EBM Working Group Focal Species Project

Part 1:
Assessment of Co-location Outcomes and Implications for Focal Species Management under EBM

Prepared for
EBM Working Group

By

H. L. Horn
P. Arcese
K. Brunt
A. E. Burger
H. Davis
F. Doyle
K. Dunsworth
P. Friele
S. Gordon
S. L. Hazlitt
A. N. Hamilton
S. Leigh-Spencer
G. MacHutchon
T. Mahon
E. McClaren
V. Michelfelder
B. Pollard
S. Taylor
F. L. Waterhouse

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Disclaimer

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Executive Summary

This document is the final report in a series prepared as part of the ecosystem-based management (EBM) Working Group Focal Species Project. The purpose of the project is to assess the implications of EBM implementation on management requirements for seven focal species (black bear, black-tailed deer, grizzly bear, marbled murrelet, mountain goat, northern goshawk, and tailed frog) at the sub-regional and landscape unit scales. A key component of conservation of wildlife habitats under EBM is the co-location of habitats within old growth retention areas (OGRAs) to meet the legal objective for biodiversity. The Focal Species Project updated mapping and information for each of the seven focal species and applied this to the development of a conservation planning tool to co-locate habitats inside OGRAs at a strategic scale using MARXAN software.

Co-location simulations using MARXAN were assessed by domain experts to determine the status of habitat protection in existing reserves and the potential for additional habitat capture in OGRAs to meet legal objectives. They also used the co-location solutions to roughly estimate outstanding gaps in habitat protection for each species under EBM. The reference point in these assessments was a “Low Risk” scenario developed by domain experts, consistent with the definition of full implementation of EBM, which includes *“conservation measures…that seek to achieve a low level of ecological risk overall…over time…”*

This report describes the key inputs to strategic co-location, reports on the assessment of the final round of co-location simulations in MARXAN and presents recommendations, at a strategic level, for locating focal species’ habitats within old growth reserves and for managing habitats on the working landbase outside of reserves. It also lists priority research and inventory projects for each species in the EBM planning area. The conclusions and recommendations in this report are based on existing habitat mapping and knowledge of each species on the B.C. Coast; outcomes may be refined over time with improved mapping and new knowledge.

Inputs to strategic co-location are described in greater detail in Part 2 of the Focal Species Project report series: *Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas.* The co-location methods document should be referred to future co-location exercises and more detailed landscape unit design.

Comparison of co-location outcomes in the Mid and South Coasts

Co-location experiments were completed for the Mid and South Coast co-location study areas but not for the North Coast. A comparison of the results of co-location runs shows better results for all focal species in the Mid Coast study area compared to the South Coast. In the Mid Coast, a greater proportion of high value habitats are captured in existing reserves compared to

the South Coast and the Co-located Land Use Objective (LUO) solution achieves the low risk target for two species (tailed frog, grizzly bear) and comes close to the low risk target for others. In the South Coast, the Co-located LUO solution falls well short of the low risk target for all species. This result is assumed to be due to a longer and more intensive history of logging in the South Coast study area, resulting in fewer options for capturing high value habitats.

Summary of co-location outcomes by focal species

The table below summarizes the results of the co-location experiments for individual focal species. The table also lists the low risk targets for each species.

Implementing Co-Location for Multiple Species

Seven species were selected for the Focal Species Project to ensure representation of a broad range of old growth-associated habitat types across the landbase. At the same time, it is a goal of the co-location to overlap multiple habitats to the extent possible to minimize economic impacts. Optimal co-location outcomes for multiple species can be achieved by: (1) maximizing overlap of high quality habitats; (2) setting priorities for habitat capture within individual landscape units; (3) applying the range of EBM objectives to achieve co-located solutions; and (4) ensuring that habitats are distributed across landscape units, including lower elevation areas that often represent highest habitat values for multiple species. The 'specified areas' approach developed in the Mid Coast may be a useful method to guide planning for multiple species during landscape unit design.

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
1. Black bear	There is no appropriate habitat suitability layer for black bear for use in co-location at this time. The final focal species project report recommends habitat features for black bears to be included in future co-location work, such as: • Ensuring a dispersal of reserves across landscape units, with an emphasis on providing cover and security	The conclusion of domain experts is that black bear habitats are not adequately addressed in old growth retention areas (OGRAs) but there is an overall positive contribution of EBM to the quality and quantity of habitats.	As per South Coast

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	across female home ranges; and • Mapping and retaining areas of high denning potential at the landscape and stand scale.		
2. Black-tailed Deer	Deer winter habitats were modelled for the entire coast as part of the focal species project. While there is a reasonable level of confidence in the South Coast map product; more work is needed before the Mid Coast product can be used in the co-location and deer winter habitat mapping will not be completed for the North Coast. The Low Risk target is to retain 90% of high value (Deer_1) winter habitats or an equivalent area of minimum 70% Deer_1 and twice the area of Deer_2 (moderate value habitat).	• 35% of Deer_1 habitats are in existing reserves. Three LUs are almost all reserve, so meet targets for low risk. • The Co-located LUO scenario results in 63% of Deer_1 habitats captured overall (mid risk). This result is distributed across LUs so that approximately one-third are high risk, one-third are mid risk and one-third are low risk. • >85% of unprotected Deer_1 habitats in LUs at mid and high risk are located in the THLB There is only a small amount of high value deer habitat in the South Coast (4719 ha in total), much of it in the THLB. Because deer habitats can be managed effectively using a combination of spatial reserves and management of habitats on the working landbase, the Co-located	Not assessed

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
		LUO scenario is thought to contribute well to the habitat needs of deer under EBM. Spatial configuration is an important consideration. There is a concern that pushing co-location solutions out of the THLB may fragment the cross-elevational connectivity that is important for deer and concentrate the solution in areas of relatively lower habitat quality.	
3. Grizzly bear	Low Risk = 100% of Class 1 and Class 2 Best Habitats for purposes of the co-location exercise = 100% of Class 1, 50% of the highest priority Class 2 habitats. Assume rules were applied in MARXAN to pick up the best of the Class 2 habitats: 1. Early and late spring habitats in valley bottoms and at low elevations, in particular ecosystem units on floodplains or associated with wetlands and estuaries in CWH variants.	Class 1 fixed in reserves so focused assessment on Class 2. 39% of Class 2 is captured over the South Coast, and so, falls short of the 50% target. However, Class 2 habitats represent 1.2 % of total forested area and only 24% is in existing reserves. Also, due to mapping technique, one landscape unit (Phillips) captures most of the Class 2 for the sub-region. 73% of Class 2 habitats are forested. 44% of forested habitats, representing 32% of all Class 2, is captured in existing and projected	The Co-Located LUO scenario for the Mid Coast captures more that the 50% of Class 2 grizzly bear habitat recommended as a minimum by domain experts. About 46% of Class 2 habitats are in existing reserves and the co-located solution, overall, captures 68% of habitats. 74% of Class 2 habitats in the Mid Coast are forested. 79% of forested Class 2, representing 58% of all Class 2 habitat, is captured in the co-located solution. Of habitats outside of existing and

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	2. 100% of habitats in hypermaritime BEC subzones (i.e., CWHvh). 3. Fall habitats that protect salmon spawning areas, near where bears fish, if these areas are not already protected by hydro-riparian management. Other key aspects of grizzly bear habitat management under EBM include hydroriparian management, seral stage distribution and within-stand retention. Class 1 habitats are already protected under the coastal orders and 50% of Class 2 habitats are protected in the Central & North order.	reserves. Of forested habitats not captured in the co-located solution, 82% (46% of total forested Class 2) is in the THLB and therefore vulnerable to being logged. Overall, there is concern that enough Class 2 has not been captured in OGRAs, particularly forested habitats in the THLB.	projected reserves, only 8% is located in the THLB. Overall, domain experts are comfortable with the amount of grizzly bear habitat captured by the Co-Located LUO scenario in the Mid Coast study area.
4. Marbled murrelet	The overall target for habitat retention is based on Recovery Team goals i.e., a minimum of 69% of suitable (Class 1 – 3) habitats retained. For the purposes of the co-location work, the habitat retention target was reduced to 62% to reflect 10% use of lower value habitats by murrelets. The low risk scenario is to capture 100% of Class 1 and	48% of Class 1 - 3 habitat captured in the Co-located LUO solution (below the overall 62% habitat retention target). This solution includes 56% of combined Class 1 and 2 habitats (below the 100% target) 43% of habitats outside of reserves and projected OGRAs are in the THLB and, therefore, vulnerable	68% of Class 1 – 3 habitat captured in the Co-located LUO solution (above the overall 62% habitat retention target). The co-located solution includes 84% of Class 1, 72% of Class 2 and 75% of the combined 1 and 2. 10,853 ha of Class 1 and 2 habitats are not captured by this scenario. However, the overall capture of 68%

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	2 habitats, the remainder made up to 62% with Class 3. Because forested stands acquire suitable structural characteristics for nesting for marbled murrelets at approximately 200 years (Burger 2002), the focus of management is on protecting existing areas of high value habitat within reserves or other areas constrained to development activity.	to being logged. Class 1 and 2 habitats not evenly distributed across LUs, occurring in one-third of LUs. In general, achieving the CMMRT goal and doing so in a way that minimizes risk to murrelets will be difficult to achieve in the South Coast study area due to a historic loss of habitat and the cost of retaining high value habitats in the THLB.	of the combined Class 1 – 3 habitats exceeds the habitat retention target by 6%, which will help to mitigate the shortfall of Class 1 and 2 habitats. Class 1 and 2 habitats are more evenly distributed across landscape units in the Mid Coast study area compared to the South Coast.
5. Mountain goat	Different models were used to map winter habitat quality in each of the three sub-regions. In the South Coast, a resource selection function (RSF) was developed for female goats based on research using GPS collars from an adjacent area. The Low Risk target for the South Coast is to retain 90% of very high value (Goat_1) winter habitats or an equivalent area of minimum 70% Goat_1 and twice the area of Goat_2 (high value) habitat. In the Mid Coast, the bimodal habitat layer was derived using a GIS	At the sub-regional scale, 33% of Goat_1 winter habitats are captured in existing reserves. 54% are captured in the Co-located LUO scenario (= a high risk solution); this increases to 78% (mid risk) if habitats in the NTHLB are included. There are 13 landscape units that are priorities for landscape unit planning due to the high harvest rate. There is significant concern regarding the implications of mountain goat management under the Co-located LUO scenario with respect to the	At the sub-regional scale, 58% of suitable habitats occur in existing reserves, just below the high risk target. There is also a higher level of base protection, on average, within each LU compared to the South Coast. The Co-located LUO solution results in 76% of suitable habitats being captured (mid risk). This increases to 95% (low risk) if the NTHLB is included. At the landscape scale, 20 landscape units, representing 23% of all habitats, are within low risk targets. Nine of the

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	algorithm based on aspect, slope and elevation. The Low Risk target for habitat retention is 90% of suitable habitat. Mapping of mountain goat habitats in the North Coast is based on a resource selection probability function (RSPF). The Low Risk target for habitat retention is 100% of suitable habitat. In all study areas, 100% of approved ungulate winter ranges are included.	persistence of the current distribution and abundance of mountain goat populations. Lower elevation habitats are of particular concern. There is a high level of confidence in the location of mountain goat winter range that have been designated under the Government Actions Regulation as winter use of these areas have been confirmed through field inventory.	landscape units, representing 17% of all habitats, exceed high risk targets. 60% of goat habitats are within mid risk landscape units. Overall, the co-located solution improves the area of suitable habitat conserved in existing and projected reserves compared to the base case. However, the risk of localized extirpation is still high where occupancy has not been verified.
6. Northern goshawk	The following targets were identified for the purposes of the co-location experiments for nesting and foraging habitat. Targets do not necessarily represent the views of the NG Recovery Team but they were developed by species experts who participate on the NG Recovery Team for the purposes of the co-location exercise. Nesting habitat: 100% of known nest sites and associated nest areas/post-fledging areas. Modelled nest areas: 60% [N1 + N2] with at least half	Domain experts did not complete an assessment of the South Coast study area as the MARXAN method recommended by the northern goshawk species experts was not fully applied. The suggested method was applied in full in the Mid Coast.	Co-location provides protection for all known nest and post-fledging areas within the Mid-Coast sub-region. However , at this time, there are too few confirmed breeding areas to maintain the population of northern goshawks in the sub-region. Until targets for population recovery have been determine by the NG Recovery Team, it will be critical to the species to protect all additional nest/ post-fledging areas as they are identified, even if these are outside of old growth reserves

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	(30%) of this scenario comprised of N1. Modelled nesting habitat is a priority over modelled foraging habitat in the co-located solution Foraging habitat: 60% [F1 + F2] with at least half (30%) of this scenario comprised of F1.		established under EBM. Overall, modelled High and Moderate value nesting habitat for northern goshawks comprises only a small amount (approximately 11%) of the total land area in the Mid Coast. This likely represents a significant reduction in the historic amount of suitable nesting habitat in the sub-region. Therefore, while the Co-located LUO solution appears to meet the targets in the Low Risk scenario for nesting and foraging habitats, the total amounts of suitable nesting habitat are very unlikely sufficient to sustain a viable population even if targets for co-location are met. In order to fully understand how well co-location will assist in habitat protection for northern goshawks, it will be important to further examine the spatial distribution and configuration of habitat protection for the species. At the landscape unit scale, it will be important

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
			to determine which landscape units should have northern goshawks as a focus for habitat protection to ensure that insufficient amounts of habitat are not scattered among landscape units. There is a high amount of overlap between suitable goshawk nesting and foraging habitats and the THLB and, therefore, habitat protection beyond the OGRAs will be important for persistence of the species in the long term.
7. Tailed frog	Experimental low risk target: 50% Class 1; 45% Class 2; 30% Class 3; 40% Class 4 by landscape unit. Fragmentation: low The above targets are based on expert opinion and are suggested as a starting point for experimenting with co-location. Targets will be better defined as inventory and research improves understanding of coastal tailed frogs and their response to changes in	In the Co-Located LUO scenario, Class 2 - 4 habitats meet low risk targets. However, insufficient old growth is captured to achieve the precautionary low risk target of 50% Class 1 habitat. This is a concern because the Class 1 habitats are the highest value habitats for tailed frogs. At the landscape scale, it is Class 1 and 2 habitats (stream buffers) that are most consistently below targets for low risk and	Habitat captured within existing reserves appears to be sufficient to achieve the precautionary low risk targets for all classes of tailed frog habitat. In the Co-Located LUO scenario, the amount of habitat captured exceeds 70% for all habitat classes, suggesting that tailed frog habitat co-locates well on the Mid Coast. This result is well above the low risk targets for all habitat classes. Fourteen of the 62 landscape units with tailed

Species	Low Risk Scenario	Co-location Outcomes: South Coast	Co-location Outcomes: Mid Coast
	habitat.	these are the habitats of greatest concern. In the South Coast study area, Class 1 and 2 stream segments appear fragmented in the final solution. The fragmentation of habitats in the South Coast solution reduces the effectiveness of the OGRAs in protecting tailed frog habitats, which is assumed to increase the level of risk to the species.	frog habitat in the Mid Coast do not achieve Low Risk targets for Class 1 habitat, but most are within 5% of the target. A cautious conclusion is that sufficient habitats for tailed frog will be conserved through a combination of existing protection and incremental retention of habitats in OGRAs, although there are many uncertainties that should be tested through research, monitoring and adaptive management.

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1.0 Introduction

The EI02c Focal Species Project (full title: "Focal and Fine Filter Species Analysis to inform full implementation of Ecosystem-based Management) was undertaken to assess the implications of various land use scenarios on management requirements for focal and fine filter species at the sub-regional and landscape unit scales under ecosystem-based management (EBM). The objectives of the project are to:

- Develop and test a methodology for optimally co-locating focal species habitats in old growth reserves, as per objectives in the Coastal Orders, which includes
  - defining the habitat requirements for each species, in terms of quality of habitat and sufficiency of habitat supply with the EBM definition of "seeking to achieve a low risk to ecological integrity";
  - updating and improving the quality of existing habitat models; and
  - defining inputs and rules for each focal species, to be applied in a strategic co-location planning tool using MARXAN conservation planning software.
- Assess how well co-location simulations in MARXAN address the habitat needs of these species, and
- Provide recommendations, at a strategic scale, for management of focal species' habitats within and outside of reserves.

This document summarizes the outcome of the co-location simulations for each species and provides recommendations for the management within, and outside of, reserves.

1.1 Background

A key outcome of strategic planning exercises on the mainland coast of BC has been the adoption of Ecosystem-based Management (EBM) as the approach to planning and management of coastal resources. The definition of EBM, as agreed to in Government-to-Government (G2G) Agreements between the various First Nations on the Coast and the Province of B.C. is

"… an adaptive, systematic approach to managing human activities, guided by the Coast Information Team EBM Handbook, that seeks to ensure the co-existence of healthy, fully functioning ecosystems and human communities."

The G2G Agreements include an agreement to achieve "*full implementation of EBM by March 31 2009.*" With regard to Ecological Integrity, full implementation of EBM is defined as:

"Conservation measures…that seek to achieve a low level of ecological risk overall…over time…"

Ecosystem-Based Management Planning Handbook

Guidance to the management of habitats for wildlife is provided by the EBM Planning Handbook ('EBM Handbook') (CIT 2004). The EBM Handbook identifies the need to manage focal / fine filter species as a component of achieving full implementation of EMB. The EBM approach to conservation planning includes:

- Coarse filter strategies to "identify and protect representative samples of … habitat for focal, umbrella or keystone species, as needed, at appropriate scales";
- Fine filter strategies to "identify and protect specific elements and features …not adequately protected and//or maintained by the coarse filter";
- Landscape level reserve design to "achieve objectives to maintain ecosystem representation, wildlife habitat, movement corridors, riparian forest and other landscape design elements"; and
- Stand level retention to "provide for seasonal and critical wildlife habitat and protect special ecological elements.

This is to be achieved through a multi-scale approach to "maintain ecological integrity by achieving management that does not exceed low risk for all environmental indicators" at the regional and sub-regional scales. The objective for focal species management is to "maintain healthy, well-distributed populations/ sub-populations of focal species", which includes measures to "protect and where needed restore, critical habitats for … and focal wildlife species (including corridors)" and "establish habitat supply objectives for … and focal wildlife species based on assessment of habitat capability, habitat suitability, carrying capacity and population estimates".

Legal direction: Coastal Land Use Orders

Co-location of focal species habitats within old growth retention areas is enabled under Section 14 of the Central & North and South-Central Coastal Orders. Section 14 (Objectives for Landscape Level Biodiversity) requires the retention of a specified amount of old forest within each site series. Subsection (7) states:

"To the extent practicable, include within old forest retention areas, stands of monumental cedar for future cultural cedar use, rare and at risk old forest ecosystems, habitat elements important for species at risk, ungulate winter range, and regionally important wildlife, including:

(a) mountain goats;

(b) grizzly bears;

(c) northern goshawks;

(d) tailed frogs; and

(e) marbled murrelets".

The Coastal Orders contain objectives that specifically address grizzly bear habitats and black bears within Kermode Stewardship Areas but other wildlife species are only addressed through co-location under section 14. With the exception of bears, strategic direction concerning habitats for specific wildlife species was not provided by the Central Coast or the North Coast Land and Resource Management Plans (LRMPs). Both planning processes recommended that zoning and objectives for individual species be completed through a subsequent process.

1.2 Project Implementation

1.2.1 Phases of Project Completion

The Focal Species Project was completed in three phases in close collaboration with the DS04 Co-Location Project to design a strategic co-location planning tool using MARXAN conservation planning software. Each phase of the Focal Species Project informed the Co-location Project, which in turn, informed the next phase of the Focal Species Project (Figure 1).

Phase 1: Preparation for strategic co-location scenarios

In Phase 1, domain experts provided information and literature references on focal species in the coastal planning area, reviewed and recommended improvements to mapping, and made preliminary recommendations into co-location scenarios.

The inputs from Phase 1 were used to prepare a proof of concept of a 'Co-location Tool' using MARXAN conservation planning software to strategically co-locate areas of old growth retention with habitats for focal species. The proof of concept was tested for the South Coast planning sub-region.

Phase 2: Testing of strategic co-location scenarios

In Phase 2, domain experts reviewed outputs of various scenarios using MARXAN to test and assessed the sensitivity of the scenarios to changes in targets for old growth retention areas. Scenarios were run for the South Coast planning sub-region.

Domain experts met in December to review the scenarios and develop recommendations for improving habitat mapping and to refine inputs into MARXAN.

Phase 3: Synthesizing results

In Phase 3, domain experts reviewed a final set of MARXAN outputs derived from running the Low Risk, Best Habitats and Co-located LUO scenarios, as described in Section 2.0 of this report. Scenarios were run for the Mid and South Coast sub-regions. Domain experts used this review to develop strategic recommendations for the co-location of focal species' habitats in old growth reserves and management of habitats outside of reserves under EBM. Note that, due to funding and time constraints, not all scenarios were re-run or recommended revisions fully applied. For some species, this hindered the ability of domain experts to fully assess MARXAN solutions.

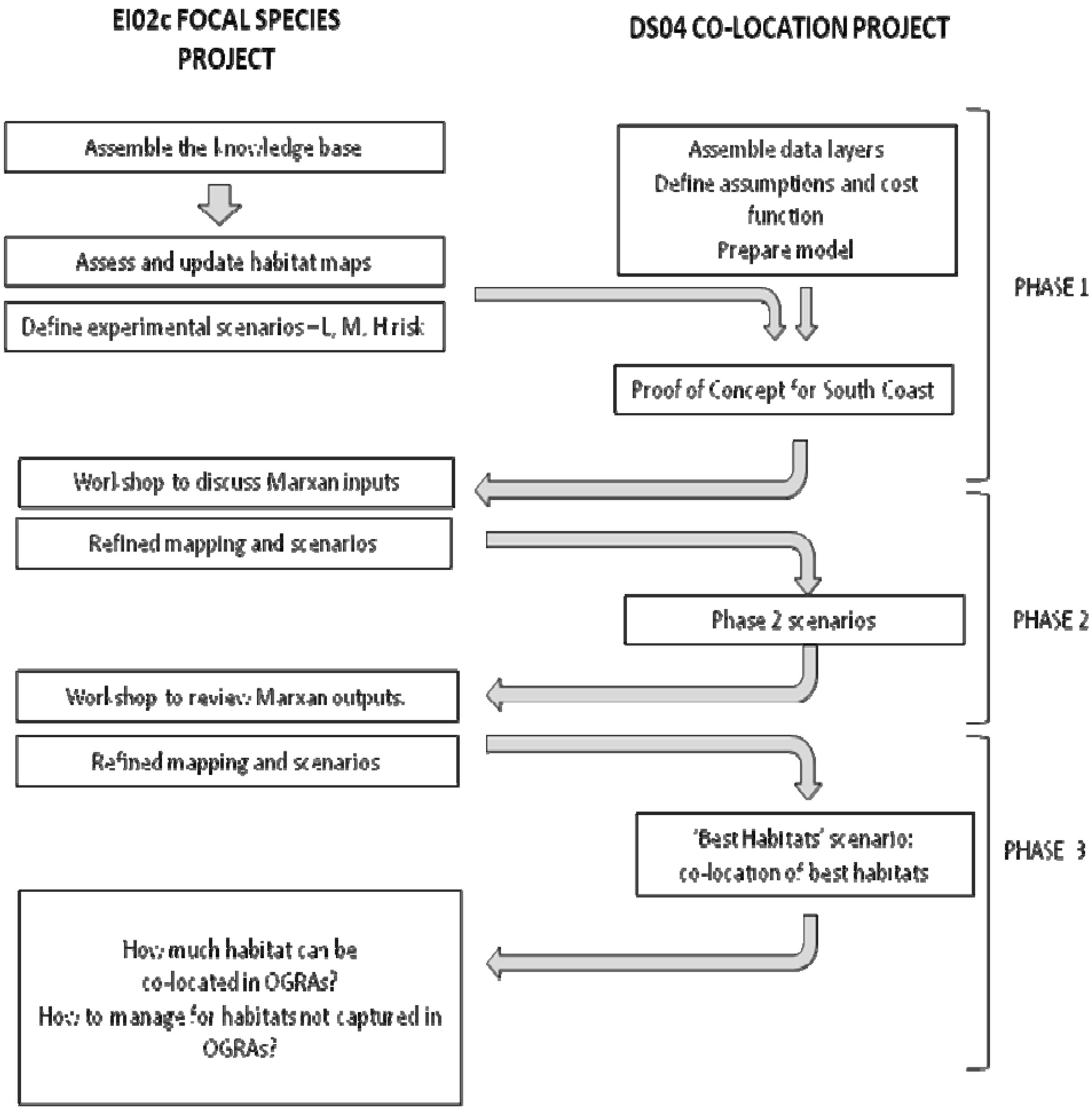

Figure 1. Relationship between the EI02c focal species and DS04 co-location projects

1.2.2 Domain experts

The input to this document was provided by the following biologists with expertise in the habitat, management and conservation of a focal species in a coastal context:

Name	Affiliation	Topic area
Helen Davis	Artemis Wildlife Consultants	Black bears
Tony Hamilton	Ministry of Environment	Black and grizzly bears
Grant MacHutchon	A Grant MacHutchon Consulting	Black and grizzly bears
Kim Brunt	Ministry of Environment	Black-tailed deer
Ken Dunsworth	Ministry of Environment	Black-tailed deer
Peter Arcese	University of British Columbia	Marbled murrelet
Alan Burger	Alan Burger Consulting	Marbled murrelet
Stephanie Hazlitt	University of British Columbia	Marbled murrelet
Louise Waterhouse	Ministry of Forests and Range	Marbled murrelet
Frank Doyle	Wildlife Dynamics Consulting	Northern goshawk
Todd Mahon	Wildfor Consultants	Northern goshawk
Erica McClaren	Ministry of Environment	Northern goshawk
Pierre Friele	Cordilleran Geoscience	Tailed frog
Volker Michelfelder	Ministry of Environment	Tailed frog
Steve Gordon	Integrated Land Management Bureau	Mountain goat
Sally Leigh-Spencer	Consulting biologist	Mountain goat
Brad Pollard	McElhanney Consulting Services	Mountain goat
Shawn Taylor	Goat Mountain Resources	Mountain goat

These domain experts have provided input throughout the Focal Species Project. They shared knowledge on the habitat requirements for each species, in a coastal context, and applied that knowledge in developing inputs into the MARXAN conservation planning tool. These inputs included a review and recommendations to improve habitat mapping as well as targets for habitat retention during co-location. In the final phases of the project, domain experts reviewed the MARXAN outputs, assessed the potential implications of the various scenarios and provided recommendations for improvements to the co-location process, based on the results. This document summarizes their input.

1.3 Description of Study Areas

The coastal planning region comprises the boundaries of the North and Central Coast Land and Resource Management Plans (LRMPs). For the purposes of the Focal Species Project, the region is divided into three sub-regions that are referred to in this report: North Coast, Mid Coast and South Coast (Figure 2). The boundaries of each sub-region are defined by the landscape units that are in each.

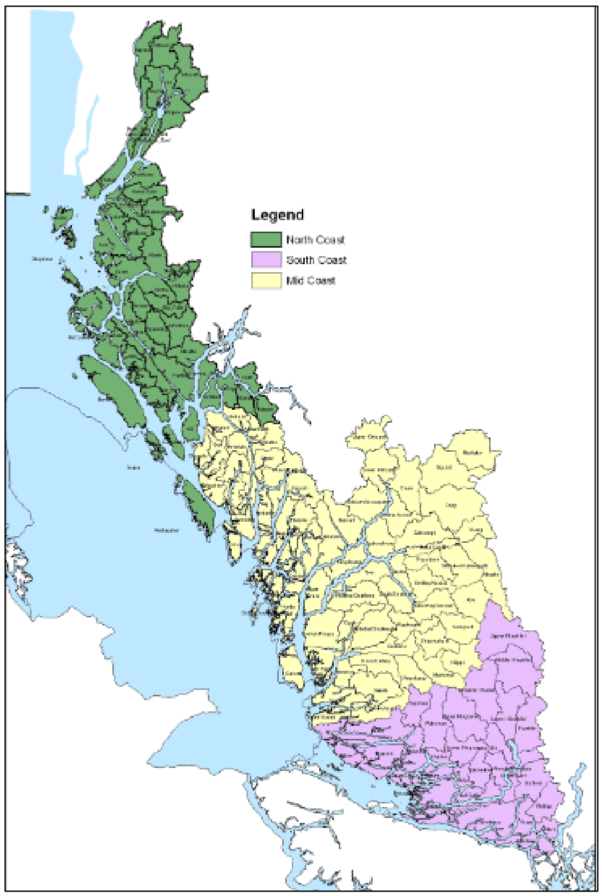

Figure 2. Study areas for applying co-location of focal species

1.4 Document Outline

This report provides strategic recommendations for co-location focal species' habitats within old growth retention areas and management of habitats outside of reserves as part of EBM Implementation. Chapters 3 - 9 set out recommendations for the management of each of seven focal species. Each chapter contains the following:

- A summary of inputs into strategic co-location using MARXAN conservation software and associated rationale;
- Results of simulations in strategic co-location for the Mid and South Coast sub-regions using MARXAN. These results include a comparison between multi-species ‘Low Risk’, ‘Best Habitats’, and ‘Co-located LUO’ scenarios as described in section 2.0 ;
- An assessment of implications of the co-location results with respect to the habitat requirements for each focal species;
- Recommendations for strategic co-location of habitats within OGRAs and for improving future iterations in MARXAN; and
- Recommendations for management of the species outside of OGRAs (in the working landbase).

Chapter 10 discusses strategic planning for the co-location of multiple focal species.

Chapter 11 lists research and inventory priorities for each species.

This report is Part 1 of six reports prepared as part of the EBM Working Focal Species Project. The suite of reports includes:

Part 1: Assessment of Co-location Outcomes and Implications for Focal Species Management under EBM

Part 2: Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas

Part 3: Knowledge Base for Focal Species and their Habitats in Coastal B.C.

Part 4: Summary of Habitat Mapping to Support EBM Implementation

Part 5: Review of Phase 2 Co-Location Scenario Outputs

Part 6: Summary of Peer Review Comments and Responses

The content resulting in Parts 2 - 5 underwent peer review in February 2009 (see Appendix 1 for a list of peer viewers). The peer reviewed content also forms the basis for the recommendations in this document.

2.0 Description of Co-Location Scenarios

One of the important tasks of the Focal Species Project was to provide input into the development and testing of a conservation planning software program to strategically co-locate old growth reserves with habitats for focal species. This was an iterative process leading to a set of rules in MARXAN to optimally achieve co-location of the highest value habitats for multiple focal species in old growth reserves (see section 1.2.1).

The following scenarios were run as part of Phase 3 of the Focal Species Project to "book end" the options for design of old growth reserves (Figure 2).

1. **Low Risk scenario:** Domain experts identified a preferred set of `low risk` targets for habitats of each focal species. The Low Risk scenario combines low risk targets for all seven focal species with targets for old growth retention by site series/surrogate as set out in Section 14 of the Central & North and South-Central Coastal Orders.
2. **Best Habitats scenario**: The Best Habitats scenario uses the solution from the Low Risk scenario as its starting point. The Best Habitats scenario sets targets for capture of the highest value habitats in the Low Risk solution, with the intent of concentrating 'best habitats' in a layer that is used a base for the Co-located LUO scenario. The purpose of this scenario is to provide a bridge between the Low Risk and Co-located LUO scenarios; this interim 'Best Habitats' scenario narrows down the options for habitat selection to ensure the capture of the highest value habitats in the final co-located solution.
3. **Co-located LUO scenario**: 'Best Habitats' goals were applied for each focal species, but the amount of old growth (the ``budget' for the scenario) is the targets for old growth retention[1], as specified in the Coastal Orders. In the Co-located LUO scenario, all targets for old growth retention are met while maximizing co-location with focal species` habitats, but shortfalls in reaching habitat goals are expected due to limitations on amount of old growth available for the solution.

The outputs of these scenarios will be used during the technical design phase to guide hands-on landscape unit design. A full description of inputs to the co-location simulations can be found in Part 2 of the Focal Species Project report series: *Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas.* Details regarding the MARXAN conservation planning tool

[1] Note: the South Coast Co-Located LUO scenario was run against the Low Risk solution rather than the Best Habitats solution. Because there is not a large amount of difference between the inputs to the Low Risk and Best Habitats scenarios in terms of habitat targets, the product was unlikely to be very different. However, as a methodology, the Co-Located solution should be run against the Best Habitats solution in the future.

are provided in *Co-location Modelling to Inform Old Growth Reserve Selection: EBMWG Project DS04a, Final Report* (Rumsey 2009).

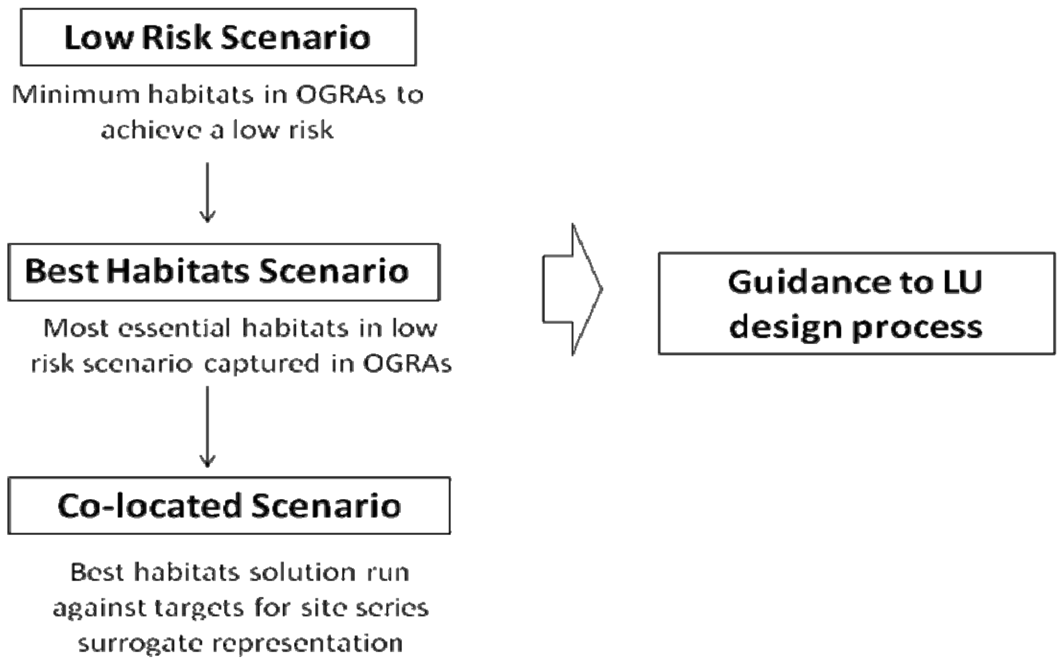

Figure 2. Link between strategic focal species co-location outputs (in MARXN) and landscape level design

Table 1 summarizes the targets used in the Low Risk and Best Habitats scenarios.

Table 1. Low Risk and Best Habitats targets used in the Phase 3 scenario runs. These targets are being adjusted over time as mapping is improved and new information becomes available.

Species	Locked in	Low Risk scenario	Best Habitats
Deer	Approved UWRs	≥ 90% of the area of H habitat but could achieve with a minimum of 70% H and twice the M	100% of H habitats captured in Low Risk solution
Grizzly bear	100% of Class 1 habitats as per Schedule 2 map; Approved WHAs	100% of Class 2	50% of overall Class 2 habitats in order of priority: early/late spring; vh1; floodplains
Marbled murrelet	Approved WHAs	100% of Class 1, 100% of Class 2, make up to 62% with Class 3 x distance to ocean class x LU	100% of Class 1 and 100% of Class 2; 100% of proposed WHAs in MC and NC;
Mountain goat	Approved WHAs	South Coast: ≥ 90% of area of Goat_1 habitat, but could achieve with a minimum 70% Goat_1 and twice the Goat_2	100% of Low Risk solution; 100% of proposed UWR

Species	Locked in	Low Risk scenario	Best Habitats
		Mid Coast: ≥ 90% of suitable habitat North Coast: 100% of suitable habitat	
Northern goshawk	Approved WHAs	100% of buffered nest areas (all age classes) 60% of M or H foraging habitat, at least half to be H; 60% of M or H nesting habitat, at least half to be H	100% of known nest areas; 100% of nesting habitat captured in the Low Risk solution; 33% of foraging habitat captured in the Low Risk solution
Tailed frog	Approved WHAs	50% of Class 1 streams, 45% of Class2 streams, 30% of Class 3 basins, 40% of Class 4 basins 100% of Class1 and 2 streams that overlap known tailed frog occurrences	100% of Low Risk solution for buffered streams (Class 1 + Class 2); 100% of Tier 1 tailed frog habitats in the Mid Coast

3.0 Recommended Management for Black Bears

Domain experts:

Helen Davis, Artemis Wildlife Consultants

Tony Hamilton, B.C. Ministry of Environment

Grant MacHutchon, A. Grant MacHutchon Consulting

3.1 Recommended Inputs to Strategic Co-Location in MARXAN

Until such time as habitat mapping for black bears is completed, the general guideline is to provide a distribution of important habitats and habitat elements and a distribution of age classes within each landscape unit. Reserves should be large enough to provide for bear cover and security requirements and reserves of varying sizes should be dispersed across the landbase, rather than clustered, in order to be available for female bears whose home ranges are small.

Currently the EBM Handbook treats dens as site-specific elements. While this is important, something broader than a den-by-den approach is needed. Locating OGRAs to capture stands with high potential to provide den structures will augment within-stand retention and help to ensure a supply of denning habitat across landscapes and through time. Recruitment of den cavities in the heavily logged landscapes of the South Coast may be required as well as full protection of existing dens in these landscapes.

Addressing security needs during OGRA design

OGRAs should be located to provide security for dominant and sub-dominant bears. Both of the following are important:

- Areas of old growth close to fish-bearing rivers will provide security and bedding adjacent to important fishing habitat and help maintain connectivity
- OGRAs in mid-elevation stands with big, old trees within the scale of female home ranges will provide denning and other secure habitat for females and cubs.

3.2 Assessment of Co-location Outcomes

Because no suitable model existed for black bears, habitats for the species could not be used as a driver in the MARXAN co-location process. Therefore habitat requirements for black bears were only partly addressed in the MARXAN solution through existing reserves and the co-location of habitats for other focal species within old growth retention areas.

Domain experts had originally assumed that the needs of black bears would be partly addressed in the Class 2 grizzly bear habitats within the grizzly bear occupied area. In assessing the results of the co-location in the South Coast, they determined that this was not the case because Class 2 habitats are not spread out across landscape units enough and habitats that are good for grizzly bears may be too risky for black bears to use due to predation risk.

Black bears require large, old forest structures for denning. Habitat mapping does not necessarily pick up the large structural elements required by black bears for denning, although a model of denning habitat could be used as an input to future analysis.

Black bear habitat requirements were not well-captured by those of other focal species. There is some overlap with the needs of grizzly bears. There is also some overlap between habitat requirements of black bears and marbled murrelets in the hypermaritime, but this needs to be investigated further. There may be some capture of the needs of black bear denning habitat if there is a stand age filter associated with deer and goshawk OGRAs. There is little overlap of habitat requirements between black bears and tailed frogs, although changes to the model that include more of the basins around occupied streams could capture some denning habitat.

3.3 Implications of Co-location for Management of Black Bears

In the current scenarios, black bears will not be adequately addressed in OGRAs through co-location. However, the combined components of EBM, as defined in the Central North and South-Central Coastal Orders, will contribute positively to the maintenance of black bear habitat quality and quantity. These specifically include:

- Objectives for Kermode bear habitat in the Central and North Coastal Order (Section 18), including targets for maximum amounts of early and mid-seral within defined Kermode stewardship areas;
- Objectives to maintain grizzly bear habitats identified in Schedule 2 of the Central & North and South-Central Coastal Orders (Section 17);
- Objectives for landscape level biodiversity and co-location of focal species habitats (as well as targets for maximum amounts of mid-seral forest within site series / site series surrogates (Section 14);
- Objectives for stand level retention (Section 16): Minimum 15% stand level retention, capturing suitable stand level elements which, for bears, could include dens, future dens and security trees.
- Objectives for hydroriparian areas, including active fluvial units and fans and forested swamps (Sections 10 – 13).

- Objectives to manage the rate of harvest in mapped 'important fisheries watersheds' (Section 8) and to apply reserve zones along streams having high value fish habitat (Section 9).
- Objectives for monumental cedar (Section 6) and Objectives for stand level retention of western redcedar and yellow cedar (Section 7) will not necessarily address the needs of black bears for denning unless this retention is in the form of stand level reserves containing cedar trees of varying quality and ages. Monumental cedars, as defined in the LUO, are generally selected for their structural integrity and, therefore, may not have the structural features necessary for denning (e.g., decayed core).

3.4 Recommendations for Management of Habitats Outside of Spatial Reserves

Within-stand retention is a fundamental component of EBM related to black bear habitat requirements. This is particularly important to ensure that the quality and quantity of understory growth for forage and structures for denning are not diminished over successive rotations.

One of the issues associated with the creation of large openings during logging is that it creates food-rich habitats in the short term due to the growth of forbs and fruit-bearing shrubs, but these become out-shaded and forage depleted during mid-seral stages, resulting in a lack of forage potential. Silvicultural activities that open up regenerating stands will also foster growth of forage plants (e.g., through pruning, juvenile spacing, cluster planning, and reduced stocking standards; Davis et al. 2006) provided the understory has not been overly reduced by multiple pass harvesting.

On the operable landbase, it is important to retain adequate structural legacies of logging for black bears for denning.

Strategies to achieve this include:

- within stand retention of wildlife tree patches that contain dens;
- high stumping large trees;
- leaving large logs in the block;
- leaving some large hollow cedar logs (prevent salvage for roof shakes); and
- in second growth stands, retaining legacies from the previous rotation. This will allow stand level legacies to last 2 - 3 rotations. Some dens in the Nimpkish Valley were found in 2nd growth (in stumps, under root wads and in hollow logs). Overall, though, old growth

provides better den habitat. Second growth structures are typically not large enough and are too sound to enable denning.

As roads are one of the highest mortality risks to bear, logging roads should be permanently deactivated or debuilt following harvest (Davis et al. 2006), including the removal of bridges, to create areas within watersheds that are generally inaccessible to the public. The location of a road along the boundaries of OGRAs can reduce the effectiveness of the reserve for bears.

Management for black bears should consider habitat effectiveness and mortality risk as well as habitat supply.

3.5 Recommendations to Improve / Refine the Co-location

3.5.1 Improvements to MARXAN methods

Complete coast-wide habitat suitability mapping for black bears, using available den data and based on resource selection function (RSF) or an expert-based approach, to be used as an input to future MARXAN co-location efforts. In this way, a specific model can be applied for black bears rather than basing mapping on the current grizzly bear classifications.

Regardless of mapping approach, e.g., TEM, PEM, or RSF, two different habitat ranking models are required for black bears:

- Black bear habitats outside of grizzly-occupied areas (e.g., in hypermaritime areas).
- In areas where there is overlap with grizzly bears, mapping to provide interpretation of all habitat classes within landscape units (currently only Class 1 and 2 grizzly bear habitats have been comprehensively mapped).

Ranking of habitat unit values should be based on telemetry data or field surveys by bear experts in as many study areas as possible.

Incorporate into suitability mapping a ranking of den potential based on age class, structural stage and site series.

4.0 Recommended Management for Coastal Black-tailed Deer

Domain experts:

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

4.1 Recommended Inputs to Strategic Co-Location in Marxan

This section summarizes key inputs to co-location for black-tailed deer habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas* (Part 2 of the EBM Working Group Focal Species Project) (Horn and Rumsey 2009).

4.1.1 Population objective

Objective: To maintain existing populations and a distribution of deer that satisfies both ecological and social objectives.

4.1.2 Targets for co-location of habitats in old growth retention areas

Targets shown below for Low Risk and Best Habitats scenarios will be used as a base for ‘seeding’ a final co-located solution in MARXAN (the Co-located LUO scenario) that meets, but does not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The targets shown here are for the capture of habitats that are not otherwise designated under the Coast Orders or as wildlife habitat areas under the *Forest and Range Practices Act* (FRPA).

4.1.2.1 Low Risk scenario

Recommended low risk target for black-tailed deer critical winter habitat:

> $\geq$ 90% of an “equivalent area” of Deer_1 (high value) habitat within each landscape unit.

This could be achieved by capturing either:

- ≥ 90% of Deer_1 habitat; or
- a combination of Deer_1 and Deer_2 (moderate value) habitats such that a minimum of 70% of the area of Deer_1 is captured, and the remaining target is achieved by capturing twice the area of Deer_2 (i.e. 1 ha of Deer_1 = 2 ha of Deer_2).

For example:

- *A total of 1,000 ha of Deer_1 habitat occurs in Landscape Unit X.*
- *The low risk target can be achieved by capturing:*
  - *a.) a minimum of 900 ha of Deer_1; or*
  - *b.) a minimum of 700 ha Deer_1 and 400 ha of Deer_2 (or, 800 ha of Deer_1 and 200 ha of Deer_2, etc.).*

This target reflects a low risk of not achieving the stated population objective. The target is based on expert opinion and was not derived through a formal risk assessment.

Analysis Unit: Landscape Unit to ensure a distribution of habitats across each sub-region.

4.1.2.2 Best Habitats scenario

100% of Deer_1 habitats captured in the Low Risk solution

4.1.2.3 Habitats to be locked into co-located solution

Ungulate Winter Ranges approved or proposed for approval under FRPA are to be locked into the final solution. These ungulate winter ranges represent some of the best known winter habitats available for black-tailed deer and many have been field verified.

In the Mid Coast, the general wildlife measure for habitat retention within designated black-tailed deer and moose winter polygons requires a minimum of 25% of each polygon to be functioning critical winter habitat at any point in time. Therefore, an equivalent area of UWR should be achieved in the final co-located outcome. This general wildlife measure is well-suited to the co-location exercise, as it allows flexibility in meeting the habitat requirements for deer as well as co-locating with habitats of other focal species.

4.1.2.4 Upper limit of habitat change

Domain experts have suggested that maintaining less than 60% of existing high value deer winter range within a landscape unit will result in a high risk scenario (i.e., reducing the area of modelled Deer_1 habitat by more than 40%).

This upper limit is the expert opinion of domain experts and has not been tested through research on deer populations in the study area.

4.1.3 Rationale for co-location targets

The rationale for the co-location targets is an expert opinion based on the amount of the area remaining as functional winter range compared to historic levels. The amount of habitat loss varies across the coastal planning region. The North Coast, for example, has not experienced as much forestry activity as in the Mid and South Coasts and, therefore, the threshold of change to deer winter habitats in the North Coast may be higher. Management of deer habitats in the North Coast is a low priority for this reason.

4.2 Assessment of Co-Location Outcomes

An assessment of co-location outcomes was only completed for the South Coast sub-region. This is because there were problems identified in the Mid Coast mapping following the MARXAN runs (see Brunt et al. 2009).

4.2.1 Assessment Methods

1. "Co-Located LUO" and "Low Risk" scenarios were assessed based the amount of Deer_1 critical winter range captured in existing reserves and projected OGRAs, by sub-region and landscape unit. For each sub-region and landscape unit, the areas captured in the co-located solution were compared with the total amount of modelled Deer_1 habitat identified in that landscape.

   These results were assessed against the following 'risk cut-offs' (H = high; M = Mid; L = Low) as presented in section 4.1.2 above:

   - Low Risk = $\geq$ 90% retention of Deer_1 habitat or equivalent combination of Deer_1 and Deer_2 habitats;
   - High Risk (upper limit of habitat change) = < 60% retention of Deer_1 habitat.

2. Where 70 - 89% of Deer_1 was captured, a further analysis was made of the amount of Deer_2 habitat to determine if the combined habitats met the 'low risk' equivalent of 90% of Deer_1 habitat (as described in section 4.1.2.1).

3. An overall estimate of the 'relative risk' of each landscape unit was determined based on the sum of the following:

   - the relative proportion of Deer_1 habitat in the LU compared to the total amount of Deer_1 habitat in the South Coast study area;
   - the relative proportion of Deer_1 habitat occurring in the LU that is not protected; and

- the relative proportion of Deer_1 habitat that is not protected that is in the THLB (based on the assumption that habitat in the THLB is more 'vulnerable' to loss through forest development than habitat in the non-THLB).

4.2.2 South Coast Results

a. Sub-regional scale

There is a total of 4719 ha of Deer_1 habitat in the South Coast sub-region, which is not evenly distributed across landscape units. Only 21 of the 29 landscape units in the South Coast have more than 30 ha of Deer_1 habitat and only 16 landscape units have more than 100 ha of Deer_1 habitat. The Middle Klinaklini has the largest amount of Deer_1 habitat at 575 ha, almost all of which is located within existing reserves.

The average proportion of Deer_1 habitats protected in existing reserves (protected areas, WHAs, UWRs, grizzly bear Class 1 habitat, riparian) is 35 % for the South Coast sub-region as a whole. Three of the 29 landscape units meet the definition of Low Risk (≥ 90% of Deer_1 habitat protected) based on the area of high value habitats in existing reserves (Ahnuhati-kwalate, Middle Klinaklini, Upper Klinaklini).

For deer, the bulk of high value habitats occur within the THLB. At the sub-regional scale, the Co-Located LUO scenario results in 63% of Deer_1 habitats in the solution (an overall mid risk). Of the 37% of habitats not captured in reserves and OGRAs, 89% is in the THLB.

b. Landscape unit scale

Landscape units having less than 30 ha of Deer_1 habitat were not included in the assessment at the landscape unit scale.

Table 2 summarizes the estimated risk for landscape units in the South Coast under the Co-located LUOs compared to the Low Risk scenario. The outcome is split somewhat evenly among low, mid and high risk outcomes. Seven of the 29 landscape units meet low risk targets, either > 90% of Deer_1 habitat or an equivalent combination of Deer_1 and Deer_ habitats. Eight landscape units, representing 38% of the Deer_1 habitats by area, have a level of habitat retention in the Co-located LUO solution that is below the high risk target (< 60% Deer_1 habitat retained). Six landscape units are mid risk.

By comparison, in the Low Risk scenario (Table 3), with the exception of the Lull-Sallie LU, all landscape units that meet targets for low risk based on the 90% Deer_1 or equivalent combination of Deer_1 and Deer_2 habitats. The Lull-Sallie LU is mid risk but is with 5% of meeting the low risk target as well.

Table 2. Risk to black-tailed deer by landscape unit under the Co-located LUO scenario: South Coast

Risk Value	Number (%) of landscape units	Proportion of total Deer_1 habitat represented
H	8 (28%)	38%
M	6 (21%)	28%
L	7 (24%)	32%
Not counted (<30 ha)	8 (28%)	2%

Table 3. Risk to black-tailed by landscape unit under the Low Risk scenario: South Coast

Risk Value	Number (%) of landscape units	Proportion of total Deer_1 habitat represented
H	0	0
M	1 (3%)	5%
L	20 (69%)	93%
Not counted (< 30 ha)	8 (28%)	2%

Table 4 summarizes the results of the Co-Located LUO scenario within individual landscape units. Four landscape units capture more than 90% of Deer_1 habitats and directly meet the target for low risk. An additional three landscape units capture more than 70% of Deer_1 habitats and, overall, meet the targets for low risk based on the equivalent area of Deer_2 habitats in the co-located solution. In the Charles LU there is only a small amount of Deer_2 habitat relative to the amount of Deer_1 and very little Deer_2 is captured in the solution, so the LU remains at mid risk. For other LUs, there is a relatively large amount of Deer_2 captured in the co-located solution, allowing the risk level to be assessed as 'low'.

In 12 of the landscape units assessed as mid to high risk, a very large proportion of the habitat area (> 85%) outside of existing and projected reserves are located in the THLB. Habitat in the THLB is assumed to be more 'vulnerable' to loss through forest development than habitat in the non-THLB.

'Based on the calculation of relative risk (see section 4.2.1(3)), the landscape units at the highest 'risk' are Snowdrift, Lull-Sallie, Allison, Belize, Lower Klinaklini, Broughton and Thurlow (Table 4).

Table 4. Results of Co-Located LUO Scenario by landscape unit (only LUs having > 30 ha of Deer_1 habitat shown)

Landscape Unit	LU Habitat ha	LU Habitat in current reserve	Ha added to reserve by Marxan	Remaining habitat in NTHLB	Remaining habitat in THLB	% protected	Risk estimate based on % Deer_1 or equiv captured	Deer_1 in LU/ total Deer_1 (%)	% Deer_1 not protected	% Deer_1 not protected in THLB	Relative risk for LU
Snowdrift	279	1	51	8	218	19	H	6	81	96	184
Lull-Sallie	221	4	66	5	146	32	H	5	68	97	170
Allison	89	17	6	6	60	26	H	2	74	92	168
Belize	280	5	83	17	175	31	H	6	69	91	166
Lower Klinaklini	446	73	89	24	260	36	H	10	64	91	165
Stafford	64	5	17	1	41	35	H	1	65	99	165
Broughton	53	11	11	2	29	41	H	1	59	93	152
Thurlow	368	28	171	4	165	54	H	8	46	98	152
Huaskin	124	18	56	3	47	60	M	3	40	94	137
Gilford	292	8	176	7	101	63	M	6	37	93	137
Miriam	177	0	105	10	62	59	M	4	41	86	130
Fulmore	253	8	156	11	78	65	M	5	35	87	128
Upper Kingcome	249	123	47	12	66	69	M	5	31	84	121
Klinaklini Glacier	36	12	16	1	7	77	L	1	23	91	114
Phillips	170	109	43	1	16	90	L	4	10	94	108
Knight East	55	39	7	1	8	84	L	1	16	89	107
Charles	221	0	186	10	26	84	M	5	16	72	93
Middle Klinaklini	575	564	1	7	4	98	L	12	2	35	49
Sim	122	88	6	26	2	76	L	3	24	9	35
Ahnuhati-kwalate	411	386	0	24	0	94	L	9	6	2	17
Upper Klinaklini	128	128	0	0	0	100	L	3	0	0	3

4.2.3 Mid Coast Results

An assessment of Mid Coast results was not completed for black-tailed deer due to uncertainties with the map products. Until such time as the Mid Coast deer habitat model is corrected, it should not be used in co-location exercises. However, co-location runs should continue to include designated UWRs as these polygons have been defined based on careful mapping and most have been field verified.

4.2.4 Uncertainties and limitations

- The rationale for the co-location targets is an expert opinion based on an assumption about the amount of the area remaining as functional winter range compared to historic levels.
- There is a lack of empirical evidence to support the estimated risk associated with different levels of habitat retention.
- Modelling at the scale undertaken in this project has inherent problems including a high likelihood of mis-identifying areas as either high or low value habitat (due to limitations in forest cover and other input variables). There is no substitute for site specific information in making decisions on the designation of critical habitat. Model input variables (especially forest cover) should be considered questionable at best, so model output should not be relied upon as a definitive representation of reality.
- In general, any issues affecting the reliability of the forest cover layer may compromise the reliability of the deer mapping output. This is an issue for all habitat mapping that uses the forest cover layer as an input.

4.3 Implications of Co-Location Results for Management of Black-tailed deer

4.3.1 South Coast

There is only a small amount of high value deer habitat in the South Coast (4719 ha in total), much of it in the THLB. A certain level of habitat protection already exists in the sub-region: almost a third of the highest value (Deer_1) habitats are captured in designated UWRs or other existing reserves. The co-located solution is projected to protect an additional 30% of habitats in OGRAs at a sub-regional scale, although this outcome is not evenly distributed across landscape units.

Within landscape units assessed as being mid or high risk in the Co-located LUO solution (six and eight landscape units, respectively), unprotected habitats are particularly vulnerable as such a high proportion of these (> 85%) are located in the THLB. In three of these landscape units, the total amount of deer habitat is less than 100 ha therefore the area of unprotected habitat is not large. However, the small amount of habitat in these landscape units should not be assumed to be inconsequential; their scarcity may mean that these habitats are particularly important as refuge during harsh winters.

The implications of these results cannot be judged solely on the % habitat captured within each landscape unit. Deer select suitable habitat based on site specific habitat attributes that represent a combination of many variables. The Co-Located LUO scenario does represent a significant increase (almost a doubling) in the area of Deer_1 habitat protected compared to the existing reserves alone. Because deer habitats can be managed effectively using a combination of spatial reserves and management of habitats on the working landbase, the Co-located LUO scenario is thought to contribute well to the habitat needs of deer under EBM. This assumption should be tested by field-verifying the quality of habitats located within OGRAs and assessing the effectiveness of these habitats for deer during severe winter conditions.

4.3.2 Mid Coast

Designated UWRs provide general wildlife measures for black-tailed deer within priority habitat areas over large portions of the Mid Coast plan area. These UWRs, combined with other deer winter habitats that are picked up incidentally as part of the co-location of OGRAs will contribute to the overall winter habitat requirements for deer in the sub-region. However, future co-location exercises should seek to incorporate modelled deer winter ranges for the Mid Coast, if possible.

4.3.3 North Coast

A co-location experiment was not completed for the North Coast in time for this assessment. There is no mapping of deer habitats for the North Coast at this time and, so, future MARXAN runs involving the North Coast will not be directed to capture deer habitats. Deer habitats are a low priority for management in the North Coast and Skeena Region has no plans to pursue habitat mapping or to designate UWRs in the future.

4.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

4.4.1 Key considerations for strategic co-location

4.4.1.1 Spatial versus aspatial reserves:

Deer habitats can be managed through hard (spatially defined) or soft (aspatial) reserves. There are pros and cons to both.

- *Spatial reserves* provide certainty that an area of high habitat value will not be altered through development activity. However, these 'hard reserves' are vulnerable to natural disturbance and a potential limiting factor of spatially-defined UWRs is that they do not allow for replacement following disturbance events.
- *Aspatial reserves* are managed over time without a hard boundary being applied into perpetuity. These types of reserve allow for loss of forest to development or natural disturbance. However, there is a risk that winter ranges will be defined 'by default' as those that are not deemed acceptable for harvesting. Because the characteristics that make stands attractive for harvesting are often the same ones that provide high quality winter range, the areas selected as aspatial reserves may end up being of less than optimal quality.

A combined approach (spatial and aspatial) may be most effective in some areas. The optimal solution is one that provides adequate habitat (both forage and cover) distributed in space and time to satisfy seasonal life requisites in perpetuity.

4.4.2 Setting priorities among landscape units

Based on the assessment of 'relative risk' summarized in section 4.2.2.1(3), the following landscape units are at highest risk and are, therefore, the highest priorities for capture of Deer_1 habitat during co-location: Snowdrift, Lull-Sallie, Allison, Belize, Lower Klinaklini, Broughton and Thurlow.

In the Mid-Coast, all approved UWRs should be included in co-location solutions; there are no priorities for individual landscape units for deer at this time.

4.4.3 Improvements to MARXAN methods

The modelled deer habitat layer for the Mid Coast will need to be revised for future co-location runs in MARXAN.

4.5 Recommendations for Management of Habitats Outside of Spatial Reserves

4.5.1 Management outside of old growth reserves to maintain the effectiveness of the reserves

Because the quality of deer habitat is influenced by the juxtaposition of habitats that satisfy both forage and cover requirements, the effectiveness of old growth reserves as winter range will be influenced by forestry activities outside of the reserve. In addition, management adjacent to old growth reserves can impact connectivity. The following should be considered in forest management decisions adjacent to old growth reserves:

Road locations: Roads that bisect winter ranges can severely compromise the effectiveness of the reserve. Roads on steep hillsides may have right of ways which restrict elevational movements that are necessary to access critical winter habitat. In addition, deep snow berms may impede cross-elevational movement.

Creeping edges: If a hard boundary is created with the reserve, there is a risk that windthrow will occur. Repeated salvage operations ('chasing windthrow') may result in additional windthrow and reduced effective winter range area. Feathering of edges may reduce the likelihood of repeated windthrow.

Delayed reforestation: Where forage production is an objective (such as in spring forage areas adjacent to winter ranges), delay establishment of confers to 'free-to-grow' stage following harvest. This might be accomplished through reduced stocking density and/or juvenile spacing.

Rotational logging around a winter range: The timing of forest harvesting adjacent to winter ranges can dramatically improve the quality and effectiveness of the winter range by maintaining a continuous supply of spring forage.

Maintaining spring forage within 2.5 km of deer winter ranges is desirable.

Openings within winter ranges: The policy of MOE is that any harvesting within winter ranges has a high likelihood of reducing the effectiveness of the area to satisfy habitat requirements during critical winter conditions.

4.5.2 Management across the working landbase outside of spatial reserves

If managed correctly, forest development can enhance deer populations. Man-made and natural openings provide forage that will be utilized if adjacent cover is available. Natural openings on the coast typically include wetlands, alpine habitats, and natural burn areas.

Managed forests do not typically achieve the old growth characteristics to satisfy winter range requirements in the deep snowpack zone (Nyberg and Janz 1990).

Forage production on the working landbase can be maintained by:

- managing harvest to maintain a variety of forest ages, and;
- creating gaps and openings in the forest that mimic the natural gap dynamic of coastal forests.

Boom and bust cycles of forest development are not conducive to long-term seasonal range habitat suitability for deer. In the 1960s, large areas of Vancouver Island were clearcut, burnt and planted to fir. In response to the increase in forage supply, deer populations increased dramatically. After 15 – 20 years, most areas became closed canopy second-growth stands with limited forage production and snow interception cover and deer populations decreased accordingly (Ministry of Forests 1996).

4.5.2.1 Managing seral stage distribution

Openings created during logging create food-rich habitats for a relatively short term. Canopy closure during mid-seral stages results in a decline in forage production, but an increase in cover capabilities. Harvest management can ensure that the mix of seral stages within each landscape unit maintains deer habitat suitability in both space and time. This is addressed in section 14 of the Central & North and South-Central Coastal Orders (objectives for biodiversity) in the objective to maintain less than 50% of each site series or site series surrogate in mid-seral forest age classes within each landscape unit.

4.5.2.2 Mimicking gap dynamic conditions

The following approaches to management will promote conditions similar to those created through gap dynamic disturbances:

- Patch size distribution. Patches should be a minimum of 40 ha in size. Coastal logged forest stands in Southeastern Alaska that retained >50% of the basal area retained understories similar to gap-phase forest for the duration of the rotation. Less than 50% retention resulted in depauperate understories (Kirchhoff and Thomson 1998; Deal 2001).
- Spacing and thinning: Hemlock-dominated stands reach closed canopy conditions most quickly. Forage production can be enhanced and maintained in regenerating hemlock stands through a combination of juvenile spacing or commercial thinning. Silvicultural techniques may also be necessary to enhance the development of wider, stronger crowns to provide better snow interception capabilities in the canopy (Nyberg and Janz 1990).
- Other silvicultural activities that mimic gap dynamics and promote forage production include pruning, cluster planning, and reduced stocking standards (MoF 2001).
- Silvicultural techniques such as cluster planting, juvenile spacing, and commercial thinning may provide functional connectivity that links forested patches that provide cover with early seral stands that provide forage.

5.0 Recommended Management for Grizzly Bears

Domain experts:

Tony Hamilton, B.C. Ministry of Environment

Grant MacHutchon, A. Grant MacHutchon Consulting

5.1 Recommended Inputs to Strategic Co-Location in MARXAN

This section summarizes key inputs to co-location for grizzly bear habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Part 2: Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas (Horn and Rumsey 2009).*

5.1.1 Population objective

Objective: To ensure grizzly populations that are healthy enough to allow limited consumptive use (e.g., hunter harvest, traditional use) as well as non-consumptive uses (e.g., bear viewing).

A healthy population should be relatively stable and sustainable, account for desired human use, be able to maintain its organization and function over time, and be resilient to stressors, including cumulative human impacts and stochastic environmental and demographic events. In addition, linkages between and within populations should be maintained over the long term and efforts made to recover populations, where necessary.

5.1.2 Targets for co-location of habitats in old growth retention areas

Targets shown here for Low Risk and Best Habitat scenarios were used as a base for 'seeding' a final co-located solution in MARXAN (the Co-located LUO scenario) that met, but did not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The targets shown here are for the capture of habitats that are not otherwise designated under the Coast Orders or as wildlife habitat areas under the *Forest and Range Practices Act* (FRPA). Section 17 in the South-Central Coastal Order is to maintain Class 1 grizzly bear habitats identified in the Schedule 2 map associated with the Order. Section 17 in the Central and North Coast Order is to maintain 100% of Class 1 and 50% of Class 2 grizzly bear habitats as identified in the Schedule 2 map associated with the Order. A revision of the Schedule 2 maps is underway and will be completed by December 31 2009. Grizzly bear habitat not addressed directly by the legal orders can also be co-located under Section 14 of the legal orders (Objectives for Biodiversity).

Domain experts feel the Best Habitat target is the minimum required to help achieve the population objective, with the assumption that a suite of other factors that influence the health of grizzly bear populations are addressed. Final mapping of grizzly bear habitats within old growth reserves will need to occur through detailed planning that balances the ecosystem types (forested and non-forested) represented in Class 2 habitats within each landscape unit.

5.1.2.1 Low Risk scenario

100% of Class 1 and 2 Class 2 habitats.

This target reflects the perceived risk of not achieving the stated population objective. The target is based on expert opinion and was not derived through a formal risk assessment.

5.1.2.2 Best Habitat scenario

100% of Class 1 and 50% of Class 2 habitats by BEC variant by landscape unit, where the Class 2 habitats selected are the most essential Class 2 habitats. The following Class 2 habitats are a priority for retention in OGRAs:

a. Early and late spring habitats in valley bottoms and at low elevations due to their rarity and lack of seasonal alternatives. Ecosystem units on floodplains or associated with wetlands and estuaries in CWH variants are particularly important.

b. 100% of habitats in hypermaritime BEC subzones (i.e., CWHvh) because the few essential habitats that occur in the hypermaritime are likely to have disproportionate value to resident and transient bears.

c. Fall habitats that protect salmon spawning areas, near where bears fish, if these areas are not already protected by hydro-riparian management.

Targets under the Best Habitat scenario may need to be varied by landscape unit and/or BEC variant based on:

- amount of Class 1 and 2 habitat available,
- status of the grizzly bear population unit,
- current seral stage distribution in the landscape unit, and
- location of the grizzly bear population unit with respect to the edge of their distribution and occupancy.

5.1.2.3 Habitats to be locked into co-located solution

Grizzly bear habitats reserved under Section 17 of the Coastal Orders are locked into the final solution. This includes all Class 1 habitat identified in Schedule 2. 50% of Class 2 habitats are also reserved in the Central & North Coastal Coastal Order but the specific location of these habitats has not been defined in the schedule to the Order.

5.1.2.4 Upper limit of habitat change

The retention of old growth is only one component of a suite of factors that influence the health of grizzly bear populations (other factors include mortality risk from human interaction, the health of salmon populations, etc.). Aside from the retention of essential habitat, it is not possible to directly link the retention of forest cover to the conservation of grizzly bear populations or define an upper limit of habitat change that could be expected to compromise their population trend. Therefore, domain experts did not define a high risk habitat threshold for the purposes of co-location. The magnitude of effects on bear populations depends on the type, amount, and distribution of land use and other human activities, associated habitat loss and displacement, and bear mortality related to human activity.

5.1.3 Rationale for targets

- If essential habitats are not provided, bears cannot meet their life requisites therefore individual animal fecundity and survivorship and population trend may be negatively affected.
- Class 1 habitats are the highest suitability and all Class 1 habitats are considered essential to the health of individual grizzly bears or local grizzly bear populations.
- Class 2 habitats are also high value but do not have quite the same habitat (primarily foraging) suitability as Class 1 habitats.

5.2 Assessment of co-location outcomes

Since Class 1 habitats are locked into all solutions, the emphasis of the evaluations was on the relative amount and quality of the Class 2 captured in each scenario (see section 5.1.2).

5.2.1 South Coast sub-region

Note: Because of the different mapping methods used, there is a disproportionate area of Class 2 habitat selected in the Fulmore and Phillips LUs under each scenario compared to the other 14 landscape units with mapped Class 2 grizzly bear habitats in the South Coast. Re-mapping of the Fulmore and Phillips LUs is underway and will be completed prior to December 31 2009.

5.2.1.1 Co-location Results

Table 5 summarizes outputs of scenarios for co-location of grizzly bear Class 2 habitats in OGRAs in the South Coast sub-region. Class 2 habitats were captured in MARXAN according to priorities identified in section 5.1.2(b), with highest priority given to early and late spring habitats at low elevations, hypermaritime BEC subzones, and salmon spawning areas not protected under hydroriparian objectives.

There are 16,294 ha of Class 2 habitats (forested and non-forested combined) in the South Coast. 24% of these are captured in existing reserves (protected areas, conservancies, WHAs, UWRs, riparian reserves and Class 1 grizzly bear habitat). This emphasizes the importance of protecting a sufficient quantity of Class 2 habitats in additional old growth reserves or through other habitat designations.

In the Co-located LUO scenario, the addition of the MARXAN solution increases to 39% the area of habitats in reserves (Table 5). This result is less than the Best Habitats target of 50% for the sub-region as a whole and outcomes are not distributed across the range of grizzly bears on the South Coast.

Table 5. Summary of scenario outcomes in the South Coast (forested and non-forested habitats)

Scenario	Amount in existing reserves[2]	Added by MARXAN	Total amount of Class 2 habitat captured
Low Risk	3923 ha (24%)	9138 ha (56%)	13,061 ha (80%)
Best Habitats Scenario	3923 ha (24%)	4704 ha (29%)	8627 ha (53%)
Co-Located LUO	3923 ha (24%)	2448 ha (15%)	6371 ha (39%)

5.2.1.2 Class 1 and 2 habitats as a % of total forested

One of the important considerations in the co-location of grizzly bear habitats is the amount of forested habitat that is included in the solution, compared to non-forested. A balance between the two is optimal. However, as forested habitats are more vulnerable to logging activity and, because old growth retention targets are met on the forested landbase, specific focus is placed in forested habitats in this assessment. The total forested landbase in the South Coast study area amounts to 959,543 ha. Table 6 summarizes the amount of Class 1 and 2 habitats in the forested landbase in the South Coast. Class 2 habitats comprise only a small proportion of the total forested area at 1.2%.

[2] Existing reserves = protected areas, WHAs, UWRs, riparian, biodiversity areas, grizzly bear class 1 habitat

Table 6. Forested grizzly bear habitats as a proportion of total forested landbase: South Coast

	Amount of forested habitat (ha)	% of total forested
Class 1 habitat	25,666	2.7
Class 2 habitat	11,875	1.2
Total Class 1 + 2	**37,541**	**3.9**

Table 7 summarizes the outcome of the Co-located LUO scenario for forested habitats and non-forested habitats. 73% of Class 2 habitats are forested in the South Coast. 44% of forested habitats, representing 32% of all Class 2 habitats, are captured in existing reserves and projected OGRAs. A large proportion of the forested habitats not captured in reserves (46% of forested Class 2; 5457 ha) is in the THLB and are, therefore, particularly vulnerable to being logged.

Table 7. Forested and non-forested grizzly bear habitats in the Co-Located LUO for the South Coast

Area assessed	Ha Class 2 habitat	% of total Class 2 habitat	% of forested Class 2
a. Forested habitats			
Total area of forested Class 2 habitat	11,875	73	100
Amount in co-located solution (existing reserves + OGRAs)	5185	32	44
Amount outside of reserves / OGRAs - In the THLB: 5457 ha (46% of total Class 2 forested) - In the NTHLB: 1233 ha (10% of total Class 2 forested)	6690	41	56
b. Non-forested habitats			
Total area of non-forested Class 2 habitat	4419	27	0
Amount in co-located solution (existing reserves + OGRAs)	1186	7	0
Amount outside of reserves / OGRAs	3233	20	0

5.2.2 Mid Coast sub-region

5.2.2.1 Co-location Results

Table 8 summarizes outputs of scenarios for co-location of grizzly bear Class 2 habitats in OGRAs in the Mid Coast sub-region. The two Coastal Orders (Central & North and South-Central) deal differently with Class 2 grizzly bear habitats. Class 2 habitats are not automatically protected under the South-Central Coast Order but 50% is reserved under the Central & North

Coast Order. However, MARXAN applied the same rules across the all study areas, capturing habitats according to priorities identified in section 5.1.2(b), with highest priority given to early and late spring habitats at low elevations, hypermaritime BEC subzones, and salmon spawning areas not protected under hydroriparian objectives.

There are a total of 34,502 ha of Class 2 habitats in the Mid Coast. 46% of Class 2 habitats occur in existing reserves (protected areas, conservancies, WHAs, UWRs, riparian reserves and Class 1 grizzly bear habitat). This is just short of the Best Habitats target of 50% of Class 2 habitats identified by domain experts, although further assessment is required to determine whether these habitats are well-distributed across landscape units. In the Co-located LUO solution, an additional 22% of Class 2 habitats are captured, increasing the overall area of Class 2 habitats in the solution to 68% (Table 8).

Table 8. Summary of scenario outcomes in the Mid Coast sub-region

Scenario	Amount in existing reserves[3]	Added by MARXAN	Total amount of Class 2 habitat captured
Low Risk	Not assessed*		
Best Habitats Scenario	15,696 ha (46%)	14,238 ha (41%)	29,934 ha (87%)
Co-Located LUO	15,696 ha (46%)	7,573 ha (22%)	23,269 ha (68%)

* The Low Risk scenario run for Mid Coast did not include the Low Risk target for grizzly bears (100% Class 2) so only outcomes of the Best Habitat and Co-Located LUO scenarios are reported in Table 8.

5.2.2.2 Class 2 habitats as a % of total forested

The total area of forest in the Mid Coast sub-region amounts to 1,741,915 ha. Of this, 25,526 ha is forested Class 2 habitat. Similar to the South Coast, Class 2 habitats in the Mid Coast comprise only a small proportion (1.5%) of the total forested landbase.

5.2.2.3 Assessment of forested vs non-forested habitats

Table 9 summarizes the outcome of the Co-located LUO scenario for forested habitats and non-forested habitats. 74% of Class 2 habitats are forested in the Mid Coast. 79% of forested habitats, representing 58% of all Class 2 habitats, are captured in existing reserves and projected OGRAs. This outcome meets the Best Habitats target of 50%. Outside of existing and projected reserves, there is less forested habitat in the THLB compared to the NTHLB (8% and 14% respectively), however, this remaining 2008 ha within the THLB is particularly vulnerable to being logged.

[3] Existing reserves = protected areas, WHAs, UWRs, riparian, biodiversity areas, grizzly bear class 1 habitat

Table 9. Forested and non-forested grizzly bear habitats in the Co-Located LUO for the Mid Coast

Area assessed	Ha Class 2 habitat	% of total Class 2 habitat	% of forested Class 2
c. Forested habitats			
Total area of forested Class 2 habitat	25,526	74	100
Amount in co-located solution (existing reserves + OGRAs)	20,055	58	79
Amount outside of reserves / OGRAs - In the THLB: 2008 ha (8% of total Class 2 forested) - In the NTHLB: 3463 ha (14% of total Class 2 forested)	5471	16	21
d. Non-forested habitats			
Total area of non-forested Class 2 habitat	8977	26	0
Amount in co-located solution (existing reserves + OGRAs)	3214	9	0
Amount outside of reserves / OGRAs	5763	17	0

5.2.3 Uncertainties and limitations

Targets for strategic co-location are based on the opinion of domain experts, but assumed to reflect the best-available understanding of grizzly bear habitat requirements.

The reliability of outcomes from the MARXAN co-locations for grizzly bears is influenced by limitations in the mapping, as described in *Part 4: Summary of Habitat Mapping to Support EBM Implementation* (Part 4 of EBM Working Group Focal Species Project Reports) (Horn 2009).

Reliability is also influenced by the level of scientific knowledge regarding grizzly bear food habits and habitat use and selection. Current assumptions are based only on a few studies in coastal B.C.

5.3 Implications of Co-Location for Management of Grizzly Bears

5.3.1 Adequacy of co-location of grizzly bear Class 2 habitats in existing reserve and old growth retention areas

Sections (a) and (b) below discuss the adequacy of co-location outcomes in addressing the habitat requirements of grizzly bears, based on the results summarized in section 5.2. This assessment assumes that other important aspects of grizzly bear management in place, including:

Hydroriparian management. Functional hydroriparian buffers that provide habitat for food, cover (security and thermal), and travel are fundamental to the overall quality and quantity of grizzly bear habitat. It is assumed that EBM objectives for aquatic habitats will contribute to the maintenance of grizzly bear habitat suitability and effectiveness.

Adequate within-block retention. Objectives in the Coastal Orders require 15% within stand retention. The contribution of within-block retention is dependent on the habitat elements retained. For example, are security trees inside or adjacent to the block being retained for bears? Is the understorey kept intact?

Grizzly Bear Management Areas (GBMAs) GBMAs are areas designated for no hunting of grizzly bears. The purpose of these areas is to provide benchmark areas for monitoring populations through time without the confounding influences of human mortality. Three GBMAs were designated in the coastal sub-regions as an outcome of the North and Central Coast LRMP processes and were located to represent a variety of ecosystems across south, central and northern coastal BC.

The retention of habitats is only one component of a suite of factors that influence the health of grizzly bear populations (other factors include mortality risk from roads and other human interaction, the health of salmon populations, etc.).

5.3.1.1 South Coast

The Co-Located LUO scenario for the South Coast sub-region falls short (39%) of capturing the 50% of Class 2 grizzly bear habitat recommended as a minimum by domain experts (section 5.1.2). Given that Class 2 habitats make up a relatively small proportion (1.2%) of the total forested area in the South Coast (Table 6), only 24% of Class 2 habitats is located in existing reserves (Table 5), and the majority of the Class 2 habitat captured is within the Phillips LU (and secondly the Fulmore LU), there is concern about the vulnerability of the remaining Class 2 habitat outside the Co-Located LUO scenario (61%; Table 5).

Forested habitats are of particular concern. A large proportion (73%) of Class 2 habitat is forested; 44% of forested habitats are captured in the Co-located LUO solution, which is less than the 50% target. A key concern is that, of forested habitats not captured in existing and projected reserves, 82% (46% of total forested Class 2), are located in the THLB, which increases their immediate vulnerability. In addition, due to the regular redefinition of THLB/ non-contributing areas, domain experts assume that all productive forested landbase outside of protected areas and other reserves in the NTHLB is also potentially vulnerable to harvest.

5.3.1.2 Mid Coast

The Co-Located LUO scenario for the Mid Coast captures 68% of Class 2 habitats, more than the 50% recommended as a minimum by domain experts. In addition, almost 80% of forested Class

2 habitats are captured in the solution. Given that about 46% of Class 2 habitats occur in existing reserves (Table 8) and all MARXAN scenarios capture a relatively high proportion of Class 2 habitat, including those identified as high priority, domain experts are more comfortable with the amount of grizzly bear habitat captured by the Co-Located LUO scenario in the Mid Coast sub-region.

A caution is that, of forested habitats not captured in the solution, 2008 ha is in the THLB and therefore vulnerable to being logged. Also, domain experts regard habitats in the NTHLB as also being potentially vulnerable to harvesting. More detailed assessment of habitats in and outside of the reserve solution is required during the landscape unit design phase.

5.3.1.3 Comparison of Mid and South Coast outcomes

As expected, given the long harvest history and much higher proportion of THLB to the total forested landbase in the South Coast compared to the Mid Coast, a considerably larger area of Class 2 remains at risk in the South Coast sub-region compared to the Mid Coast (5457 ha and 2008 ha, respectively, in the THLB). Domain experts caution that all co-location results must be put into a landscape-specific context; the amount and distribution of Class 2 habitats has to be examined at the scale of adult female home ranges, approximated by landscape units.

5.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

5.4.1 Key considerations for the co-location of grizzly bear habitats

- Although Class 2 habitats have the same suitability ranking for grizzly bears, they are not all comparable in terms of their relative importance to bears. For example, compared to lower elevation habitats, higher elevation habitats tend to have later phenology therefore are most suitable in a later season, are often much more common therefore cover a larger total area, and are typically not as vulnerable to development activity because they are more often outside of the THLB.
- If only a portion of Class 2 habitats can be conserved in the co-location solution, then these habitats need to be stratified and the rarest and most seasonally important habitats retained in reserves (section 5.1.2(b)).
- Focussing on undisturbed Class 2 habitats at higher elevations (e.g., avalanche chutes) does not replace lost or altered habitat at lower elevations.
- Aside from the retention of essential habitat (class 1), it is not possible to directly link the retention of forest cover to the conservation of grizzly bear populations or define an upper

limit of habitat change that could be expected to compromise their population trend for the reasons outlined in section 5.1.2(d).

- There is continued concern about the potential impact on security-conscious or sub-dominant bears, in particular females with cubs if implementation of the Coastal Orders results in increased development pressure on relatively poorer quality (Class 3 and 4) bear habitats, since these habitats are more likely to be used for security from other bears. This is a particularly important consideration for highly altered landscapes that have received historic high rates of cut and where overall habitat supply has been compromised (high proportion of THLB: total forested).

5.4.2 Setting priorities among landscape units

In addition to the focus on high priority Class 2 habitats, it is suggested that MARXAN focus on high priority landscape units first. Priority landscape units for grizzly bears are identified based on relative amount of Class 1 and 2 habitat available, status of the relevant grizzly bear population unit, current seral stage distribution in the landscape unit, and location of the grizzly bear population unit with respect to the edge of their distribution and occupancy, abundance and distribution of Pacific salmon, and other priority environmental values. The protection of Class 2 habitats within a landscape unit becomes even more important where there is a high ratio of THLB to total forested and there has been a long history of forestry development (logging and roads).

The following list of landscape unit priorities was developed in 2005 by Ministry of Environment staff, using the above criteria, to support strategic planning and associated impact assessments in the Central Coast LRMP area.

Landscape Unit	Rank	Landscape Unit	Rank
Ahnuhati / Kwalate	1	Sim	22
Talchako/Gyllenspetz	2	Franklin	23
Ahta	3	Belize	24
Bella Coola	4	Fulmore	25
Lower Klinaklini	5	Huaskin	26
Nusatsum	6	Lull-Sallie	27
Phillips	7	Estero	28
Taleomey/Asseek	8	Charles	29
Seymour	9	Snowdrift	30
Smitley/Noeick	10	Knight East	31
Wakeman	11	Miriam	32
Saloompt	12	Draney	33
Stafford	13	Allison	34
Ape	14	Gray	35
Nekite	15	Smith Sound	36
South Bentinck	16	Middle Klinaklini	37
Kakweiken	17	Upper Klinaklini	38
Clayton	18	Klinaklini Glacier	39
Smokehouse	19	Gilford	40
Upper Kingcome	20	Thurlow	41
Lower Kingcome	21	Walker	42

5.4.3 Improvements to MARXAN methods

- In the South Coast, the Scott Paper license area in the Klinaklini River is missing spatial data for the co-location effort therefore MARXAN is still not capturing much Class 2 habitat there. Gaps in coverage of habitat mapping for grizzly bears in the Mid Coast sub-region continues to be filled.
- In the short term, area-based results for the Fulmore and Phillips LUs in the South Coast should be reported separately from other LUs because of the difference in results arising from the different habitat mapping methods used. Re-mapping of the Fulmore and Phillips LUs is underway and will be completed prior to December 31 2009.
- At the landscape scale, identify and incorporate into OGRAs, nodes of (a) highest quality and concentration of habitats and (b) highest densities of overlapping home ranges that anchor the regional population. These nodes can be identified using broad scale population distribution modelling and should be prioritized for conservation.
- It is important to capture entire habitat complexes for grizzly bears, including old forest adjacent to essential non-forested habitats. One way to address this issue is to ensure that forested buffers are captured as part of the co-location solution and that these 'carry along' the adjacent non-forested habitat. This approach will ensure that , even though the non-forested habitats do not contribute to the achievement of SSS targets, they are nonetheless included as an integral part of habitats associated with OGRAs in the final solution. The following points describe how this might be achieved in MARXAN and during more detailed landscape unit design:
    - Class 1 habitat polygons are locked in as reserves as per the Coastal Orders. However, only the forested portion of these polygons is toward meeting OGRA habitat retention goals.
    - Class 2 habitat polygons form part of the solution based on the priorities identified in section 5.1.2.2 above, that is early & late spring habitats on valley bottoms and low elevations and 100% of habitats in the hypermaritime BEC subzones. However, only the forested portion of these polygons should contribute to habitat retention goals within OGRAs.
    - The final results, in terms of hectares and % of GB habitat reserved in a) LU Habitat Area, b) Habitat Protected, c) MARXAN added, d) Outside solution in THLB, and e) Outside solution in NTHLB would need to be reported as the amount or percent forested and non-forested. In this way, the impact on the THLB can be seen to be only the amount forested and that the amount non-forested does not actually contribute to meeting the

retention targets nor does it impact the amount of THLB available for harvest. It also allows an assessment of how close the solutions are to capturing 50% of the class 2 habitat (or more) and what the breakdown is in terms of forested versus non-forested both inside and outside the solution.

5.5 Recommendations for management of habitats outside of spatial reserves

Management of the habitats outside of OGRAs and other spatial reserves primarily occurs at two spatial scales: landscape and stand.

5.5.1 Landscape scale

At the landscape scale, outside of OGRAs, the key management issue is the maintenance of adequate forage supply over time. Forage supply is assessed at the landscape scale in terms of seral stage distribution. Openings created during logging enable food-rich habitats in the short term due to the growth of forbs and nutrient rich berry shrubs, but these become shaded-out and forage supply is depleted during mid-seral stages, resulting in a lack of forage potential. Managing the amount of mid-seral forest within each landscape unit ensures its amount does not become a limiting factor to forage production for bears. Section 14 in the Coastal Orders (objectives for landscape level biodiversity) includes an objective to maintain less than 50% of each site series or site series surrogate in mid-seral forest age classes within each landscape unit.

5.5.1.1 Management of access and human-caused mortality

Roads and the human access they provide and promote are one of the most significant mortality risks to grizzly bears, consequently logging roads should be deactivated or debuilt following harvest, including the removal of bridges, to create areas within watersheds that are generally inaccessible to the public. A priority should be put on access management on connected road networks e.g., in the Bella Coola Valley.

Rates of human-caused mortalities must be minimized through proactive efforts to prevent bear-human conflicts before they occur. Reproductive rates can be maximized through the maintenance of adequate habitat quality, quantity, distribution and linkages.

5.5.2 Stand scale

At the stand scale, there are a number of management practices that can be applied as part of silviculture treatments and cutblock layout to promote forage availability and retain stand attributes for bears. Stand level attributes to be managed include understory vegetation, bedding sites, wallows, mark trees and trails, dens, and coarse woody debris. EBM objectives requiring within-stand retention equal to or greater than 15% of a cutblock (section 16 in the Coastal Orders) and variable retention harvesting will contribute to the achievement of stand level management to promote bear habitat attributes.

5.5.2.1 Forage availability (promotion of understory)

Small gap forestry that mimics natural disturbance or the retention of large patches of trees within stands will contribute to greater forage supply over time. Silvicultural activities that open up regenerating stands will also foster growth of forage plants (e.g., through pruning, juvenile spacing, cluster planting, and reduced stocking standards; L'Anson 1996, MoF 2001). These silvicultural techniques are both preventative and rehabilitative, depending on when they are applied during stand regeneration. It is preferable, and potentially more cost effective, to proactively manage a regenerating stand to maintain forage growth rather than to rehabilitate the stand once canopy closure has occurred.

High retention or small patch harvesting is not always beneficial to bears on the Coast as it depends on the forest type. For example, if a stand is comprised of Western hemlock it may infill too quickly to provide adequate forage. Managed Douglas-fir stands tend to provide more understory forage.

After 2nd growth is harvested there may be a further reduction in forage supply as third growth stands may not provide the same quality and quantity of understory forage growth. This emphasizes the importance of within-stand retention that enables colonization of understory shrubs into new openings from retention areas.

5.5.2.2 Retention of habitat features:

Practitioners should consider anchoring stand level retention at the following features, where they are identified during pre-harvesting site reconnaissance:

- The identification of some of the stand level features for coastal grizzly bears (mark trees, trails, wallows, beds and dens) are described in *A Guidebook for Grizzly Habitat Features in Coastal British Columbia* (Himmer and Power 2003).
- Coastal grizzly bears also make extensive use of coarse woody debris for insect feeding. Large pieces of coarse woody debris retain the moisture required to sustain insect colonies through summer drought.
- Adult females with cubs of the year may be reluctant to use larger openings. Interspersion of windfirm trees that cubs can climb when threatened (escape trees) will allow females to use a larger proportion of an opening.

6.0 Recommended Management for Marbled Murrelets

Domain experts:

Peter Arcese, University of British Columbia

Alan Burger, Alan Burger Consulting and University of Victoria

Stephanie Hazlitt, University of British Columbia

Louise Waterhouse, B.C. Ministry of Forests and Range

6.1 Recommended Inputs to Strategic Co-Location in MARXAN

This section summarizes key inputs to co-location for marbled murrelet habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas* (Part 2 of the EBM Working Group Focal Species Project) (Horn and Rumsey 2009).

6.1.1 Population objective

Objectives: As per the short and long-term goals identified by the CMMRT for the recovery of marbled murrelets i.e., to slow the decline to the B.C. population and its nesting habitat to a stable level of 70% of 2002 levels throughout the range of the species in B.C. (69% in the Northern and Central Mainland Coast Marbled Murrelet Conservation Regions) (CMMRT 2003).

For the purposes of co-location under the Coast Order, domain experts identified the following objectives associated with the CMMRT recovery goals:

- To achieve the CCMRT goal of 69% retention of suitable habitat within each sub-region covered by the Coastal Orders, adjusted down to 62% to account for 10% potential nesting in lower quality (Class 4, 5 and Nil) unmanaged habitat.
- To provide a preferred distribution of Class 1 - 3 habitats using the air photo Interpretation Standard.

6.1.2 Targets for co-location of habitats in old growth retention areas

Targets shown below for Low Risk and Best Habitats scenarios will be used as a base for 'seeding' a final co-located solution in MARXAN (the Co-located LUO scenario) that meets, but does not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The targets shown here are for the capture of habitats that are not otherwise designated under the Coast Orders or as wildlife habitat areas under the *Forest and Range Practices Act* (FRPA).

6.1.2.1 Recommended habitat retention target:

Maintain 62% suitable marbled murrelet habitat within each sub-region (adjusted from 69% as explained in section 6.1.1). The denominator in calculating 62% is the sum of habitat in Classes 1-3. This target is thought to most likely achieve the habitat retention goal of the CMMRT given the current understanding of habitat selectivity by marbled murrelets. Habitat classes 4 to 6 should not be considered as contributing to the 62% target; the potential use of these lower ranked habitats is accounted for in the adjustment from CMMRT goal of 69% to a habitat retention target of 62%.

The achievement of 62% of suitable habitats is not necessary within individual landscape units, rather, the achievement of this target is best aligned with the CCMRT goals for the Northern and Central Mainland Coast Marbled Murrelet Conservation Regions. The larger the short-fall in habitat conserved (under the 62% target), the more likely it is that the national and provincial conservation assessment of this species will change to a higher category i.e., the perceived level of risk to the species will remain static or increase in future.

6.1.2.2 Low Risk scenario

- Targets for habitat retention:
    - For habitat mapping with a 6-level ranking system:

      62% of [Classes 1 + 2 + 3]: Capture 100% of Class 1 and 2 habitats (where Class 1 = Class 2) and achieve the remainder with Class 3 where necessary
    - For habitat mapping with a 4-level ranking system (Hobbs model):

      62% of [Superior + Good + Fair habitats]: Capture 100% of Superior and Good habitats (where S = G) and achieve the remainder with Fair where necessary

Analysis units: Distance to ocean class (0 – 30km and 30 – 50km) by sub-region, reported by landscape unit.

The term ‘risk’ is used here to describe *relative* levels of vulnerability of murrelets to habitat management options; it is not used to link a particular outcome to an absolute number of birds in terms of persistence. Domain experts propose that, for the purposes of strategic co-location, the level of risk to murrelets will vary depending on the distribution of habitat classes within the overall habitat retention target of 62%. The ‘Low Risk’ scenario, therefore, is the most precautionary solution, as it captures all of the highest quality (Class 1 and 2) habitats first and then seeks to meet the 62% with Class 3 habitat. Higher risk scenarios will have less Class 1 and 2 habitats and more Class 3 habitats in the solution. This approach to the concept of ‘risk’ reflects expert opinion and recent research on habitat quality (e.g., (Waterhouse et al. 2008, 2009; Burger and Waterhouse 2009).

At the time of preparing this report, the low risk targets using the 4-level ranking system (Hobbs model) had not been tested in MARXAN.

6.1.2.3 Best Habitats scenario

100% of Class 1 and 2 habitats captured in the Low Risk solution supplemented by Class 3 habitats to achieve an overall habitat retention target of 62% in each sub-region.

6.1.2.4 Habitats to be locked into co-located solution

Approved and proposed WHAs for marbled murrelets.

6.1.2.5 Upper limit of habitat change

Domain experts recommend keeping with the adjusted CMMRT Recovery Goal as a limit of change. As such, a minimum of 62% of suitable (Class 1 - 3) habitat needs be retained (see section 6.1.1). Within the 62% goal for overall habitat retention, the co-location outcomes that retain more habitat in higher quality classes (Classes 1 and 2), with the remainder of the 62% being met with Class 3 habitats, are expected to provide the best management options for murrelets due to known higher probability of use of Class 1 and 2 habitats by murrelets. However, it is not possible, at this time, to quantify the association between the distribution of suitable habitat classes and risk to murrelets.

6.1.3 Rationale for targets

- The recommended habitat retention target is based on the CMMRT goal of conserving 69% of suitable habitat in Northern and Central Mainland Coast Conservation Regions in the long term (CMMRT 2003). The CMMRT goal is taken from the Canadian Committee on the Status of Endangered Wildlife in Canada (COSEWIC) criteria for listing species at risk, in which a Threatened Species is defined as one with a population decline of at least 30% in three generations *based on decline in areas of occupancy, extent of occurrence and/or quality of habitat*. A generation is estimated to be 10 years for marbled murrelets (Burger 2002). CMMRT has refined this overall goal to set a % goal for habitat retention in each marbled murrelet conservation region.
- The 62% target assumes that approximately 10% of marbled murrelet nests are found outside of 'suitable' habitat areas (10% of 69% (CMMRT habitat goal) = 6.9%) (Waterhouse et al. 2008, 2009; Burger and Waterhouse 2009).
- Murrelets preferentially select for nesting air photo Classes 1 and 2 (high value habitat), while Class 3 (moderate value habitat) is likely to be used in proportion to its availability and

lower classes (4-6) avoided (Waterhouse et al. 2008, reviewed; Burger and Waterhouse 2009).

- Due to the higher probability of use of Class 1 and 2 habitats by marbled murrelets, their loss is likely to reduce options for nesting, particularly within 30 km of the ocean.
- While the likelihood of murrelets using Class 3 habitats for nesting is lower, these habitats, nonetheless, provide the attributes required for nesting and should be included in the solution.

6.2 Assessment of Co-location Outcomes

Domain experts compared the Co-located LUO outcome to the Low Risk scenario. They did not compare to the Best Habitats scenario because the results from the Low Risk and Best Habitats scenarios are identical with respect to the amount of Class 1 and 2 habitats captured.

For comparisons of scenarios, domain experts showed data as all suitable habitat (Classes 1 - 3) pooled, with each class separate and with Classes 1 and 2 combined. Murrelets select for nesting air photo classes 1 and 2 , while Class 3 (Moderate) is likely to be used in proportion to its availability and lower classes (4 - 6) avoided (Waterhouse et al. 2008, reviewed; Burger and Waterhouse 2009).

The assessment also focused on the habitat in the 0 - 30 km zone (within 30 km of the ocean). Support for this distance parameter is provided by recent analysis by Simon Fraser University, which showed that that 99% of nests in Desolation Sound, Toba Inlet and Clayoquot Sound (pooled n = 157 nests) were within 30 km of the ocean and over 90% were within 20 km[4] (D. Lank and J. Barrett, SFU, pers. comm.).

6.2.1 South Coast EBM Planning Sub-region

The results for the South Coast EBM planning sub-region are summarised in Table 10. The Co-located LUO scenario captured 48% of suitable marbled murrelet habitat (all classes combined) which fails to meet the minimum 62% target for overall habitat retention. Compared to the Low Risk scenario, the Co-located LUO scenario falls short by 37,000 ha of habitat classes 1-3 combined (Table 10). 19% of Class 1 – 3 habitats fall within existing reserves.

[4] D. Lank notes that the SFU data is limited because the survey method likely introduced bias to finding nests closer to the ocean. A few nests have been found further from the sea, and Lank and Barrett also note that birds regularly fed at distances further than 30 km from the nest. However, the number of samples (n = 157) likely reflects a high proportion of all radio-tagged birds thought to have nests.

Inclusion of habitats within the NTHLB added a further 8,959 ha or 10% (Table 10) thus increasing the amount of habitat available to murrelets to 58% ; 4% short of the 62% habitat retention target.

With respect to capture of individual habitat classes: the Co-location LUO scenario captured only 74% of Class 1, 53% of Class 2, and 56% of combined Class 1 and 2, and therefore does not meet (by 10,390 ha; Table 10) the Low Risk goal of retaining 100% of Class 1 and Class 2 habitats in the co-located solution.

The spatial distribution of available suitable habitat is very patchy and uneven across landscape units: 8 to 10 of the 29 landscape units in the South Coast contain most of the Class 1 and 2 habitats. Class 3 tends to be more evenly distributed. Many of the historic Class 1 and 2 habitats have been logged, which may explain the uneven distribution of high quality habitats.

Table 10. Comparison of the Co-located LUO and Low Risk scenario outputs in terms of marbled murrelet habitats (0 – 30 km from the ocean) for the South Coast EBM planning sub-region. Marbled murrelet habitat is broken down by habitat quality class and in each case the habitat area (hectares) and % of the total in each class selected by each scenario are compared. A negative value in the Difference row indicates a shortfall of habitat by the Co-located LUO scenario.

Habitat Type	Scenario	Existing Reserve	Added by MARXAN	TOTAL IN SOLUTION	NTHLB habitat outside solution	THLB Habitat outside solution	Total of habitat
MAMU_0_30	Co-located LUO (ha)	17672	26089.5	43761.08	8958.5	39345	92064
(All of Classes 1-3)	As % of total habitat	19	28	**48**	10	43	100
	Low Risk (ha)	17672	63101	80772.56	2396.3	8868.6	92037
	As % of total habitat	19	69	88	3	10	100
	Difference (ha)	**0**	**-37011**	**-37011**			
MAMU_0_30_1	Co-located LUO (ha)	1655.2	1000.51	2655.72	118.83	804.76	3579
(Class 1 habitat)	As % of total habitat	46	28	**74**	3	22	100
	Low Risk (ha)	1655.2	1906.49	3561.7	0	0	3562
	As % of total habitat	46	54	100	0	0	100

Habitat Type	Scenario	Existing Reserve	Added by MARXAN	TOTAL IN SOLUTION	NTHLB habitat outside solution	THLB Habitat outside solution	Total of habitat
	Difference (ha)	**0**	**-906**	**-906**			
MAMU_0_30_2	Co-located LUO (ha)	4301.2	6309.13	10610.31	1437.6	8055.6	20103
(Class 2 habitat)	As % of total habitat	21	31	**53**	7	40	100
	Low Risk (ha)	4301.2	15793.2	20094.42	0	0	20094
	As % of total habitat	21	79	100	0	0	100
	Difference (ha)	**0**	**-9484**	**-9484**			
MAMU_0_30_3	Co-located LUO (ha)	11715	18779.9	30495.05	7402.1	30484	68381
(Class 3 habitat)	As % of total habitat	17	27	**45**	11	45	100
	Low Risk (ha)	11715	45401.3	57116.44	2396.3	8868.6	68381
	As % of total habitat	17	66	84	4	13	100
	Difference (ha)	**0**	**-26621**	**-26621**			
Combined Classes 1 + 2	Co-located LUO (ha)	5956	7310	13266	1556	8860	23683
	As % of total habitat	25	31	56	7	37	100
	Low Risk (ha)	5956	17700	23656	0	0	23656
	As % of total habitat	25	75	100	0	0	100
	Difference (ha)	**0**	**-10390**	**-10390**			

6.2.2 Mid Coast EBM Planning Sub-region

Table 11 summarises the results for the Mid Coast. With all habitat classes pooled, the Co-located LUO scenario captures 68% of the Class 1 -3 habitats, with a large amount of this habitat already captured in existing reserves (46%). This meets the overall recommended habitat retention target of 62%.

While the Co-located LUO scenario does meet the overall target for habitat retention, closer scrutiny of the results shows that the scenario outcome fails to retain all of the Class 1 and 2 marbled murrelet habitat, and therefore the Low Risk goal is not achieved. The Co-located LUO scenario retains 84% of Class 1, 72% of Class 2 and 75% of the combined 1 and 2 (Table 11). There is therefore 10,853 ha of Class 1 and 2 habitat not captured by this scenario. However, the overall capture of 68% of the combined Class 1 – 3 habitats exceeds the habitat retention target by 6%, which will help to mitigate the shortfall of Class 1 and 2 habitats.

Class 1 and 2 habitats are more evenly distributed across landscape units in the Mid Coast compared to the South Coast. Only 13 of the 67 landscape units have less than 400 ha of high value habitat and the remaining 54 landscape units comprise 96% of the Class 1 and 2 habitats in the sub-region.

Table 11. Comparison of the Co-located LUO and Low Risk scenario outputs in terms of marbled murrelet habitats (0 – 30 km from the ocean) for the Mid Coast EBM planning sub-region. Marbled murrelet habitat is broken down by habitat quality class and in each case the habitat area (hectares) and % of the total in each class selected by each scenario are compared. A negative value in the Difference row indicates a shortfall of habitat by the Co-located LUO scenario.

Habitat Type	Scenario	Existing Reserve	Added by MARXAN	TOTAL IN SOLUTION	NTHLB habitat outside solution	THLB Habitat outside solution	Total of habitat
MAMU_0_30	Co-located LUO (ha)	74121	34991	109112	17940	33809	160860
(All of Classes 1-3)	As % of total habitat	46	22	**68**	11	21	100
	Low Risk (ha)	74121	63804	137925	10757	12179	160860
	As % of total habitat	46	40	86	7	8	100
	Difference (ha)	**0**	**-28813**	**-28813**			
MAMU_0_30_1	Co-located LUO (ha)	6815	953	7768	266	1195	9229
(Class 1 habitat)	As % of total habitat	74	10	**84**	3	13	100
	Low Risk (ha)	6815	2412	9227	1	2	9229
	As % of total habitat	74	26	100	0	0	100

Habitat Type	Scenario	Existing Reserve	Added by MARXAN	TOTAL IN SOLUTION	NTHLB habitat outside solution	THLB Habitat outside solution	Total of habitat
	Difference (ha)	**0**	**-1458**	**-1458**			
MAMU_0_30_2	Co-located LUO (ha)	17843	6519	24363	2169	7250	33782
(Class 2 habitat)	As % of total habitat	53	19	**72**	6	21	100
	Low Risk (ha)	17843	15914	33758	9	16	33782
	As % of total habitat	53	47	100	0	0	100
	Difference (ha)	**0**	**-9395**	**-9395**			
MAMU_0_30_3	Co-located LUO (ha)	49132	27849	76981	15505	25364	117849
(Class 3 habitat)	As % of total habitat	42	24	**65**	13	22	100
	Low Risk (ha)	49132	45809	94941	10747	12161	117849
	As % of total habitat	42	39	81	9	10	100
	Difference (ha)	**0**	**-17960**	**-17960**			
Combined Classes 1 + 2	Co-located LUO (ha)	24658	7473	32131	2435	8445	43011
	As % of total habitat	57	17	75	6	20	100
	Low Risk (ha)	24658	18326	42984	10	17	43011
	As % of total habitat	57	43	100	0	0	100
	Difference (ha)	**0**	**-10853**	**-10853**			

6.2.3 Comparison of Solutions for the South and Mid Coast Study Areas

- With all habitat classes pooled, the Co-located LUO scenario captures 68% of the Class 1 -3 habitat in the Mid Coast EBM planning sub-region compared to 48% in the South Coast region. Consequently, the Co-located LUO scenario does reasonably well on the Mid Coast sub-region but fails to meet the minimum target of 62% for overall habitat retention in the South Coast sub-region.
- The Mid Coast sub-region has a higher proportion of marbled murrelet habitat within existing reserves than in the South Coast sub-region (46% and 19%, respectively);

Tables 10 & 11). The capture of habitats in existing reserves in the Mid Coast provides greater certainty for conservation.

- Conversely, the South Coast sub-region has a higher proportion of unprotected habitats within the THLB than on the Mid Coast sub-region (43% and 21%, respectively). This outcome indicates a greater vulnerability of unprotected murrelet habitats in the South Coast sub-region and a higher potential cost for habitat conservation.
- Meeting the 62% habitat retention target on the South Coast sub-region requires some inclusion of the THLB, in addition to most or all of Class 1 and 2 habitats in the NTHLB, and is therefore a more "costly" solution than on the Mid Coast sub-region.
- Class 1 and 2 habitats are more evenly distributed across landscape units in the Mid Coast sub-region compared to the South Coast sub-region.

6.2.4 Uncertainties and limitations

- Targets for strategic co-location are based on expert opinion supported by best available science related to the habitat requirements of marbled murrelets. There are uncertainties associated with the relationship between murrelets and their terrestrial habitats.
- Knowledge of the densities at which murrelets nest in various habitat classes is limited. Consequently we cannot accurately assess the net value of each habitat class in supporting viable populations.

  More research is needed about the relationship between the quality of habitat and density of marbled murrelets (Waterhouse et al. 2008). Although a relationship between habitat quality and murrelet density has not been determined, researchers found that marbled murrelets are more likely to select Class1 and 2 air photo classed habitats than Class 3 habitats (Waterhouse et al. 2007, 2008).
- Mapping of habitat suitability does not always correlate with breeding success, therefore research is needed regarding other influences on breeding productivity such as predators and hierarchical habitat selection. (Waterhouse et al. 2008).
- More research is required to understand how different map products compare: air photo, aerial, Hobbs method.
- The CMMRT goal is to limit population decline from a baseline year of 2002. The co-location analysis uses post-2002 data in areas where logging has occurred without some corresponding compensation. This likely means that the risk of not attaining the CMMRT goal is higher than estimated in the co-location exercise.

- These results are based on the air photo mapping. To ensure that habitat is actually suitable for nesting marbled murrelets, field verification (using low-level aerial surveys or ground surveys) should be undertaken to confirm the quality of habitat polygons selected in the co-located solution.
- Studies are underway to assess the relationship between marine foraging areas and terrestrial nesting habitats. This includes a UBC study to characterize the marine-terrestrial interface of marbled murrelet habitats on the Central Coast and assess the most suitable areas for conservation of murrelet habitat.

6.3 Implications of Co-Location for Management of Marbled Murrelets

For the Mid Coast EBM planning sub-region the Co-located LUO scenario exceeded the overall habitat retention target (i.e., capturing > 62% of the combined Classes 1, 2 and 3) but fell short of meeting targets in the Low Risk scenario (i.e., 100% of the Class 1 and 2 were not captured). While it would be preferable to have all Class 1 and 2 captured, the amount of overall habitat captured through co-location will contribute to conservation goals. In addition, the 46% of habitat within existing reserves provides some certainty of long-term habitat conservation. The small amount of unprotected habitats in the THLB compared to the South Coast indicates that there are more options for conservation solutions in the Mid-Coast sub-region while minimizing impacts to timber supply.

For the South Coast EBM planning sub-region, the Co-located LUO failed to meet the target for habitat retention or the Low Risk targets for capture of Class 1 and 2 habitats. Habitat within the THLB will have to be included to meet either of these scenarios. In general, achieving the CMMRT goal and doing so in a way that minimizes risk to murrelets will be difficult to achieve in the South Coast sub-region due to a historic loss of habitat and the cost of retaining high value habitats in the THLB.

Forested stands acquire suitable structural characteristics for nesting for marbled murrelets at approximately 200 years (Burger 2002), which is more than two times the current rotation age for timber harvesting in coastal forests (80 – 100 years). The focus of management, therefore, is to protect adequate areas of nesting habitat in reserves or other areas constrained to development activity over the long term e.g., through the designation of wildlife habitat areas or old growth reserves (MOE 2004).

There is an uneven distribution of Class 1 and 2 habitats in the South Coast EBM sub-region. Achieving a spatially even distribution of habitats is not considered by domain experts to be as important as picking up the best remaining habitat. Because of the long time period required for forests to recover suitable habitat attributes post-logging, the CMMRT[5] has not put emphasis on recruitment of habitat in the Central and North Coastal Mainland Marbled Murrelet Conservation Regions.

There are no recommendations at this time, for managing for marbled murrelet habitat over time on the working landbase outside of reserves. However, the following strategic decisions could help to compensate for the habitat gap for marbled murrelets:

- Given that habitat within 30 km of the ocean has the highest value for nesting Marbled Murrelets, there could be some trade-off in retaining a higher proportion of the Co-located LUO within this zone and less in the forests >30 km from the shore.
- Aerial surveys will help to confirm the suitability of the Class 3 habitat. In both sub-regions the bulk of the habitat selected by the Co-location LUO scenario is Class 3 (Moderate) habitat. Confidence in the viability of the scenario would improve if most of this Class 3 habitat proved to be suitable in the aerial surveys.
- Some of the NTHLB habitat could be added to the solution. Adding this land to the solution incurs less "cost" than adding THLB habitat. The gains achieved by adding NTHLB land would, however, be relatively modest since there are only 6% (Mid Coast) and 7% (South Coast) of the Class 1 and 2 habitat outside the MARXAN solution which are in the NTHLB (Tables 10 & 11). Marbled murrelet habitat in NTHLB should be spatially defined and receive some form of protection designation to ensure that it is retained over the long-term.
- Consideration should be given to adding some of the THLB lands to the solution, especially in the South Coast planning sub-region. It will be impossible to achieve either the High Risk or the Low Risk scenarios for marbled murrelet without some inclusion of these lands in the South Coast.
- Riparian reserves might provide additional habitat, but until the width and buffering of such reserves is known, their value to nesting marbled murrelets remains uncertain.
- Radar surveys may confirm the use and apparent nest density within retained habitat at the landscape scale, and there could be some adjustments made so that a higher proportion of habitat is retained in those landscape units and watersheds where there are above-average

[5] CMMRT (Canadian Marbled Murrelet Recovery Team). 2003. *Marbled Murrelet Conservation Assessment 2003, Part B – Marbled Murrelet Recovery Team Advisory Document on Conservation and Management*. Canadian Wildlife Service, Delta, B.C.. URL: http://www.sfu.ca/biology/wildberg/bertram/mamurt/links.htm

numbers of likely nesting murrelets. This would necessitate additional radar surveys since there are currently data on less than 20 watersheds in the Mid and South Coast sub-regions.

6.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

6.4.1 Key considerations for strategic co-location

- Class 1 and 2 habitats have the highest value for marbled murrelets and should be retained on the landbase wherever possible. The loss of Class 1 and 2 habitats in a landscape unit generally represents a move away from a lower risk and to a higher risk scenario, particularly when these habitats occur within 30 km of the ocean.
- Class 3 habitats are less likely to be selected by nesting murrelets than Class 1 and 2 habitats, therefore they are a lower priority for capture in old growth reserves.
- The hypermaritime should not be over-represented in OGRAs due to variability in the suitability of marbled murrelet habitats. This situation is being assessed by Ministry of Environment (Contact: D. Donald, MOE Vancouver Island Region).
- Where possible, cluster habitats to reduce the amount of edge.
- Habitats within 30 km of the ocean are a higher priority for retention in OGRAs than those within 30 – 50 km (habitats > 30 km from the ocean should be traded off before habitats within 30 km of the ocean). Habitats greater than 50 km from the ocean should be excluded from the co-location.
- Conserving existing high quality habitats is the priority; existing habitat should not be traded off against recruitment of future potential habitats.

6.4.1 Setting priorities among landscape units

As a guiding principle for the co-location exercise retention of habitat across the entire sub-region was given priority over trying to achieve the retention goals within each landscape unit. Murrelets are mobile and are likely to seek out suitable habitat within their commuting range of marine foraging areas (in practice within 30 km of the ocean).

Prioritizing specific landscape units for marbled murrelets would take some careful consideration that should be done on the basis of area of available habitat (giving some priority to landscape units with large areas of class 1 &2) and also numbers of birds likely to use the landscape unit (based on radar counts and if no radar data some assessment of at-sea distribution). There is very little information on where murrelets forage in the Mid Coast and

South Coast sub-regions, so we cannot assess which watersheds or landscape units should be given priority for habitat retention.

6.4.2 Improvements to MARXAN methods

Refined identification of essential habitats might be achieved by:

- Completing the air photo interpretation of those areas where the analysis was forced to use the Hobbs or the MMRT models. These are mostly areas in the north of the Mid Coast which fall along the boundaries with the North Coast management areas. This would allow a seamless classification of habitat across the entire region.
- Improved definitions of the suitability of the Hypermaritime (CWHvh) BEC sub-zone. There is currently conflicting evidence of the suitability of these forests for nesting marbled murrelets and additional information is needed to decide when to upgrade, downgrade or leave unchanged the air photo classification of this sub-zone.
- The possible effects of habitat fragmentation and isolation could be investigated further, including tabulation of patch size per habitat area retained by the scenarios, edge-interior ratios etc. These would give some indications of the functionality of the selected habitats and risks of predation and deleterious microclimates in the edge forests.

6.5 Recommendations for Management of Habitats Outside of Spatial Reserves

- Locate camps and recreation sites away from habitat areas to prevent an increase numbers of corvids (crows, ravens and jays) and an associated increase in predation risk. Where camps are close to habitat areas, manage garbage and camp cleanliness to prevent an increase in corvids.
- Schedule timber harvesting operations and prescribed burning adjacent to habitat areas to minimize disturbance to nesting birds (nesting occurs May 1 to July 31).
- In planning wind and run-of-river energy projects, locate powerlines to reduce the potential for marbled murrelets to collide with lines when flying to and from their nests and to reduce habitat loss.

7.0 Recommended Management for Mountain Goats

Domain experts:

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

Steve Gordon, Integrated Land Management Bureau

Brad Pollard, McElhanney Consulting Services, Ltd.

Shawn Taylor, Goat Mountain Resources

7.1 Recommended Inputs to Strategic Co-Location in Marxan

This section summarizes key inputs to co-location for mountain goat habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas* (Part 2 of the EBM Working Group Focal Species Project) (Horn and Rumsey 2009).

7.1.1 Population objective

Objective: to sustain healthy populations of mountain goats by preventing localized extirpation.

7.1.2 Instructions for co-location of habitats in old growth retention areas

Targets shown below for Low Risk and Best Habitats scenarios will be used as a base for 'seeding' a final co-located solution in MARXAN (the Co-located LUO scenario) that meets, but does not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The targets shown here are for the capture of habitats that are not otherwise designated under the Coast Orders, or as wildlife habitat areas or ungulate winter ranges under the *Forest and Range Practices Act* (FRPA).

7.1.2.1 Low Risk scenario

Targets for the Low Risk scenario are as follows. The Low Risk targets outlined below reflect the risk of not achieving the stated population objective. These targets are based on expert opinion and were not derived through a formal risk assessment.

Each sub-region has a different modelled winter habitat layer, resulting in a different low risk target for each. Inter habitat layers are described in more detail in Part 4 of the Focal Species Project Report series: *Summary of Habitat Mapping to Support EBM Implementation*.

North Coast: Recommended low risk target: 100% suitable winter habitat

Habitat layer: A resource selection probability function (RSPF) model to predict areas with a high probability of use.

Mid Coast: Recommended low risk target: 90% suitable winter habitat

Habitat layer: A GIS algorithm that ranks habitat as suitable or not suitable based on specific slope, aspect and elevation criteria

South Coast: Recommended low risk target:

≥ 90% of an "equivalent area" of Goat_1 (very high value) habitat within each landscape unit.

This could be achieved by capturing either:

- ≥ 90% of Goat_1 habitat; or
- a combination of Goat_1 and Goat_2 (high value) habitats such that a minimum of 70% of the area of Goat_1 habitat is captured, and the remaining target is achieved by capturing twice the area of Goat_2 habitat (i.e. 1 ha of Goat_1 = 2 ha of Goat_2).

For example:

- *A total of 1,000 ha of Goat_1 habitat occurs in Landscape Unit X.*
- *The low risk target can be achieved by capturing:*
  - *a.) a minimum of 900 ha of Goat_1 habitat; or*
  - *b.) a minimum of 700 ha Goat_1 and 400 ha of Goat_2 habitat (or, 800 ha of Goat_1 and 200 ha of Goat_2, etc.).*

Habitat layer: A resource selection function (RSF) model that uses the environmental variables of stand age, elevation, slope, solar loading, and distance to escape terrain.

These targets are accompanied by an important proviso regarding their application on the ground: in the Mid and South Coasts (≥ 90% target), the risk of removal of 10% can be disproportionately high depending on where it comes from i.e., removal of the best 10% snow interception habitat would have greater impact than removal of peripheral habitat.

7.1.2.2 Best Habitats scenario

100% of the Low Risk solution

7.1.2.3 Habitats to be locked into co-located solution

Using the information currently available, it is recommended that the key areas that need to be included in the OGRA solution as critical mountain goat winter habitat are:

- Designated Ungulate Winter Ranges. These ungulate winter ranges represent some of the highest quality winter habitats available for mountain goats and many have been field verified.; and
- Goat_1 habitat where winter goat use has been confirmed (= suitable habitat in the Mid and North Coasts).

Subsequent work should involve field verification to determine the most appropriate final locations of goat winter ranges (see section 7.4.3).

7.1.2.4 Upper limit of habitat change

Loss of more than 40% of winter habitats defined as suitable (North and Mid Coast) or Goat_1 (South Coast) within a landscape unit is considered a very high risk to achieving the objective of sustaining local populations of mountain goats and should be avoided as an outcome. While there may be a low probability of exceeding 40% habitat loss, the consequences of this loss are considered to be very detrimental to goat populations.

This upper limit is based on the expert opinion of domain experts and has not been tested through research with actual mountain goat populations.

7.1.3 Rationale for targets

- Goat winter ranges are essential habitats for the survival of mountain goat populations and the proximity of forested cover to escape terrain is a critical habitat feature. With the exception of sub-adult males, mountain goats have high site fidelity and removing any of these habitats incurs a risk.
- Anecdotal information suggests that in some areas, mountain goat populations are currently in decline, including areas where active forest harvesting is not occurring. The dearth of inventory and monitoring of coastal goat populations increases the need to manage known habitats conservatively.
- Habitats at low elevations, particularly those that are marine influenced and occur at the lower end of watersheds (towards it confluence with the ocean or another tributary), are known to have very high value as winter range. Many of these habitats may have already

been harvested on the Coast and the retention of remaining high quality, low elevation habitats can, therefore, be particularly important. The low risk target is intended to ensure that these habitats are retained in every watershed where they occur, particularly since they often possess attributes such as high timber value and favourable terrain that make them vulnerable to logging. Removal of even 10% of the forested component of occupied winter range may have significant adverse impacts to goat populations in the longer-term.

- Legally designated mountain goat habitats were located to minimize impacts to timber supply, consistent with provincial policy, so many of the areas designated in the Mid and North Coast sub-regions are in the non-contributing forest.
- The objectives for ecosystem-based management do not apply to other factors that are putting pressure on mountain goats (e.g., heli-skiing, other winter recreation activities in and around goat habitat). There is a need to manage more conservatively to compensate for disturbance due to other factors.

7.2 Assessment of Co-location Outcomes

7.2.1 Assessment Methods

“Co-Located LUO” and “Low Risk” scenarios were assessed based the amount of suitable (Mid and North Coasts) or Goat_1 (South Coast) critical winter range captured in existing reserves and projected old growth reserves, by sub-region and landscape unit. For each sub-region and landscape unit, the areas captured in the co-located solution were compared with the total amount of modelled habitat identified in that unit. These results were assessed against the ‘risk cut-offs’ as presented in section 7.1.2 above.

In the South Coast, where 70 - 89% of Goat_1 was captured, a further analysis was made of the amount of Goat_2 habitat to determine if the combined habitats met the ‘low risk’ equivalent of 90% of Goast_1 habitat, as described in section 7.1.2.1.

An overall estimate of the ‘relative risk’ of each landscape unit was determined based on the sum of the following:

- relative proportion of Goat_1 habitat in the LU compared to the total amount of suitable / Goat_1 habitat in the study area;
- relative proportion of suitable / Goat_1 habitat occurring in the LU that is not protected; and
- relative proportion of suitable / Goat_1 habitat that is not protected that is in the THLB (under the assumption that habitat in the THLB is more immediately vulnerable to loss through forest development than habitat in the non-THLB).

7.2.2 South Coast Results

a. Sub-regional scale

There are an estimated 70,259 ha of modelled Goat_1 habitat in the South Coast sub-region. The average proportion of Goat_1 habitats protected in existing reserves is 33% for the sub-region as a whole.

At the sub-regional scale, the Co-located LUO scenario results in 54% of Goat_1 habitats captured (high risk) in existing reserves and projected old growth reserves. The amount in the solution increases to 78% (mid risk) if the NTHLB is included. However, domain experts assume that any forested habitats outside of reserves are vulnerable to logging, including in the NTHLB, because:

- the NTHLB line is always changing, and
- high value habitats for goats are also likely to be high value timber (i.e., most vulnerable to harvesting).

In the Co-located LUO solution, 48% of habitats outside of reserves are in the THLB.

The Low Risk scenario results in 84% of Goat_1 habitats being captured at the sub-regional scale (mid risk). The solution comes very close to a low risk if the equivalent representation of Goat_2 habitats is considered (see section 7.1.2.1).

b. Landscape unit scale

The proportion of Goat_1 habitats protected in existing reserves ranges from 1% to 95% within landscape units. Only one landscape unit (Ahnuhati-kwalate) has more than 90% of Goat_1 habitats captured in existing protection (i.e., is a Low Risk).

Table 12 summarizes the estimated risk for the 29 landscape units in the sub-region. Six landscape units do not occur within the known distribution of mountain goats landscape units in the South Coast and were not included in this assessment. Under the Co-located LUO scenario, thirteen landscape units, representing 68% of the Goat_1 habitats by area, have a level of habitat retention in the co-location solution that exceeds a high risk.

Even in the Low Risk scenario (Table 13), while none of the landscape units exceed a high risk, only four achieve the low risk target; almost all are mid risk. The mid risk solution represents 97% of Goat_1 habitats in the sub-region. This result does not change when Goat_2 habitats are considered.

In eight of the 22 of the landscape units assessed as mid to high risk in the Co-Located LUO solution, $\geq$ 50% of 'unprotected' habitats occur in the THLB, representing 13,506 ha (19% of total Goat_1 habitat).

Based on the calculation of relative risk (see section 7.2.1(3)), the landscape units at the highest 'risk', based on proportion of overall habitat in the sub-region, proportion of unprotected habitat in the LU and proportion of unprotected habitat in the THLB, are (in order of relative risk value; largest to smallest): Lower Klinaklini, Franklin, Stafford, Phillips, Snowdrift, Estero, Belize and Wakeman.

Table 12. Risk to mountain goats by landscape unit under the Co-located LUO scenario: South Coast

Risk Value	Number/ % of landscape units	Proportion of Goat_1 habitat represented
H	13 (45%)	68%
M	9 (31%)	23%
L	1 (3%)	9%
No mtn goat habitat	6 (21%)	0

Table 13. Risk to mountain goats by landscape unit under the Low Risk scenario: South Coast

Risk Value	Number/ % of landscape units	Proportion of Goat_1 habitat represented
H	0	0
M	19 (66%)	97%
L	4 (14%)	13%
No mtn goat habitat	6 (21%)	0

7.2.3 Mid Coast sub-region

a. Sub-regional scale

There are 34,674 ha of suitable goat habitat in the Mid Coast sub-region. Habitat mapping for goat habitats in the Mid Coast is based on a binary habitat algorithm (habitat / no habitat). The average baseline level of protection within existing reserves for suitable habitats in the Mid Coast sub-region a whole is 58% i.e., just below the high risk target. There is a higher level of base protection, on average, within each LU compared to the South Coast.

At the sub-regional scale, the Co-located LUO scenario in the Mid Coast results in 76% of suitable habitats being captured (mid risk); 95% (low risk) if the NTHLB is included. However, domain experts do not consider the latter a low risk outcome due to their concern that any forested habitats outside of reserves are vulnerable to logging, including in the NTHLB. In the Co-located LUO solution, 20% of habitats outside of reserves are in the THLB.

b. Landscape unit scale

Table 14 summarizes the results for the 67 landscape units in the Mid Coast under the Co-located LUO scenario. Twenty landscape units, representing 23% of all habitats, are within low risk targets. Seven of these have 100% retention of suitable habitats. Nine of the landscape units, representing 17% of all habitats, exceed high risk targets. 60% of goat habitats are within mid risk landscape units.

The results for the Low Risk scenario show that, with the exception of 1 landscape unit, all landscape units achieve the targets for low risk (Table 15). The one landscape unit with a mid risk result captures 89% of goat habitats, so is on the cusp of being low risk.

In the Co-located LUO solution, only 2 of the 44 landscape units assessed as mid to high risk have more than 50% of 'unprotected' habitats in the THLB (56% and 57%,) but these habitats only represent a negligible amount (29 ha) of the total area of suitable habitat in the sub-region.

Based on the calculation of relative risk (see section 7.2.1(3)), the landscape units at the highest ‘risk’, based on proportion of overall habitat in the sub-region, proportion of unprotected habitat in the LU and proportion of unprotected habitat in the THLB are (in order of relative risk value; largest to smallest): Denny, Roderick, Draney, Tolmie and Clayton.

Table 14. Risk to mountain goats by landscape unit under the Co-located LUO scenario: Mid Coast

Risk Value	Number/ % of landscape units	Proportion of suitable habitat represented
H	9 (13%)	12%
M	35 (52%)	66%
L	18 (27%)	23%
< 5 ha of habitat in LU	5 (7%)	< 1%

Table 15. Risk to mountain goats by landscape unit under the Low Risk scenario: Mid Coast

Risk Value	Number/ % of landscape units	Proportion of suitable habitat represented
H	0	0
M	1 (1%)	0.1%
L	61 (97%)	99.9%
< 5 ha of habitat in LU	5 (7%)	< 1%

7.2.4 Comparison of outcomes in the Mid and South Coasts

Table 16 summarizes the comparison between MARXAN outcomes for the Mid and South Coasts. In regarding this comparison, it is important to note that a different modelled habitat layer was used in each sub-region. The South Coast mapping is based on a resource selection function and the Mid Coast on a bimodal GIS algorithm (section 7.1.2.1).

These results indicate that there is more high quality mountain goat habitat in the South Coast compared to the Mid Coast, although this result may be due to differences in mapping methods. There is a less high value habitat in existing reserves (protected areas, riparian reserves, Class 1 grizzly bear habitat, WHAs, UWRs) in the South Coast compared to the Mid Coast (33% and 58% respectively) and the Co-located LUO scenario projects that there is less high value habitat captured in the co-located solution in the South Coast compared to the Mid Coast (54% and 76% respectively). In the Co-located LUO solution, there is a much higher proportion of unprotected habitats (i.e., outside of existing and projected reserves) in the THLB in the South Coast (48% compared to 20% in the Mid Coast).

Landscape units are much smaller in area, on average, in the Mid Coast compared to the South Coast and there are many more of them (67 compared to 29 in the South Coast). However, the results still indicate that a greater number of landscape units and a greater proportion of overall habitats are captured in existing reserves and projected OGRAs in the Co-located LUO solution in the Mid Coast. The overall proportion of habitat within landscape units that are at high risk is approximately the same in both sub-regions, although the proportion of habitat that is in the THLB is higher in the South Coast and is, therefore, potentially more vulnerable to timber harvesting and more costly to include in a reserve network.

Table 16. Comparison of MARXAN outcomes for mountain goats: Mid and South Coast EBM sub-regions

Parameter assessed	Scenario	South Coast result (Goat-1 habitat)	Mid Coast result (Suitable habitat)
Total area of habitat by sub-region	All	70,259 ha	34,674
Habitat in existing reserves by sub-region	All	33%	58%
Habitat in existing reserves + projected OGRAs (+ NTHLB)	Co-located LUO	54% (78%)	76% (95%)
Proportion of habitats outside of reserves in the THLB	Co-located LUO	48	20
# of LUs at low risk	Co-located LUO	1 out of 29	20 out of 67
Area of habitat represented in LUs at low risk	Co-located LUO	3%	23%
# of LUs at high risk	Co-located LUO	13 out of 29	9 out of 67
Area of habitat represented in LUs at high risk	Co-located LUO	68%	60%
# of LUs at mid + high risk	Co-located LUO	22	44
# of LUs at mid + high risk with > 50% of unprotected habitats in the THLB (% of total habitat in the sub-region))	Co-located LUO	8 (19%)	2 (<1%)

7.2.5 Uncertainties and limitations

- There are recognized limitations in the veracity of model input (especially forest cover) and the habitat modelling process in general. As a result, for both deer and mountain goats, it is likely that there are areas that have been identified by the models as high quality winter range that may not be suitable habitat, and conversely, there are likely high quality winter range areas that the models did not identify. **There is no substitute for site specific ground verification. Model input variables (especially forest cover) should be considered questionable at best, so model output should not be relied upon as a definitive representation of reality.**
- Areas identified as already protected in existing goat winter ranges may (and often do in Region 1) include relatively large areas of higher elevation 'rock and ice' where boundaries were drawn to the height of land to specify easily identifiable boundaries. This results in significant areas identified as 'in reserve' that are not actually critical mountain goat winter

habitat, and subsequent analyses (such as was done here) comparing the actual proportion of area protected vs. the amount of habitat in the LU will be biased.

7.3 Implications of Co-Location Results for Management of Mountain Goats

The co-located outcome for mountain goats in the South Coasts improves the area of habitat retained but, since the impact of habitat loss is relatively localized for mountain goats due to the high fidelity they have for their winter habitats, landscape units at mid to high risk are still of concern. Further work to confirm occupancy of modelled habitats, particularly where these are located in OGRAs, is important to reduce uncertainties associated with the contribution of old growth reserves to conservation of mountain goats.

The co-location exercise appears to provide a useful high level planning tool for assessing of the relative benefits and risks of potential co-located reserves given the targets for old growth retention currently in place in the Coastal Orders. Subsequent initiatives to propose specific reserve locations within each landscape unit will need to include local knowledge and ground-truthing to reduce risks to ungulates.

7.3.1 South Coast

The implications of mountain goat management with respect to the persistence of the current distribution and abundance of mountain goat populations under the Lo-located LUO scenario is a significant concern. At a sub-regional scale, the amount of habitat captured in existing reserves and projected OGRAs is within the high risk category (< 60% Goat_1 habitat protected). There is only one LU (the Ahnuhati-Kwalate) which falls under the category of Low Risk (> 90% Goat_1 habitat protected). Thirteen of the 23 landscape units assessed have a high risk rating and nine have a mid risk rating. The Lower Klinaklini LU could be considered at particularly high risk for mountain goats at both the landscape unit and sub-regional scale as it contains the highest amount of Goat_1 habitat in the study area (over 7,000 ha), only 40% of which would be protected under this scenario.

The co-located solution is not evenly distributed across landscape units. The maximum relative amounts of habitat added by MARXAN occur in the Estero, Snowdrift, Fulmore and Gray LUs where 5 to 36 times more habitat is added than currently exists in reserve. However, these coastal landscape units have a significantly higher marine influence – and therefore relatively less goat habitat and lower goat populations – than more interior landscape units, so relatively little habitat occurs in these landscape units, or is captured by existing reserves.

The co-located MARXAN solution typically adds around 0.5 to 1.5 times the amount of habitat currently in reserve in interior landscape units with relatively high goat habitat capability and goat populations. Generally speaking, as the relative amount of available high quality habitat captured by existing reserves (compared to the total amount within the landscape unit) increases, the relative amount added by the MARXAN solution decreases.

Within landscape units at mid to high risk, 19% of habitats that are unprotected occur in the THLB. Habitat in the THLB is assumed to be more 'vulnerable' to loss through forest development than habitat in the non-THLB. Therefore these habitats are thought to be particularly at risk.

It is important to note that these analyses assume that model output is correctly identifying critical goat winter habitat. The limitations of the modelling process (as previously outlined) are significant enough that it is difficult to specifically identify what management action is needed to ensure that goat distribution and abundance in the South Coast study area are maintained. Significant local knowledge exists to support the refinement of OGRAs with respect to goat winter habitat.

7.3.2 Mid Coast

Overall, the co-located solution improves the area of suitable habitat conserved in existing and projected reserves compared to the base case. In particular, if habitats in the NTHLB are included as part of the solution, the result at a sub-regional scale is within the low risk category. However, the risk of localized extirpation is still high where occupancy has not been verified and further assessment is needed to determine the actual value of habitats captured in OGRAs and to ensure that occupied high value habitats outside of OGRAs are not altered through development.

In the Mid Coast, the number of landscape units with a low risk rating and the proportion of habitats represented in these landscape units is higher than in the South Coast. This is likely because there is a shorter history of logging in the Mid Coast, so fewer high value habitats have been lost to date and there are more options for locating OGRAs. There is also a large proportion of suitable habitats in existing reserves compared to the South Coast and a smaller proportion of habitats in the THLB. Therefore the economic cost of habitat protection in the Mid Coast is likely to be lower than in the South Coast.

7.3.3 North Coast

Analysis was not performed on the North Coast due to time constraints. Proposed UWR designations in the North Coast are restricted to the NTHLB due to arbitrary policy caps on allowable impacts to timber supply, therefore no opportunities for UWR designation currently exist within the THLB. Based on the limited accessibility of timber in the North Coast and the relatively low proportion of THLB (<6% based on MOFR estimates (Tamblyn and Horn 2001), forest harvesting within goat winter ranges will be focused on the productive forest available. This may result in a disproportionate impact to the functionality of individual winter ranges. Opportunities for co-location of goat winter ranges with old forest retention need to be carefully explored to increase the opportunities for habitat protection for mountain goats in the North Coast.

7.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

7.4.1 Key considerations for strategic co-location

1. Due to the fidelity of mountain goats to their habitats, any loss or reduced functionality of winter habitat complexes will have a direct effect on localized groups or populations. The more habitat retained in old growth reserves, the lower the risk to mountain goats. Therefore, the mandate to co-locate well is very important for this focal species. The co-location with other species can have a significant effect on the amount of habitat captured for mountain goats.

   The health of nursery groups, and, therefore, the maintenance of habitat used by those groups (including winter and natal ranges) is especially important to the reproductive success and persistence of goat populations (Côté and Festa-Bianchet, 2001).

2. The retention of high quality, low elevation habitats within the THLB can be particularly important as these areas are particularly vulnerable to harvesting (high timber value and favourable terrain) and therefore many historic habitats may already have been logged.

   In many landscape units across the sub-regions, retention of the NTHLB forest in suitable goat winter range is critical to reduce the overall risk category to the species. The majority of South Coast landscape units in particular are at or above the established thresholds for high risk. Certainty of habitat protection is required for as much of the remaining NTHLB forest within identified goat habitat as possible. Current policy does not provide any certainty with respect to retention of NTHLB within goat habitat outside of established UWRs. Since this scenario applies across the South Coast portion of the plan area (and thus over a significant portion of the range of the coastal mountain goat ecotype), further removal of snow interception cover by harvesting in the NTHLB could have significant negative long-term implications to the persistence of coastal mountain goat populations.

3. All habitats that have been verified as occupied should be included within OGRAs or other forms of protection.

4. Further field work is necessary to confirm mountain goat occupation of modelled habitats, and to verify the quality of goat habitats identified through modelling.
5. There is a high likelihood that critical habitat in the "Non-THLB" category is actually operable timber, and therefore at similar risk to forest development as areas in the "THLB" category. In general, the fact that the model selected these areas indicates that they are old-growth timber of suitable volume to qualify as goat winter range, and therefore of potential interest to harvesting (typically by non-conventional methods such as heli-logging). This assumption is mainly applicable to stands with commercial value such as Western redcedar, Yellow cedar and Douglas-fir.

7.4.2 Setting priorities among landscape units

An overall estimate of the 'relative risk' of each landscape unit was determined based on the sum of the following:

- relative proportion of suitable (MC and NC) or Goat_1 (SC) habitat in the lansdscape unit compared to the total amount of Goat_1 habitat in the sub-region;
- relative proportion of suitable/Goat_1 habitat occurring in the LU that is not protected; and
- relative proportion of suitable/Goat_1 habitat that is not protected that is in the THLB (under the assumption that habitat in the THLB is more immediately vulnerable to loss through forest development than habitat in the non-THLB).

Based on this calculation, the landscape units at the highest 'risk' are, in order of relative risk value (largest to smallest):

South Coast: Lower Klinaklini, Franklin, Stafford, Phillips, Snowdrift, Estero, Belize and Wakeman.

Mid Coast: Denny, Roderick, Draney, Tolmie and Clayton

7.4.3 Improvements to MARXAN methods

- Subsequent work should involve field verification to determine the most appropriate final locations of goat winter ranges. The work that needs to be carried out (roughly in order of importance) would include:
  - determining the relative quality of areas where winter use has been confirmed that have not been modelled as either Goat_1 or Goat_2 habitats;
  - determining the relative quality of modelled Goat_1 habitats where winter use has not been confirmed; and

- determining the relative quality of modelled Goat_2 habitats where winter use has not been confirmed;

After the above proposed work has been done, a better understanding of the relative value of all potential goat winter range habitats would be available, and a final determination of the most appropriate locations of goat winter range reserves could be made.

- Suitability, not capability, was modelled, so areas of high suitability in reserve that currently are in an age class that does not qualify as critical habitat are not identified in the analysis. The key message from this is that the resource might better be served by identifying high capability second growth than 'marginal' old growth.
- An assessment of co-location outcomes by meta-population level is recommended for future study.
- A review of estimated co-location outcomes for the North Coast should be completed.

7.5 Recommendations for Management of Habitats Outside of Spatial Reserves

7.5.1 Management adjacent to OGRAs to maintain the effectiveness of the reserves

Mountain goats are particularly vulnerable to access development because they are closely tied to their habitats (particularly escape terrain) and do not venture far from them (the exception is the dispersal of young billies). The timing and location of forest harvesting adjacent to winter ranges should be managed over a rotation to avoid creating movement barriers and to ensure availability of suitable snow interception cover within escape terrain complexes over the entire rotation. For example, to completely encompass a mountain block with road access and harvesting would adversely impact goats. South-facing aspects are more vulnerable as they have the highest levels of use; they need to be managed accordingly (B. Pollard, pers.comm.).

Roads increase the risk of over-harvest of mountain goats. Although the regulated harvest of goats is carefully managed, roads increase the probability of poaching and there is risk that local populations may be impacted before problems are detected and harvest levels can be adjusted.

Access controls should be considered to manage access into goat habitat areas (e.g., deactivate a road after use with no re-entry for 25 years, re-contour and replant; close roads and deactivate so that they are not accessible to snowmobile and ATV traffic). For example, general wildlife measures for mountain goat UWRs in the Kalum Forest District do not permit construction of semi-permanent mainline roads within 500m of designated mountain goat UWR unless no other options exist to access timber beyond the goat winter range (UWR Order 6-001, Ministry of Environment).

Limit activities within proximity of natal areas during kidding (Mid-April to mid-June). For example, General Wildlife Measures for goat UWRs in the Kalum Forest District require that forestry activities within 500m of UWRs take place between June 15 and October 31 (UWR Orders 6-001 and 6-010, Ministry of Environment).

Manage helicopter activity adjacent to occupied mountain goat habitats, particularly winter range. Precautionary distances for flight restrictions are to be 1500 – 2000m adjacent to occupied goat winter ranges, especially during winter and kidding periods. MOE policy regarding setback distances for aerial supported commercial recreation can be found at:

www.env.gov.bc.ca/wld/twg/guidelines/aeriel.html.

7.5.2 Management across the working landbase outside of spatial reserves

The level of habitat disturbance is not directly proportional to the level of impact (i.e., 20% reduction of habitat could equal 50% reduction in use). If logging occurs in one area, mountain goats may not be adversely impacted; if it occurs in another, goats could be locally extirpated. For example, removal of snow interception cover in areas occupied by nursery groups in winter could have disproportionate population level impacts.

The importance of a particular habitat to a local population is tied to various factors associated with the quality of the habitat e.g., the availability of escape terrain and a combination of other factors such as: snow shedding capability of a location, relative position of an individual winter range in a given valley, and such factors affecting the rate of snow-shedding of a given winter range (elevation, aspect, and exposure to wind).

Recommendations:

1. A field assessment by a suitability qualified biologist is required prior to undertaking any developments in areas of potential goat winter range. The assessment should focus on determining the importance of the habitat to mountain goats and the potential impacts if any of the habitat is disturbed.

   This assessment cannot be generalized to the landscape scale. A biologist is needed to assess the habitat, verify occupancy of an area by mountain goats and determine the value of the habitat in the field at the individual winter range level. A caveat is that it is not always possible to actually assess habitats on the ground due to safety concerns and in accessibility. In many cases, only a very small proportion of winter ranges can actually be traversed.

2. The management of goat winter ranges outside of old growth reserves is strongly tied to adaptive management. However, domain experts do not recommend conducting trials within occupied mountain goat winter habitats. Due to the potential vulnerability of mountain goats to any modification within their winter habitats, domain experts propose adaptive management trials be conducted in areas that are not occupied by goats (for example, to assess the affect of forest cover removal on snow interception cover).
3. It is not possible to recruit or enhance winter range by logging within existing habitats. Domain experts do not recommend silvicultural trials to enhance existing winter range. However, it may be possible to accelerate recovery in habitats that are already logged using silvicultural treatments that accelerate the redevelopment of old/mature forest characteristics.

Long-term planning of harvest location and timing, as well as access management planning, should be applied to the larger forest matrix. Other management considerations include:

- At the landscape level, maintain connectivity of contiguous forest cover between goat seasonal habitats.
- Goats will use whatever is available to provide winter shelter, including individual structural elements to escape harsh weather. For this reason, large hollow trees (cedar) should be included within wildlife retention patches at the stand level.
- Establish management strategies for non-habitat factors such as helicopter activity/ industrial disturbance. Management strategies are in place for recreational activities (Ministry of Environment Tourism Wildlife Guidelines, 2006 http://www.env.gov.bc.ca/wld/twg/index.html). A multi-year project is also underway in the Skeena Region to assess the responses of mountain goats to heli-skiing activity (contact: Mike Gillingham, University of Northern B.C.).
- Undertake monitoring of habitat effectiveness. The Forest and Range Evaluation Program (FREP) has begun evaluations of habitat effectiveness (contact: Kathy Paige, Ministry of Environment). This work should be continued to enable replicable field assessments of winter range habitat quality/ functionality. It is also important to monitor trends in habitat availability through time.

8.0 Recommended Management for Northern Goshawk

This chapter was prepared by:

Frank Doyle, Wildlife Dynamics Consulting

Todd Mahon, Wildfor Consultants

Erica McClaren, Ministry of Environment

8.1 Recommended Inputs to Strategic Co-Location in MARXAN

This section summarizes key inputs to co-location for northern goshawk habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Part 2: Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas (Horn and Rumsey 2009).* Please note, opinions provided within this document are those of the domain experts and do not necessarily represent the views of the Northern Goshawk *A. g. laingi* Recovery Team.

8.1.1 Population objective

Objective: Maintain sufficient and well distributed habitat to maintain viable breeding territories and, therefore, populations

8.1.2 Targets for co-location of habitats in old growth retention areas

Targets shown below for Low Risk and Best Habitats scenarios will be used as a base for 'seeding' a final co-located solution in MARXAN (the Co-located LUO scenario) that meets, but does not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The Northern Goshawk Recovery Team has insufficient information at this time to set measurable habitat and population goals for recovery[6] However, for the purpose of this co-location work, domain experts identified targets associated with amounts of nesting and foraging habitat recommended for retention within old growth reserves.

Northern Goshawks should be addressed in MARXAN with three separate, but linked, scenarios for known nesting areas, modelled nesting habitat and modelled foraging habitat. Known nest

[6] See Northern Goshawk *A. g. laingi* Recovery Team. 2008. http://www.env.gov.bc.ca/wld/documents/recovery/rcvrystrat/northern_goshawk_rcvry_strat_200508.pdf

areas/post-fledging areas (PFAs) need to be protected as essential habitat. Protection of the viability of nest areas involves:

- Maintaining the integrity of the 200 ha nest area/PFA. This area can be approximated by applying an 800 m buffer around the centroid of known nest locations within a territory; and
- Ensuring that the nest area is within a forest matrix that will provide adequate habitat quality and quantity for foraging over time. A nest area should not be an isolated patch surrounded by young seral forest.

It is important to emphasize that, if this project is taken to the stage of actually identifying candidate OGRAs spatially on a map, goshawk model predictions should be verified through ground assessments and review of recent harvest layers.

Habitat definitions:

Mapped nest areas: All forest within the (minimum 800 m) buffer around known nest areas/PFAs.

Modelled nesting layer: Nesting 1 (N1) (high value habitat) = [0.75 - 1.0];
Nesting 2 (N2) (moderate and high value habitat) = [0.5 - 1.0]
To ensure that a proportion of high quality nesting habitat was selected in the solution, we had to include a combination of moderate and high in N2.

Modelled foraging layer: Forage 1 (F1) (high value habitat) = [0.75 - 1.0];
Forage 2 (F2) (moderate and high value habitat) = [0.5 - 1.0]
To ensure that a proportion of high quality foraging habitat was selected in the solution, we had to include a combination of moderate and high in N2.

8.1.2.1 Low Risk scenario

Targets for the Low Risk scenario were developed based on the assumption that foraging habitat will not be met entirely within OGRAs and other reserves. Foraging areas are far too large for a fine-filter management approach and need to be managed using a dynamic coarse-filter landscape approach.

i. Nest areas + PFAs

Recommended Low Risk scenario: 100% of nest areas/PFAs (all forested habitat within a minimum 200 ha buffer centered on nest areas)

For the purposes of co-location, nest areas were mapped based on a combination of field verified wildlife habitat areas (WHAs) and 800 m buffers to ensure a minimum 200 ha nest area.

ii. Modelled nesting habitat

Recommended low risk scenario: 60% [N1 + N2] with at least half (30%) of this scenario comprised of N1

Analysis unit: Landscape unit

iii. Modelled foraging areas

Recommended low risk scenario: 60% [F1 + F2] with at least half (30%) of this scenario comprised of F1

Analysis unit: Landscape unit

8.1.2.2 Best Habitat scenario

100% of known nest areas;

100% of modelled nesting habitat captured in the Low Risk solution;

33% of modelled foraging habitat captured in the Low Risk solution;

8.1.2.3 Habitats to be locked into co-located solution

- Due to the species' strong territoriality and high fidelity to their nest areas, known nest areas/PFAs should be included in all old-growth reserve area solutions. It is important to have flexibility in OGRAs to include new nest area/PFAs, as they are located in the future.
- 100% of WHAs (approved and proposed)

8.1.2.4 Upper limit of habitat change

Domain experts are unable to set an upper limit of change at this time, due to a lack of knowledge around factors influencing populations at these upper limits.

8.1.3 Rationale for targets

Studies have demonstrated a positive relationship between amount of mature forest within goshawk home ranges and nest area occupancy and productivity (see northern goshawk chapter in McClaren et al. (2009). Most studies suggest between 40 - 60% of suitable foraging habitat within goshawk home ranges will support pairs over time. The Northern Goshawk *A. g.*

laingi Recovery Team and Habitat Recovery Implementation Group (RIG) have identified three thresholds of foraging habitat abundance within goshawk home ranges and associated probabilities of continued occupancy, using the precautionary principle:

20 - 40% low probability of occupancy

40 - 60% medium probability of occupancy

> 60% high probability of occupancy

8.2 Assessment of Co-location Outcomes

8.2.1 Mid Coast

In this section, domain experts based their assessment of the MARXAN outputs for the Mid Coast only. They do not report on the South Coast results because a Best Habitat scenario was not run in the Co-Location solution for goshawks in the South Coast.

For the Mid Coast, there was very little difference in MARXAN scenarios for Best Habitat and Low Risk Habitat for goshawks and so this indicates that our definition of Best Habitat was still very restrictive. The small difference between our 'refined' Best Habitat scenario and Low Risk scenario is because of the large amount of goshawk foraging habitat on the land base relative to the amount of habitat that can be captured in OGRAs. Consequently, when we reduced the amount of foraging habitat target from 60% in the Low Risk scenario to 20% in the Best Habitats scenario, the total amount of foraging habitat captured in OGRAs remained similar.

There are still substantial gaps between the amount of goshawk nesting and foraging habitats captured in Co-located LUO scenarios and Best Habitat scenarios for goshawks (see Table 17).

Table 17. The percentage of Northern Goshawk goal set for nesting and foraging habitats that are obtained in the Co-located LUO MARXAN scenario compared to the Best Habitat scenario (Mid Coast sub-region).

	Northern Goshawk Habitat Type			
Scenario	**N1**	**N2**	**F1**	**F2**
Co-located LUO	65%	64%	67%	62%
Best Habitat	98%	85%	82%	76%

Domain experts have emphasized the importance of trying to capture as much suitable goshawk nesting habitat in MARXAN scenarios. OGRA strategies lend themselves to nest area/PFA habitat protection for goshawks more than foraging habitat protection. Table 17 shows that proportionately similar amounts of goals set for goshawk foraging and nesting habitats are achieved in the Co-located LUO scenario. However, there is a wider gap between Best Habitat scenario and Co-located LUO scenario for goshawk nesting habitat than for foraging habitat. This is not too surprising because the goal for nesting habitat amounts was more restrictive than for foraging. Domain experts reduced the total amount of foraging habitats that should be obtained in the Best Habitat scenario for goshawks to 20% because we recognized from earlier MARXAN runs that it was unlikely that OGRAs would achieve total targets we set for foraging habitat in the Low Risk scenario. However, it remains important that some foraging habitat protection in OGRAs is important because it is essential to protect a variety of foraging habitat types to maintain a diversity of prey species. Although suitable nesting habitat is typically suitable foraging habitat, some types of foraging habitat are not suitable for breeding and these may be underrepresented in MARXAN runs if foraging habitat was not explicitly included in solutions.

8.2.2 Comparison of Mid Coast and South Coast results

In terms of hectares of habitat, the Mid Coast has over 20 times as much goshawk habitat as South Coast. This is probably related to a) size of study areas and b) more extensive logging in the South Coast, but a more thorough analysis would be required to confirm the source of the differences. Regardless, overall amounts of modelled suitable (high and moderate) nesting habitat in the Mid Coast planning area is low and encompasses approximately 11% of the total area.

8.2.3 Uncertainties and limitations

Domain experts cannot assess the degree to which habitat requirements for goshawks are met through the Co-located LUO scenario because population targets, and associated habitat targets, have not been established for the species by the Northern Goshawk Recovery Team. Targets provided by the domain experts for the Focal Species Project do have an ecological basis (habitat-fitness and habitat-population relationships in the literature), but the parameters of those relationships are not locally known. As well, goshawks utilize mature forests for nesting and foraging and so as part of a longer term, dynamic planning process, it is important to include habitat capability i.e., recruitment, for goshawks, and, not just suitability (probably conducted at the landscape unit level), which was beyond the scope of this exercise.

Recognizing this issue, targets were based on the following principles 1) a substantial amount of goshawk habitat will still need to occur outside of OGRAs to sustain territories and populations, 2) the three target levels provided (60, 40, 20) are not directly tied to local population or fitness relationships, but the more captured, the better the likely outcome for goshawks (or conversely, less is riskier); and 3) specifying target levels, while acknowledging the uncertainty around them, was a fundamental requirement to getting goshawk habitat 'in play' in the MARXAN runs.

A caution with the MARXAN exercise is that targets are based on percentage of existing habitat, not absolute habitat amount. Therefore a landscape unit with only 100 ha of suitable goshawk habitat (much too little to support even one nesting pair) could report 100% habitat protection, but still be well below providing any meaningful habitat protection value for goshawks. One must consider the overall habitat amount as well as the % captured.

There is little opportunity to refine the nesting and foraging models used to identify goshawk habitat because 1) of limited accuracy of the underlying forest cover data, and 2) because goshawks use a range of habitats and that use varies in response to a number of factors. Model refinement could occur as forest cover data is improved within the planning area and as we gain more information about the relationship between habitat and goshawk population metrics. Ground verification work and subsequent analyses of data have led to some minor revisions in the model parameter estimates.

8.3 Implications of Co-Location Results for Management of Northern Goshawks

Protection of northern goshawk habitat through co-location in old growth retention areas will almost certainly not be adequate to maintain species persistence and reproduction at most territories or at the population level. Goshawks have very large foraging areas within territories and so substantial goshawk habitat management will need to occur within the 'working forest' or as part of other conservation strategies.

Ultimately, the issue for goshawk habitat management is more complex than just identifying and protecting the very best habitat in OGRAs; it involves maintaining a sufficient amount of suitable habitat across a somewhat broad range of 'mature-old forest' conditions, and is distributed at distances that reflect the territorial nature of goshawks across landscape units. In other words, goshawks will not pack into habitat. A substantial amount of habitat will need to be provided through broader integrated resource planning or additional conservation strategies. The Northern Goshawk Recovery Team anticipates a combination of fine filter and coarse filter strategies will be required to conserve habitat for the species. This OGRA co-location project should integrate well into the broader habitat management strategy being developed by the Recovery Team.

Although the total amount of goshawk habitat within OGRAs will be insufficient alone to support viable populations, maintaining goshawks as a focal species in the co-location exercise increases the total amount of suitable nesting and foraging habitat in solutions and will therefore, be beneficial to goshawks. MARXAN co-location LUO scenario adds a significant amount of goshawk nesting (N1 & N2) and foraging (F1 & F2) habitats when compared to just the LUO Base scenario without co-location.

8.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

8.4.1 Key considerations for strategic co-location

In general goshawk habitat will be well-represented by

(a) locating known nest areas/PFAs within OGRAs;

(b) seeking to capture all nesting habitat that meets the low risk scenarios;

(c) designing OGRAs to be distributed across landscape units in relatively large patch sizes (100-200 ha);

(d) co-locating as much low risk foraging habitat as possible opportunistically through representation targets for site series surrogates and the habitats of other focal species;

(e) opportunistically capturing foraging habitat in close proximity to large patches of nesting habitat; and

(f) providing representation of mature and old forest habitats across the landscape over time inside and outside of OGRAs. Consider the mapping of 'floating reserves' for foraging habitat, that change over time and are linked to landscape-unit wide targets for habitat retention.

8.4.2 Setting priorities among landscape units

Both the amount/proportion of suitable goshawk habitat overall and the amount in OGRAs vary considerably among landscape units. In addition, some landscape units have significant second growth that will be recruited as suitable habitat within a relatively short time period (i.e. capable habitat).

One management strategy, if there is a limited OGRA budget, would be to increase the amount of goshawk habitat protection via OGRAs in some landscape units and decrease it in others (to ensure some winners and losers versus every landscape unit being designated an insufficient amount). Under this approach domain experts recommend giving priority to landscape units with relatively high proportions of suitable and capable habitat (> 200 ha for nesting habitat and > 3900 ha for a territory (McClaren 2003)). Note that this is only a rule of thumb; there needs to be consideration for shape, configuration and proximity relationships among foraging habitat amounts and nest area habitat (E. McClaren, MoE, pers. comm). As an example, a quick analysis of the number of hectares of suitable goshawk nesting habitat (N1 + N2) and foraging habitat (F1 + F2) within landscape units for the Mid Coast showed at least three landscape units with insufficient nesting habitat to support one nest area/PFA (< 200 ha) and approximately seven landscape units with insufficient foraging habitat to support one territory (< 3900 ha). This number may be an underestimate because landscape units with no suitable nesting or foraging habitat were not shown in spreadsheets.

Furthermore, co-location should plan for the long-term and should consider habitat capability, not just current suitability, as does the timber cost model.

8.4.3 Improvements to MARXAN methods

- Ultimately, domain experts would like to see the Recovery Team's territory model run across the various scenarios to see how they might translate to densities and distribution of viable territories. If the Recovery Team's territory model cannot be run, some analysis of patch size, shape and distribution of suitable habitats across the landscape should be conducted. Northern goshawk nesting habitat quality is influenced by patch size, with most nests being located >200 m from hard edges[7]. As well, the location of adjacent goshawk pairs will significantly influence nesting habitat quality for goshawks.
- Northern goshawks utilize mature forests for nesting and foraging and so as part of a longer term, dynamic planning process, it is important to include habitat capability i.e., recruitment, for goshawks. Therefore, in order for domain experts to provide targets that more directly relate to territory occupancy or population levels requires a habitat amount target based on habitat capability, not just suitability (probably conducted at the landscape unit level).
- The Mid Coast has over 20 times as much modelled habitat for northern goshawks as the South Coast. This difference in amount of habitat emphasizes the potential problem of setting targets based on a percent of existing suitable habitat. It may be more effective to set separate targets for each sub-region. The question then becomes, to what level should targets be tailored? For example, are sub-regional targets appropriate or should a target be established for each landscape unit based on the amount of suitable and capable habitat? A more effective approach for targets would be to identify absolute habitat amount targets, and if they cannot be met by existing suitable habitat, then include capable habitat that will be recruited as it matures.

[7] A hard edge is defined as where mature forest meets non-forested or early seral habitats and the difference in height is >15 m. Typically, hard edges are created as a result of human activities such as developments.

- Co-location should focus on species with similar habitat requirements. Co-location of species with coincidental overlap may result in bias to sub-optimal habitats. For example, goshawk habitat that overlaps with goats is likely sub-optimal because suitability is generally lower for goshawks on steep slopes than on flat to moderate slopes. In hindsight, perhaps a better method for co-location would have included suites of species with similar patterns of habitat selection. As well, successful co-location for focal species does not only include overlap of suitable habitat but the relative extents to which species habitats co-exist, should be examined.

8.5 Recommendations for Management of Habitats Outside of Spatial Reserves

To provide foraging habitat for goshawks outside of old growth reserves, apply a coarse filter management strategy that ensures mature and old forests with high prey abundance and accessibility exist in the longer term. As well, until population targets are set by the Northern Goshawk Recovery Team, ensure newly located nest area/PFAs are protected with 100-200 ha buffers.

Within harvested areas, any structure left behind is beneficial. Retention harvest systems are preferable to clearcuts (Doyle 2006b). Wildlife tree retention within cutblocks can create useful microsites (e.g., providing perch trees and sources of prey). Coarse woody debris provides cover for prey to maintain population abundance.

Apply thinning and pruning lifts to reduce the density of dominant trees and promote crown closure and an open understorey for flyways. This will result in a shorter time required to recover suitable stand structure (Doyle 2006a).

9.0 Recommendations for Management of Tailed Frog

Domain experts:

Pierre Friele, Cordilleran Geoscience

Volker Michelfelder, Ministry of Environment

9.1 Recommended Inputs to Strategic Co-Location in MARXAN

This section summarizes key inputs to co-location for tailed frog habitats to be applied during landscape unit design and planning. A more detailed set of considerations for strategic co-location of focal species habitats is provided in the companion document to this report entitled *Part 2: Methods for Strategic Co-Location of Habitats within Old Growth Retention Areas (Horn and Rumsey 2009).*

9.1.1 Population objective

Objective: To maintain population viability by capturing the full range of habitat variability across each landscape unit.

9.1.2 Targets for co-location of habitats in old growth retention areas

Targets shown below for Low Risk and Best Habitats scenarios will be used as a base for 'seeding' a final co-located solution in MARXAN (the Co-located LUO scenario) that meets, but does not exceed, targets under Section 14 in the Coastal Orders for retention of old forest by site series/ site series surrogate (SSS).

The targets shown here are for the capture of habitats that are not otherwise designated under the Coast Orders or as wildlife habitat areas under the *Forest and Range Practices Act* (FRPA).

Due to lack of inventory it is not possible at this time to provide absolute targets for habitat retention for tailed frogs. The targets shown below are based on expert opinion and are suggested as a starting point for experimenting with co-location. Targets will be better defined as inventory and research improves understanding of coastal tailed frogs and their response to changes in habitat.

9.1.2.1 Low Risk scenario

Experimental targets[8]: 50% Class 1; 45% Class 2; 30% Class 3; 40% Class 4 by landscape unit.

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[8] Due to lack of inventory it is not possible at this time to provide absolute targets for habitat retention. The above targets are based on expert opinion and are suggested as a starting point for experimenting with co-

Fragmentation: low

9.1.2.2 Best Habitats scenario

100% of Class 1 and 2 habitats captured in the low risk solution.

9.1.2.3 Habitats to be locked into co-located solution

The following habitats should be locked into the final solution:

- Class 1 habitats (buffered streams) having known tailed frog occupancy.
- Approved WHAs for the South Coast
- Class 1 and 2 habitat within proposed WHAs for Mid Coast.

9.1.2.4 Upper limit of habitat change

Experimental targets[5]: 20% Class 1; 20% Class 2; 20% Class 3; 20% Class 4.

Fragmentation: moderate

9.1.3 Rationale for targets

- Mature (>100 years of age) and old growth forests are equally important for retention.
- Stream buffers have the highest retention targets because maintaining forested cover on either side of stream segments has been shown to be the most important factor in maintaining the quality and function of both the aquatic and riparian components of tailed frog habitat (Dupuis and Steventon 1999).

  Domain experts assume that a disproportional amount of ecological benefit (around 80%) is gained through provision of adequate streamside buffers, and that the remaining ecological benefit (20%) is gained through watershed level measures.
- Stream buffers allow for within-basin connectivity, which is important for dispersal of tailed frogs within watersheds. As there is no requirement to buffer S5 and S6 streams under FRPA, it is important to consider buffering by including them within OGRAs.
- The 45% - 50% targets for capture of stream buffers in the experimental low risk scenario are based on inventory results (Dupuis and Friele 2003, Frid et. al. 2003, Michelfelder and Dunsworth 2007) that indicate about 60-70% of potentially capable creeks are actually occupied.

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location. Targets will be better defined as inventory and research improves understanding of coastal tailed frogs and their response to changes in habitat (see section 9.2.3).

- Class 4 contributing basins have a slightly higher target than Class 3 basins because Class 4 basins are steeper and more fragile and are therefore more vulnerable to disturbance.
- Although it is less critical for basin areas outside of the stream buffers to be captured in OGRAs, the more overall area that is captured within a watershed, the greater the potential conservation value for tailed frogs and the greater the dispersal capability between watersheds. Within the contributing basin, appropriate management with regard to hydrological green-up and road development and maintenance will contribute to the conservation of tailed frog habitat within buffered streams.
- 20% conservation of Class 1 to 4 habitats would be insufficient to protect this species (i.e., be a high risk level) because: (1) tailed frog breeding habitats are dynamic and unpredictable, and they lack resiliency in some settings; and (2) they have poor terrestrial dispersal capabilities particularly when the risk of desiccation from sun and wind is high (e.g., in the latter half of their short growing season – especially in the absence of shade and wind screening).

9.2 Assessment of Co-location Outcomes

Based on precautionary considerations, the Low Risk scenario for tailed frog habitats is used as a benchmark in this assessment. Overall, the Co-located LUO scenario appears to result in a more effective capture of habitats for tailed frog on the Mid Coast compared to the South Coast.

9.2.1 South Coast sub-region

9.2.1.1 Amount of habitat

a. Sub-regional scale

At the sub regional scale, the amount of habitat captured in existing reserves is insufficient to achieve low risk targets for any of the habitat classes (Table 18).

With the MARXAN solution added in the Co-Located LUO scenario, Class 2 - 4 habitats meet low risk targets. However, insufficient old growth is captured to achieve the low risk target of 50% Class 1 habitat.

b. Landscape scale

Table 19 summarizes the results of the Co-located LUO scenario within individual landscape units. For all classes of habitat, there are at least 40% of landscape units that are below the targets for low risk.

Stream buffer habitat (Class 1 and 2) is most poorly represented. Over 80% of landscape units (21 of 26) do not meet the experimental low risk targets for capture of Class 1 habitats and more than 70% do not meet targets for capture of Class 2 habitats (Table 19).

Two landscape units (Allison and Sim) are at or below the experimental high risk threshold of 20% for capture of Class 1 habitat (20% and 14% respectively) and Class 3 habitat (10% and 19% respectively).

Table 18. Results of the Co-located LUO scenario at the sub-regional scale: South Coast

Scenario	Habitat type	Total habitat (ha)	Amount in existing reserves[9]	Added by MARXAN	Total amount habitat captured (reserves + OGRAs)	Low risk target (for comparison)
Co-Located LUO	Class 1 stream buffers	35,476	7761 ha (22%)	6001 ha (17%)	13,761 ha (39%)	50%
	Class 2 stream buffers	27,058	6647 ha (25%)	4633 ha (17%)	11,281 ha (42%)	45%
	Class 3 basins	200,939	24,195 ha (12%)	45,137 ha (22%)	69,332 ha (35%)	30%
	Class 4 basins	117,576	23,235 (10%)	26,356 ha (22%)	49,592 ha (42%)	40%

Table 19. Results of the Co-located LUO scenario at the scale of landscape units: South Coast

Scenario	Habitat type	Number (%) of landscape units that do not achieve the experimental low risk target
Co-Located LUO	Class 1 stream buffers	21 (81%)
	Class 2 stream buffers	19 (73%)
	Class 3 basins	11 (42%)
	Class 4 basins	15 (48%)

[9] Existing reserves = protected areas, WHAs, UWRs, riparian, biodiversity areas, grizzly bear critical habitat

9.2.1.2 Spatial configuration

In the South Coast, Class 1 and 2 stream segments appear fragmented in the final solution and it appears that tailed frog habitat is selected somewhat incidentally. A different algorithm was applied to the subsequent Mid Coast run to address this issue (see section 9.2.2.2). It may also be that, with the polygon data available to the modelling exercise, some degree of fragmentation is unavoidable.

The fragmentation of habitats in the South Coast solution reduces the effectiveness of the OGRAs in protecting tailed frog habitats and the risk levels are likely to be slightly higher than is described in section 9.2.2.2.

9.2.2 Mid Coast sub-region

9.2.2.1 Amount of habitat

a. Sub-regional scale

In the Mid Coast sub-region, habitat captured within existing reserves appears to be sufficient to achieve the precautionary low risk targets for all classes of tailed frog habitat (Table 20).

With the MARXAN solution added in the Co-Located LUO scenario, the amount of habitat captured exceeds 70% for all habitat classes, suggesting that tailed frog habitat co-locates well on the Mid Coast. This is because targets for habitat retention are already met in existing reserves, which suggests that incremental habitat is being captured through co-location with other focal species. This result is well above the low risk targets for all habitat classes.

b. Landscape scale

Fourteen of the 62 landscape units with tailed frog habitat in the Mid Coast do not achieve Low Risk targets for Class 1 habitat (Table 21), but most are within 5% of the target. However, two landscape units (Smith Sound and Tolmie) are well below the 50% target (20% and 35% respectively).

Low risk targets for Class 2 habitats are met in all landscape units with the exception of Don Peninsula, Draney, Smith Sound and Tolmie. Of these, amounts captured in Smith Sound and Tolmie are below the high risk target of 20%, although there are only 30 ha of Class 2 habitat in the Smith Sound LU.

Low risk targets for Class 3 and 4 habitats are met in all landscape units will the exception of Draney and Smith Sound. Only 3 ha of 146 ha of Class 4 habitat are captured in the Smith Sound LU.

Table 20. Results of the Co-located LUO scenario at the sub-regional scale: Mid Coast

Scenario	Habitat type	Total habitat (ha)	Amount in existing reserves[10]	Added by MARXAN	Total amount habitat captured (reserves + OGRAs)	Low risk target (for comparison)
Co-Located LUO	Class 1 stream buffers	100,739	56,671 (56%)	15,831 ha (16%)	72,502 ha (72%)	50%
	Class 2 stream buffers	75,475	43,611 (58%)	12,203 ha (16%)	55,813 ha (74%)	45%
	Class 3 basins	588,634	356,511 (61%)	77,573 ha (13%)	434,084 ha (74%)	30%
	Class 4 basins	336,015	214,379 (64%)	40,913 ha (12%)	255,291 ha (76%)	40%

Table 21. Results of the Co-located LUO scenario at the scale of landscape units: Mid Coast

Scenario	Habitat type	Number (%) of landscape units below the experimental low risk target
Co-Located LUO	Class 1 stream buffers	14 (23%)
	Class 2 stream buffers	4 (7%)
	Class 3 basins	2 (3%)
	Class 4 basins	2 (3%)

9.2.2.2 Spatial configuration

Stream segments in the Mid Coast solution appear fragmented, although not to the same extent as in the South Coast solution. However, the fundamental requirement that entire stream lengths be reserved is not always being met. The difference in spatial configuration between the Mid and South Coast solutions is likely in part due to changes to the MARXAN method, which were applied in the Mid Coast, to reduce fragmentation and better link stream buffers to their contributing basins (see Horn and Rumsey 2009). The other factor resulting in less fragmentation on the Mid Coast may be the historically lower level of timber harvesting on the Mid Coast.

[10] Existing reserves = protected areas, WHAs, UWRs, riparian, biodiversity areas, grizzly bear critical habitat((83%)

In some landscape units, entire stream lengths are captured in existing reserves. While the capture of entire stream lengths is desirable, excessive clumping may occur when solutions are driven to existing large reserves and are not adequately dispersed across the landscape unit. This effect is countered somewhat by the need to meet targets for site series under the land use objective and to co-locate with other species' habitats.

9.2.3 *Uncertainties and limitations*

Since little to no data exists on tailed frog population levels, targets established for strategic co-location are based on expert opinion and subject to change.

It is a significant limitation to use polygon-based source data (for site series surrogates) to capture habitats for a species with a linear habitat. The MARXAN method for the South Coast, revised in Phase 3, did not completely rectify this issue and it may be insoluble. Thus, while a strategic approach to OGRA design using MARXAN may *suggest* a solution, the real solution for tailed frogs will need to be identified during more detailed hands-on design and planning (as described in Lewis and Kremsater 2009).

9.3 Implications of Co-Location Results for Management of Tailed Frogs

The amount of habitat captured in the co-located solution is much higher in the Mid Coast than in the South Coast, for all classes of habitat. Precautionary low risk targets are already met within existing reserves in the Mid Coast and co-location within OGRAs increases the overall amount of habitat retained to over 70% across habitat classes at a sub-regional scale. This result is not evenly distributed across landscape units, but, with a couple of exceptions, most landscape units meet or are close to the low risk targets.

Therefore, in the Mid Coast, a cautious conclusion is that sufficient habitats for tailed frog will be conserved through a combination of existing protection and incremental retention of habitats in OGRAs. However, there are many uncertainties associated with tailed frog abundance and distribution, the reliability of mapping, and the MARXAN result. Therefore further assessment is needed as part of more detailed hands-on OGRA design and subsequent monitoring and adaptive management.

The result is quite different in the South Coast. Existing reserves do not provide the same level of protection to tailed frog habitats and contributing basins. The co-located solution appears to meet precautionary low risk targets for all classes of habitat except Class 1 stream buffers. This is a concern because the Class 1 habitats are the highest value habitats for tailed frogs. At the landscape unit scale, the amount of habitat captured varies across landscape units. At the landscape scale, it is Class 1 and 2 habitats (stream buffers) that are most consistently below targets for low risk and these are the habitats of greatest concern. However, these results need to be treated with caution due to uncertainties in the mapping and issues with spatial configuration.

Due to the sensitivity of tailed frogs to changes in their aquatic and terrestrial habitats, the management of habitats outside of spatial reserves, as well as within reserves, is very important (section 9.5). As the Coastal Orders do not provide direct protection to tailed frog streams via streamside buffers, the objectives for upland streams (s12) are assumed to only minimally contribute to the highest value (Class 1 and 2) *A. truei* habitat. However, the upland stream objective, with its requirements to maintain functional riparian forest and hydrologically effective green-up, may contribute to tailed frog habitat protection, mainly within contributing basins (Class 3 and 4 habitats) and to a limited extend within Class 1 and 2 habitat.

Because of the need to ensure habitat protection in stream buffers as well as contributing basins, effective co-location of tailed frog habitats within OGRAs will make an important contribution to the conservation of tailed frogs. This is particularly important in the South Coast, where tailed frog habitats are not captured in existing reserves to the same extent as in the Mid Coast.

Where shortfalls are identified by MARXAN then these areas should be targeted for recruitment of buffers (Class 1 and 2 habitats) and ECA thresholds (Class 3 and 4 habitats). The fact that these areas do not meet targets implies they are extensively logged. In such settings there may be “road legacies” that need to be mitigated. Thus, level 1 watershed assessments might be conducted to identify these legacies, and follow up road deactivation projects implemented. These comments are based on the assumption that extensive logging has a significant impact on tailed frog distributions (as per previous research). This notion could be tested by comparing tailed frog distributions in those landscapes that do not meet high risk targets with those in those landscapes that meet low risk targets.

In some landscape units the habitats captured under the Co-located LUO scenario are below the experimental high risk target of 20% in each habitat class (Allison and Sim in the South Coast and Draney, Smith Sound and Tolmie in the Mid Coast). Future research could explore the implication of this outcome by comparing population distributions in these landscape units with those in unmodified landscape units of equivalent habitat quality.

The targets used in the MARXAN co-location scenario should be treated as experimental as there is not enough known at this time about the relationship between the amount and quality of terrestrial habitat and tailed frog abundance. Therefore an adaptive management approach is appropriate in setting future targets and management direction for habitats for this species.

9.4 Recommendations for Co-Location of Habitats within Old Growth Reserves

9.4.1 Key considerations for strategic co-location

- In the final OGRA solution, the priority is to retain buffered stream segments. Class 1 stream segments are a priority over Class 2 stream segments. If it isn't possible to protect all Class 1 (and 2) habitat within a given basin, lower elevation stream buffer sections should be preferred over higher elevation sections.
- Establish stream buffers on the entire length of selected streams (valley bottom to headwater). An adequate riparian buffer is large enough to moderate stream temperature and riparian microclimate conditions, and be resilient to extensive windthrow.
- Ensure that co-located solutions link buffered streams with old growth in the contributing basin. Class 3 and 4 basin areas should be directly adjacent to protected stream buffer sections; a solution where old forests in class 3 and 4 basins are protected but the associated stream buffers are not protected will be minimally effective.
- Preferably link buffered streams to stands in contributing basins that coincide with moist microsites (seepages, depressions) and upland forests that are conducive to potential meta-population exchange across traversable passes.
- Consider dispersal of habitats at multiple scales:
    - At the landscape scale: to maintain meta-population dynamics, selected streams need to be dispersed across multiple basins rather than clumped.
    - At the basin scale, clump reserves to protect dentritic stream networks and minimize localized fragmentation of habitats. Dendritic stream networks and channels with complex long profiles offer a greater re-colonization potential in the event that channel events locally extirpate a segment of the population.
- OGRAs containing tailed frog basins should not be isolated by topographic barriers (cirque headwalls), but should be linked to other basins by dispersal nodes over passable divides.
- Consider the effects of existing roads and road density on the functionality of the solutions.

9.4.2 Setting priorities among landscape units

There is not enough inventory data at this time to identify priority landscape units for tailed frogs based on abundance.

Tailed frog populations exhibit clumpy distributions at various scales; but not enough information is available to prioritize one landscape unit over another based on habitat characteristics. Although much uncertainty exists, there is some indication that the habitat quality in the hypermaritime is, overall, not as good as in the sub and maritime units.

9.4.3 Improvements to MARXAN methods

- Apply Mid Coast MARXAN algorithms in combination with recommendations on spatial configurations to future co-location runs for the South Coast.
- It would be useful to run a co-location scenario for tailed frog alone (no other focal species) to more effectively diagnose and rectify the cause of habitat fragmentation. The complexity of multi-species co-location scenarios impedes this diagnosis and may, in fact, be contributing to the fragmentation problem.
- Create a new riparian layer specific to upland streams to provide greater certainty for habitat mapping and conservation planning.
- Develop a 'dispersal nodes' layer to be used as an input to MARXAN to drive the spatial configuration of OGRA solutions to assess linkages between meta-populations. Dispersal nodes are linkages between headwater streams that Tailed Frogs are able to navigate through.

9.5 Recommendations for Management of Habitats Outside of Spatial Reserves

The following measures are recommended (see Dupuis and Friele 2003, 2004) to manage effectively for coastal tailed frogs outside of OGRAs.

a. For any hillslope channel having known tailed frog occurrences, apply sound management from valley bottom to ridge top. Management should seek to minimize direct disturbance to the channel, and not allow cross-stream yarding. As a minimum, resource managers should fall-away, yard away, and apply a windfirm riparian buffers the entire length of the stream. In general a 50m buffer is recommended as this buffer width has been shown to positively correlated with tailed frog densities (Stoddard and Hayes 2005). Within this riparian buffer, maintain soil and humidity regimes e.g., by maintaining forested cover and coarse woody debris, to allow tailed frog movement on land. These are operational choices based on site specific conditions including such factors a drainage density, number occupied, soil moisture, terrain sensitivity, windthrow potential, degree of gullying, etc.

b. Delineate the watershed contributing to a given stream, and manage to a maximum equivalent clearcut area as per the Coast Order

c. Minimize road crossings, which are a direct cause of sedimentation; the fewer road crossings the better.

d. Undertake other measures to minimize impacts to streams (refer to Dupuis and Friele 2003):

   - To avoid stream sedimentation sourced from road surfaces and ditches, install cross drain culverts and do not connect ditchlines to the stream;
   - Keep roads off steep slopes with direct connectivity to streams, or use geotechnical measures designed to reduce cutslope and fillslope instability;
   - Maintain naturally dispersed water flows by installation of cross drain culverts at all seepages and streams;
   - Use sediment control measures on slopes and ditch lines;
   - De-activate roads once operations are complete;
   - Minimize site disturbance during harvesting, especially in terrain with the potential for high sediment transfer to streams; and
   - Minimize the use of chemical applications and herbicides because of their potential toxicity to amphibians.

10.0 Implementing Co-Location for Multiple Species

There are opportunities and challenges when co-locating the habitats of multiple focal species during a strategic reserve design process using the site selection software MARXAN. If, as is indicated by the outcomes of co-location simulations, the low risk target for all focal species will not be achieved within the current 'budget' for old growth retention under the Coastal Land Use Orders, there is a need to consider methods:

- At the sub-regional scale, to maximize overlap of the highest quality habitats for all focal species within the limited amount of old growth available; and
- At the landscape unit scale, to guide the selection of an optimal mix of habitats for focal species in each landscape unit.

Overall, the goal at the sub-regional and landscape scale, is to ensure that OGRAs come as close as possible to achieving the low risk scenario for all focal species' habitats, with a spatial configuration appropriate to each species.

The previous seven chapters discussed strategic co-location from the perspective of individual focal species at a strategic sub-regional scale, based on simulations in MARXAN. This chapter discusses co-location for multiple focal species. This information is presented under five headings:

- Maximizing overlap of high value habitats
- Prioritizing habitats within landscape units
- Prioritizing focal species
- Assessing co-location outcomes with respect to focal specie habitats
- Other considerations.

10.1 Maximizing overlap of high value habitats

Each of chapters 3 through 9 describes a series of targets to be applied in MARXAN for co-locating focal species' habitats in old growth reserves (see section x.1 in each of chapter). These targets are described in more detail in *Methods for Strategic Co-Location of Habitats within Areas of Old Growth Retention* (Part 2 of the EBM Working Group Focal Species Project report series).

When the targets for individual focal species are combined in MARXAN, they create a series of scenarios ('Low Risk' and 'Best Habitats' as described in section 2.0). These targets are applied sequentially in MARXAN with the intent of locating OGRA solutions in the highest quality habitats for all focal species combined: the Low Risk scenario is used as a base to create the Best Habitats scenario, which is, in turn, used as the base to create a 'Co-located LUO' scenario which is capped by the targets for old growth retention in the Central & North and South-Central Coastal Land Use Orders. The more that MARXAN can overlap habitats for multiple species, the more efficient the solution in terms of meeting the habitat requirements for all focal species within a limited budget for old growth.

The focal species selected for the co-location exercises were chosen because each represents a distinct habitat niche on a broad scale:

- Mountain goats: mid to high elevation habitats
- Grizzly bears: cross-elevational – alpine to lower valley
- Tailed frogs: upland streams
- Northern goshawks: generalist predator but specialist of mature/old growth structured habitats
- Marbled murrelets: old growth dependent.
- Black-tailed deer: mid to low elevation habitats.
- Black bears: bear habitats outside of the 'occupied area' for grizzly bears.

By design, therefore, the different habitat requirements of these species will not completely overlap during co-location. Nevertheless, there still are ecosystems that provide important habitat components for a number of focal species. The ecosystems of primary overlap can be broadly characterized as mid-slope to valley bottom zonal forest on rich sites. They are often on south aspects, but not always. Forested noses at the toe of slopes are often the warmest sites and also have the attributes of good habitat for multiple species. These sites provide good cover with snow interception for ungulates and have characteristics important for goshawk breeding and forage. They also often provide the structural attributes of high value in marbled murrelet habitat. They are generally not as important for bears except on richer sites. These sites also typically have high timber values, which increases their vulnerability to being modified through logging.

One consideration to maximize overlap of focal species' habitats in MARXAN would be to give heavier weighting to polygons that are 'best habitats' for two or more focal species. A caution, though, is that methods to maximize overlap of habitats in MARXAN should not be at the expense of capturing the highest quality habitats for individual species. For example, there appears to be a large quantity of lower quality Class 3 habitat for marbled murrelets that provides greater overlap with other focal species' habitats and at a lower timber cost than the higher value Class 1 and 2 habitats. Nonetheless, the priority should be on retaining as many Class 1 and 2 habitats as possible. It is also important to keep in mind that the 'Best Habitats' definitions, for most focal species, are already a compromise of the preferred Low Risk scenario e.g., the definitions for Class 2 grizzly bear habitat change from 100% under Low Risk to 50% under 'Best Habitats'.

10.2 Prioritizing habitats within landscape units

There are two ways to set priorities for landscape units: (a) to prioritize landscape units as a whole, based on conservation and other values, or (b) to prioritize focal species' habitats within landscape units. This section focuses on the latter. Priorities for landscape units as a whole have already been identified as part of various strategic land use planning processes, in updating targets for old growth retention in the Coastal Orders, and as part of planning for EBM implementation.

During landscape unit design, when challenging decisions have to be made about the habitats to include in the OGRA solution, it may be useful to provide some kind of ranking based on ecological importance to achieving focal species habitat protection. The following are guidelines for prioritizing habitats within individual landscape units:

- Habitat available within each landscape unit should be assessed with respect to its contribution to overall habitats at both the landscape scale and the regional/ sub-regional scale.
- Landscape unit priorities will be specific to each focal species. Priorities should be identified in the context of the conservation objective for the species, its habitat needs and habitat values within the landscape unit. The following are some criteria that might be applied:
  - Where there is a large amount of high value suitable habitat in the landscape unit, it could be ranked high priority because of its overall conservation value;
  - Where habitats are highly capable but the landscape unit is heavily modified it may be a priority to capture any remaining habitat; and/or
  - Where a species is highly threatened in a population unit, maintaining habitats in that population unit is a priority, wherever they occur.
- Because each landscape unit will have a different combination of species habitat values, it si recommended that domain experts be involved in the landscape unit design process so that they can provide opinion on the priorities and best strategy for achieving a multi-species solution.

The following is recommended for setting priorities within landscape units:

Step 1: Seek to maximally overlap multiple species habitats by sub-region and landscape unit using MARXAN, by applying the rules and targets developed as part of the co-location exercises and the conditions established by the Coastal Orders.

Step 2: Design OGRAs for individual landscape units in consideration of:

- Habitat values at the sub-regional scale as well as within individual landscape units (suitability and capability) (as per the above criteria);
- The amount of habitat captured within the landscape unit as well as the overall tally for the sub-region. This combined assessment should occur on an ongoing basis;
- Habitat available and captured in reserves in adjacent landscape units;
- Priorities already identified through strategic planning processes (e.g., biodiversity emphasis options)
- Overall seral stage distribution within landscape units (this applies to northern goshawk, black-tailed deer and grizzly bears)
- Contribution of other EBM objectives such as the objectives for aquatic habitats and the upland streams objective.
- Implications for human use of wildlife e.g., harvest of deer for sustenance purposes; wildlife viewing.

Table 22 summarizes species specific considerations when setting priorities for habitats within a landscape unit.

Table 22. Guidance to priority setting for habitats within individual landscape units

Focal species	**Considerations for priority-setting**
Black bear	In the absence of habitat suitability mapping, the focus of management for black bear habitats is to retain forested stands having existing and known den potential and to achieve a distribution of reserves across landscape units.
Black-tailed deer	Identify priority landscape units based on the 'relative risk' of each unit in the sub-region. This is determined by the sum of the following: i. the relative proportion of Deer_1 habitat in the LU compared to the total amount of Deer_1 habitat in the sub-region; ii. the relative proportion of Deer_1 habitat occurring in the landscape unit that is not protected; and iii. the relative proportion of Deer_1 habitat that is not in the

Focal species	Considerations for priority-setting
	THLB (under the assumption that habitat in the THLB is more immediately vulnerable to loss through forest development than habitat in the non-THLB). Deer mapping is currently only available for the South Coast. See section 4.4.2 for a list of priority landscape units in the South Coast.
Grizzly bear	High priority landscape units are identified based on relative amount of Class 1 and 2 habitat available, status of the relevant grizzly bear population unit, current seral stage distribution in the landscape unit, and location of the grizzly bear population unit with respect to the edge of their distribution and occupancy. In the South Coast, where Class 2 habitats are not protected under the legal order, Class 2 habitats with higher habitat values should be protected, where possible (see section 5.1.2). In all sub-regions, the protection of Class 2 habitats within a landscape unit becomes even more important where there is a high ratio of THLB to total forested and there has been a long history of forestry development (logging and roads). A list of priority landscape units is provided in section 5.4.2.
Marbled murrelet	Retention of habitat across the entire sub-region is a priority over trying to achieve the retention goals within each landscape unit. Marbled murrelets are mobile and are likely to seek out suitable habitat within their commuting range of marine foraging areas (in practice within 30 km of the ocean). Prioritizing specific landscape units for marbled murrelets would take careful consideration that should be done on the basis of area of available habitat (giving some priority to landscape units with large areas of Class 1 &2) and also numbers of birds likely to use the landscape unit (based on radar count where possible and, if no radar data, some assessment of at-sea distribution).
Mountain goat	Identify priority landscape units based on the 'relative risk' of each unit in the sub-region. This is determined by the sum of the following: - relative proportion of suitable (MC and NC) or Goat_1 (SC) habitat in the landscape unit compared to the total amount of Goat_1 habitat in the sub-region;

Focal species	Considerations for priority-setting
	- relative proportion of suitable/Goat_1 habitat occurring in the LU that is not protected; and - the relative proportion of suitable/Goat_1 habitat that is not in the THLB (under the assumption that habitat in the THLB is more immediately vulnerable to loss through forest development than habitat in the non-THLB). See section 7.4.2 for a list of priority landscape units in the Mid and South Coast sub-regions. In addition, all winter ranges with known occupancy should be captured in OGRAs.
Northern goshawk	Both the amount/proportion of suitable goshawk habitat overall and the amount in OGRAs vary considerably among landscape units. Detailed analysis of the amount and distribution of habitats is needed before priorities can be identified. One approach to priority setting is to increase the amount of goshawk habitat protection via OGRAs in some landscape units and decrease it in others (to ensure some winners and losers versus every landscape unit getting a little). Under this approach priority would be given to landscape units with relatively high proportions of suitable and capable habitat (> 200 ha for nesting habitat and > 3900 ha for a territory (see section 9.4.2)). Note that this is only a rule of thumb; there needs to be consideration for shape, configuration and proximity relationships among foraging habitat amounts and nest area habitat. Some landscape units have significant second growth that will be recruited as suitable habitat within a relatively short time period (i.e. capable habitat). Ideally, co-location should plan for the long-term and should consider habitat capability, not just current suitability.
Tailed frog	Tailed frog populations exhibit clumpy distributions at various scales; but not enough information is available to prioritize one landscape unit over another based on habitat characteristics. There is also not enough inventory data at this time to identify priority landscape units for tailed frogs based on abundance. Each landscape unit will need to be assessed on an individual basis.

Ministry of Environment, Cariboo Region, is implementing a ‘specific area’ approach to designation of habitat areas in the Mid Coast to implement Section 9 of the Government Actions Regulation (GAR). Under this approach, ‘tiers’ of habitats are identified for each species that indicate the priority habitats for designation:

Tier 1 - high value habitats that have had the highest level of verification (i.e., high model rigour, field truthing)

Tier 2 -- high value habitats which have had lesser levels of verification (i.e., air photo interpretation and/or aerial survey instead of ground truthing; less confidence in model outputs)

Tier 3 -- lower value habitats

Some domain experts suggested use of the ‘specified area’ approach for implementation throughout the EBM planning area as a way to establish priorities for habitats within landscape units.

10.3 Prioritizing focal species

The legal orders do not set priorities among the identified focal species. Objective 14(7) of the Central & North and South-Central Coastal Orders suggests that all values are to be considered equally, including human values e.g., First Nations’ access to cedar.

Domain experts do not recommend setting priorities among focal species during the co-location exercises. Instead, as noted above, they recommend:

1. Co-locating high value habitats for multiple species to the extent possible; and
2. Identifying priorities for habitat capture within individual landscape units as part of landscape unit design (see section 10.2), with the input of domain experts, as necessary, and guided by the considerations in the focal species’ reports.

10.4 Assessing co-location outcomes for multiple species

The approach to the assessment of co-location outcomes varies depending on the focal species, the type of habitat, and other conservation factors, such as spatial configuration of OGRAs and habitat distribution. There is no one approach for all focal species. For example, the goal for marbled murrelets is to capture as much high value old growth habitat as possible (100% of Class 1 and 2); for northern goshawks, the priority is to retain known nest areas and a proportion of modelled nesting and foraging habitats while most foraging habitat will need to be addressed more broadly by the distribution of mature and old forest across the landbase.

Depending on the species, co-location outcomes may be assessed by the absolute amount of habitat retained within established OGRAs or the relative (%) amount retained or both.

The reliability of information should be factored into assessing the effectiveness of draft OGRAs for habitat protection. Where information is more reliable, the certainty about habitats and their conservation within OGRAs may be greater than where information is more uncertain. This will vary from species to species (see section 11: Research and Inventory Priorities).

Another important consideration for some focal species is what is happening outside of reserves, in the working forest.

10.5 Other considerations

10.5.1 Other EBM objectives

Co-location should be undertaken in consideration of all constrained areas, to maximize benefit to focal species while minimizing economic impacts. Therefore, the full suite of EBM objectives needs to be considered to create an optimal co-location solution. For example, objectives for hydroriparian areas may provide opportunities for additional habitat gains e.g., the requirements for recruitment of functional riparian forest within the reserve zone (S9(3)). A coarse riparian reserve layer was included in MARXAN but additional aquatic habitats will be mapped on a more site-specific basis. Other EBM-related strategies include targets for seral stage distribution and within-stand retention and the suite of objectives for aquatic habitats, including objectives for high value fish habitats and upland streams.

10.5.2 Factoring the THLB and NTHLB

Selecting OGRAs in MARXAN to minimize cost to timber supply can impact the effectiveness of co-located solutions. For example, pushing OGRAs to higher elevation habitats reduces opportunities to address lowland – upland connectivity for deer. Also, a full distribution of high value habitats may not be captured because the solution preferentially selects habitats in the non-contributing landbase. For example, for the Northern Goshawk nestingodel, the cost layer forces selection of habitat on steeper or higher elevation areas that may be poorer habitat quality than equivalent model predictions on gentle slopes at lower elevations

The following are guidelines for dealing with the THLB and NTHLB during strategic co-location:

- Both the spatial and tabular outcomes of the MARXAN runs need to be assessed to ensure an optimal spatial distribution as well as sufficient habitat. Where applicable, targets for MARXAN scenarios can be stratified to ensure representativeness across the landbase, e.g., by BEC.

- Apply formal designations to habitats to be reserved in the NTHLB to safeguard against future accessibility to development.
- The NTHLB should not be considered part of the 'reserve layer' in MARXAN. It has not been included as a reserve layer in the previous co-location scenarios. Also, when assessing the co-location outcomes, do not assume that habitats in the NTHLB are de facto protected as harvesting does occur in areas outside of the defined THLB.

Domain experts recommend running a low risk MARXAN scenario without the cost layer to project the possible OGRA layer without timber values influencing the solution. This scenario would provide a better understanding of the implications of the cost layer. It would also provide an additional layer for comparison to other scenarios (Low Risk with the cost layer applied, Best Habitats, Co-located LUO) during landscape unit design.

10.5.3 Habitat recruitment

Objective 9(3) of the Central & North and South-Central Coastal Orders (objectives for high value fish habitat) requires functional riparian forest to be recruited where harvesting or alteration has occurred in the reserve zone (to be dealt with during detailed strategic planning). In addition, Objective 14(3) requires recruitment of second growth where there is less than the default old forest to meet targets for old growth retention.

Table 23 summarizes considerations for recruitment of habitats where there is a shortfall of old forest. During the co-location experiments, MARXAN picked up recruitment forest based on 'oldest first' approach, which may not result in the specific attributes of capable habitats for individual focal species.

Table 23. Strategies for recruitment of habitats in old growth retention areas

Species	Recruitment strategy
Black bear	Recruitment of trees to provide future den cavities may be required in heavily modified landscapes e.g., the South Coast
Coastal black-tailed deer	For recruitment of habitat for deer, it is recommended that managers consider including managed (spaced) stands where they provide increased levels of desirable habitat variability. Compare habitat capability to current suitability; it may be preferable to select younger stands that will provide better habitat in the future, regardless of current stand age. Managed forests may, in some cases, begin to take on suitable characteristics of adequate winter range in low snowpack areas at 80 years, primarily with respect to snow interception and thermal cover. However, it is unlikely that forests of this age will

Species	Recruitment strategy
	provide adequate forage unless silvicultural techniques are applied to open up stands and encourage understory growth. Silvicultural techniques may also be necessary to enhance the development of wider, stronger crowns to provide better snow interception capabilities in the canopy (Nyberg and Janz 1990).
Grizzly bear	If targets for old and mature forest cannot be achieved, place a priority on recruitment from submesic sites to zonal berry-producing sites because most wetter and drier sites will already have gaps and associated understory food plants. In highly disturbed and fragmented landscapes (e.g., from logging), recruit with a distribution of habitats in mind (i.e., do not clump all future habitats in one area). This is important to provide habitat for more security conscious females as well as males who typically exploit the best habitats in the absence of concentrated human use. In areas where old growth targets cannot be met and recruitment is proposed, the rate of habitat restoration can be accelerated through a variety of silvicultural interventions, including pre-commercial and commercial thinning and pruning. The objective is to create canopy gaps and enhance productive understories in existing canopy gaps. These restoration activities will only work in some site series where understory potential is relatively high and debris loading low (see MoF 2001).
Marbled murrelet	At a strategic scale, the priority is to capture existing high quality habitat. Where existing suitable habitat exists, it should not be traded-off against recruitment of capable habitat that may provide suitable habitat in the future. However, where there is an issue with representation and distribution of habitats at a landscape scale, the recruitment of capable habitat might be considered during the landscape design phase, but only after options for capture of suitable habitats are met.
Mountain goat	Recruit from oldest forest first in areas that provide juxtaposition to geological formations that provide suitable escape terrain.
Northern goshawk	Suitable nesting and foraging habitat may occur in second growth stands as young as 60 years, so long as the stand is tall enough and has thinned enough to provide subcanopy flyways and tree branches are large enough to support nests. Generally, suitability will continue to improve as the stand ages through mature and old growth stages. Priority ecosystems for recruitment of old forest within reserves is on mesic-subhydric sites dominated by Western hemlock, Douglas-fir, or Sitka spruce. Second-growth forests that have moderate and high goshawk capability (medium-high site index) can be encouraged to provide good foraging and nesting opportunities by thinning that reduces the density of dominant trees and promotes an open understory

Species	Recruitment strategy
	for flyways (Doyle 2006b). Pruning lifts may also assist to accelerate younger second-growth forests to develop habitat attributes suitable for goshawk nesting and foraging.
Tailed frog	Recruitment efforts should focus on • drier, more vulnerable ecosystems by BEC unit; and • areas of less competent rock, where channels are more susceptible to sedimentation. Bedrock geology is not included in the existing habitat model because bedrock data is too coarse for use in modelling, but this information could be assessed at a more detailed level.

One of the issues associated with habitat recruitment is that, to date, inputs to co-location exercises in MARXAN have used habitat suitability (i.e., the present quality of habitat), rather than habitat capability (i.e., the quality of potential habitat when vegetation is at its optimum seral stage for that particular species). In the rules for the MARXAN tool, habitat inputs are based on current suitability (time-limited) but timber values are based on vegetation capability over a 400 year time period. The result is that solutions may be pushed out of future potential habitats because (a) they are not identified as high value (due to not being currently suitable and (b) they are noted as high timber value over all projected time periods and are, therefore, part of the cost layer throughout. This issue is especially significant for species that can use maturing second growth forest, such as northern goshawks and black-tailed deer. Often these areas are excluded from MARXAN solutions because of the high timber cost associated with them. For other species, like marbled murrelets, key habitat elements (e.g. large mossy branches for murrelets) take such a long time to develop that incorporating recruitment strategies is impractical.

Domain experts recommend that, where there is a shortfall of old growth, the highest capability lands be spatially identified to support focal species. This can be considered at the LU design phase. Given constraints on amount of habitat able to be included in reserves, for some of the focal species, this could result in a better solution compared to co-location based only on current suitability. Additionally, some attributes of old forest retention may be promoted for individual species (i.e., using silvicultural treatments) as second growth stands mature.

11.0 Research and Inventory Priorities

Domain experts were asked to identify their priorities for research and inventory for their species. Table 24 summarizes these priorities, which can be used to guide decisions on future adaptive management projects. All future research questions need to be cognizant of the potential that climate change is continually changing the environment in which these species live.

Table 24. Priorities for research and inventory related to focal species

Species	Research Priorities	Inventory Priorities
Black bear	• How well do EBM objectives contribute to habitat needs of black bear at the stand and landscape scale? • What are the critical habitat elements for black bears? What happens if they are lost? • What are the limiting habitat elements for black bears? What happens if they are lost? • How does the distribution of harvesting affect black bears (e.g., spatial configuration of openings and security cover, amount of area harvested, etc.)? • What are the implications of not managing for lower class habitats to subdominant black bears and females with cubs? Typically higher quality (Class 1 and 2) grizzly bear habitats are the focus of conservation efforts and these may not be as suitable for all black bears in areas where the two species overlap. • Female black bears with cubs may choose to use lower quality habitats for security reasons – are the bears	• A better overall inventory of black bears is needed in B.C. • Monitoring at viewing sites should be conducted to detect if there is a decrease in the number of bears at a site or a shift in the age or sex classes of bears using a viewing site. • The Kermode Bear Scientific Panel (2007) recommends the following to better understand the distribution of Kermode bears and trends over time: - Systematic DNA sampling to more precisely estimate the frequency of the white-phase gene and ascertain whether this frequency is changing over time. - Monitoring of Kermode bear populations on Princess Royal Island, Gribbell, Roderick, and Pooley islands (the 4 main “Kermode islands”) using indices. - Monitoring the number of Kermode and black bears, as well as grizzly bears, in the Green River (index of numbers and frequencies as opposed to a total count). The Green River has been an area of contention re

Species	Research Priorities	Inventory Priorities
	therefore more vulnerable if that habitat is lost? • What is the home range size, habitat selection and behaviour of black bears in unharvested areas where there is overlap with grizzly bears? Many wildlife studies focus on single species; but it would be useful to know what black bears are doing around grizzly bears. • What are the effects on forage quality, quantity and diversity following second growth harvesting? • What is the impact for black bears of a reduction in salmon returns? Will it increase predation of black bears by grizzly bears, or increase cannibalism amongst black bears? • What is the impact of forest harvesting on the strength of the *kermodei* genotype, especially on smaller near-shore islands? • What are the impacts of bear viewing on black bear behaviour?	harvesting and effects on Kermode populations.
Coastal black-tailed deer	• How much habitat is enough? The current guidelines are only for deer and are based on rough estimates of deer densities during winter in DWRs vs. across the landscape. They have not been tested on the ground. This is a significant unknown that would require new research in all three sub-regions. • What are the differences in habitat quality and use by	• Ongoing inventory is required to monitor responses to habitat changes. This is both a gap and a priority. • Update GIS-derived habitat maps and ground truth for errors.

Species	Research Priorities	Inventory Priorities
	deer in the hypermaritime compared to the submaritime and maritime? What kind of management is needed to maintain habitat conditions in the hypermaritime? What areas should and should not be harvested? • More research is needed about how to manage for ungulate winter range under a variety of habitat conditions e.g., what is the difference in habitat conditions and management approaches for Vancouver Island and the Mid Coast? This includes research into how deer use low-volume stands. • Effectiveness monitoring is needed to track how well management approaches are working. Researchers in Alaska are developing a tool to estimate deer populations using DNA extracted from pellets. The project has been very successful and should be an excellent tool for monitoring (D. Person, pers. comm.). • Research is needed to define the connectivity requirements of deer in coastal forests e.g., with respect to width and composition of corridors to maintain movement between habitats while minimizing risk of predation. The impedence of deer movement e.g., by roads or dense second growth, is also poorly understood.	
Grizzly bear	1. Undertake finer scale research to fill knowledge gaps re local ecology of grizzly bears. For example, further work is needed regarding the suitability and effectiveness of	A comprehensive population monitoring program for coastal grizzly bears is a high priority for the Ministry of Environment. • Extend work in the South Coast ranges using non-invasive

Species	Research Priorities	Inventory Priorities
	habitats in highly altered landscapes, particularly regarding security for adult females with cubs. 2. Effect on food quality, quantity and diversity following second growth harvesting. 3. Impacts of bear viewing on grizzly bears. 4. Predictive studies to estimate and assess the effects of climate change, including the risks and uncertainties associated with food quality, quantity and diversity.	hair snagging techniques for population sampling to assess and monitor the distribution and abundance of the existing populations as well as connectivity between populations. Systematic sampling is needed over very large areas. • Establish permanent vegetation monitoring plots in association with a variety of restorative silviculture activities designed to mitigate longer term impacts of forestry-related activities on grizzly bear habitats.
Marbled murrelet	Arcese et al (2008) have designed an adaptive monitoring program to test hypotheses associated with the effect of timber harvesting on populations of marbled murrelets using radar surveys. This program has been endorsed by the CMMRT and could be applied in the coastal planning area. The program recommends experimental areas to be intensively managed and monitored. Suitable watersheds have been identified through simulation modelling using SELES (Spatially Explicit Landscape Events Simulator) (Contact: P. Arcese, University of B.C.). • What is the link between perceived quality of nesting habitat (from algorithms, air photo interpretation or low-level aerial surveys) and density of marbled murrelets? (Currently a research project at Simon Fraser University [Dr. David Lank] is investigating this) • What is the link between perceived quality of nesting	Undertake ongoing inventories of the number and distribution of marbled murrelets on land and at sea. The Canadian Wildlife Service (CWS) has a multi-year program underway to monitor marbled murrelets in coastal watersheds using radar surveys. The data from this program is an important component of long-term monitoring of murrelets on the Coast (Contact: D. Bertram).

Species	Research Priorities	Inventory Priorities
	habitat and nesting success? • What is the link between the quality of terrestrial habitat and the quality of marine foraging habitat re marbled murrelet use? • What factors limit marbled murrelet populations (nesting habitat limits carrying capacity, marine conditions affect recruitment)? • What factors contribute to the quality of marbled murrelet habitat e.g., lower elevation, steep slope vs valley bottom? There are currently different views in the literature. • What is the effect of commuting distance on likelihood of nesting successfully in suitable habitat (e.g., effects of long inlets and use of habitat >30 km inland)? • At what age do second-growth stands begin to provide platforms and other attributes necessary for nesting, and how are these trends affected by regional, topographic & biogeoclimatic factors? • What drives the spatial distribution of murrelet nests – are they territorial or do they use some other social spacing mechanism? • What is the influence of forest edge and type of edge (hard vs. soft vs. natural) on habitat quality? • Impact of developments other than timber harvesting e.g.	

Species	Research Priorities	Inventory Priorities
	independent power projects. • How will murrelets in B.C. respond to global climate change?	
Mountain goat	• In general, winter habitat is well described for the coastal mountain goat ecotype. What is needed is research that is more experimental and manipulative in design, with more experimental observations, (e.g., using collared animals), to see what happens when the habitat is altered. Considerable uncertainties exist, both in the estimates of habitats that mountain goats use and the effect of removing mountain goat habitat on the localized or larger populations. This is something that needs to be evaluated in relatively strict adaptive management trials. The long-term impacts of forest canopy removal are of particular concern in relation to population viability and habitat selection. • What are the implications of loss of forested winter range at low elevations to mountain goat survival? Due to timber impact policies, legal UWRs tend to under-represent habitats in the contributing forest which may have a high importance to mountain goat survival. • More information is needed about the effects of helicopter activity on mountain goat behaviour, habitat selection and rates of movement. • What are the effects and the implications of potential	• There are large information gaps on the Coast. The entire coastal planning area has been mapped for habitat suitability but this information is not suitable for population analysis. What is needed is an inventory program to measure vital rates (primarily productivity, recruitment and mortality). This should be continued on a regular frequency at a sub-regional level to monitor population trends and direct research gaps. A structured program would significantly add to our understanding for the species. • The mountain goat harvest is currently assessed at the MU scale through monitoring of legal harvest and local inventories with sightability correction. There has been no comprehensive inventory of mountain goats on the Coast. With the current level of inventory, the probability of detecting localized loss of goats is low and local goat censuses are needed. However, the priority is to monitor population trends and vital rates.

Species	Research Priorities	Inventory Priorities
	climate change-related shifts? • Spatial patterns of road development and risk to mountain goats. What are the effects of different road densities within varying distances from escape terrain? • How do changes in land-use (including road building) affect predator-prey relationships?	
Northern goshawk	All future research questions need to be cognisant of the potential that climate change is continually changing the environment in which the birds live, such that the relationship between habitat-prey-nesting may not remain static. The following information gaps are identified as priorities for research: • The relationship between nesting and foraging habitat attributes and population parameters such as productivity and survival. • Habitat thresholds at the territory level e.g., thresholds of % foraging habitat in different landscape types that are required to maintain long-term occupancy and successful reproduction by goshawk pairs. • Spatial configuration of nesting and foraging habitat necessary to support successful territories. Further information is needed about the spacing pattern of territories on the north and south coast of B.C. • Winter habitat use/prey selection by goshawks. This	Very little goshawk inventory work has occurred throughout coastal BC. Two years of standardized inventory work occurred out of Bella Coola in 2007-2008 which resulted in the discovery of seven nest areas. Although more inventories would be ideal to examine some research questions (i.e., territory spacing patterns) above, it is impractical to complete a census of the entire BC coast for goshawk nest areas/PFAs. Therefore, domain experts recommend a move away from requiring known goshawk nest areas to create reserves and use our best available methods to identify and protect areas with high nesting and foraging habitat suitability.and protect areas with high nesting and foraging habitat suitability.

Species	Research Priorities	Inventory Priorities
	information is necessary to create annual habitat management plans for this species.	
Tailed frog	• Habitat association studies (Dupuis and Friele 2003; Frid et al 2003) show significant drop in occurrence rates (20 - 60%) in logged versus unlogged streams, and in remaining occupied streams, a significant drop (40%) in abundance. Major unknowns are: o How quickly do subpopulations with reduced abundance bounce back? o How quickly are local extirpations re-colonised? o How does local extirpation affect population viability and meta-population dynamics? o What are minimum landscape level thresholds for population collapse? • What is the optimal spatial configuration of conservation areas for *A. truei* e.g., ribbons vs. basins. • What is the effect of climate change on *A. truei?* o Is changing climate additively increasing the risk of loss of subpopulations in managed watersheds? o Monitoring temperature and flow regimes in small basins (moderately steep and very steep) could shed light on breeding success in relation to weather (climate).	There are numerous gaps in the existing inventory. Although extensive (i.e., wide ranging) sampling has been conducted throughout the coast, the density of samples is low. Continued inventory and monitoring is required to adequately assess population trends. Rather than routine reconnaissance surveys of tailed frog presence, undertake intensive surveys that are designed to inform responses to land uses (e.g., how timber harvesting impacts the ability of tailed frogs to move across the landscape; how tailed frogs respond to microclimate changes as a result of forest cover removal) and climate change. Examples include • stratified random sampling of geomorphically different landscapes. • paired basin studies of cohort-specific survival rates under different conditions of temperature and channel stability. A priority project is a radio-telemetry study of movement and/or inter- and intra-population genetics. More inventory and demographics work is needed with regard to presence and distribution on coastal islands and eastern range limits. Inventory of temperature sensitive streams. There are different types of temperature-sensitive stream: streams that might

Species	Research Priorities	Inventory Priorities
	• *A. truei* do not extend into lowland environments such as the Hecate Lowland. There is a need to better define the limiting conditions in lowland streams (water chemistry, flashiness, seasonality). For example, the tannic waters in lowland coastal streams may be more acid. • Additional research should focus on more thorough studies of home range movements and large-scale dispersal using radio telemetry, and/or on inter- and intra-population genetics. • Landscape-level modeling studies of tailed frog habitat associations could continue to refine our knowledge of this species' management needs, especially if there is some focus on forest variables (e.g., patch size, frequency and distribution).	become too warm with land use or climate change; those that are too cold but might become suitable; and those that are too cold.

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Appendix 1. List of peer reviewers of focal species project reports

The following people recommended co-location methods for each focal species and provided peer review comments to the focal species chapters (Parts 2 – 5 of the EBM Working Group Focal Species Project series) that informed the recommendations this document. Peer review comments and responses will be summarized in Part 6 of the report series.

Name	Affiliation	Species expertise
Alvin Cober	Ministry of Environment	Black bear
Wayne McCrory	McCrory Wildlife Services Ltd.	Black bear
Scott McNay	Wildlife Infometrics	Coastal black-tailed deer
Dave Person	Alaska Dept of Fish and Game	Coastal black-tailed deer
Clayton Apps	Aspen Wildlife Research	Grizzly bear
Rod Flynn	Alaska Dept of Fish and Game	Grizzly bear
Debra Wellwood	Raven Ecological Services	Grizzly bear
Anne Harfenist	Private consultant	Marbled murrelet
Kim Nelson	University of Oregon	Marbled murrelet
Wayne Wall	International Forest Products	Marbled murrelet
Doug Janz	Private consultant	Mountain goat
Troy Larden	Ministry of Environment	Mountain goat
Wayne Wall	International Forest Products	Mountain goat
Steve Brockman	US Fish and Wildlife Service	Northern goshawk
John Deal	Western Forest Products	Northern goshawk
Richard Reynolds	Rocky Mountain Research Station	Northern goshawk
Linda Dupuis	Private consultant	Tailed frog