Decision Support System: Static Experiments

Static Experiments

October 2003

Prepared by

Donald G. Reid, Skeena Region, MSRM, Smithers

Ken Bush, Skeena Region, MSRM, Smithers.

Tiemin Sheng, Skeena Region, MSRM, Smithers

Donald Morgan, Skeena Region, MSRM, Smithers

Laura Bolster, Skeena Region, MSRM, Smithers

James Warren, Skeena Region, MSRM, Smithers,

Table of Contents

Acknowledgements

The process of conducting GIS static experiments for the LRMP is built on a wide base of collaborative modelling, which requires input from a large number of people. Most participants are listed below, including domain experts who assisted with the development of conceptual models and model interpretation. To facilitate their participation a multi-disciplined team, the NC Analysis Team was formed. This team has expertise in data management, spatial analysis, environmental risk assessment , decision support systems, timber supply, resource inventories, operational forestry, operational biology, and the linkage of domain knowledge to LRMP decision making. This team is co-ordinated and integrated with NC LRMP Government Technical Team and the NC LRMP process, and also with the government and contracted professionals involved in coast-wide strategic planning through the CIT. The collaborative modelling effort evolved over several years with a great amount effort by all involved. Participants have a common vision of its purpose, and actively promote a positive professional environment that allows the collaborative modelling framework to succeed.

Ministry of Sustainable Resource Management

*Hubert Burger
*Laura Bolster
*Sarma Liepins
*Don Reid
*Don Morgan
*James Warren
*Ken Bush
*Johanna Pfalz
*Cheryl MacMillan
Tiemin Sheng
Debbie Narver
Jamie Popkin

Ministry of Forests

Northern Forest Region

Dave Coates
Jim Pojar
Doug Steventon

Coastal Forest Region

Allen Banner

Headquarters

Marvin Eng
Adrian Walton

Ministry of Water, Air and Land Protection

Tony Hamilton
Kristin Karr
Anne Hetherington

Forest Industry

Davide Cuzner

Consultants

Rachel Holt
Glenn Sutherland
Hannah Horn
Todd Mahon
Frank Doyle
Brad Pollard
Dave Daust
Denise van Raalte

*North Coast Analysis Team members.

Audience

This report is intended primarily as a source of information for deliberations by the North Coast LRMP Table and Working Group members. It is also designed to inform the Government Technical Team and domain experts.

1.0 Introduction

1.1 Background

The North Coast LRMP Table is responsible for developing a strategic land use plan for the North Coast region of BC. To support the Table the government has assembled a number of groups including a process team, a government technical team and an analysis team (Figure 1). In addition to these teams, the government technical team has a number of domain experts who have expertise with a particular resource value, and who undertake focussed analyses regarding these resources.

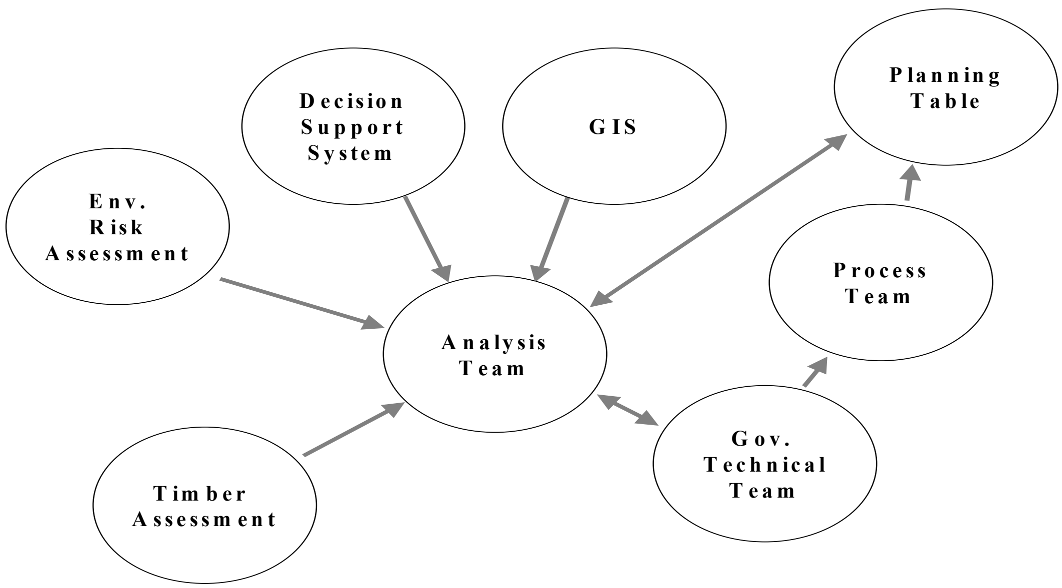

Figure 1. North Coast LRMP Table support teams

The North Coast Analysis Team is made up of technical experts, and has been assembled to assist the North Coast LRMP Table, Government Technical Team and domain experts to deliver the benchmark scenario, explore planning options, and help the Table develop a final plan.

Decision Support is a system of knowledge integration, analysis and projection that has been implemented by the Analysis Team to assess the responses of various resource values to land-based resource management options or scenarios in the North Coast LRMP area. The principal scenario analysed to date has been the base line (or benchmark) scenario.

One key tool in this system is the North Coast Landscape Model, which projects land management activities through 250 years, and has been run for the base line, focussing on timber values (Morgan et al. 2002). Base line results from the Landscape Model have been analysed for other individual resource values by specific domain experts: Coarse Filter Biodiversity (Holt and Sutherland 2003), Marbled Murrelet (*Brachyramphus marmoratus*) (Steventon 2003), Mountain Goat (*Oreamnos americanus*) (Pollard 2003), Grizzly Bear (*Ursus arctos*) (Hamilton 2003).

1.2 Purpose

This document describes another tool in the decision support system, the spatial overlap of resource values as assessed in GIS. In this process particular attributes of various resource values are overlain spatially to assess potential impact of one on another. The overlays generally depict the resource values at present, so assess immediate impacts only. They are referred to as "static" experiments. The LRMP Table and the Government Technical Team provided direction on which experiments needed to be done.

A parallel report (Morgan et al. 2003) summarizes results from the Landscape Model run under alternative land management scenarios such as variable retention projected through time. These are referred to as "temporal" experiments. The results of these alternative scenario model runs will be assessed by the domain experts with regard to impact on their individual resource values, and reported in Environmental Risk Assessment Team (2003)..

2.0 Experiments

This section of the report provides some background as to the nature of the individual static experiments. Most of the static experiments involve assessing what proportion of the Timber Harvesting Land Base (THLB) overlaps the distribution of key environmental resource values, such as locations of ecosystems at risk or critical habitat for focal species.

2.1 Hydroriparian Planning Guide

The Coast Information Team has prepared a Hydroriparian Planning Guide (HPG) which outlines land use practices for maintaining hydroriparian functions in coastal watersheds. The North Coast Government Technical team commissioned Karen Price to test the precautionary level guidelines of the HPG on two North Coast watersheds: Paril River (two third-order watersheds with substantial historical harvesting), and Chambers Creek (one third-order watershed with little development). She applied the HPG tactical level planning steps to map the hydroriparian ecosystems, which, under the precautionary guidelines, are removed from the Timber Harvesting Land Base (Price 2003). Her work can then be viewed as a static experiment. This report summarizes some of Karen Price's results for comparison to other static experiments.

2.2 Coarse Filter Ecosystems

The Coarse Filter Biodiversity Risk Analysis (Holt and Sutherland 2003) assesses risk to old forest ecosystems, classed as Analysis Units (AUs). These are groupings of forest stands classed as leading species by site index. This risk is based on a comparison of the current area of old forest within each AU, with the area of old forest that would be expected under a natural disturbance regime. Risk is classed as the proportion of expected area that is still currently old growth: Very Low (80-100%), Low (60-80%), Moderate (40-60%), High (20-40%) and Very High (0-20%). What is of particular interest here is the overlap of risk classes Moderate, High and Very High with the THLB, because the draft General Management Direction for Coarse

Filter Biodiversity proposes a Low Risk Target for current spatial extent of old forest of 70% of expected, for each ecosystem.

2.3 Goal 1 proposed protected areas

The Protected Areas Strategy (PAS) for the Prince Rupert Forest Region (Province of BC 1996) recommends a number of areas for protection, which would likely mean removal from the THLB. These were classed as Goal 1 (larger areas recommended for representation of ecological values) and Goal 2 (small sites identified for rarity, diversity and vulnerability of special ecological and cultural elements). This experiment is designed to understand what proportion of the THLB would be lost if Goal 1 PAS areas were to be protected.

2.4 Rare and Endangered Ecosystems

The General Management Direction for Coarse Filter Biodiversity includes a recommendation for complete protection for all red and blue-listed ecosystems identified by the B.C. Conservation Data Centre. An inventory of such ecosystems is only partially complete within the plan area (Ronalds and McLennan 2002). It focussed exclusively on the distribution of rare ecosystems associated with floodplains and alluvial/colluvial fans and toe slopes. The authors concluded that they had mapped all watersheds with a significant component of red-listed ecosystems in floodplains and valley floors, but may not have covered all blue-listed floodplain and valley floor ecosystems as thoroughly (Ronalds and McLennan 2002:6). The inventory does not include distribution of rare salt-spray-zone listed communities, nor the upslope rare communities associated with base-rich bedrock.

The inventory discovered that one blue-listed ecosystem (the BaSs-Devil's Club, CWHvm1/08) is so numerous that it could be down-listed, but recommended that these ecosystems receive special management attention because most are on fans and because harvesting them until they are rare enough to be listed again would not be appropriate (Ronalds and McLennan 2002).

This experiment estimates the proportion of the THLB that would be impacted by: (a) removing all currently inventoried red and blue listed ecosystems, and (b) all of those except the currently blue-listed CWHvm1/08, which proved to be relatively abundant in the inventory. The results reported here underestimate the impacts of applying the General Management Direction because the inventory is incomplete for a number of ecosystems.

2.5 Islands less than 300 hectares

The General Management Direction for Coarse Filter Biodiversity acknowledges that a large, though incompletely documented, proportion of the biodiversity of the North Coast region is comprised of genetically unique species, subspecies or populations that have become isolated on numerous islands. The genetic lineages on smaller islands (< 300 ha) are particularly vulnerable to divergence from old growth forest conditions because their populations are relatively small and consequently more easily driven to extinction, and yet large enough to have a substantial likelihood of being viable over sufficient time to allow for genetic divergence from the mainland. This experiment assesses the impact of removing such islands from the THLB.

2.6 Critical Habitats for Focal Higher-level Plan Species

LRMP Tables have the responsibility of deciding whether or not to recommend land management that would protect critical habitats for a certain set of species whose ranges are large or whose habitat use is widely dispersed, and for any species whose distribution or abundance in the Plan Area make it of particular interest to the Table. The species and habitats of concern in the NC LRMP are: Mountain Goat (winter range), Grizzly Bear (highest capability foraging habitat), Marbled Murrelet (most likely nesting habitat), and Northern Goshawk (highest suitability nesting habitat). A series of overlay experiments assesses the proportion of the THLB comprised of each of these sets of critical habitats.

The details of data inputs to these overlays is as follows:
Mountain Goat: We overlaid the Mountain Goat winter range inventory (Pollard 2002), inclusive of both confidence levels, on the THLB, and reported results by Landscape Unit.
Marbled Murrelet: We overlaid the Most Likely Nesting Habitat area for Marbled Murrelets on the THLB, and reported results by Landscape Unit. The Most Likely Nesting Habitat algorithm was compiled by members of the Marbled Murrelet Recovery Team and is being used in the Coast Information Team Ecosystem Spatial Analysis (CIT 2003). We use it here because it has the widest credibility professionally, and for sake of consistency with CIT products. The Most Likely Nesting Habitat consists of forests of age class 8 or 9 (i.e. > 140 years old), AND height class 4 or older (i.e. >28.5 m) , AND canopy closure 4,5 or 6 (i.e. 36-65%), AND less than 600 m in elevation.

In addition, the General Management Direction for Marbled Murrelets (MAMU) recognizes that the overlap of Most Likely Nesting Habitat and the THLB is likely to be high, so includes a means of assessing the area of other forest types (whether within or without the THLB) required to make up for loss of some of the most likely habitat. The GMD also puts forward three spatial scales for assessing population thresholds: (i) the MAMU Recovery Team's threshold of 69% of the 2002 functional nesting habitat PLAN-WIDE; (ii) the MAMU Recovery Team's recommendation for Core Areas (each of which would maintain 10% of the population), and (iii) the idea of Zones, within each of which the threshold 69% of 2002 functional nesting habitat would be met. Based on the Environmental Risk Assessment model (Steventon 2003), and fitting the necessary MAMU population level into the available habitat, we report potential timber supply impacts of these recommendations. These impacts are not THLB impacts, as are the rest of the results of these static experiments. Rather, they assume that the timber value is approximately proportional to habitat value (i.e. higher quality habitat, which is bigger and older trees, has more value than other habitat), and use the rate of change in population size over the population projection to estimate how much the population 30 years from now will deviate from the recommended threshold of 69% of current population. The extent of that deviation is the timber impact.

Grizzly Bear: We overlaid critical grizzly bear foraging habitat on the THLB and reported results by Landscape Unit. Tony Hamilton developed the definition of critical grizzly bear habitat. He used the small-scale Predictive Ecosystem Mapping (ssPEM) produced by the Coast Information Team, and assessed the grizzly bear foraging capability of each unique site series (ecosystem) or site series complex (mix of ecosystems) mapped in ssPEM. His capability ratings ranged from 1 (highest) to 6 (nil). He considered critical habitat to be all class 1 polygons plus 50% of class 2 polygons, and including a 50 m buffer around those polygons that were non-forested. This assessment was applied plan wide, but results were divided between those portions of the plan area either occupied or not-occupied by grizzly bears.

Northern Goshawk: We overlaid highest quality northern goshawk nesting suitability on the THLB and reported results by Landscape Unit. The goshawk nesting suitability model was developed by domain experts Frank Doyle and Todd Mahon for this LRMP and for the Coast Information Team (Mahon et al. 2003). Nest area habitat suitability is based on stand height, canopy closure, tree species and distance to edge. It is rated in 4 classes, with class 1 being High, and class 4 being Nil. This static experiment only considered the overlap of class 1 with THLB.

2.7 Cumulative Impacts of Environmental Resource Values

The various overlays of resource values on THLB outlined above are reported individually. However, we recognize that there may be substantial overlap among resource values: an area of high risk for coarse filter biodiversity may well also be high grizzly bear habitat capability. To give some idea of the spatial overlap of the environmental resource values we did sequential overlays of these layers on THLB, reporting the incremental new area of overlap with each value in the sequence. This allows a few different interpretations: (i) the sum total of all area overlaps with THLB that satisfy one or more of the environmental resource values; (ii) the proportion of THLB required to satisfy a resource value when other resource values have already been accommodated. This second interpretation depends on the order in which the overlays are applied to the THLB. We used the following order, thinking that this order would best point out where overlaps exist:

- Coarse Filter Biodiversity (High and Very High Risk polygons only)
- Rare and Endangered Ecosystems (All types)
- Grizzly Bear Habitat Capability (All of classes 1 and 2)
- Marbled Murrelet Most Likely Nesting Habitat
- Northern Goshawk Highest Nest Area Suitability (Class 1 only)
- Mountain Goat Winter Range (Confidence levels 1 and 2)

Note that the areas reported from this analysis might deviate somewhat from those reported from the individual overlays, because this sequential analysis had to be done in GRID format.

3.0 Experiment Methods and Design

The methods and designs for each of the static experiments described in Section 2.0 were similar. Selected values were extracted from existing inventories and overlain with administrative and landscape features. Summaries of these overlays were then created to illustrate the desired output.

For each experiment one or more existing inventories were used, with specific elements extracted (Table 1).

Table 1. Summary of inventories used in each overlay experiment.

Experiment	Inventories
Coarse Filter Biodiversity ecosystems	Analysis Units from Forest Cover and TSR, Modified Risk at t=0, THLB
Goal 1 Proposed Protected Areas	Analysis Units, RPAT Goal 1 Areas, THLB
Mountain Goat Winter Range	Mtn Goat Winter Range (both confidence levels),

	THLB
Marbled Murrelet Nesting Suitability	Marbled Murrelet Most Likely Nesting Habitat (Marbled Murrelet Recovery Team / CIT) , Analysis Units,THLB
Northern Goshawk Nesting Suitability	Northern Goshawk Nesting Suitability Class 1 , THLB
Grizzly Bear Foraging Capability	Grizzly Bear area of occupancy, Small-scale PEM (CIT) interpreted for Grizzly bear capability (class 1 and 50% class 2), THLB
Rare and Endangered Ecosystems	Rare Ecosystem Mapping, THLB
Islands <= 300 hectares	TRIM coastline features, THLB

Each experiment assesses the overlap of a particular set of resource values with the Timber Harvesting Land Base (THLB). This is designed to assist an interpretation of any impacts to the THLB that may result from precluding harvest on the area of overlap.

It is important to note that the THLB inventory layer used in these analyses does not include spatial representation of areas reserved for riparian management following the zoning specifications of the Riparian Management Guidebook of the former Forest Practices Code (e.g. Riparian Reserve Zones which are current normal practice in riparian management). Approximately 7.5% of the THLB in the North Coast TSA is estimated to be in these riparian reserve zones, and therefore effectively excluded from the THLB (Bolster 2002). So each of the analyses could overestimate the proportion of the THLB overlapping a particular habitat layer by an unknown amount. For layers that are often coincident with the riparian reserve zone (e.g., Coarse Filter High and Very High Risk ecosystems, or rare and endangered ecosystems), the overestimate may be a relatively large proportion of the total overlap. For layers that rarely coincide with the riparian reserve zone (e.g., mountain goat winter range), the overestimate is probably negligible.

Analysis Units play an important role in some of these experiments. The descriptions for identifying analysis units for the North Coast were taken from Bolster (2002), and are summarized in Table 2.

Table 2. Classification system for Analysis Units from Forest Cover data.

AU #	Analysis Unit Name	Inventory Type Groups	Site Index (metres at 50 yr)
1	Cedar, Hem/cedar-High	C, CH, HC (9,10,11,14)	>22
2 & 42	Cedar, Hem/cedar-Medium	""	15-22
3, 23 & 43	Cedar, Hem/cedar-Low	""	<15
4	Hem, Bal-High	H, HB, HS, H DEC, B, BH, BS (12, 13,15, 16, 17, 18, 19, 20)	>22
5 & 10	Hem, Bal-High with thinning	“”	>22
6 & 26	Hem, Bal-Medium	""	15-22
7 & 10	Hem, Bal-Medium with thinning		15-22
8 & 28	Hem, Bal-Low	""	<15

9	Spruce-High	S, SH, SB, S DEC (21, 22, 23, 24, 25, 26)	>22
10 & 30	Spruce-Medium	""	15-22
11	Spruce-Low	""	<15
12	Cottonwood	Ac (35, 36)	All
13	Pine	Pl (28)	All

ARC Version 8.0.2 from Environmental Research Systems Institute, Inc. was used to select appropriate criteria and to perform the spatial overlays. The resultant datasets were then summarized in Oracle 8i using Oracle Discoverer 3.1. The final formatting and output was performed using Microsoft Excel 2002.

4.0 Results

4.1 Hydroriparian Planning Guide

Key results from Price (2003):

- *The precautionary hydroriparian ecosystem network covers a large portion of the operable forest (THLB) in the two sample drainages: Paril (64%), Chambers (56%).* (Note that these two drainages are at best representative of the Kitimat Ranges, or mainland mountainous sections of the plan area, and would not apply to the Hecate Lowlands (Price 2003)). This result is important because the economic effects of the precautionary guidelines are clearly substantial, and there would be frequent desire to apply the risk-managed guidelines in order to reduce the size of this hydroriparian ecosystem network.
- *In both drainages the combination of class IV/V terrain (potentially unstable slopes), and active fluvial units, resulted in the largest contribution to the overlap of the hydroriparian ecosystems and the THLB:* 35 of the 64% in the Paril, and 48 of the 56% in the Chambers. This is important because managers would have to focus risk-managed guidelines on timber harvesting in class IV and V terrain, and in proximity to active fluvial units, in order to produce any substantial reduction in the economic impacts of the precautionary guidelines.
- *In both drainages designation of rare ecosystems and of set-asides for biodiversity representation had relatively small impacts on THLB (5 of 64% in Paril, and 0 of 56% in Chambers), because these values had largely been satisfied under set-asides for the other components of the hydroriparian ecosystems (such as class IV/V terrain or active fluvial units).* This is important because it suggests that precautionary hydroriparian planning, especially early in watershed development, can satisfy a number of other resource values.

4.2 Coarse Filter Ecosystems

The base line assessment of risk to old forest ecosystems (Analysis Units) by Biogeoclimatic (BEC) variant classified Analysis Units into five risk classes: Very Low, Low, Moderate, High and Very High (Holt and Sutherland 2003). In addition, this report illustrated that Analysis Units can be divided into three major classes: (i) those at current High or Very High risk; (ii) those at Moderate to High risk when projected through 250 years; (iii) those persistently at Low or Very Low risk through 250 years. Appendix 1 details the statistics on proportion of each

Analysis Unit by BEC variant falling in the THLB, and provides summary statistics on this overlap by risk class and across the entire plan area. Key results:

- *As risk increases from Very Low to Very High, the proportion of each AU falling in the THLB increases dramatically* (Table 3). This is another way of depicting the underlying cause of the risk; ecosystems that fall mainly in the THLB are at higher risk because a larger proportion of each one is likely to be harvested, or has already been harvested.
- Regarding the three general classes of Analysis Unit (based on projected risk), *those currently at least at High Risk comprise a very small proportion of the forested land base (1.14%) and of the THLB (6.62%)* (Table 4). This is important because adherence to the Low Risk Threshold in the General Management Direction would effectively preclude future harvesting of these units. *Those units projected to increase substantially in risk over time comprise a modest proportion of the forested land base (14.44%), but a substantial proportion of the THLB (42.47%).* This is important because the ability to harvest these units while adhering to the Low Risk Thresholds will require substantial proportions of these units to be maintained or recovered with old growth characteristics (e.g., variable retention, or longer rotations). *The third category (persistent low risk) comprises the vast majority of the forested land base (84.42%) and a slim majority of the THLB (50.91%).* This is important because its low risk status reflects relatively low historical harvest, but harvesting in these units will have to increase if the General Management Direction thresholds are adhered to for the other classes.

Table 3. Proportion of total area of all Analysis Units in a Risk Class overlapping the THLB (results taken directly from Appendix 1.A).

Risk Class	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Plan Area**
Proportion (%) of total area of all AUs overlapping the THLB	**6.8**	**29.8**	**36.1**	**62.2**	**67.3**	**11.4**

Table 4. Statistics regarding the THLB overlap of Analysis Units in each of the three risk groups.

RISK GROUPS	Total Area (ha)	% Forested Land Base	Area within the THLB (ha)	% of the THLB
High or Very High Risk at Present	12,297	1.14	8,117	6.62
Moderate or High Risk over 250 years	155,169	14.44	52,050	42.47
Low or Very Low Risk over 250 years	907,447	84.42	62,390	50.91

Landscape Units vary in the extent to which they include Analysis Units within each of the risk classes (Appendix 1.B). This reflects the uneven distribution of analysis units and of timber harvesting among landscape units. Key results:

- *The High and Very High risk AUs are widespread and located in a lot of Landscape Units with THLB: Belle Bay, Big Falls, Bishop, Brown, Chambers, Gribbell, Hartley, Hawkesbury South, Kaien, Khtada, Khyex, Kitkiata, Kumealon, Kwinamass, Porcher,*

Quottoon, Red Bluff, Scotia, Somerville, Sparkling, Stagoo, and Triumph. These are the areas where such units may need to be removed from future harvesting in order to satisfy the General Management Direction.
- *Two Landscape Units have substantial representation of these Analysis Units outside the THLB, the Khutzeymateen (a protected area) and the Kshwan.* The lack of THLB in the Kshwan makes this an intriguing prospect for a protected area.
- *Five other Landscape Units have small representation of these Analysis Units outside the THLB: Anyox, Aristazabal, Captain, Monckton, and Observatory West.* These areas warrant special attention in terms of validating their distribution in Predictive Ecosystem Mapping, and considering their protection in future Timber Supply Reviews and general land management.

4.3 Goal 1 Protected Areas

Key results:
- *Only four Landscape Units have substantial areas proposed for protection under Goal 1 (Appendix 2).* These are Captain, Dundas, Porcher and Quottoon. Very small portions of two other Landscape Units, McCauley and Stephens, are included in proposed Goal 1 areas.
- *1.51% of the THLB would be removed if timber harvesting were terminated in all Goal 1 proposed protected areas (Appendix 2).*
- *Proposed protected areas do not cover a substantial area of Analysis Units at High Risk* (84.7 ha, or 4.6% of the Goal 1 areas and 2.7% of the High Risk AU area), *or at Very High Risk* (12.9 ha, or 0.7% of the Goal 1 areas and 0.01% of the Very High Risk area). This is important because new protected areas, as previously proposed, cannot appreciably reduce risk to these ecosystems. Therefore risk reduction would entail localized set-asides of these ecosystems within the THLB, or the designation of different protected areas.

4.4 Rare and Endangered Ecosystems

The following results are likely underestimates because the red and blue-listed ecosystem inventory did not cover the entire plan area. Key results:
- *Eleven of the 60 Landscape Units have some documented overlap of Red and Blue listed ecosystems and the THLB (Appendix 3.A).* Predictive ecosystem mapping can be used to identify locations of some other rare ecosystems, beyond the inventory reported here, at least for tactical planning.
- *On average 6.24% of the THLB is in mapped red and blue listed ecosystems (Appendix 3.A).* This is a relatively high proportion of the THLB. *When the CWHvm1/08 ecosystem is removed from the inventory (somewhat equivalent to the downlisting suggested by Ronalds and McLennan (2002)), then the overlap drops to 1.95% (Appendix 3.B).* This drop is expected given how extensive this ecosystem proved to be in the inventory.
- *When all ecosystems are considered, the overlaps with THLB are most extensive, and above average, in Sparkling, Khyex, Johnston, Skeena Islands and Quottoon Landscape Units, in descending order (Appendix 3.A). Removal of the CWHvm1/08 ecosystem changes this listing to Skeena Islands, Sparkling, Khyex, Kwinamass, and Kitkiata*

(Appendix 3.B). This latter listing would seem to be the Landscape Units where operational planning for protection of rare ecosystems is most urgent.

4.5 Islands less than 300 hectares.

Key results:

- *Across the plan area 0.5% of the THLB (total of 663 ha) falls on islands less than 300 ha in total size* (Appendix 4). Removal of these islands from the THLB would have a relatively small impact.
- *26 of 60 Landscape Units have some THLB on islands < 300 ha, but there is substantial (i.e. >50 ha) THLB on such islands in only 5 Landscape Units: Hevenor, Kaien, McCauley, Porcher and Triumph.* The impact of the Coarse Filter Biodiversity recommendation not to harvest on these islands largely depends on whether or not harvesting in these areas is considered economical and/or is affected by visual quality restrictions.

4.6 Mountain Goat Winter Range

Key results:

- *Goat winter range overlapped the THLB in 28 of 60 Landscape Units (Appendix 5).*
- *Across the plan area, 2.8% of the THLB is in mountain goat winter range (Appendix 5).* Complete removal of winter range from the THLB, as recommended in the Low Risk approach of the General Management Direction, could have a relatively small impact on THLB.
- *The overlap is particularly high (above the 2.8%) in a number of Landscape Units, listed in descending order as follows: Kitsault, Marmot, Quottoon, Bishop, Big Falls, Stagoo, Belle Bay, Somerville, Gribbell, Kwinamass, Sparkling, Brown.* This result suggests that these are the areas first in need of some assessment and confirmation of goat winter range. This largely matches the results of the risk assessment for mountain goats (Pollard 2003) which pointed out that goats are at moderate risk from loss of winter range in Kitsault and Pa_aat LUs. However, the proportion of THLB in the winter range was somewhat higher for many LUs when calculated from the NC Landscape model runs (as used in the risk assessment – Pollard 2003) as compared to this overlay experiment.

4.7 Marbled Murrelet Most Likely Nesting Habitat, and Zonation.

Key results of the overlay of Most Likely Nesting Habitat and THLB are:

- *47 of the 60 Landscape Units have at least some of the THLB covered by most likely nesting habitat (Appendix 6).*
- *59.7% of the THLB is in the most likely nesting habitat, with anywhere from 0% to 100% of the THLB, by Landscape Unit, being in the most likely nesting habitat.* Clearly the potential impact of conserving all of the most likely nesting habitat is huge. The question remains as to what proportion of that high quality nesting habitat within the THLB the Table would like to conserve.

Key results of the GMD recommendations regarding zonation are as follows:

- *Across the Plan area, implementing the 69% threshold will have a 2% timber supply impact.* The details of this are in the following Table 5; the 2 % is the sum of Plan Area Timber Impacts across all zones.
- *Implementing the 69% threshold in each of the 6 recommended zones, will have a Plan area timber supply impact of approximately 16%.* The details of this are in the following Table 5; the 16% is the sum of the positive Plan Area Timber Impacts (i.e. two zones only).

Table 5. Summary of the timber supply impact by zone needed to achieve the 69% threshold for current MAMU population on a zone by zone basis.

ZONE	% of MAMU nesting capacity at current time	% of THLB removed in the base line scenario	Plan Area Timber Impact *
1	11	23	-2
2	25	40	9
3	21	25	-4
4	15	45	7
5	13	4	-11
6	6	23	-1

* When the value is negative, then there is no timber supply impact in order to meet the 69% threshold. When the value is positive, then the threshold cannot be met (i.e. %THLB removed is >31%).

- *Implementing the MAMU Recovery Team recommendation of three core areas will have a higher timber impact than the 6 zone approach, because each core area is required to maintain 10% of the population (and therefore would have to currently have >10% of the population if it were to sustain any timber harvest at all). One estimate based on 3 core areas (Johnston-Kitkiata; Kwinamass-Chambers-Somerville; Kumealon-Pa_aat-Captain) is of an approximate 30% timber impact plan-wide.*

4.8 Grizzly Bear Critical Habitat Capability

Key results of the critical grizzly bear habitat capability are:

- *28 of 60 Landscape Units have some proportion of the critical grizzly bear habitat capability overlapping the THLB (Appendix 7). Landscape Units without an overlap are those outside the area occupied by grizzly bears, and/or those without THLB.*
- *Across the plan area, 10.4% of the THLB falls within the critical grizzly bear habitat.* Conserving all grizzly bear critical habitat could have a substantial impact on timber supply; the acceptable level of impact will be a key subject of negotiation.
- *The following Landscape Units have the highest proportions (i.e. ≥15%) of THLB within the critical grizzly bear habitat (in descending order): Olh, Stagoo, Observatory East, Khyex, Sparkling, Big Falls, Observatory West, Scotia, Marmot, Johnston, Kwinamass,*

Belle Bay, Khtada, Brown, Chambers, Bishop, Quottoon. This information could help in designating zones for management of grizzly bear habitat.

4.9 Northern Goshawk High Nesting Suitability

Key results are:

- *All Landscape Units with any appreciable THLB have high quality goshawk nesting habitat potential in the THLB, and this includes 45 of the 60 Landscape Units (Appendix 8).*
- *About 57% of the high quality nesting habitat is outside the THLB.*
- *Plan wide, about 41.4% of the THLB is in high quality northern goshawk nesting habitat.* Although this overlap is high, the General Management Direction does not advocate removal of such large areas from the THLB. The critical steps in managing for goshawks are: (i) to find the nest areas, (ii) protect the nest areas and (iii) protect sufficient contiguous foraging habitat. The GMD recommends retention of 36 ha unharvested for each nest area. Regarding (i) and (ii), we do not have an accurate estimate of how many potential nest areas (breeding pairs) are in the plan area, but it may range from 50 to 150 (Mahon, pers. comm.).. This amounts to from 1800 to 5400 ha. If these nest areas are spread relatively evenly through the high quality nesting habitat, then approximately 43% of them would be in the THLB (i.e. 775 to 2320 ha). Removal of this hectarage amounts to a 0.6% to 1.9% overlap with THLB. Regarding (iii), there would likely be a further THLB overlap resulting from retention of high quality foraging habitat around known nest areas, because this habitat often includes mature and old-growth forest. We cannot estimate this impact right now because the domain experts are unable to give a quantitative estimate of the proportion of the goshawk territory that needs to be in such high quality foraging habitat. However, we note that much of the high quality foraging habitat is also likely to be outside the THLB, and management will have to maintain connectivity between the nest area and the foraging areas.

4.10 Cumulative Impacts of Various Layers

Key results are:

- *Despite the potential overlaps among resource values, the cumulative impact of all on the THLB is still very high (72.0%) (Appendix 9).* This can be compared to an approximate 126.8% additive overlap of THLB on the various layers when those overlaps are calculated individually and then summed.
- *We can get some idea of where the biggest overlaps exist by comparing the results from the individual overlaps (first number) with the results from the cumulative overlaps (second number):*
  - Coarse Filter (6.6 / 6.1)
  - Rare (6.2 / 1.5)
  - Grizzly Bear (14.0 / 10.5)
  - Marbled Murrelet (59.7 / 43.2)
  - Northern Goshawk (41.6 / 6.2)
  - Mountain Goat (2.8 / 0.9)

The counterintuitive result for Coarse Filter is because we used vector model overlays for the individual analyses, and a grid model with 1 ha pixels for the cumulative overlays and all the goshawk overlays. We had to do this to reduce computing time, and allow effective overlays of different inventories.

The counterintuitive result for the Grizzly Bear is because the cumulative overlap used all of Class 2, whereas the individual overlap used only 50% of Class 2 habitat. If the individual overlap had used all of class 2 , the proportion of THLB in the critical habitat would have been 17.4% instead of 10.5% (Appendix 7).

We can conclude that:

- Most of the Rare and Endangered Ecosystems are encompassed in the High and Very High Risk Coarse Filter polygons.
- Some of the Grizzly Bear critical habitats are covered by the Coarse Filter and Rare ecosystems, but Grizzly Bear critical habitat is largely additive to coarse filter and rare ecosystems. We reach this conclusion by comparing all of both classes 1 and 2 in the individual analysis (17.4%) with both these classes in the cumulative overlap (14.0%); (3.4/17.4)*100=19.5% of the critical habitat is covered by coarse filter and rare ecosystems.
- Marbled Murrelet Most Likely Nesting Habitat has the biggest single impact on THLB. (Northern Goshawk nesting habitat would have a similarly large impact, if it had been added to the sequence ahead of the MAMU layer. However, as noted in Section 4.9 above, the habitat retention needed to satisfy goshawks need not be so high as the THLB overlap suggests). Murrelets are problematic because nest sites are not predictable in spacing or density, and are very difficult to find, so large scale habitat retention is the only management approach likely to conserve a nesting population. The crux of the issue then is deciding what land zoning approach to take for murrelets given the choices outlined in the GMD. None of those options advocates THLB impacts as high as this cumulative overlap suggests, but the choices are quite different as noted in Section 4.7 above.
- The Northern Goshawk nesting habitat is largely coincident with the previous layers. Most probably this coincidence is largely with the marbled murrelet nesting habitat; both species have similar nesting habitat requirements.
- A considerable proportion of the mountain goat winter range coincides with previous layers. Once again this coincidence is likely to be largely with the marbled murrelet and goshawk layers. We suspect that the goat winter range is mostly additive to coarse filter, rare ecosystems, and grizzly bear layers.

5.0 Literature Cited

Bolster, L. 2002. Description of data inputs and assumptions for the timber supply analysis (base case) for the North Coast TSA. Report for the North Coast LRMP Government Technical Team, Smithers, B.C..

Environmental Risk Assessment Team (2003). Environmental Risk Assessment: Temporal Experiments - Synopsis. Report for the North Coast LRMP Government Technical Team, Smithers, B.C..

Coast Information Team. 2003. An Ecosystem Spatial Analysis for Haida Gwaii, Central Coast and North Coast British Columbia. Unpublished report of the Coast Information Team, Victoria, BC. . September, 2003.

Fall, A. and Fall, J. 2001. A domain-specific language for models of landscape dynamics. *Ecological Modelling* **141**(1-3): 1-18.

Holt, R. and G. Sutherland. 2003. Environmental Risk Assessment Base Case: Coarse Filter Biodiversity. Report to the NC LRMP Government Technical Team, Smithers, BC.

Mahon, T., D. Morgan and F. Doyle. 2003. Northern Goshawk (*Accipiter gentiles*) Habitat in the North Coast Forest District: Foraging area and nest area habitat suitability models. Report prepared for the North Coast LRMP Government Technical Team.

Morgan, D., Daust, D. and Fall, A. 2002. North Coast Landscape Model. Internal Ministry of Sustainable Resource Management report.

Pollard, B.T. 2002. Mountain goat winter range mapping for the North Coast Forest District. Contracted report for the North Coast Land and Resource Planning Team. Smithers, BC, pp. 30 with 130 attached maps.

Ronalds, I. and D.McLennan. 2002. Terrestrial ecosystem mapping of the CDC-listed Ecosystems in the North Coast LRMP area. Report by Oikos Ecological Services Ltd. to the North Coast LRMP Government Technical Team.

Steventon, J.D. 2003. Environmental Risk Assessment: Base Line Scenario – Marbled Murrelets. Report to the North Coast LRMP Government Technical Team, Smithers, BC..

6.0 Appendices