that forest operations can alter stream flow is by altering soil conditions or routes of water movement though soil. Except during exceptional storm events or prolonged rainy periods, forest soils normally conduct virtually all water to streams via sub-surface routes. However when an area is developed for logging, road building, yarding, burning, scarification, and compaction of soils by logging equipment can all interfere with movement of water into and through the soil to watercourses. Water moving through road ditches may get there quicker than it would have before roads were built. On the other hand, water may be delayed or prevented from getting to streams if it is blocked by soil compaction.

The combined result of changes in loss of water from forest canopy, changes in snow accumulation and snow melt, and changes in water movement routes to streams is very complex. The end result for a given watershed will depend not only on what happens in and near a given cutblock, but also the timing of effects relative to other influences on flow in the watershed. Although a given cut block may increase peak flows in the area immediately downstream, it may decrease peak flows elsewhere by “getting rid” of snow before other locations reach peak snowmelt. In addition to the issue of spatial synchrony, seasonal issues are also important. Even if greater water yield during spring snowmelt occurs as a result of logging in a particular watershed, flows in the same watershed during low flow periods in late summer may be reduced. Interaction between effects is also possible. Increased peak flows during spring could cause channel changes which make impacts of lowered late summer flows worse (e.g. aggraded channels could dewater altogether, loss of coarse woody debris could reduce pool habitat and cover used as refuge during low flows). There is much to be learned about such interactions, especially in the long term, and especially in interior watersheds such as are typical in the LRMP area.

The only specific problem identified by Schell (2003a) regarding stream flow is the upper Bulkley which has experienced a continuing trend toward lower late summer flows for several years. Schell believes that, given the recent trends in streamflow in the upper Bulkley, pro-active intervention will be required just to keep flows at their current levels.

4.5.1.3 Stream temperature

Removal of streamside vegetation causes warming of streams primarily by exposing them to direct sunshine (Chamberlin et al., 1991), but recent evidence suggests that some warming may also occur as a result of warmer soil temperatures and consequent warmer ground water, and as a result of heat conduction from stream substrates. Removal of streamside vegetation can also result in stream cooling in fall due to increased radiation of heat into the atmosphere (Macdonald et al., 2003).

Impacts on fish and aquatic ecosystems as a result of warming are complex. Hypothetically at least, slight warming of some cool northern streams might be a benefit. However, evidence suggests that local fish populations are often adapted to local environmental conditions and timing, and hypothetical advantages of warmer water can turn out to be problems. In the Carnation Creek study, quicker development and earlier departure of coho to sea as 1 year olds did not translate into more returning adults because ocean survival of 1 year old fish was poor. Similarly, chum salmon which went to sea earlier as a result of higher temperatures also met with lower ocean survival (Hicks et al., 1991). Consequently unless specific information suggests otherwise, it would not be prudent to assume temperature benefits for fish.

(Bustard and Schell, 2002; Schell, 2003a) identify several specific temperature risks within the LRMP area:

Nadina River – As discussed above, this river hosts a number of important fish populations, and in particular, some 14,000 (but up to over 50,000) sockeye, about 9% of the Nechako sockeye run. This river is warm because of the influence of Nadina and Newcombe Lakes; temperatures up to 22.6 have been measured, which are above BC guidelines for spawning and rearing salmonids, and are close to the 25.8 degrees observed as lethal to sockeye salmon (Bjornn and Reiser, 1991). These temperatures are also far higher than the 12-14 degrees preferred by native salmonids in the area (Bjornn and Reiser, 1991), and are high enough to exclude rearing bull trout (Haas, 2001).

Cool tributaries draining the northern slopes of the Shelford Hills have been demonstrated to exert a cooling influence on Nadina River. Currently these tributaries are being managed as temperature sensitive, and 30 meter buffers are being left pending further research into means for avoiding temperature impacts.

An aquatic and riparian habitat assessment on the lower Nadina Watershed (Oikos Ecological Services Ltd., 1999, 1999; SKR Consultants Ltd. and Oikos Ecological Services Ltd., 1999) found that, prior to implementation of streamside buffers, logging had removed forest along considerable lengths of tributary stream, thereby reducing stream shading and potentially exacerbating high water temperatures in tributaries and the lower Nadina River. However, in most areas, deciduous regrowth was providing some shade already, and conifer stocking was already established. The report recommended planting of conifers in some under-stocked locations to provide more shading in the long term as well as assist with other riparian functions such as provision of large woody debris.

Owen and Lamprey Creeks - These warm, lake-headed tributaries provide important habitat for Morice River steelhead. They are warm enough already that even small temperature increases could shift the fish community away from steelhead and towards long nose dace.

Other temperature sensitive systems - Other systems known to be temperature sensitive include upper Bulkley River, Gloyazikut Creek, and Hautete Creek. Generally, any lake headed stream with significant fish populations can be considered potentially temperature sensitive (Schell, 2003b).

4.5.1.4 Stream siltation

Addition of fine sediment to spawning gravel can reduce survival of eggs or recently hatched fish, and can trap young fish below the surface of the gravel (see review by Chamberlin et al., 1991). It can also interfere with primary production and invertebrate abundance, thereby reducing food availability for rearing fish. While the detrimental impacts of large amounts of sediment on benthic communities are generally accepted, precise thresholds at which damage become serious are not clear (Hicks et al., 1991), and importance in a given instance would have to be judged in the context of natural sediment regimes in the waters affected.

Generally, siltation effects tend to be temporary except for those associated with long term road use and maintenance. In the nearby Stuart-Takla Fisheries/Forestry Interaction Project just north-east of the LRMP, in two partially logged watersheds sediment production during spring runoff recovered to pre-logging levels in 2-3 years.

Direct impacts on fish and their habitat are not the only problems presented by siltation. In some locations, such as the Morice River, unseasonal turbidity can also substantially interfere with important recreational fisheries.

Sedimentation is probably most important in particular streams or reaches in which normal sediment loads are low, and in which flows may not vary enough to flush sediments from spawning gravels. Two important examples are documented by Bustard and Schell (2002) and Schell (2003a), numerous smaller but functionally similar examples probably exist elsewhere in the LRMP area.

Morice River from Morice Lake to Gosnell Creek – This section of the Morice River provides spawning habitat for 80% of the large Morice chinook salmon run, is used by smaller numbers of steelhead and coho, is a core year-round holding and feeding area for adult bull trout, and provides important habitat for adult Morice rainbow trout. Flows and sediment levels in this reach are buffered by Morice Lake, consequently natural sediment inputs are low and the ability of the reach to flush sediment is limited. Major input of suspended sediments or fine bedload to this section of river could be highly detrimental to major fish populations. Great care in managing riparian zones on tributaries to this reach is needed, and Bustard and Schell (2002) suggest that some high risk tributaries may need to be excluded from logging due to the high sensitivity of this reach to siltation.

Nanika River from Nanika Falls to Glacier Creek - This area is the only significant spawning area for the Nanika sockeye run, and the only known spawning area for the population of resident rainbow trout using Nanika River, Morice Lake, and upper Morice River. This area is also used by small runs of chinook and coho, and small numbers of steelhead. It is the second of only two key year-round holding areas for Morice bull trout. This reach has a sensitivity to siltation similar to that described above for the upper Morice.

Nadina River

The Nadina river below Nadina and Newcombe Lakes supports a run of about 14,000 sockeye, and a few chinook salmon. The river is also used by rainbow trout from Francois and possibly Tagetochlain Lakes for spawning, and provides rearing habitat for a substantial proportion of juveniles rainbow trout for Francois Lake. Bull trout also spawn in the river, although summer temperatures are too high for this species, so juveniles may move into colder tributaries to rear.

In addition to its temperature sensitivity, which was discussed earlier, this river also shares the sensitivity to siltation that upper Morice and Nanika rivers do.

Other important spawning areas – Other key spawning areas vulnerable to siltation are:

- for steelhead, Owen, Lamprey and Shea Creeks; Upper Thautil above Starr Creek;
- for coho, Gosnell Creek, especially the mainstem and tributaries upstream of Shea Creek;
- for bull trout, upper headwaters of Gosnell Creek are key for Morice fish, Glacier Creek is key for Nanika fish; Denys, Lojuh and upper Starr Creeks are important; and Houston Tommy and Gold Creek have some spawning in them.

4.5.1.5 Projection summary and perspective

Projected forest development in the LRMP area has the potential to harm fish habitat and aquatic ecosystems, particularly through influences on stream channel structure (including barriers to fish passage), increased peak flows and/or decreased low flows, increased stream temperature, and increased siltation. Whether potential impacts will occur in a given locality will depend on the nature of the site being developed, and on how well operations are planned and executed.

One final element of perspective should be raised. Although the ultimate capacity of stream habitat to support fish in the LRMP might be reduced by forest development, it is less clear whether or when this might cause reductions in fish populations. Many fish populations are currently limited more by fishing than by habitat. Bustard and Schell (2002) argued strongly that the combination of commercial, First Nations, and recreational kill is probably a far greater influence than habitat is on populations of salmon and steelhead in the Morice Watershed. They argued further that lake trout, bull trout and rainbow trout may, given decades of liberal catch regulations, also be currently limited by recreational catch, not by habitat.

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Appendix 1. Ecological composition of LRMP area.

	Babine Upland	Bulkley Basin	Bulkley Ranges	Kimsquit Mountains	Kitimat Ranges	Manson Plateau	Nass Mountains	Nechako upland	Total ha in BEC unit
AT	0	0	50	39	2	0	5	1	98
CWHws 2	0	0	0	45	0	0	0	0	45
ESSFmc	38	38	116	1	0	2	0	26	221
ESSFmcp	2	1	30	0	0	0	0	0	34
ESSFmk	0	0	47	92	0	0	0	0	139
ESSFmkp	0	0	13	31	0	0	0	0	45
ESSFmv 3	20	0	0	0	0	5	0	0	25
ESSFmvp3	1	0	0	0	0	0	0	0	1
MH mm 2	0	0	0	7	1	0	0	0	8
MH mmp2	0	0	0	6	0	0	0	0	6
SBS dk	1	124	0	0	0	0	0	3	128
SBS mc 2	312	88	188	0	0	3	0	118	710
SBS wk 3	41	0	0	0	0	1	0	0	42
Total ha in Ecosection	416	251	445	222	3	12	5	147	1502

Note: Table contents are areas in 1000's of hectares.

Appendix 2. Regional representation within current protected areas.

In the following summary tables, all areas are expressed in 1000's of hectares. BEC variants not found in the Morice LRMP area, and those which individually make up less than 1% of the LRMP area are aggregated under "Other Variants". This was done to limit the size of the table, and focus on representation of BEC units important within the LRMP area.

The protected areas listed are those which are believed to be functional in a representation or "Goal 1" role, not merely a special features or "Goal 2" role . Accordingly, protected areas less than 200ha are excluded from the summary.

Babine Upland:

	ESSF mc	ESSF mv 3	SBS dk	SBS mc 2	SBS wk 3	Other Variants	Total Area
Total area in Ecosection	95.8	183.9	119.4	792.6	197.8	651.5	2041.0
% of Ecosection	4.7	9.0	5.8	38.8	9.7	31.9	100.0
Babine River Corridor	0.0	0.0	0.0	10.5	0.0	0.0	10.5
Mount Blanchet	0.0	0.1	0.0	0.0	2.1	0.0	2.3
Mudzenchoot	0.0	0.6	0.0	0.0	0.0	0.0	0.6
Rubyrock Lake	0.0	0.0	7.8	17.0	0.5	15.9	41.2
Stuart Lake	0.0	0.0	0.3	0.0	0.0	0.0	0.3
Sutherland River	0.0	0.0	9.0	3.5	0.0	1.0	13.6
Sutherland River - (PA)	0.0	0.0	3.4	1.3	0.0	0.1	4.8
Torkelson Lake - (ER)	0.0	0.0	0.0	0.2	0.0	0.0	0.2
Total ha Protected	0.0	0.8	20.6	32.6	2.6	17.1	73.7
% Protected in Ecosection	0.0	0.4	17.3	4.1	1.3	2.6	3.6

Bulkley Basin:

	ESSFmc	SBS dk	SBS mc 2	Other Variants	Total ha
Total area in Ecosection	53	918	268	82	1,320
% of Ecosection	4.0	69.5	20.3	6.2	100.0
Babine Mountains	0.0	0.1	2.1	0.0	2.2
Burnt Cabin Bog - (ER)	0.0	0.0	0.7	0.0	0.7
Entiako	0.0	1.1	0.0	0.0	1.1
Entiako - (PA)	0.0	11.7	0.0	0.0	11.7
Francois Lake	0.0	0.1	2.5	4.6	7.2
Morice River - (ER)	0.0	0.4	0.0	0.0	0.4
Nechako Canyon - (PA)	0.0	1.2	0.0	0.0	1.2
Tweedsmuir North	0.0	5.4	0.0	0.0	5.4
Uncha Mountain Red Hills	0.0	7.4	1.9	0.0	9.3
Total ha Protected	0	27	7	5	39
% Protected in Ecosection	0.1	3.0	2.7	5.7	3.0

Bulkley Ranges:

(There are currently no significantly sized protected areas in the Bulkley Ranges Ecosection, so no table is presented.)

Kimsquit Ranges:

	AT un	AT unp	CWH ws 2	ESSF mk	ESSF mkp	MH mm 2	Other Variants	Total
Total area in Ecosection	39	203	145	121	31	138	86	763
% of Ecosection	5	27	19	16	4	18	11	100.0
Kitlope Heritage Conservancy	0.0	34.4	16.0	0.0	0.0	19.2	18.4	88
Tweedsmuir (South)	0.0	1.5	0.0	0.0	0.0	0.0	0.2	2
Tweedsmuir North	0.0	34.1	12.6	24.4	0.0	10.8	0.0	82
Currently protected ha	0	70	29	24	0	30	19	172
Currently protected %	0.0	34.4	19.7	20.2	0.0	21.8	21.6	22.5

Nechako Upland:

	AT unp	ESSFmc	SBS dk	SBS mc 2	Other Variants	Total
Total area in Ecosection	59	266	29	383	3	741
% of Ecosection	7.9	35.9	3.9	51.8	0.4	100.0
Entiako - (PA)	0.0	0.9	2.9	0.0	0.0	4
Tweedsmuir (South)	10.6	61.2	0.0	88.1	0.1	160
Tweedsmuir North	47.6	160.5	6.1	142.3	2.2	359
Total ha Protected	58	223	9	230	2	522
% Protected in Ecosection	99.0	83.7	30.7	60.1	70.3	70.5

Appendix 3. 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.

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., 2002b). 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, nonmerchantable forest types, sites with low timber growing potential, roads and landings, and areas uneconomic to harvest (Province of B.C., 2002b).

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., 2002b; 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.

Appendix 4. Forest age composition by BEC subzone/variant.

The table below illustrates changes in forest age composition over the 250 year Base Case Simulation for BEC units in which significant amounts of logging occurred.

Columns 2 through 8 show the percentage of each BEC unit that is covered by of forest of each age class. RNV (Range of Natural Variation is the median, maximum, and minimum percentages which occurred in 100 sample landscapes generated by the Natural Case Simulation. Columns under "Percent Composition by Age" show percent composition over time during the Base Case Simulation. Columns under "RNV Index" shows relative departure from the natural median. An RNV index between 1 and -1 means the managed forest is within the Range of Natural Variation. Values more than one means there is more of that type of forest than is natural, and values less than -1 means that there is less of that type than natural.

An RNV Index of 2 would mean that the observed percent composition was twice as far from the median as the maximum percentage observed in the 100 Natural Case landscapes. For example, ESSFmk for year 250 is calculated: RNV Index for age class 3 = (Observed %-Natural median%)/(Natural median%- Natural minimum%) = (74.1-87.3)/(87.3-84.5) = -4.7.

LU	AGECLASS	RNV			Percent Composition by Age					RNV Index				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
ESSFmk	0	3.8	6.6	2.0	4.0	6.5	10.5	12.2	11.5	0.1	1.0	2.4	3.0	2.7
	1	5.1	8.1	2.1	5.7	4.9	3.8	9.8	10.0	0.2	-0.1	-0.4	1.6	1.6
	2	3.4	5.6	1.8	3.5	3.5	4.5	2.6	4.3	0.1	0.1	0.5	-0.5	0.4
	3	87.3	91.1	84.5	86.8	85.1	81.2	75.3	74.1	-0.2	-0.8	-2.2	-4.3	-4.7
ESSFmv3	0	8.2	21.3	2.8	8.3	29.1	46.3	30.0	27.6	0.0	1.6	2.9	1.7	1.5
	1	11.6	21.9	5.0	8.1	6.1	7.3	43.6	43.6	-0.5	-0.8	-0.7	3.1	3.1
	2	6.6	14.3	1.7	10.4	8.8	6.6	3.9	6.4	0.5	0.3	0.0	-0.6	0.0
	3	72.5	84.1	59.6	73.1	56.0	39.8	22.6	22.3	0.1	-1.3	-2.5	-3.9	-3.9
SBSmc2	0	25.8	36.7	15.2	26.7	49.9	52.5	43.1	47.2	0.1	2.2	2.4	1.6	2.0
	1	26.3	35.6	15.6	16.4	13.3	18.2	40.9	35.4	-0.9	-1.2	-0.8	1.6	1.0
	2	11.8	18.1	6.6	19.1	12.2	11.0	6.4	8.3	1.2	0.1	-0.2	-1.1	-0.7
	3	35.5	44.9	26.2	37.8	24.6	18.4	9.7	9.2	0.3	-1.2	-1.9	-2.8	-2.9
ESSFmc	0	18.5	28.1	11.2	10.1	24.5	35.4	25.7	24.5	-1.2	0.6	1.8	0.8	0.6
	1	20.7	27.7	12.7	13.3	10.1	10.3	34.3	33.1	-0.9	-1.3	-1.3	1.9	1.8
	2	10.6	15.1	5.4	12.4	11.5	9.8	5.8	9.0	0.4	0.2	-0.1	-0.9	-0.3
	3	50.5	58.3	42.4	64.3	53.8	44.4	34.1	33.4	1.8	0.4	-0.7	-2.0	-2.1
SBSwk3	0	27.1	42.9	13.8	24.4	55.5	59.6	36.8	40.0	-0.2	1.8	2.1	0.6	0.8
	1	27.1	38.2	11.3	3.3	4.1	15.2	47.1	40.0	-1.5	-1.5	-0.8	1.8	1.2
	2	11.8	21.7	5.1	18.1	7.7	4.6	5.7	10.2	0.6	-0.6	-1.1	-0.9	-0.2
SBSwk3 cont.	3	34.2	46.2	22.2	54.2	32.8	20.6	10.3	9.8	1.7	-0.1	-1.1	-2.0	-2.0

LU	AGECLASS	RNV			Percent Composition by Age					RNV Index				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
SBSdk	0	35.8	50.0	18.4	28.4	39.0	35.6	39.4	38.1	-0.4	0.2	0.0	0.3	0.2
	1	28.7	41.4	16.3	33.0	31.5	34.2	37.0	39.3	0.3	0.2	0.4	0.7	0.8
	2	11.0	18.3	5.0	18.3	15.1	17.9	14.9	14.0	1.0	0.6	0.9	0.5	0.4
	3	23.6	34.3	15.6	20.3	14.4	12.3	8.6	8.6	-0.4	-1.1	-1.4	-1.9	-1.9
CWHws2	0	7.6	14.1	3.6	4.5	5.1	6.4	8.5	9.1	-0.8	-0.6	-0.3	0.1	0.2
	1	10.1	16.6	3.7	0.4	0.4	0.4	2.3	3.6	-1.5	-1.5	-1.5	-1.2	-1.0
	2	5.9	11.6	2.1	2.3	2.2	2.2	2.2	5.3	-0.9	-1.0	-1.0	-1.0	-0.1
	3	75.8	83.3	68.0	92.8	92.3	91.0	87.0	82.0	2.2	2.2	2.0	1.5	0.8

The table below shows simulation results for BEC units in which little or no logging took place, and little or none of the BEC unit was within the THLB. Blank cells signify that none of that age class was present in that year.

LU	AGECLASS	RNV			Percent Composition by Age					RNV Index				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
ATp	0	0.6	14.0	0.1	13.3	13.3	13.3	13.3	13.3	0.9	0.9	0.9	0.9	0.9
	1	0.7	8.9	0.1	0.1	0.1	0.1	0.1	0.1	-1.0	-1.0	-1.0	-1.0	-1.0
	2	0.6	12.2	0.1	3.1	3.1	3.1	3.1	3.1	0.2	0.2	0.2	0.2	0.2
	3	98.5	100.0	85.3	83.5	83.5	83.5	83.5	83.5	-1.1	-1.1	-1.1	-1.1	-1.1
ESSFmcp	0	11.9	23.1	5.3	4.0	6.4	8.3	6.3	7.1	-1.2	-0.8	-0.5	-0.8	-0.7
	1	15.8	30.6	7.5	9.9	9.8	9.8	14.1	12.8	-0.7	-0.7	-0.7	-0.2	-0.4
	2	8.3	17.0	3.0	11.0	10.9	10.9	10.8	11.9	0.3	0.3	0.3	0.3	0.4
	3	62.5	76.9	50.5	75.1	72.9	71.0	68.8	68.2	0.9	0.7	0.6	0.4	0.4
ESSFmkp	0	2.7	10.9	0.6	2.2	2.8	4.1	3.0	2.8	-0.2	0.0	0.2	0.0	0.0
	1	3.7	7.6	0.8	0.1	0.1	0.1	2.0	2.2	-1.2	-1.2	-1.2	-0.6	-0.5
	2	2.5	5.9	0.2	1.7	1.7	1.7	1.7	1.7	-0.4	-0.4	-0.4	-0.4	-0.4
	3	91.0	95.3	85.0	96.0	95.4	94.2	93.4	93.3	1.2	1.0	0.7	0.5	0.5
ESSFmvp3	0	6.9	28.2	0.2	6.2	6.2	7.4	6.2	7.4	-0.1	-0.1	0.0	-0.1	0.0
	1	3.3	23.4	0.2				1.2					-0.7	
	2	2.4	33.2	0.2	1.9	1.9	1.9	1.9	1.9	-0.2	-0.2	-0.2	-0.2	-0.2
	3	98.8	100.0	63.5	91.9	91.9	90.7	90.7	90.7	-0.2	-0.2	-0.2	-0.2	-0.2
MHmm2	0	2.8	17.9	0.0	3.8	3.8	3.8	3.8	3.8	0.1	0.1	0.1	0.1	0.1
MHmm2 cont.	1	5.0	19.3	0.0										
	2	2.9	14.1	0.0	1.0	1.0	1.0	1.0	1.0	-0.7	-0.7	-0.7	-0.7	-0.7
	3	87.3	97.0	71.8	95.2	95.2	95.2	95.2	95.2	0.8	0.8	0.8	0.8	0.8
MHmmp2	0	3.9	26.0	0.6	13.6	13.6	13.6	13.6	13.6	0.4	0.4	0.4	0.4	0.4
	1	4.5	26.0	0.6										

LU	AGECLASS	RNV			Percent Composition by Age					RNV Index				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
	2	2.6	20.8	0.6										
	3	99.4	100.0	74.0	86.4	86.4	86.4	86.4	86.4	-0.5	-0.5	-0.5	-0.5	-0.5

Appendix 5. Forest age composition by Landscape Unit.

The following table follows the format used for BEC subzones in the previous Appendix. Landscape units are sorted according to how far they departed from the RNV for old forest during the 250 year simulation. Units which departed the farthest are at the top of the table.

LU	AGECLASS	RNV			Percent Composition by age					RNV departure				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
NorthBabine	0	22.3	38.5	7.5	37.4	53.8	51.6	39.3	45.1	0.9	1.9	1.8	1.0	1.4
	1	23.3	36.1	13.8	4.4	7.5	20.7	39.0	32.5	-2.0	-1.7	-0.3	1.2	0.7
	2	11.1	18.7	5.7	13.9	9.7	7.7	11.7	12.1	0.4	-0.3	-0.6	0.1	0.1
	3	41.6	58.0	32.1	44.3	29.1	20.0	9.9	10.2	0.2	-1.3	-2.3	-3.3	-3.3
Kidprice	0	20.0	30.6	9.5	25.2	45.3	45.6	40.9	41.0	0.5	2.4	2.4	2.0	2.0
	1	21.5	32.5	11.2	12.6	13.1	20.1	35.7	35.3	-0.9	-0.8	-0.1	1.3	1.3
	2	10.0	16.9	4.2	8.4	7.3	7.4	5.3	5.9	-0.3	-0.5	-0.4	-0.8	-0.7
	3	48.5	59.7	39.2	53.8	34.4	26.9	18.0	17.8	0.5	-1.5	-2.3	-3.2	-3.3
Thautil	0	20.6	32.6	9.4	8.5	34.4	43.1	26.2	30.8	-1.1	1.2	1.9	0.5	0.8
	1	22.6	33.4	12.3	13.6	8.3	11.3	40.3	34.3	-0.9	-1.4	-1.1	1.6	1.1
	2	11.1	18.5	4.9	35.7	20.0	12.5	9.1	15.2	3.3	1.2	0.2	-0.3	0.6
	3	45.0	56.8	36.0	42.1	37.3	33.2	24.4	19.8	-0.3	-0.9	-1.3	-2.3	-2.8
Fulton	0	25.0	35.8	13.0	24.2	48.3	47.7	44.9	41.8	-0.1	2.1	2.1	1.8	1.6
	1	25.3	36.2	16.7	21.0	17.0	18.1	37.6	38.1	-0.5	-1.0	-0.8	1.1	1.2
	2	11.5	19.3	6.4	17.4	10.5	15.1	4.6	7.6	0.8	-0.2	0.5	-1.3	-0.8
	3	37.3	49.8	28.2	37.4	24.2	19.2	12.9	12.4	0.0	-1.4	-2.0	-2.7	-2.7
TochchaNatow	0	22.9	35.9	11.3	22.4	45.5	50.0	38.7	38.0	0.0	1.7	2.1	1.2	1.2
	1	23.8	33.7	11.8	10.1	10.1	17.7	43.1	41.4	-1.1	-1.1	-0.5	1.9	1.8
	2	10.7	18.0	5.2	12.4	8.5	7.6	5.7	8.6	0.2	-0.4	-0.6	-0.9	-0.4
	3	43.0	50.6	31.2	55.1	36.0	24.7	12.6	12.0	1.6	-0.6	-1.5	-2.6	-2.6
Morrison	0	24.3	35.3	11.9	18.2	43.5	46.9	36.5	39.0	-0.5	1.7	2.0	1.1	1.3
	1	25.2	36.6	17.0	17.6	13.2	18.0	41.6	36.9	-0.9	-1.5	-0.9	1.4	1.0
	2	11.1	20.1	5.9	20.2	15.1	13.0	7.8	11.0	1.0	0.4	0.2	-0.6	0.0
	3	39.0	52.0	28.9	44.0	28.2	22.1	14.1	13.0	0.4	-1.1	-1.7	-2.5	-2.6
Buck	0	25.7	37.1	12.4	31.2	40.2	46.6	43.7	39.7	0.5	1.3	1.8	1.6	1.2
	1	25.1	33.2	14.6	13.2	14.1	19.5	33.6	36.9	-1.1	-1.0	-0.5	1.1	1.5
	2	11.1	21.3	5.3	11.6	8.5	10.4	8.6	9.2	0.1	-0.4	-0.1	-0.4	-0.3
	3	38.2	50.8	28.4	44.0	37.3	23.5	14.0	14.2	0.5	-0.1	-1.5	-2.5	-2.5
Tahtsa	0	24.6	34.7	11.4	27.4	46.9	60.4	32.1	54.3	0.3	2.2	3.5	0.7	2.9
	1	25.1	35.1	14.5	10.1	11.8	12.5	48.4	26.5	-1.4	-1.3	-1.2	2.3	0.1
Tahtsa cont.	2	11.5	22.0	5.4	21.2	11.2	6.6	7.1	7.5	0.9	-0.1	-0.8	-0.7	-0.7
	3	37.7	52.7	26.9	41.2	30.2	20.5	12.5	11.6	0.2	-0.7	-1.6	-2.3	-2.4
Valley	0	28.8	43.4	12.6	18.1	30.1	37.0	34.8	33.5	-0.7	0.1	0.6	0.4	0.3
	1	26.6	39.5	13.4	34.4	29.2	25.4	41.5	41.3	0.6	0.2	-0.1	1.2	1.1

LU	AGECLASS	RNV			Percent Composition by age					RNV departure				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
	2	11.4	17.3	4.9	22.7	20.3	18.0	10.2	11.8	1.9	1.5	1.1	-0.2	0.1
	3	32.9	45.6	24.7	24.8	20.4	19.5	13.5	13.5	-1.0	-1.5	-1.6	-2.4	-2.4
Nadina	0	26.4	37.2	11.7	24.3	47.1	45.9	40.6	44.4	-0.1	1.9	1.8	1.3	1.7
	1	24.7	35.6	14.9	15.8	10.9	20.8	36.0	31.5	-0.9	-1.4	-0.4	1.0	0.6
	2	11.3	18.9	6.6	16.1	11.8	8.0	5.5	6.7	0.6	0.1	-0.7	-1.2	-1.0
	3	37.4	46.9	28.7	43.9	30.1	25.3	17.9	17.4	0.7	-0.8	-1.4	-2.2	-2.3
HoustonTommy	0	24.9	45.6	12.8	17.5	47.8	51.5	32.7	35.0	-0.6	1.1	1.3	0.4	0.5
	1	25.5	40.5	8.7	12.0	8.1	15.3	43.0	36.8	-0.8	-1.0	-0.6	1.2	0.8
	2	10.8	20.8	5.9	21.9	10.3	7.3	7.4	7.9	1.1	-0.1	-0.7	-0.7	-0.6
	3	37.1	52.2	28.3	48.6	33.8	25.9	16.9	20.3	0.8	-0.4	-1.3	-2.3	-1.9
Topley	0	23.1	51.7	11.8	7.4	17.4	31.4	43.7	40.7	-1.4	-0.5	0.3	0.7	0.6
	1	24.6	41.2	12.6	53.4	38.9	17.8	36.7	38.5	1.7	0.9	-0.6	0.7	0.8
	2	11.4	21.2	4.8	12.8	18.5	29.3	4.7	9.2	0.1	0.7	1.8	-1.0	-0.3
	3	40.7	56.0	26.9	26.4	25.2	21.5	14.9	11.7	-1.0	-1.1	-1.4	-1.9	-2.1
Gosnell	0	18.1	30.5	8.8	9.1	34.8	47.5	29.3	27.6	-1.0	1.4	2.4	0.9	0.8
	1	20.3	34.9	10.3	1.7	0.7	3.6	37.8	36.8	-1.9	-2.0	-1.7	1.2	1.1
	2	10.2	16.0	4.3	20.1	11.9	6.6	6.1	9.8	1.7	0.3	-0.6	-0.7	-0.1
	3	50.4	65.1	38.6	69.1	52.5	42.4	26.7	25.9	1.3	0.1	-0.7	-2.0	-2.1
Troitsa	0	4.2	10.6	1.1	3.9	7.9	13.5	16.6	16.6	-0.1	0.6	1.5	1.9	2.0
	1	5.5	12.4	2.5	0.7	0.7	0.6	9.8	7.6	-1.6	-1.6	-1.7	0.6	0.3
	2	3.7	7.9	1.1	4.8	3.0	3.2	3.0	6.1	0.2	-0.3	-0.2	-0.3	0.6
	3	85.9	90.5	77.4	90.6	88.4	82.8	70.6	69.7	1.0	0.5	-0.4	-1.8	-1.9
Parrotts	0	30.3	50.8	14.5	33.5	55.2	55.8	33.7	52.7	0.2	1.2	1.2	0.2	1.1
	1	27.8	41.5	16.2	19.9	17.5	19.7	49.6	29.4	-0.7	-0.9	-0.7	1.6	0.1
	2	11.6	21.1	5.4	11.0	3.6	8.5	5.6	8.5	-0.1	-1.3	-0.5	-1.0	-0.5
	3	29.9	40.5	17.2	35.7	23.8	16.0	11.0	9.4	0.6	-0.5	-1.1	-1.5	-1.6
Granisle	0	24.9	47.0	5.1	37.4	46.6	44.0	46.4	46.7	0.6	1.0	0.9	1.0	1.0
	1	25.7	40.9	16.0	18.4	19.0	21.1	33.6	33.4	-0.7	-0.7	-0.5	0.5	0.5
	2	11.5	25.3	3.9	21.3	14.6	17.0	10.7	11.9	0.7	0.2	0.4	-0.1	0.0
	3	36.7	55.8	18.9	22.9	19.9	17.9	9.3	8.1	-0.8	-0.9	-1.1	-1.5	-1.6
Owen	0	30.0	47.7	12.5	28.8	47.8	47.1	39.7	38.9	-0.1	1.0	1.0	0.5	0.5
	1	27.2	40.9	14.4	19.2	13.4	19.9	35.3	34.7	-0.6	-1.1	-0.6	0.6	0.5
	2	11.5	20.4	4.2	13.5	13.3	13.0	11.0	12.2	0.2	0.2	0.2	-0.1	0.1
Owen cont.	3	31.3	44.2	18.8	38.5	25.6	20.1	14.0	14.2	0.6	-0.5	-0.9	-1.4	-1.4
Whitesail	0	23.2	40.3	12.3	9.1	26.1	37.8	45.4	38.3	-1.3	0.2	0.9	1.3	0.9
	1	23.9	37.0	12.5	14.4	8.6	8.9	29.1	34.6	-0.8	-1.3	-1.3	0.4	0.8
	2	11.0	24.2	4.4	15.1	12.4	9.5	1.9	3.4	0.3	0.1	-0.2	-1.4	-1.2
	3	40.7	53.4	26.9	61.4	53.0	43.9	23.6	23.6	1.6	1.0	0.3	-1.2	-1.2
Nanika	0	4.6	9.0	0.5	7.1	7.1	7.1	7.1	7.1	0.6	0.6	0.6	0.6	0.6
	1	5.7	13.8	1.4	0.9	0.9	0.9	0.9	0.9	-1.1	-1.1	-1.1	-1.1	-1.1
	2	3.3	12.0	0.8	5.3	5.3	5.3	5.3	5.3	0.2	0.2	0.2	0.2	0.2

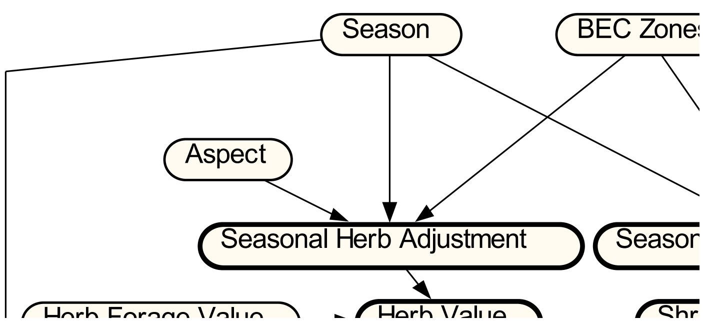
LU	AGECLASS	RNV			Percent Composition by age					RNV departure				
		MEDIAN %	Maximum %	Minimum %	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250	Yr. 0	Yr. 25	Yr. 50	Yr. 100	Yr. 250
	3	85.2	92.9	79.6	86.8	86.8	86.8	86.8	86.8	0.2	0.2	0.2	0.2	0.2
Sibola	0	6.0	13.7	2.0	2.4	6.2	11.3	7.8	9.0	-0.9	0.0	0.7	0.2	0.4
	1	8.3	14.7	2.1	0.7	0.1	0.1	7.7	6.0	-1.2	-1.3	-1.3	-0.1	-0.4
	2	5.1	11.1	2.0	2.0	2.2	1.4	1.2	2.3	-1.0	-0.9	-1.2	-1.3	-0.9
	3	80.1	89.2	70.3	94.9	91.5	87.2	83.3	82.7	1.6	1.2	0.8	0.3	0.3
Burnie	0	2.8	8.4	0.4	4.4	4.4	4.4	4.4	4.4	0.3	0.3	0.3	0.3	0.3
	1	4.0	7.3	0.9	0.8	0.8	0.8	0.8	0.8	-1.0	-1.0	-1.0	-1.0	-1.0
	2	2.7	5.6	0.4	3.1	3.1	3.1	3.1	3.1	0.2	0.2	0.2	0.2	0.2
	3	90.3	93.9	85.3	91.7	91.7	91.7	91.7	91.7	0.4	0.4	0.4	0.4	0.4
MoriceLake	0	9.4	16.2	2.9	5.6	7.2	6.2	6.3	6.4	-0.6	-0.3	-0.5	-0.5	-0.5
	1	10.2	17.9	5.3	0.4	0.2	2.4	4.6	4.4	-2.0	-2.1	-1.6	-1.1	-1.2
	2	5.8	9.9	1.9	3.4	2.5	1.9	1.7	4.9	-0.6	-0.8	-1.0	-1.0	-0.2
	3	74.5	83.8	65.5	90.7	90.2	89.5	87.4	84.2	1.7	1.7	1.6	1.4	1.0

Appendix 6. The Grizzly Bear Model

The computer model which was used to predict habitat suitability and value for grizzly bears was 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, 2003a).

Grizzly bear habitat model:



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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. Both outputs are presented in graphics and tables in this report.

Appendix 7. Grizzly bear projection

The tables below show summarized projections of grizzly bear habitat ratings by Landscape Unit. For brevity, the tables show only the combined area of moderate or higher rated habitats. Units are 1000's of Hectares.

Projection of grizzly bear spring habitat by LU:

LU	Rating Type	Year				
		1	25	50	100	250
Buck	**Val.**	5.2	2.9	2.2	1.3	1.1
	Suit.	14.1	11.9	11.0	10.0	9.7
Burnie	**Val.**	2.2	2.2	2.2	2.2	2.2
	Suit.	2.2	2.2	2.3	2.2	2.3
Fulton	**Val.**	16.3	9.0	6.5	3.1	2.4
	Suit.	33.4	27.6	21.7	19.6	19.3
Gosnell	**Val.**	7.5	2.9	2.1	1.0	0.7
	Suit.	9.2	7.7	6.5	4.6	4.7
Granisle	**Val.**	1.7	0.9	0.6	0.2	0.1
	Suit.	5.3	4.1	3.2	2.0	1.7
HoustonTommy	**Val.**	3.6	1.9	1.4	0.8	0.5
	Suit.	8.2	6.3	5.3	4.2	4.0
Kidprice	**Val.**	8.9	3.7	2.7	1.0	0.7
	Suit.	18.6	12.8	9.7	8.5	7.8
MoriceLake	**Val.**	5.7	5.3	5.2	5.1	3.7
	Suit.	6.7	6.5	6.3	6.3	5.7
Morrison	**Val.**	27.3	12.8	9.9	6.2	5.1
	Suit.	35.6	29.1	24.5	19.8	20.0
Nadina	**Val.**	17.6	5.6	4.5	3.0	2.4
	Suit.	26.0	20.1	16.5	14.8	14.3
Nanika	**Val.**	2.4	2.4	2.4	2.4	1.9
	Suit.	2.4	2.4	2.4	2.4	2.4
NorthBabine	**Val.**	10.3	6.3	4.9	3.6	3.1
	Suit.	19.4	15.9	12.8	11.7	12.3
Owen	**Val.**	5.2	3.1	2.4	1.8	1.7
	Suit.	11.8	10.3	8.9	8.0	7.7
Parrotts	**Val.**	3.0	1.9	1.7	1.3	1.1
	Suit.	10.2	8.7	7.8	6.7	6.9
Sibola	**Val.**	4.4	3.8	3.3	2.9	2.2
	Suit.	4.4	4.2	3.8	3.5	3.4
Tahtsa	**Val.**	16.4	4.0	3.0	1.9	1.5
	Suit.	19.8	16.3	13.4	9.5	11.4
Thautil	**Val.**	6.5	2.8	2.3	1.4	1.0
	Suit.	9.5	8.2	6.9	5.7	5.8
TochchaNatowite	**Val.**	7.4	5.0	3.7	1.3	1.0
	Suit.	21.7	16.5	12.9	9.0	8.6
Topley	**Val.**	3.8	2.4	1.6	0.5	0.3

LU	Rating Type	Year				
		1	25	50	100	250
	Suit.	5.2	5.6	5.1	2.9	2.7
Troitsa	**Val.**	3.0	2.3	2.1	1.4	1.2
	Suit.	3.0	2.8	2.6	2.4	2.3
Valley	**Val.**	9.3	7.6	6.1	3.5	3.1
	Suit.	28.4	27.7	25.3	22.0	21.8
Whitesail	**Val.**	14.1	4.3	3.5	1.7	1.5
	Suit.	14.1	12.3	9.8	6.7	6.5

Val. = Habitat Value; Suit. = Forage Suitability

Projection of grizzly bear summer habitat by LU:

LU	Rating Type	Year				
		1	25	50	100	250
Buck	**Val.**	13.6	9.7	8.2	6.2	5.6
	Suit.	28.0	26.3	23.1	21.8	21.1
Burnie	**Val.**	19.2	18.6	18.4	18.2	18.0
	Suit.	19.2	19.2	19.2	19.2	19.2
Fulton	**Val.**	27.7	19.3	15.8	9.8	8.5
	Suit.	47.7	43.9	36.2	33.8	33.5
Gosnell	**Val.**	23.9	13.9	11.8	8.6	7.2
	Suit.	27.5	25.5	23.2	18.6	18.8
Granisle	**Val.**	4.9	3.3	2.7	1.2	0.8
	Suit.	9.5	8.9	7.1	6.9	6.9
HoustonTommy	**Val.**	14.8	10.9	9.1	6.8	5.7
	Suit.	20.2	18.6	16.6	14.2	14.2
Kidprice	**Val.**	32.7	21.5	18.1	10.4	8.5
	Suit.	42.6	38.6	33.0	30.7	29.3
MoriceLake	**Val.**	36.5	36.1	35.7	34.9	29.7
	Suit.	37.5	37.2	36.9	36.9	35.7
Morrison	**Val.**	37.5	21.2	17.0	11.5	9.5
	Suit.	45.9	43.2	36.2	31.5	32.3
Nadina	**Val.**	37.6	19.6	16.9	12.7	11.3
	Suit.	48.3	43.1	37.4	34.9	34.7
Nanika	**Val.**	18.9	18.9	18.9	18.8	15.6
	Suit.	18.9	18.9	18.9	18.9	18.9
NorthBabine	**Val.**	13.9	9.1	7.1	5.1	4.5
	Suit.	23.8	21.5	17.7	15.7	17.0
Owen	**Val.**	11.6	7.9	6.3	4.8	4.4
	Suit.	22.1	20.7	18.0	16.3	16.1
Parrotts	**Val.**	4.8	3.4	3.0	2.5	2.2
	Suit.	13.4	11.9	10.3	8.3	8.8
Sibola	**Val.**	28.2	27.2	25.9	24.2	21.8
	Suit.	28.2	28.0	27.5	26.4	26.5

LU	Rating Type	Year				
		1	25	50	100	250
Tahtsa	**Val.**	28.9	10.9	9.0	6.6	5.8
	Suit.	32.7	30.2	27.1	19.2	24.2
Thautil	**Val.**	19.6	13.9	12.3	10.1	8.2
	Suit.	22.6	21.6	19.8	17.2	17.2
TochchaNatowite	**Val.**	22.1	14.8	11.4	6.1	5.1
	Suit.	44.5	35.6	28.4	22.9	22.2
Topley	**Val.**	8.9	7.2	6.2	3.6	2.8
	Suit.	11.1	12.3	11.8	9.3	9.4
Troitsa	**Val.**	27.3	25.4	24.1	18.1	16.2
	Suit.	27.3	26.9	25.9	23.5	23.0
Valley	**Val.**	24.6	21.0	18.5	13.7	12.3
	Suit.	51.2	50.9	46.6	42.3	41.3
Whitesail	**Val.**	23.8	13.8	11.9	7.8	7.0
	Suit.	23.8	23.3	20.7	17.0	16.9

Projection of grizzly bear fall habitat by LU:

LU	Rating Type	Year				
		1	25	50	100	250
Buck	**Val.**	1.5	0.4	0.2	0.1	0.1
	Suit.	4.8	2.7	2.2	1.3	1.2
Burnie	**Val.**	1.8	1.7	1.7	1.7	1.7
	Suit.	1.8	1.8	1.8	1.8	1.8
Fulton	**Val.**					
	Suit.	16.8	9.8	7.1	3.3	3.2
Gosnell	**Val.**	6.4	1.9	1.3	0.6	0.4
	Suit.	8.4	6.2	4.7	3.0	2.9
Granisle	**Val.**	1.3	0.5	0.2	0.1	0.1
	Suit.	4.6	3.5	2.7	1.2	1.0
HoustonTommy	**Val.**	2.7	1.2	0.8	0.3	0.2
	Suit.	5.9	3.5	2.5	1.7	1.6
Kidprice	**Val.**	6.3	2.4	1.8	0.8	0.6
	Suit.	14.5	8.5	6.0	3.8	3.6
MoriceLake	**Val.**	4.2	3.7	3.6	3.4	2.5
	Suit.	5.1	4.9	4.8	4.5	4.1
Morrison	**Val.**	16.7	5.8	4.0	2.1	1.4
	Suit.	23.2	15.1	11.9	8.7	7.6
Nadina	**Val.**	9.0	1.3	1.0	0.5	0.3
	Suit.	13.5	8.7	6.1	4.0	3.5
Nanika	**Val.**	0.8	0.8	0.8	0.8	0.7
	Suit.	0.8	0.8	0.8	0.8	0.8
NorthBabine	**Val.**	5.6	2.3	1.7	0.9	0.7
	Suit.	13.3	8.9	6.8	5.4	5.2
Owen	**Val.**	2.3	0.5	0.3	0.1	0.1

LU	Rating Type	Year				
		1	25	50	100	250
	Suit.	4.9	3.4	2.6	1.6	1.5
Parrotts	**Val.**	0.4	0.1	0.0	0.0	0.0
	Suit.	1.5	1.1	0.8	0.6	0.5
Sibola	**Val.**	2.7	2.2	1.9	1.7	1.5
	Suit.	2.7	2.4	2.0	1.8	1.8
Tahtsa	**Val.**	6.9	0.4	0.3	0.1	0.1
	Suit.	8.8	4.9	2.6	1.1	0.9
Thautil	**Val.**	4.3	1.4	1.1	0.7	0.5
	Suit.	6.0	4.2	3.5	2.3	2.2
TochchaNatowite	**Val.**	4.2	2.0	1.2	0.2	0.2
	Suit.	11.7	7.9	5.6	2.2	2.0
Topley	**Val.**	2.9	1.5	1.0	0.4	0.3
	Suit.	3.9	4.2	3.7	1.7	1.5
Troitsa	**Val.**	1.5	1.0	0.9	0.6	0.5
	Suit.	1.5	1.3	1.1	0.9	0.8
Valley	**Val.**	2.8	1.9	1.2	0.5	0.3
	Suit.	9.6	7.8	6.5	4.2	4.1
Whitesail	**Val.**	9.6	1.5	1.1	0.5	0.4
	Suit.	9.6	7.1	5.1	2.0	1.8

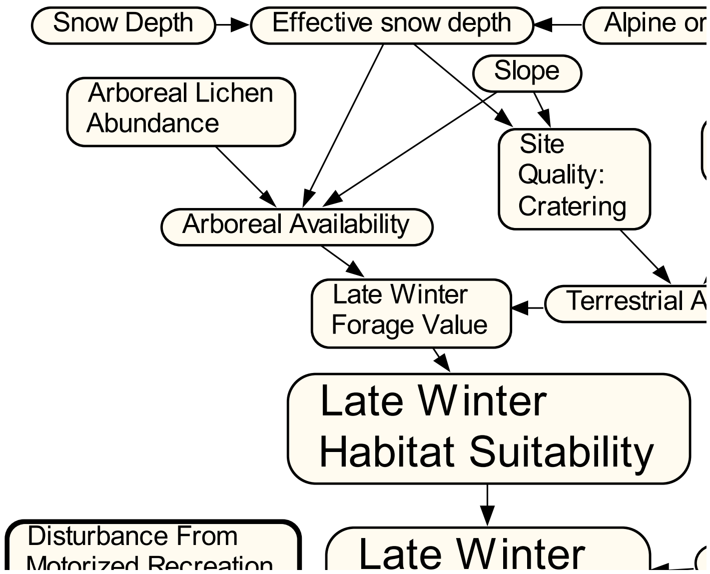
Appendix 8. Caribou models

The basic function of the caribou models was similar to the grizzly bear models described above. Three models were 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.

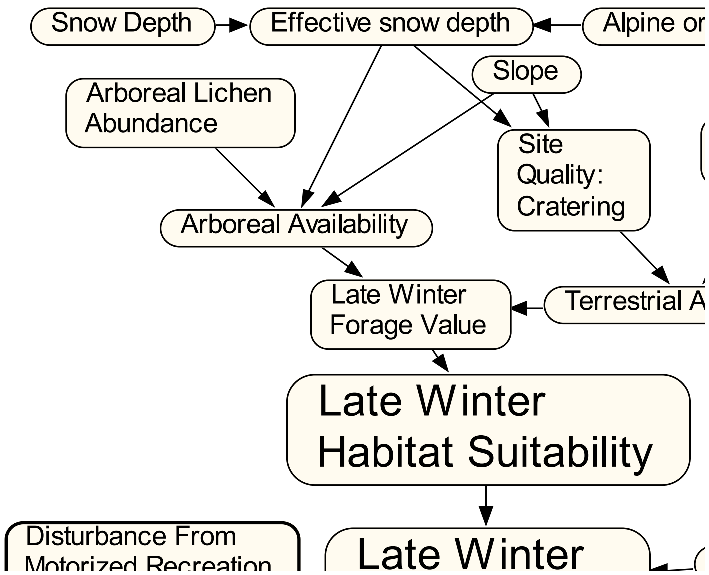
Winter Habitat Model

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

Caribou winter habitat model:


Snow Depth
Effective snow depth
Alpine or
Slope
Arboreal Lichen Abundance
Site Quality: Cratering
Arboreal Availability
Late Winter Forage Value
Terrestrial A
Late Winter Habitat Suitability
Disturbance From Motorized Recreation
Late Winter

shppict



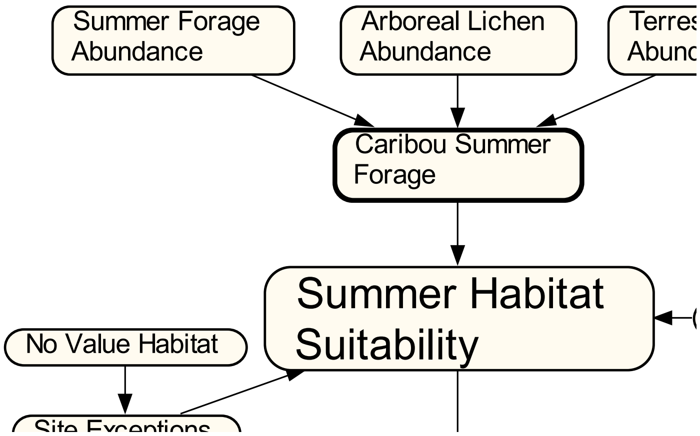
The model produces two outputs, late winter habitat suitability, and late winter habitat value. Suitability is derived from abundance and availability of terrestrial lichens (those that grow on the ground) and/or aboreal lichens (those that grow on trees), which are in turn predicted on the basis of 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.

<u>Summer Habitat Model</u>

A schematic of the Netica summer habitat model is shown below

Caribou summer habitat model:



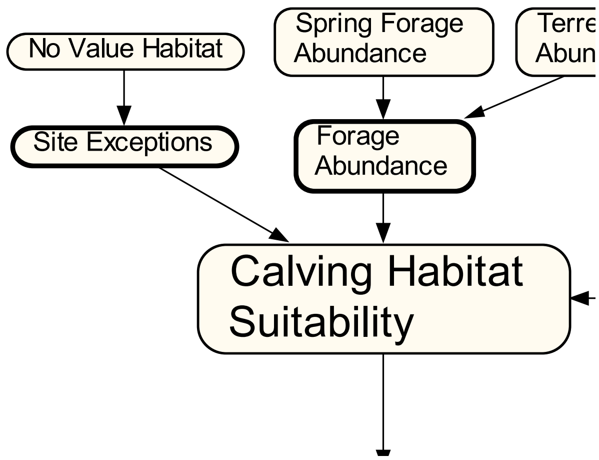
As the winter model did, the summer model produces two outputs, habitat suitability and habitat value. Habitat suitability is derived from abundance of terrestrial lichens, arboreal lichens, and other forage species, as modified by terrain (higher elevations and islands are better) or by special habitat 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.

<u>Calving Habitat Model</u>

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 9. Caribou Projection

Numbers in all tables are 1000's of hectares. BEC subzones with less than 1000 ha. of habitat of a given class are not shown.

Projection of caribou summer habitat suitability

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Takla	High	ESSFmv3	4.5	6.1	7.0	5.1	5.2
	Medium	ESSFmv3	15.6	14.0	13.1	14.9	14.9
		SBSmc2	22.5	16.0	12.3	12.3	12.6
		SBSwk3	15.9	9.4	6.7	6.9	7.8
		Total Medium	54.0	39.3	32.1	34.1	35.3
	Low	SBSmc2	77.1	83.6	87.3	87.4	87.0
		SBSwk3	25.9	32.4	35.0	34.8	33.9
		Total Low	102.9	116.0	122.4	122.1	120.9
Telkwa	High	ATp	25.7	25.7	25.7	25.7	25.7
		ESSFmc	16.2	20.0	20.3	17.3	16.9
		ESSFmcp	12.4	12.4	12.4	12.4	12.4
		ESSFmk	6.7	7.0	7.8	8.0	8.0
		ESSFmkp	3.6	3.6	3.6	3.6	3.6
		Total High	64.5	68.7	69.8	66.9	66.6
	Medium	ATp	1.0	1.0	1.0	1.0	1.0
		ESSFmc	17.0	18.5	18.0	19.0	18.9
		ESSFmcp	8.5	8.5	8.5	8.5	8.5
		ESSFmk	6.4	6.0	5.2	5.0	5.0
		ESSFmkp	5.6	5.6	5.6	5.6	5.6
		SBSdk	1.7	1.7	1.7	1.7	1.7
		SBSmc2	31.0	21.3	17.5	18.0	17.3
		Total Medium	71.3	62.6	57.5	58.8	58.0
	Low	ATp	3.1	3.1	3.1	3.1	3.1
		ESSFmc	46.3	41.0	41.2	43.2	43.6
		ESSFmk	7.3	7.3	7.3	7.3	7.3
		SBSdk	37.7	37.8	37.8	37.8	37.8
		SBSmc2	101.6	111.3	115.2	114.6	115.3
		Total Low	196.0	200.5	204.6	206.0	207.2

Projection of caribou summer habitat suitability continued.

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Tweedsmuir	**High**	**ATp**	22.5	22.5	22.5	22.5	22.5
		ESSFmc	9.0	9.6	9.4	9.0	9.0
		ESSFmcp	5.9	5.9	5.9	5.9	5.9
		ESSFmk	21.6	21.9	22.2	22.8	22.7
		ESSFmkp	10.9	10.9	10.9	10.9	10.9
		MHmm2	3.0	3.0	3.0	3.0	3.0
		MHmmp2	4.3	4.3	4.3	4.3	4.3
		Total High	77.2	78.2	78.2	78.5	78.4
	Medium	**ATp**	4.9	4.9	4.9	4.9	4.9
		CWHws2	1.4	1.4	1.4	1.4	1.4
		ESSFmc	7.1	6.5	6.4	7.2	7.2
		ESSFmcp	1.7	1.7	1.7	1.7	1.7
		ESSFmk	11.3	10.8	10.3	9.7	10.2
		ESSFmkp	3.2	3.2	3.2	3.2	3.2
		MHmm2	1.7	1.7	1.7	1.7	1.7
		SBSmc2	22.1	16.8	12.6	9.7	10.2
		Total Medium	53.4	47.0	42.3	39.5	40.5
	Low	**ATp**	5.8	5.8	5.8	5.8	5.8
		CWHws2	22.8	22.8	22.8	22.8	22.8
		ESSFmc	18.3	18.2	18.6	18.2	18.2
		ESSFmk	26.0	26.2	26.3	26.3	26.0
		MHmm2	2.4	2.4	2.4	2.4	2.4
		SBSdk	5.7	5.7	5.7	5.7	5.7
		SBSmc2	86.1	91.4	95.6	98.5	97.9
		Total Low	167.1	172.5	177.2	179.7	178.8

Projection of caribou summer habitat value

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Takla	**Good**	**ESSFmv3**	1.4	3.5	4.6	2.1	2.1
	Medium	**ESSFmv3**	18.1	15.1	13.4	13.2	11.2
		SBSmc2	19.7	13.4	10.7	8.9	8.3
		SBSwk3	14.0	10.3	8.2	6.1	5.5
	Total Medium		51.8	38.8	32.2	28.2	25.0
	Poor	**SBSmc2**	79.9	86.2	89.0	90.7	91.4
		SBSwk3	27.7	31.4	33.6	35.6	36.3
	Total Poor		107.6	117.6	122.5	126.3	127.6
Telkwa	**Good**	**ATp**	26.0	26.0	26.0	26.0	26.0
		ESSFmc	1.5	1.5	1.3	0.6	0.4
		ESSFmcp	14.3	14.3	14.3	14.2	14.1
		ESSFmkp	4.5	4.5	4.5	4.5	4.5
	Total Good		46.3	46.3	46.2	45.4	44.9
	Medium	**ESSFmc**	32.6	38.5	37.4	31.6	28.1
		ESSFmcp	6.6	6.6	6.6	6.6	6.5
		ESSFmk	13.5	12.9	13.1	12.4	12.0
		ESSFmkp	4.7	4.7	4.7	4.6	4.7
		SBSmc2	29.4	20.9	17.4	15.0	12.9
	Total Medium		86.7	83.6	79.1	70.2	64.2
	Poor	**ATp**	3.1	3.1	3.1	3.1	3.1
		ESSFmc	45.4	39.5	40.7	47.2	50.9
		ESSFmk	6.8	7.4	7.3	8.0	8.3
		SBSdk	39.0	39.0	39.0	39.0	39.1
		SBSmc2	103.2	111.7	115.3	117.6	119.7
	Total Poor		197.5	200.6	205.3	214.9	221.2

Projection of caribou summer habitat value cont.

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Tweedsmuir	**Good**	**ATp**	27.3	27.3	27.3	27.3	27.2
		ESSFmcp	6.4	6.3	6.3	6.3	6.2
		ESSFmkp	13.2	13.2	13.2	13.2	13.1
		MHmm2	1.7	1.7	1.7	1.7	1.5
		MHmmp2	4.9	4.9	4.9	4.9	4.9
		Total Good	53.5	53.4	53.4	53.3	52.9
	Medium	**CWHws2**	1.6	1.7	1.8	1.8	1.7
		ESSFmc	15.8	16.4	15.8	14.6	13.8
		ESSFmcp	1.2	1.2	1.2	1.3	1.3
		ESSFmk	33.9	33.8	33.9	33.0	32.3
		MHmm2	3.2	3.2	3.2	3.2	3.3
		SBSmc2	23.7	14.8	13.3	8.5	8.4
		Total Medium	79.3	71.1	69.2	62.4	60.8
	Poor	**ATp**	5.8	5.8	5.8	5.8	5.8
		CWHws2	22.6	22.5	22.5	22.4	22.6
		ESSFmc	17.1	17.8	18.4	19.7	20.5
		ESSFmk	25.0	25.1	24.9	25.9	26.6
		MHmm2	2.4	2.4	2.4	2.4	2.4
		SBSdk	5.8	5.8	5.8	5.8	5.8
		SBSmc2	84.9	93.8	95.3	100.0	100.2
		Total Poor	163.6	173.1	175.0	182.0	183.9

Projection of caribou winter habitat suitability

Caribou Herd	Suitability Rating	BEC Subzone	Year 0	25	50	100	250
Takla	High	SBSmc2	1.8	1.4	1.2	0.9	0.8
		SBSwk3	1.9	1.0	0.9	0.7	0.7
		Total High	3.7	2.4	2.1	1.6	1.6
	Moderate	ESSFmv3	1.7	1.5	1.2	0.8	0.8
		SBSmc2	3.4	2.7	2.4	2.0	2.2
		SBSwk3	1.7	1.4	1.4	1.4	1.4
		Total Moderate	6.7	5.7	5.0	4.2	4.4
	Low	ESSFmv3	18.3	18.5	18.8	19.2	19.2
		SBSmc2	94.4	95.5	96.0	96.8	96.6
		SBSwk3	38.2	39.3	39.5	39.7	39.7
		Total Low	150.9	153.3	154.3	155.6	155.4
Telkwa	High	ATp	2.7	2.7	2.7	2.7	2.7
		ESSFmc	11.1	8.5	7.5	6.6	6.6
		ESSFmcp	3.3	3.1	2.9	2.8	2.8
		ESSFmkp	1.9	1.9	1.9	1.9	1.9
		SBSmc2	7.8	3.9	3.3	2.5	2.4
		Total High	26.8	20.2	18.4	16.6	16.4
	Moderate	ATp	11.6	11.6	11.6	11.6	11.6
		ESSFmc	4.4	3.6	3.5	3.2	3.2
		ESSFmcp	1.5	1.7	1.9	1.9	1.9
		ESSFmk	7.7	6.9	6.7	6.7	6.6
		ESSFmkp	1.5	1.4	1.4	1.4	1.4
		SBSdk	6.6	5.4	5.0	5.9	5.6
		SBSmc2	14.1	8.6	7.1	8.9	7.8
		Total Moderate	47.4	39.2	37.2	39.5	38.2
	Low	ATp	15.4	15.4	15.4	15.4	15.4
		ESSFmc	63.9	67.3	68.5	69.7	69.7
		ESSFmcp	16.8	16.8	16.8	16.9	16.9
		ESSFmk	12.0	12.8	13.0	13.1	13.1
		ESSFmkp	6.0	6.1	6.1	6.1	6.1
		SBSdk	32.5	33.7	34.2	33.3	33.6
		SBSmc2	110.8	120.1	122.2	121.2	122.4
		Total Low	257.5	272.3	276.2	275.7	277.2

Projection of caribou winter habitat suitability cont.

Caribou Herd	Suitability Rating	BEC Subzone	Year 0	25	50	100	250
Tweedsmuir	High	ATp	2.5	2.5	2.5	2.5	2.5
		CWHws2	3.0	2.7	2.7	2.5	2.5
		ESSFmc	1.8	0.9	0.8	0.6	0.6
		SBSmc2	4.0	1.1	0.7	0.4	0.4
		Total High	11.2	7.1	6.7	6.0	6.0
	Moderate	ATp	9.5	9.5	9.5	9.5	9.5
		CWHws2	1.2	1.2	1.2	1.1	1.1
		ESSFmc	1.2	1.0	1.0	0.9	0.9
		ESSFmk	18.2	16.6	16.2	15.6	15.5
		MHmm2	1.1	1.1	1.1	1.1	1.1
		SBSmc2	11.0	6.7	4.7	4.3	3.0
		Total Moderate	57.3	44.2	41.1	38.9	37.5
	Low	ATp	21.1	21.1	21.1	21.1	21.1
		CWHws2	20.0	20.4	20.3	20.5	20.6
		ESSFmc	31.5	32.5	32.7	32.9	32.9
		ESSFmcp	7.7	7.7	7.7	7.7	7.7
		ESSFmk	39.8	41.7	42.1	42.7	42.6
		ESSFmkp	14.7	14.7	14.7	14.7	14.7
		MHmm2	6.1	6.1	6.1	6.1	6.1
		MHmmp2	5.4	5.4	5.4	5.4	5.4
		SBSdk	5.5	5.6	5.6	5.7	5.7
		SBSmc2	93.6	100.8	103.2	103.9	105.2
		Total Low	245.6	256.1	258.9	260.8	262.0

Projection of caribou winter habitat value:

Caribou Herd	Suitability Rating	BEC Subzone	Year 0	25	50	100	250
Takla	Medium	ESSFmv3	1.6	1.5	1.2	0.8	0.8
		SBSmc2	3.3	2.5	2.3	1.8	1.8
		SBSwk3	3.4	2.3	2.1	2.0	2.0
	Total Medium		8.4	6.3	5.6	4.6	4.6
	Poor	ESSFmv3	18.3	18.5	18.8	19.2	19.2
		SBSmc2	96.2	97.1	97.3	97.8	97.8
		SBSwk3	38.2	39.3	39.5	39.7	39.7
	Total Poor		152.8	154.9	155.6	156.7	156.7
Telkwa	Good	ATp	2.2	2.2	2.2	2.2	2.2
		ESSFmc	7.1	5.3	4.8	4.2	3.9
		ESSFmcp	2.1	1.9	1.7	1.7	1.7
		ESSFmkp	1.4	1.4	1.3	1.3	1.3
	Total Good		12.8	10.9	10.1	9.4	9.1
	Medium	ATp	10.6	10.6	10.5	10.5	10.5
		ESSFmc	7.7	6.2	5.6	5.1	5.2
		ESSFmcp	2.4	2.5	2.7	2.7	2.8
		ESSFmk	7.6	6.8	6.7	6.6	6.6
		ESSFmkp	2.0	2.0	2.0	2.0	2.0
		SBSmc2	10.7	6.5	5.8	5.1	4.9
	Total Medium		41.0	34.6	33.4	32.1	32.0
	Poor	ATp	17.0	17.0	17.0	17.0	17.1
		ESSFmc	64.7	67.9	69.0	70.1	70.3
		ESSFmcp	17.1	17.1	17.1	17.2	17.2
		ESSFmk	12.0	12.9	13.1	13.1	13.2
		ESSFmkp	6.0	6.1	6.1	6.1	6.1
		SBSdk	39.5	39.5	39.5	39.5	39.5
		SBSmc2	121.5	125.9	126.6	127.4	127.6
	Total Poor		277.8	286.4	288.4	290.5	290.9
Tweedsmuir	Good	SBSmc2	4.0	1.1	0.7	0.4	0.4
	Medium	CWHws2	3.4	3.1	3.1	2.9	2.9
		ESSFmk	15.7	13.7	13.4	13.1	13.1
		MHmm2	1.1	1.1	1.1	1.1	1.1
		SBSmc2	11.0	6.7	4.7	4.3	3.0
	Total Medium		35.2	25.6	23.0	21.7	20.4
	Poor	ATp	32.7	32.7	32.7	32.7	32.7
		CWHws2	20.8	21.2	21.2	21.3	21.4
		ESSFmc	32.7	33.7	33.8	34.0	34.0
		ESSFmcp	7.7	7.7	7.7	7.7	7.7
		ESSFmk	43.1	45.1	45.4	45.8	45.7
		ESSFmkp	14.7	14.7	14.7	14.7	14.7
		MHmm2	6.1	6.1	6.1	6.1	6.1

Caribou Herd	Suitability Rating	BEC Subzone	Year				
			0	25	50	100	250
		MHmmp2	5.4	5.4	5.4	5.4	5.4
		SBSdk	5.5	5.6	5.6	5.7	5.7
		SBSmc2	93.6	100.8	103.2	103.9	105.2
		Total Poor	262.6	273.2	275.9	277.4	278.7

Projection of caribou calving habitat suitability:

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Takla	**High**	**ESSFmv3**	20.1	20.1	20.1	20.1	20.1
	Moderate	**SBSmc2**	2.6	2.6	2.6	2.6	2.6
		SBSwk3	2.7	2.7	2.7	2.7	2.7
	Low	**SBSmc2**	67.9	67.9	67.9	67.9	67.9
		SBSwk3	35.5	35.5	35.5	35.5	35.5
	Very_Low	**SBSmc2**	29.1	29.1	29.1	29.1	29.1
		SBSwk3	3.4	3.4	3.4	3.4	3.4
Telkwa	**High**	**ATp**	29.5	29.5	29.5	29.5	29.5
		ESSFmcp	21.5	21.5	21.5	21.5	21.5
		ESSFmkp	9.4	9.4	9.4	9.4	9.4
	Moderate	**ESSFmc**	4.7	8.6	8.9	6.0	5.8
		ESSFmk	1.6	1.5	1.5	1.5	1.5
		SBSdk	1.8	1.7	1.7	1.7	1.6
		SBSmc2	7.9	7.8	7.7	7.8	7.8
	Low	**ESSFmc**	74.5	70.6	70.3	73.2	73.4
		ESSFmk	17.8	17.9	17.9	17.9	17.9
		SBSdk	36.5	36.6	36.6	36.6	36.7
		SBSmc2	120.4	120.5	120.5	120.5	120.5
	Very_Low	**SBSdk**	1.2	1.2	1.2	1.2	1.2
		SBSmc2	4.4	4.4	4.4	4.4	4.4
Tweedsmuir	**High**	**ATp**	28.2	28.2	28.2	28.2	28.2
		ESSFmcp	7.7	7.7	7.7	7.7	7.7
		ESSFmkp	14.6	14.6	14.6	14.6	14.6
		MHmmp2	5.1	5.1	5.1	5.1	5.1
		SBSmc2	1.1	1.1	1.1	1.1	1.1
	Moderate	**ESSFmc**	2.8	3.4	3.1	2.8	2.9
		ESSFmk	4.1	3.9	3.8	3.7	4.1
		SBSmc2	5.8	5.7	5.6	5.5	5.6
	Low	**ATp**	4.9	4.9	4.9	4.9	4.9
		CWHws2	10.7	10.7	10.7	10.7	10.7
		ESSFmc	31.5	30.9	31.1	31.4	31.4
		ESSFmk	51.3	51.5	51.6	51.7	51.3
		MHmm2	7.0	7.0	7.0	7.0	7.0
		SBSdk	2.7	2.7	2.7	2.7	2.7
		SBSmc2	75.3	75.4	75.5	75.6	75.5
	Very_Low	**CWHws2**	13.1	13.1	13.1	13.1	13.1
		ESSFmk	3.4	3.4	3.4	3.4	3.4
		SBSdk	3.0	3.0	3.0	3.0	3.0
		SBSmc2	26.4	26.4	26.4	26.4	26.4

Projection of caribou calving habitat value:

Caribou Herd	Value Rating	BEC Subzone	Year 0	25	50	100	250
Takla	Good	ESSFmv3	2.0	2.0	2.0	1.9	1.9
	Poor	ESSFmv3	18.1	18.2	18.2	18.3	18.3
		SBSmc2	99.6	99.6	99.6	99.6	99.6
		SBSwk3	41.7	41.7	41.7	41.7	41.7
Telkwa	Good	ATp	29.5	29.5	29.5	29.5	29.5
		ESSFmcp	21.5	21.5	21.5	21.5	21.5
		ESSFmkp	9.4	9.4	9.4	9.4	9.4
	Medium	ESSFmc	3.0	3.0	3.0	3.0	3.0
	Poor	CWHws2	0.3	0.3	0.3	0.3	0.3
		ESSFmc	76.5	76.5	76.5	76.5	76.5
		ESSFmk	20.3	20.3	20.3	20.3	20.3
		SBSdk	39.5	39.5	39.5	39.5	39.5
		SBSmc2	132.6	132.6	132.6	132.6	132.6
Tweedsmuir	Good	ATp	28.2	28.2	28.2	28.2	28.2
		ESSFmcp	7.7	7.7	7.7	7.7	7.7
		ESSFmkp	14.6	14.6	14.6	14.6	14.6
		MHmmp2	5.1	5.1	5.1	5.1	5.1
		SBSmc2	1.1	1.1	1.1	1.1	1.1
	Medium	ESSFmc	1.7	2.0	2.1	2.0	1.9
		ESSFmk	2.7	2.5	2.4	2.4	2.7
		SBSmc2	2.0	2.0	2.0	2.0	2.0
	Poor	ATp	4.9	4.9	4.9	4.9	4.9
		CWHws2	24.2	24.2	24.2	24.2	24.2
		ESSFmc	32.7	32.4	32.3	32.4	32.5
		ESSFmk	56.1	56.3	56.4	56.4	56.1
		MHmm2	7.2	7.2	7.2	7.2	7.2
		SBSdk	5.9	5.9	5.9	5.9	5.9
		SBSmc2	105.5	105.5	105.5	105.5	105.5

Appendix 10. 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[33]. 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

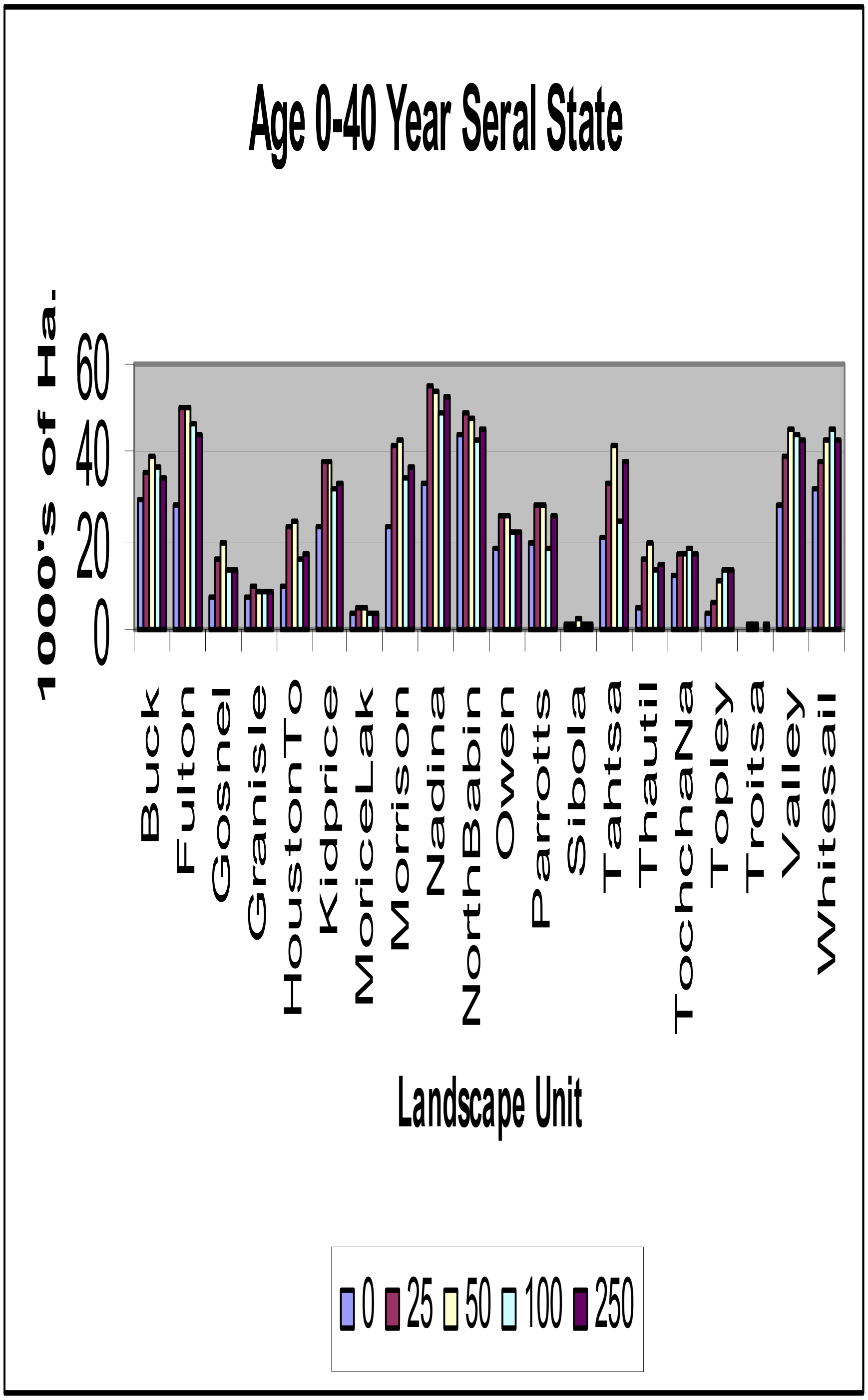
Potential Occupancy	Condition	Rationale
High	960 ha of High FA	Corresponds to 40% of 2400ha breeding HR*
Moderate	600 ha of High FA	Corresponds to 25% of 2400ha breeding HR
Low	240 ha of High FA	Corresponds to 10% of 2400ha breeding HR
Unlikely	<240 ha of High FA	Does not meet minimum foraging habitat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

[33] 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 11. Distribution of forested goat habitat by Landscape Unit

Landscape Unit	Non THLB	In THLB	% in THLB
Gosnel	1102	436	28.3
HoustonTommy	671	380	36.2
Nadina	1762	364	17.1
Buck	1213	328	21.3
Owen	2039	293	12.6
MoriceLake	6759	277	3.9
Kidprice	1419	242	14.6
Parrotts	391	199	33.7
Sibola	4035	180	4.3
Troitsa	4965	145	2.8
Tahtsa	464	144	23.7
TochchaNatowite	567	142	20.0
Fulton	149	113	43.1
Valley	864	97	10.1
Thautil	470	91	16.2
Topley	159	76	32.3
NorthBabine	460	62	11.9
Morrison	550	59	9.7
Granisle	29	35	54.7
Whitesail	357	30	7.8
Burnie	474		0.0
Nanika	2446		0.0
Grand Total	31345	3693	10.5

Appendix 12. Age 0-40 Forest by Landscape Unit.

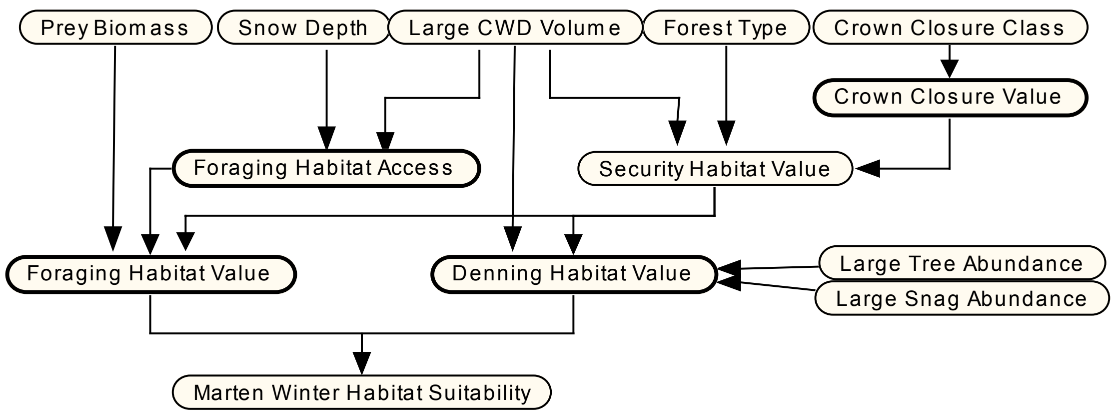


Appendix 13. The marten model

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.

Appendix 14. Marten habitat suitability by BEC subzone/variant.

BEC	High	Moderate	Nil-Low
SBSmc2	64.0	48.3	12.8
ESSFmc	20.1	18.3	3.9
ESSFmk	4.0	10.5	10.0
SBSdk	3.8	15.5	4.5
SBSwk3	3.1	4.2	12.3
ESSFmv3	2.9	0.9	5.9
Subtotal	97.9	97.7	49.4
Other BEC	2.1	2.3	50.6
Total	100.0	100.0	100.0

Values in body of table are percents of total area found the indicated suitability class at year 0 in the Base Case Management Simulation.

Appendix 15. Marten Habitat suitability projection by BEC Subzone/Variant.

	Marten	Simulation Year				
BEC	Suitability	0	25	50	100	250
ATp	Nil-Low	98	98	98	98	98
CWHws2	High	10	10	10	9	9
	Medium	5	4	4	5	5
	Nil-Low	30	31	31	31	31
ESSFmc	High	100	70	61	41	41
	Medium	43	56	59	86	85
	Nil-Low	76	94	101	93	94
ESSFmcp	Nil-Low	34	34	34	34	34
ESSFmk	High	20	24	23	20	20
	Medium	25	26	26	25	26
	Nil-Low	94	88	90	94	93
ESSFmkp	Nil-Low	45	45	45	45	45
ESSFmv3	High	14	9	6	3	3
	Medium	2	4	3	2	2
	Nil-Low	8	12	16	19	19
ESSFmvp3	Nil-Low	1	1	1	1	1
MHmm2	High	0	0	0	0	0
	Medium	0	1	1	1	1
	Nil-Low	7	7	7	7	7
MHmmp2	Nil-Low	6	6	6	6	6
SBSdk	High	19	18	17	16	15
	Medium	37	38	43	41	43
	Nil-Low	72	71	67	70	70
SBSmc2	High	319	232	178	149	148
	Medium	115	146	214	249	238
	Nil-Low	276	331	317	310	323
SBSwk3	High	16	8	5	3	3
	Medium	10	9	12	17	16
	Nil-Low	16	25	25	22	23
Grand Total		1,499	1,499	1,499	1,499	1,499

Values in body of the table are areas of habitat in 1000's of hectares. The grand total is slightly smaller than the total area of the LRMP because boundary errors in GIS mapping produced small polygons of impossible PEM/BEC combinations not recognized by the suitability model. These error polygons are not included in the table totals.

Appendix 16. Marten habitat suitability projection by Landscape Unit.

	Marten	Simulation Year				
Landscape Unit	Suitability	0	25	50	100	250
TochchaNatowite	High	41.3	27.0	18.8	13.2	12.7
	Medium	17.1	19.1	24.6	30.4	29.7
	Nil-Low	34.8	47.2	49.9	49.7	50.9
Nadina	High	44.9	31.7	24.2	21.4	19.6
	Medium	22.5	28.9	37.8	39.4	39.3
	Nil-Low	47.3	54.0	52.6	53.9	55.8
Kidprice	High	35.9	21.6	17.0	14.9	13.7
	Medium	11.0	20.1	28.3	27.3	31.0
	Nil-Low	53.7	58.9	55.4	58.5	56.0
Morrison	High	44.5	30.8	26.0	22.1	22.8
	Medium	11.2	15.7	22.1	26.1	25.0
	Nil-Low	29.5	38.7	37.1	37.0	37.3
Fulton	High	43.4	32.6	26.3	20.9	21.8
	Medium	20.6	23.6	33.0	36.7	37.0
	Nil-Low	34.7	42.5	39.4	41.2	39.9
Tahtsa	High	27.1	18.3	13.5	10.4	10.1
	Medium	13.5	16.8	21.9	33.8	25.2
	Nil-Low	31.9	37.3	37.0	28.2	37.1
Buck	High	28.3	22.4	15.5	12.2	11.4
	Medium	14.4	20.4	24.4	27.7	30.1
	Nil-Low	34.0	33.9	36.8	36.8	35.2
Whitesail	High	23.6	18.4	14.2	7.7	8.7
	Medium	6.2	8.2	10.7	15.7	15.5
	Nil-Low	41.2	44.5	46.2	47.6	46.9
HoustonTommy	High	24.1	14.4	11.3	8.6	9.5
	Medium	8.2	10.0	14.6	17.9	18.3
	Nil-Low	20.2	28.2	26.7	26.1	24.7
Thautil	High	21.9	14.3	11.2	8.3	8.3
	Medium	8.0	10.0	13.1	18.9	17.3
	Nil-Low	23.0	28.6	28.6	25.6	27.3
NorthBabine	High	24.5	16.1	12.2	11.7	11.0
	Medium	5.1	9.0	13.6	13.9	13.9
	Nil-Low	40.3	44.9	44.2	44.4	45.1
Gosnel	High	18.9	13.7	10.1	6.2	6.8
	Medium	7.9	7.4	9.9	15.1	14.8
	Nil-Low	26.5	32.2	33.4	32.1	31.7
Valley	High	33.6	31.2	29.0	24.1	22.7
	Medium	29.7	29.8	31.4	35.8	37.7
	Nil-Low	49.3	51.6	52.2	52.7	52.3
Parrotts	High	16.6	11.6	8.4	8.6	8.3
	Medium	9.0	9.9	16.2	20.5	15.3
	Nil-Low	21.1	25.2	22.0	17.5	23.1

Landscape Unit	Marten Suitability	Simulation Year 0	25	50	100	250
Owen	High	16.7	11.9	9.9	8.0	8.6
	Medium	9.0	10.6	14.6	16.0	16.1
	Nil-Low	22.3	25.6	23.5	24.1	23.3
Topley	High	11.0	11.9	11.8	7.0	6.9
	Medium	12.3	9.9	8.1	12.2	11.2
	Nil-Low	8.3	9.9	11.8	12.4	13.5
Granisle	High	8.5	7.0	5.9	5.2	4.6
	Medium	3.7	5.2	6.9	6.2	7.0
	Nil-Low	6.8	6.9	6.3	7.6	7.5
MoriceLake	High	14.6	12.8	12.3	12.3	11.9
	Medium	6.4	8.3	8.7	8.7	8.4
	Nil-Low	71.0	70.9	70.9	71.0	71.7
Troitsa	High	6.8	7.9	7.0	5.2	5.6
	Medium	6.0	7.3	7.0	7.3	7.1
	Nil-Low	48.2	45.9	47.1	48.6	48.4
Sibola	High	6.0	7.3	6.5	5.9	6.0
	Medium	6.7	6.5	6.7	7.1	7.2
	Nil-Low	50.8	49.7	50.4	50.5	50.3
Nanika	High	1.8	3.5	3.5	3.3	3.3
	Medium	3.1	3.2	3.2	3.4	3.3
	Nil-Low	32.5	30.8	30.7	30.7	30.7
Burnie	High	3.6	5.6	5.6	5.5	5.7
	Medium	5.8	4.5	4.5	4.7	4.8
	Nil-Low	35.8	35.1	35.0	34.9	34.7
Grand Total		1498.7	1498.7	1498.7	1498.7	1498.7

Figures in body of table are areas of habitat in 1000's of hectares. Landscape units are sorted according to the predicted loss of high suitability habitat, with larger losses shown at the top of the table.