EBM Working Group Focal Species Project

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

Prepared for
Ecosystem-Based Management Working Group

By

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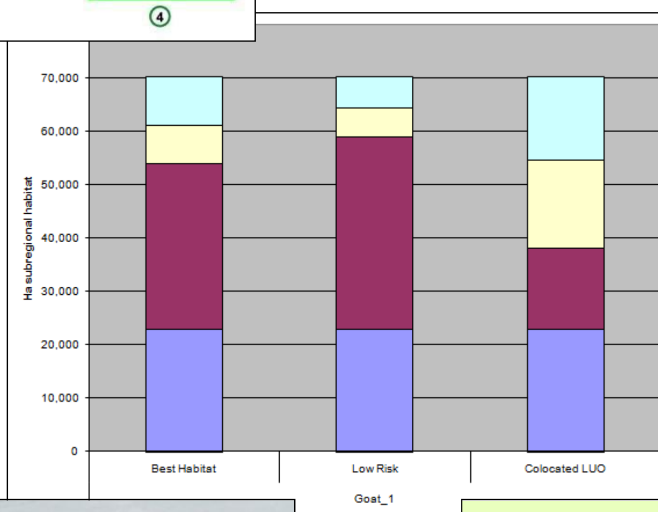
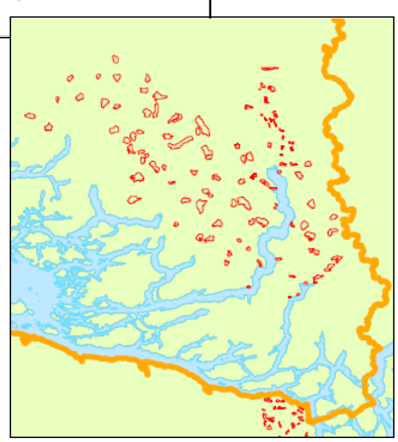
$$\overbrace{\sum_{PUs} Cost}^{1} + \underbrace{BLM \sum_{PUs} Boundary}_{3} + \overbrace{\sum_{ConValue} SPF \times Penalty}^{2} + \underbrace{CostThresholdPenalty(t)}_{4}$$





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Disclaimer

This report was commissioned by the Ecosystem-Based Management Working Group (EBM WG) to provide information to support full implementation of EBM. The conclusions and recommendations in this report are exclusively the authors', and may not reflect the values and opinions of EBM WG members.

Executive Summary

Co-location of habitats for focal species is an integral component of EBM implementation, requiring that habitats for these and other species be located ‘to the extent practicable’ within areas set aside to meet old growth representation targets under the Central & North and South Central Coastal Orders. This document summarizes methods developed by domain experts to strategically co-locate habitats for focal species within old growth retention areas. These methods have been developed to direct the preliminary design of landscape units using MARXAN conservation software and to provide guidance for more detailed ‘hands-on’ design as prelude to consultative planning.

This document addresses the following issues:

- Targets for habitat retention, including ‘Low Risk’, ‘Best Habitats’, and ‘Upper Limit of Change’;
- Spatial configuration and distribution of old growth retention areas;
- Connectivity;
- Habitat recruitment; and
- Promoting resilience to climate change.

These methods are based on current knowledge of the habitat requirements of focal species and have been refined through experimentation using MARXAN. The methods proposed here may change over time through further review of MARXAN results and as more information becomes available about each focal species.

Cover photo of mountain goat: Brad Pollard

Table of Contents

1.0 Introduction

1.1 Context to the EI02c Focal Species Project

The EI02c Focal and Fine Filter Species Analysis to Inform Full Implementation of Ecosystem-based Management ('Focal Species Project') was initiated to assess the implications of various land use scenarios on habitat supply for focal and fine filter species at the sub-regional and landscape unit scales.

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. With regard to Ecological Integrity, full implementation of EBM is defined in Government-to-Government (G2G) Agreements between First Nations and the Province of B.C. as:

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

a) Strategic land use zones (conservancies, biodiversity etc) and, as appropriate, related management plans

b) Landscape reserves (First Nations cultural areas, old growth management areas, ungulate winter range, and general wildlife measures); and

c) *Land use objectives (cultural, biodiversity, hydroriparian, wildlife, etc.)"*

Ecosystem-Based Management Planning Handbook

The EBM Planning Handbook (CIT 2004) identifies the need to manage focal / fine filter species as a component of achieving full implementation of EBM but does not provide details as to how this should be achieved.

In the Handbook, the objective for focal species management at the sub-regional scale 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.

1.2 Project Implementation

A key component of the Focal Species Project was to inform strategic co-location of habitats for focal species within areas of old forest retention. The project was completed in three phases in close conjunction with the DS04 Co-Location Project to design a planning tool for strategic co-location 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).

<u>Phase 1: Preparation for strategic co-location scenarios</u>

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. This input was summarized in *Knowledge Base for Focal Species and their Habitats in Coastal B.C.* (Part 3 of the Focal Species Project report series) (Horn 2009a).

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. 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. These inputs informed scenario runs in Phase 3.

Phase 3: Synthesizing results

In Phase 3, domain experts reviewed a final set of scenarios that represented low risk, best habitats and co-located solutions. Scenarios were run for the Mid and South Coast sub-regions. They used this review to develop strategic recommendations for management of focal species within and outside of old growth retention areas under Ecosystem-Based Management. The review and recommendations are summarized in *Management recommendations for focal and fine filter species under Ecosystem-Based Management* (Part 1 of the Focal Species Project report series) (Horn and Rumsey 2009a).

1.3 Relationship to Other EBM Working Group Projects

1.3.1 Links to the DS04 Co-Location Project

The Focal Species Project is closely linked to the Co-location project (DS04), which was initiated to develop a spatially explicit conservation site selection algorithm, using MARXAN conservation planning software as well, as a spatial timber supply model (Rumsey 2009). The purpose of the DS04 work is to identify spatially efficient ways to locate old growth retention areas (OGRAs) that meet conservation objectives while attempting to minimize impacts to timber supply.

Figure 1 summarizes the relationship between the Focal Species and Co-Location Projects. In the Focal Species Project, domain experts used best available base information and ecological knowledge to recommend map inputs and scenarios to be tested using MARXAN. The outputs of MARXAN runs were evaluated by the domain experts and the feedback from this evaluation informed the next round of scenarios (Horn and Rumsey 2009b). The eventual outcome of this iterative effort is intended to provide an automated approach for strategically locating potential areas for old growth retention in a manner that meets conservation objectives while minimizing impacts to timber supply. The Focal Species Project also assessed how much habitat is not captured within OGRAs and made strategic recommendations for managing focal species habitats outside of reserves (Horn and Rumsey 2009a).

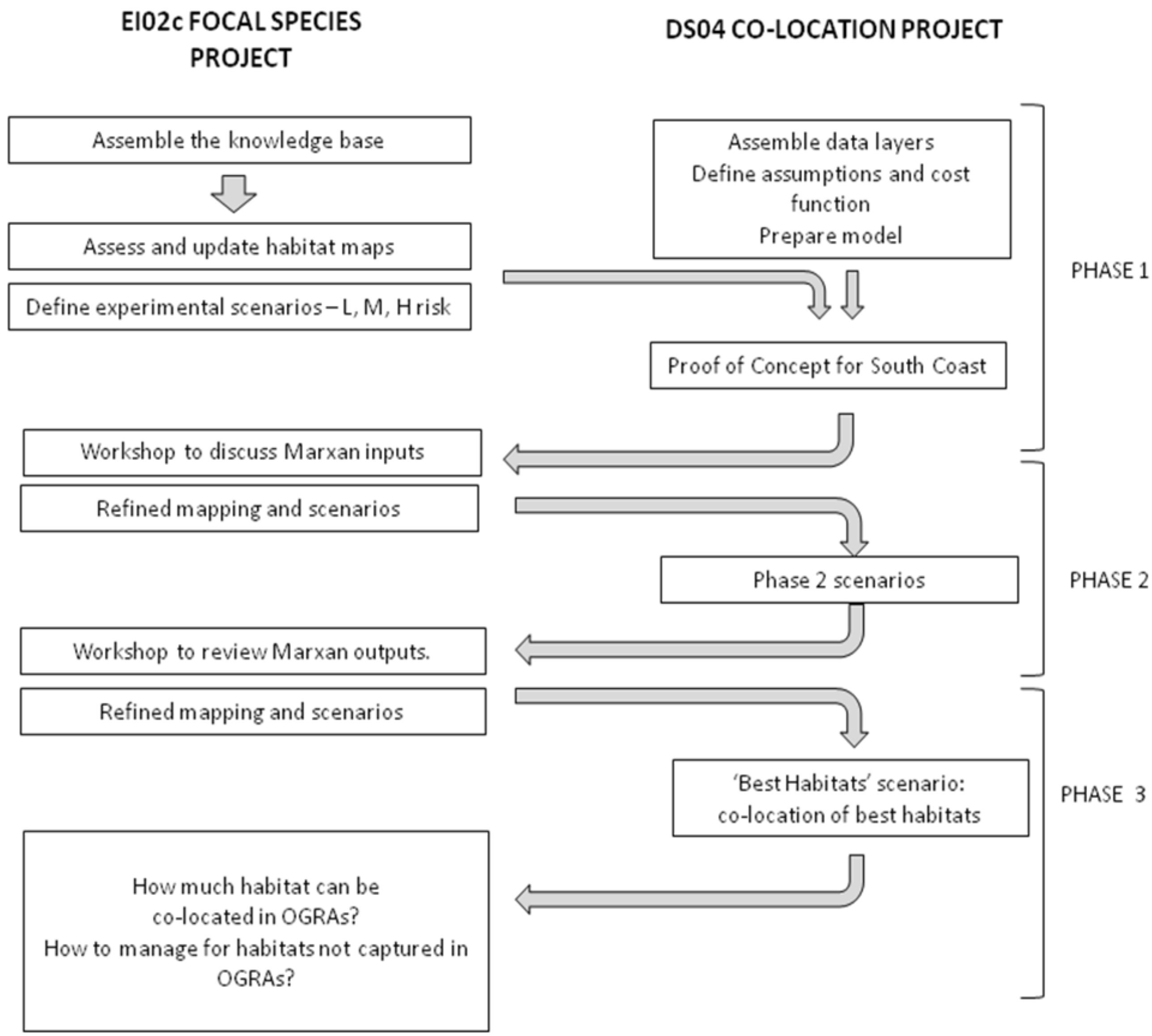

Figure 1. Relationship between the EI02c focal species and DS04 co-location projects

1.3.2 Links to the Landscape Level Reserve Project

A parallel Landscape Level Reserve Project compared the strategic DS04 MARXAN solutions to reserves designed by planners at the landscape scale using a more hands-on approach (Lewis and Kremsater 2009). The 'landscape unit design' process uses the output of scenarios based on different levels of habitat retention to guide the more detailed co-location of habitats within OGRAs.

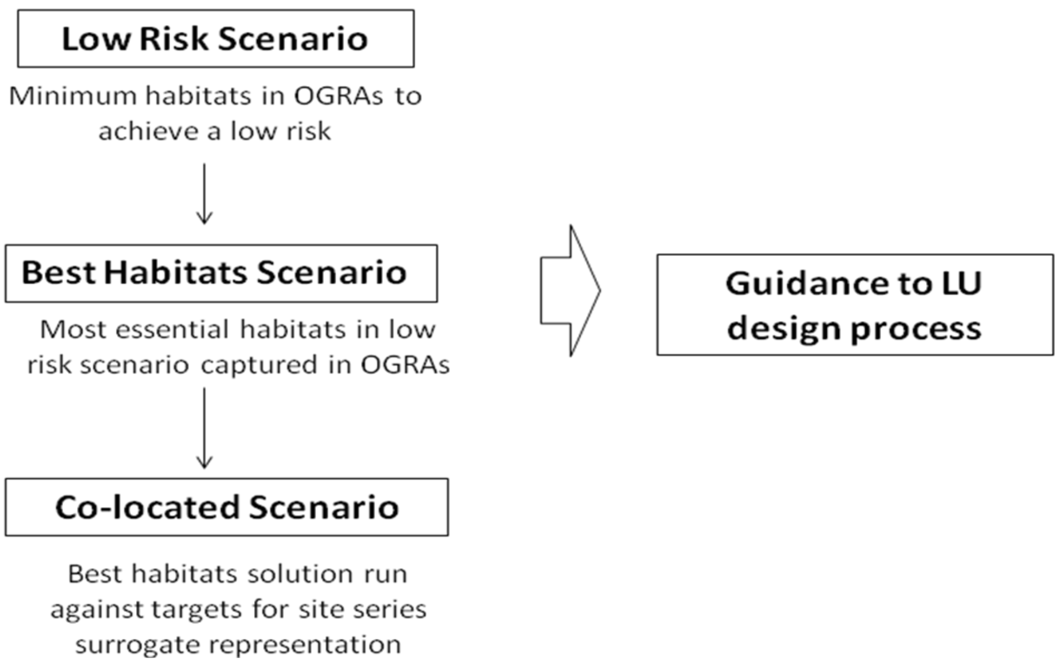

Figure 2. Link between the focal species, co-location and landscape level reserve projects and focal species project reports to be submitted in February and March. The March report will represent a convergence of the work of the strategic level (EI02c and DS04) and landscape level projects.

1.3.3 Input by 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
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
Glenn Sutherland	Cortex Consultants	Tailed frog
Steve Gordon	Integrated Land Management Bureau	Mountain goat
Brad Pollard	McElhanney Consulting Services	Mountain goat
Shawn Taylor	Goat Mountain Resources	Mountain goat

Additional expert input was provided by:

Clayton Apps	Aspen Wildlife Research Inc.	(grizzly bears)
Stephanie Hazlitt	University of British Columbia	(marbled murrelets)
Sally Leigh-Spencer	International Forest Products Ltd.	(ungulates)

1.4 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.

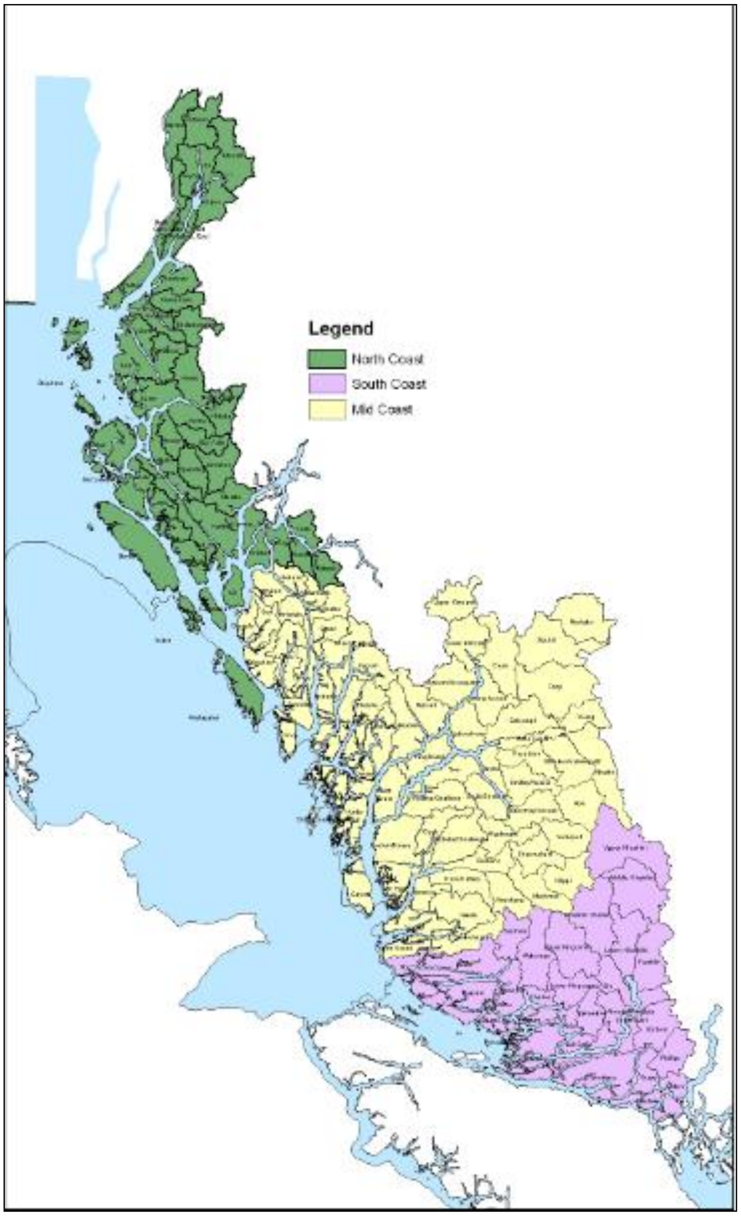

Figure 2. Sub-regions for coastal planning under EBM

1.5 Document Purpose

This report describes the method recommended by domain experts to strategically co-locate focal species habitats within old growth retention areas, including data inputs. It is a companion document to *Part 1: Management recommendations for focal and fine filter species under Ecosystem-Based Management*. The document is intended to inform future co-location efforts and to guide the application of strategic co-location outputs during detailed landscape unit design.

This report is Part 2 of six reports prepared as part of the EBM Working Focal Species Project. The suite of reports includes:

Part 1: Management recommendations for focal and fine filter species under Ecosystem-Based Management

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

Focal species reports developed with the input of domain experts underwent peer review in February 2009 (See Appendix 1 for a list of peer viewers). The content of the peer reviewed reports, which is compiled in the *Focal Species Project Interim Report,* has been used to create four separate reports for the EBM Working Group, including this report and Parts 3 – 5 above. A summary of peer review comments and responses is provided in Part 6.

2.0 Targets for Habitat Retention

2.1 Inputs to MARXAN conservation planning software

The goal for strategic OGRA design is to co-locate as many of the key habitats for focal species as possible within the targets for old forest retention specified in the Coastal Orders. As a first step in this process, domain experts were asked to define the risk to their species of different levels of old growth retention within reserves. A formal risk assessment process was not undertaken, however, focal species teams were able to define a population objective and recommend targets for habitat retention that reflect a low risk to achieving the population objective.

A review of MARXAN outputs during Phase 2 of the project indicated that a more optimal solution is achieved for all focal species where high value habitats are used as inputs to MARXAN and targets for habitat drive the solution rather than randomly picking up tjese habitats during the capture of old growth to meet site series retention targets (Horn and Rumsey 2009b).

Sections 2.2.1 to 2.2.7 summarize the targets for habitat retention applied during Phase 3 of the Focal Species Project. In developing these targets for old growth retention, domain experts explicitly acknowledge the assumptions used as well as uncertainties and limitations associated with the data inputs and the current level of knowledge about each species (see Horn and Rumsey 2009a). The targets shown in the tables below will continue to be refined over time with experimentation and as new information comes forward about each species, its habitat requirements, and the relationship between habitat and populations. Appendix 2 provides a listing of the most up-to-date habitat mapping layers to support co-location as of March 2009.

2.1.1 Defining the low risk scenario

With regard to Ecological Integrity, full implementation of EBM is defined in Government-to-Government Agreements between First Nations and the Province as,

> *Conservation measures…that seek to achieve a **low level of ecological risk overall**…over time, including:*
>
> *d) Strategic land use zones (conservancies, biodiversity etc) and, as appropriate, related management plans*
>
> *e) Landscape reserves (First Nations cultural areas, old growth management areas, ungulate winter range, and general wildlife measures); and*
>
> f) *Land use objectives (cultural, biodiversity, hydroriparian, wildlife, etc.)*

Domain experts were asked to define a low risk management scenario for each focal species. Targets for Low Risk shown in Table 1 below are based on expert opinion, supported by domain expert knowledge of the literature and observations in the field.

2.1.2 Defining an upper limit of change

Domain experts were also asked to define an upper limit of change. With the exception of goats and deer, domain experts were unable to come up with an absolute target to approximate a high risk but they did note an upper limit of change for the purposes of the co-location exercise. In general, domain experts state that the risk to the species increases, the more that habitats are lost or altered, particularly where these habitats are of high quality.

2.1.3 Defining Best Habitats

Initial MARXAN solutions have already shown that not all low risk targets for focal species will be able to be captured within targets for retention of site series surrogates (SSS) as specified in the legal orders. Domain experts have developed a stepwise `Best Habitats` approach to strategically co-locating habitats using MARXAN conservation planning software. In this approach, sequential scenarios are run in MARXAN that increasingly focus the solution on capturing the most important habitats for each species (Table 1).

When defining Best Habitats, domain experts also noted habitats that should be locked into the final OGRA solution. These include high value habitats with confirmed occupancy as well as wildlife habitat areas that have not yet received formal designation under FRPA, but that have been field verified and discussed with stakeholders.

2.1.4 Opportunities for co-location

The benefit of using MARXAN to strategically co-locate habitats is that the tool looks for opportunities to overlap high value habitats for different species, thereby reducing the overall area required to meet the habitat objectives and reducing the economic cost to the working landbase. The results of the co-location experiments do indicate that, for all species, a better solution is achieved through co-location because habitats for one species are picked up incidentally when meeting targets for other species.

Further analysis is needed to determine that actual benefit in terms of impacts to timber supply and to assess which species co-locate more effectively. In general, because focal species were selected to represent a range of habitats, the amount of overlap between individual groups of species is not high; rather there is a general overlap across species that is to be expected with species that require large areas of habitat and/or are wide-ranging.

2.2 Summary of habitat retention targets by focal species

2.2.1 Black bear

As there was no mapping of black bear habitats to support the analysis, there are no specific targets for habitat retention for the species.

Table 1. Summary of recommended habitat retention targets for black bears.

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best habitats	Habitats locked into final reserve layer	Upper limit of change
Black bear	Sub-regional habitat mapping not available at this time	No mapping available at this time	-	Targets for habitat retention to be determined once habitat mapping is available. Guidelines for capture of black bear habitats includes: • Capture black bear habitats outside of grizzly-occupied areas (e.g., in hypermaritime areas). Determine targets for habitat capture once mapping has been completed. • In areas where there is overlap with grizzly bears, capture a range of habitat values in the CWHvm and CWHwm. • Locate OGRAs to capture stands with high potential to provide den structures. This will augment within-stand retention and help to ensure a supply of denning habitat across landscapes.	Not defined at this time	Not defined at this time	-

2.2.2 Coastal black-tailed deer

2.2.2.1 Existing management designations and objectives

GAR Order Ungulate Winter Ranges

Ungulate Winter Ranges (UWRs) have been legally established for the Mid and South Coast under the Government Actions Regulations.

South Coast: There are relatively few deer winter ranges currently designated on the South Coast. The B.C. Ministry of Environment (MOE) has put more effort into designating mountain goat habitats. General Wildlife Measures state that harvesting is not permitted within the UWR except where this will enhance the quality of the winter range.

Mid Coast: General wildlife measures associated with designated deer winter ranges require 20 – 25% retention of winter range, with limits on patch size and distance between patches. Mid Coast UWR polygons do not include the hypermaritime.

North Coast: There are no UWRs proposed for the North Coast. Deer are not thought to be at risk from forestry activities and are a low priority for habitat management. MOE Skeena Region has designated ungulate winter ranges for moose and mountain goats.

2.2.2.2 Habitat definition

Modelled deer winter habitat suitability

Habitat cut-offs that define moderate and high value habitats for the purposes of co-location are shown in Appendix 3.

2.2.2.3 Targets for habitat retention

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

The risk targets outlined below reflect the risk of not achieving the stated objective. These targets are based on expert opinion and were not derived through a formal risk assessment.

a) Modelled winter habitat suitability

Recommended low risk target: 90% of the area of high value (H) habitat

This can be achieved by capturing a minimum of 70% of High (H) value habitat with the remainder made up of twice the area of Moderate (M) value habitat.

Rationale:

Twice as much M must be captured to be equivalent to H because it is assumed to support approximately half the density of deer supported by H.

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

b) Designated habitat areas

Approved UWRs form a legal requirement for consideration in the focal species co-location project and have been 'locked into' the MARXAN solution.

c) Upper limits of change

Domain experts have identified less than 60% of existing deer winter range within a landscape unit as a high risk scenario. (i.e., more than a 40% reduction in habitat area)

2.2.2.4 Rationale for targets:

This estimate of an upper limit of change is expert opinion based on the amount of the area currently 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 acceptable threshold of change to deer winter habitats may be higher.

2.2.2.5 Uncertainties and limitations

- Modeling 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.

- 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.

Table 2. Summary of recommended habitat retention targets for coastal black-tailed deer.

<table>
<tr><th>Focal species</th><th>Description of layers</th><th>Description of habitat for analysis</th><th>Analysis Unit</th><th>Low risk goal</th><th>Best Habitats</th><th>Habitats locked into final reserve layer</th><th>Upper limit of change</th></tr>
<tr><td rowspan="2">Coastal black-tailed deer

Objective:
Maintain existing populations and a distribution of deer that satisfies both ecological and social objectives.</td><td>Coast-wide habitat mapping (2008)</td><td>Habitat cut-offs vary between sub-regions and between coastal and mountain ecosections (Appendix 3).</td><td>LU</td><td>90% of the area of high value habitat (H). This target may be achieved with a mix of H and M habitats if a minimum 70% H is retained and 2x the M to make up to H equivalent area.</td><td>100% of H habitats captured in the Low Risk solution</td><td>-</td><td rowspan="2">≥ 40% reduction in existing deer winter range within a landscape unit is a high risk</td></tr>
<tr><td>Approved and proposed Ungulate Winter Ranges</td><td>UWR polygons</td><td></td><td>Approved UWRs in the South Coast are 100% retention
Approved UWRs in the Mid Coast have a target of 20 - 25% of age 141+ yr old stands.
There are no legal UWR for deer in the North Coast.</td><td>Approved and proposed UWRs, as per General Wildlife Measures</td><td>Approved and proposed UWRs, as per General Wildlife Measures</td></tr>
</table>

2.2.3 *Grizzly bear*

2.2.3.1 Assumptions

- Habitat ratings for fall habitats (e.g., salmon fishing areas) were not mapped in the South Central and Mid Coast on the assumption that these habitats are expected to be adequately addressed through EBM objectives for areas aquatic habitats (sections 8 – 13). All seasons were considered during the North Coast mapping.
- Due to the regular redefinition of THLB/ non-contributing areas, domain experts assume that all productive forested landbase outside of protected areas and other legal reserve is vulnerable to harvest.

2.2.3.2 Existing management designations and objectives

a. Coastal Land Use Orders

The Coastal Orders for the North and Central and South Central Coasts contain specific objectives to maintain grizzly bear habitat.

- Section 17 in the South Central Coast Order is to maintain 100% of grizzly bear habitats as 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.

b. Designated habitat areas

In the Mid Coast, WHA polygons for grizzly bears make up approximately 25% of the Mid-Coast Class 1 and 2 grizzly polygons. Management within Mid Coast grizzly bear WHAs is 100% retention.

2.2.3.3 Pre-analysis

- Stratify all habitat layers by landscape unit and BEC variant.
- Stratify Class 2 habitats by season.
- Evaluate the distribution of Class 1 and 2 habitats by landscape unit, BEC variant and season and determine the habitat types that are rare and those that are common.

- Testing of the assumption that fall habitats are adequately addressed through EBM objectives for management of aquatic habitats (sections 8 – 13).

2.2.3.4 Map inputs

Habitat suitability layer

Consolidated grizzly bear map layer that brings together the various products of habitat suitability mapping products for the coast (see section 3.3.1).

Designated habitat areas

Grizzly bear habitats identified in Schedule 2 of the Central & North and South Central Coastal Orders.

Existing WHAs in the Mid and South Coasts.

2.2.3.5 Habitat definition

Habitat polygon suitability for grizzly bears was rated according to the provincially accepted 6-class system (RIC 1999).

Class 1 and 2 habitats represent the highest value habitats for grizzly bears.

2.2.3.6 Targets for habitat retention

Population 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 given desired human use, able to maintain its organization and function over time, and resilient to stressors, including human impacts and stochastic environmental and demographic events.

The habitat retention targets below reflect the perceived risk of not achieving the stated population objective. These targets are based on expert opinion and were not derived through a formal risk assessment. Domain experts feel the recommended habitat retention target for EBM implementation 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.

a. Habitat suitability layer:

Lowest risk scenario: 100% of Class 1 and 100% of Class 2 habitats

Recommended target for EBM implementation: 100% of Class 1 and 50% of Class 2 habitats, 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:

1. 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.
2. 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.
3. Fall habitats that protect salmon spawning areas, near where bears fish, if these areas are not already protected by hydro-riparian management.

Summer habitats are more ubiquitous and are therefore a lower priority. Some summer habitats should also be captured, but emphasis should be on capturing the highest value summer habitats first (particularly those ecosystem units on alluvial fans and floodplains in CWH variants). Many other summer habitats are picked up through landscape level objectives for site series representation and seral stage distribution (section 16 of the Coastal Orders).

Focussing on undisturbed habitats at higher elevations (e.g., avalanche chutes) does not replace lost or altered habitat at lower elevations. Even though they have may have the same suitability for grizzly bears (Class 2), they are not necessarily comparable in terms of their relative importance to bears. For example, higher elevation habitats tend to have later phenology, are often much more common and cover a larger total area, and are typically not as vulnerable to development activity because they are often outside of the THLB.

Other considerations:

- The protection of Class 1 and 2 habitats within an LU 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).

- Targets in MARXAN may need to be varied by landscape unit and/or BEC variant (i.e., a single set of targets would not be applied over the entire project area). For example targets may need to vary 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.

b. Designated habitat areas:

Grizzly bear habitats identified in Schedule 2 of the Coastal Orders and approved WHAs should be locked into the MARXAN solution as 100% retention since they are legally required.

a. 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. The magnitude of effects on bear populations depends on the type and level of land use and other human activities and the associated habitat loss and displacement and bear mortality related to human use.

2.2.3.7 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 they were not considered to have quite the same habitat (primarily foraging) suitability as Class 1 habitats.

2.2.3.8 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. 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.

Table 3. Summary of recommended habitat retention targets for grizzly bears.

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	Habitats locked into final reserve layer	Upper limit of change
Grizzly bear **Objective:** Maintain and restore healthy enough populations to allow limited consumptive use (hunter harvest) as well as non-consumptive uses (bear viewing).	Consolidated habitat suitability mapping for the Coast, stratified by BEC.			Lowest risk scenario: 100% of Class 1 and 100% of Class 2 habitats	100% of Class 1 and 50% of Class 2 habitats, where the Class 2 habitats selected are the most important of all Class 2 habitats. The following Class 2 habitats are a priority for retention in ORGAs: 1. Early and late spring habitats in valley bottoms and at low elevations, esp ecosystem units on floodplains or associated	All Class 1 habitats are already legally protected under the Coast Orders, as is 50% of Class 2 under the Central &North Coastal Order.	Not defined. 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.). The impact on bears depends on the type

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	Habitats locked into final reserve layer	Upper limit of change
					with wetlands and estuaries in CWH variants. 2. 100% of habitats in Hypermaritime BEC variants (i.e., CWHvh). 3. Fall habitats that protect salmon spawning areas, near where bears fish.		and amount of changes to habitats and their spatial configuration and whether or not there is also mortality risk from humans.
	Grizzly bear habitats identified in Schedule 2 of the Coastal Orders Approved WHAs for the Mid and South Coasts	Grizzly bear habitat polygons WHA polygons		Legislated habitat polygons are locked into the MARXAN solution as 100% retention.	All legally designated grizzly bear habitats	All legally designated grizzly bear habitats	

2.2.4 Marbled murrelet

2.2.4.1 Assumptions

- There is a one-to-to relationship between area of suitable marbled murrelet habitat and populations (Burger and Waterhouse *In press*). By extension, if 69% of suitable habitats are maintained over the long term (CMMRT goal; based on 2002 habitat area), then the assumption is that 69% of marbled murrelet populations will be maintained
- Marbled murrelet are more likely to use of Class 1 and 2 than Class 3 habitats, as defined on air photo interpreted maps.
- A relationship between habitat quality and marbled murrelet density has not been determined but researchers do know that marbled murrelet are more likely to select Class1 and 2 air photo-classed habitats than Class 3 habitats on air photos (Waterhouse et al. 2007, 2008, *In press*). Studies have shown that approximately 10% of marbled murrelet nests occur in poorer habitats in forest greater than 140 years (Class 4 and 5) (Waterhouse et al. 2004, 2007, 2008, *In press*; Burger and Waterhouse *In press*).
- Marbled murrelets are rare >50km inland.

2.2.4.2 Existing management designations and objectives

Designated habitat areas:

- There are approved and proposed Wildlife Habitat Areas (WHAs) for marbled murrelets in the Mid-Coast.
- WHAs for marbled murrelet and northern goshawk (combined) have been delineated in the North Coast and put forward for approval.

WHAs for marbled murrelets in the Mid and North Coasts are 100% no harvesting.

2.2.4.3 Pre-analysis

- Stratify map layers by BEC variant and distance to ocean (0 – 30 km; 30 – 50 km). Exclude habitats >50km.
- Assess the distribution of suitable (Class 1 to 3) habitats by landscape unit.

2.2.4.4 Map inputs

a. Habitat suitability mapping

The best available habitat layer for use in the co-location, at this time, is mapping based on air photo interpretation (Horn 2009b). Unless there are gaps in the air photo-based layer, it is preferable to not combine air photo interpretive mapping with low level aerial assessment; only use the one layer.

Where air photo or low-level aerial mapping is not available, domain experts recommend the use of the Hobbs model (Hobbs 2003) for the purposes of MARXAN analysis.

b. Designated habitat areas

Approved and proposed WHAs for the Mid and North Coasts.

2.2.4.5 definition

For the purposes of the co-location exercise 'suitable habitats' are defined as

- Class 1 – 3 habitats for air photo and aerial assessment-based mapping
- Superior, Good and Fair habitats for maps derived using the Hobbs model.

A comparison of the Hobbs model with the CMMRT model (Burger et al. 2005) supports the use of habitats ranked as 'Fair' in the co-location exercise, but giving them less priority than 'Superior' and 'Good' habitats (Burger, pers. comm..).

2.2.4.6 Targets for habitat retention

Objectives:

- To achieve the CCMRT goal of 69% retention of suitable habitat within each sub-region.
- To provide a preferred distribution of Class 1 - 3 habitats.

The risk targets outlined below reflect the risk to marbled murrelets if the stated objectives are not achieved.

a. Habitat suitability mapping

Recommended low risk targets:

- Maintain 62% suitable MaMU habitat within each landscape unit and sub-region. The denominator in calculating 62% is the sum of habitat in Classes 1-3.

  The 62% amount 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, in press; Burger and Waterhouse *In press*).

- 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 achievement of 62% of suitable habitats is not necessary within individual landscape units, however, if the 62% target is not achieved over an entire sub-region, this will be a move away from the CCMRT goals and there is an increased risk that marbled murrelets will continue to decline over time. The larger the short-fall in habitat conserved (under the 62% target), the more likely it will be that the level of risk assigned to the species will remain static or increase in future.

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.

b. Designated habitat areas

Approved WHAs for marbled murrelets form a legal requirement for consideration in the focal species co-location project and should be ‘locked into the MARXAN solution.

Assign a 100% retention target to proposed WHAs for marbled murrelets.

2.2.4.7 Rationale for targets

- The recommended low risk target is based on the CMMRT goal of conserving 69% of suitable habitat in Northern and Central Mainland conservation regions in the long term (CMMRT 2003). The CMMRT goals have been defined based on extensive analysis by marbled murrelet experts over many years.
- There is a greater certainty of use of Class 1 and 2 habitats by marbled murrelets (Waterhouse et al. 2008, *In press*; Burger and Waterhouse *In press*) and any loss of Class 1 and 2 habitats is likely to reduce options for nesting.
- Class 3 habitats are more ubiquitous and are less certain to provide the habitat attributes required for nesting.

2.2.4.8 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.
- 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 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 do know that marbled murrelets are more likely to select Class1 and 2 air photo classed habitats than Class 3 habitats (Waterhouse et al. 2007, 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.

Table 4. Summary of recommended habitat retention targets for marbled murrelets

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
Marbled murrelet **Objectives:** • To achieve the CCMRT goal of retaining 69% of suitable habitat within the sub-region over the long term • To provide a preferred distribution of Class 1 - 3 habitats. CMMRT short and long-term recovery goals are to slow the decline to the B.C. marbled murrelet population and its nesting habitat to a stable level of 69% of 2002 levels in Northern and Central Mainland	Air photo interpretation mapping	Class 1 – 3 habitats, , stratified by BEC and distance to ocean class (0 – 30 km; 30 – 50 km)	Sub-region; LU; distance to ocean class	62% of [Classes 1 + 2 + 3]: 100% of Class 1 and 2 and achieve the remainder with Class 3 where necessary	100% of Class 1 and 2 habitats		The larger the short-fall in habitat conserved (under the 62% target), the more likely it will be that the level of risk assigned to the species will remain static or increase in future.
	Where air photo or low-level aerial mapping is not available, use the Hobbs algorithm (Hobbs 2003)	Superior (S), good (G) and fair (F) habitats, stratified by BEC and distance to ocean class (0 – 30 km; 30 – 50 km)	Sub-region; LU; distance to ocean class	62% of [S + G + F habitats]: 100% S + G and achieve the remainder with F where necessary	100% of Superior and Good habitats		
	Approved and proposed WHAs	WHA polygons	LU	Approved WHAs in the Mid Coast have been 'locked into' the	All approved and proposed	All approved and proposed	

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
conservation regions (CMMRT 2003). Domain experts identified habitat objectives to achieve CMMRT recovery goals, based on the assumption that habitat and nesting population is roughly 1:1				MARXAN solution as 100% retention. Proposed WHAs in the Mid and North Coasts have a target of 100% retention but are not locked in.	WHAs	WHAs	

2.2.5 Mountain goats

2.2.5.1 Assumptions

- 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 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).

2.2.5.2 Existing management designations and objectives

Designated Ungulate Winter Ranges

Ungulate Winter Ranges (UWRs) have been legally established or are pending for all three coastal sub-regions under the Government Actions Regulation. Legally designated UWRs represent a subset of modelled goat winter range mapping.

North Coast: UWRs for mountain goats are currently proposed for the non-contributing forested areas. A second proposal for the area that overlaps THLB (as defined by TSR II) is being considered but outside of current policy.

Mid Coast: General Wildlife Measures (GWMs) for approved UWRs in the Mid Coast state that up to 10% of a mountain goat UWR can be harvested, with restrictions on the nature and timing of activities and road development. As mountain goats appear to be on a declining trend, MOE Cariboo Region is considering amending the GWMs to prescribe no harvesting within UWRs (K. Dunsworth pers comm).

South Coast: UWRs have been approved for the entire South Coast, with the exception of the Phillips Landscape Unit, where approvals are pending. Harvesting is not permitted within the UWR except where this will enhance the quality of the winter range.

2.2.5.3 Pre-analysis

Consider stratifying the landbase into mountain blocks ("meta-populations") and use these as planning units for goat habitat management. This stratification has been completed for the North Coast.

2.2.5.4 Map inputs

a. Modelled habitat

North Coast: RSPF habitat suitability mapping as described in Pollard and Keim (2006). Habitats are defined as suitable or not suitable. Polygons rated as 'suitable' represent 90% of the area that mountain goats would select if they are in the area.

Mid Coast: Habitat suitability mapping based on GIS algorithms. Habitat is defined as suitable or not suitable.

South Coast: A Resource Selection Function (RSF) model developed by Taylor et al. (2004) was applied to assess winter habitat suitability. The resulting RSF values reflect relative likelihood of use of winter habitats by mountain goats (ranging from 0 – 1.0) if they are in the area. Type 1 (very high) and Type 2 (high) winter habitat ratings were designated after comparing model output values with known winter goat locations (as determined through telemetry and/or habitat use assessments) as follows:

Type 1 (Very High value): RSF values 0.185 – 1

Type 2 (High value): RSF values 0.024 – 0.185

For the South Coast, only the female habitat layer should be used (do not combine with the male habitat layer).

b. Legally designated habitat areas

FRPA (GAR Order) UWRs for the Mid and South Coasts; proposed UWRs for the North Coast

2.2.5.5 Targets for habitat retention

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

The 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.

a. Modelled habitat

<u>North Coast</u>: Recommended low risk target: 100% suitable habitat

<u>Mid Coast</u>: Recommended low risk target: 90% suitable habitat

<u>South Coast</u>:

Recommended low risk target: 90% suitable habitat. This could be achieved by capturing:

- the entire 90% as Type 1 habitat; or
- a combination of Type 1 and Type 2 habitats such that a minimum of 70% of the Type 1 habitat is captured and two times the Type 2 habitat to achieve the total % retention.

Analysis unit: Landscape unit. Although this hasn't been tested, an assessment by meta-population level is also recommended for future study.

b. Designated habitat areas

Approved UWRs form a legal requirement for consideration in the focal species co-location project and have been 'locked into' the MARXAN solution.

- In the South Coast, lock in 100% of approved UWRs for mountain goats; retain 100% of proposed UWRs

- In the Mid Coast, lock in 90% of approved UWRs for mountain goats
- In the North Coast, retain 100% of proposed UWRs for mountain goats

b. Upper limit of habitat change

Loss of more than 40% of habitats defined as suitable (North and Mid Coast) or Type 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. At this time, there may be a low probability of exceeding 40% habitat loss, however, the consequences of this loss are considered to be very high.

2.2.5.6 Rationale for targets

- Goat winter ranges are critical habitats 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 harvesting is not occurring. The dirth of inventory and monitoring of coastal goat populations increases the need to manage habitats conservatively.
- 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 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.
- Legally designated mountain goat habitats were located to minimize impacts to timber supply on the North and Mid Coasts, so many of the areas designated there are in the non-contributing forest. In addition, many high quality habitats at lower elevations may have already been harvested on the Coast. The retention of high quality, low elevation habitats that have not yet

been developed can, therefore, be particularly important as these areas often possess attributes such as high timber value and favourable terrain that make them particularly vulnerable to harvesting.

2.2.5.7 Uncertainties and Limitations

Targets for strategic co-location are based on expert opinion. While the targets for low risk are supported by observed population trends, the upper limit of change is an estimate based on changes to the historic landbase condition and expert knowledge of the distribution and vulnerability of coastal goat populations. This upper estimate of risk may change with increased knowledge of the response of mountain goats to changes in habitat conditions.

Table 5. Summary of recommended habitat retention targets for mountain goats

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
Mountain goat **Objective**: to sustain healthy populations of goats by preventing localized extirpation.	North Coast: RSPF habitat suitability mapping as described in Pollard and Keim (2006).	Suitable / not suitable	LU	100% of suitable habitat	100% of suitable habitat		Any loss of winter range habitat is considered a risk and the amount of risk increases with the amount of alteration. Loss of more than 40% of habitats defined as suitable (North and Mid Coast) or Type 1 (South Coast) within a landscape unit is
	Mid Coast: Habitat suitability mapping based	Suitable / not suitable	LU	90% of suitable habitat	90% of suitable habitat		

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
	on GIS algorithms.						considered a very high risk to achieving the objective of sustaining local populations of mountain goats and should be avoided as an outcome. At this time, there may be a low probability of exceeding 40% habitat loss, however, the consequences of this loss are considered to be very high.
	<u>South Coast:</u> RSF habitat suitability mapping completed in 2008/ 2009	Type 1 (Very High value): RSF values 0.185 – 1 Type 2 (High value): RSF values 0.024 – 0.185	LU	90% of the area of Type 1 (VH) habitat. This could be achieved by capturing: • the entire 90% as Type 1 habitat; or • a combination of Type 1 and Type 2 habitats such that a minimum of 70% of the Type 1 habitat is captured and two times the Type 2 habitat to achieve the total % retention.	100% of habitats captured in the Low Risk solution		

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
	Approved and proposed Ungulate Winter Ranges	UWR polygons		Approved UWRs in the South Coast are 100% retention. Approved UWRs in the Mid Coast are 90% retention. Proposed UWRs in the North and South Coasts have a target of 100% retention.	All approved and proposed UWRs	All approved and proposed UWRs	

2.2.6 *Northern goshawks*

2.2.6.1 Assumptions

- Nesting and foraging habitat suitability models were developed on the assumption that forest cover data is adequate to use at a strategic level but poor at a stand level.

2.2.6.2 Existing management designations and objectives

Wildlife Habitat Areas:

- There is one approved WHA for goshawks in the North Coast and no other WHAs established throughout the rest of coastal mainland B.C.
- There are 15, 9, and 3 known nest areas for goshawks within the south-coast, mid-coast and north coast planning units of the central-coast land and resource management plan (CCLRMP) area, respectively.

Focal Species:

- Goshawks are identified as one of five focal species in the South Central and Central & North Coastal Orders. As such, the implementation of land use order objectives for ecosystem-based management should overlap, to the extent possible, with goshawk habitat suitability.

2.2.6.3 Pre-analysis

There are no recommendations for pre-analysis.

2.2.6.4 Map inputs

a. Habitat mapping

There are three map layers to be used as input to MARXAN:

- Known nest areas, buffered by 800 m to approximate a 200 ha nest area/PFA. If a known next area has been field-mapped e.g., as part of WHA establishment, the buffer may extend beyond 800m.

- Northern Goshawk Recovery Team modelled nesting habitat suitability layer
- Northern Goshawk Recovery Team modelled foraging habitat suitability layer

b. Designated habitat areas

There is one approved wildlife habitat area for goshawks in the North Coast sub-region.

A number of wildlife habitat areas that capture habitats of both goshawks and marbled murrelets are proposed in the North Coast sub-region.

2.2.6.5 Habitat definition

Mapped nest areas:	All forest within the (minimum 800m) 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.

2.2.6.6 Scenarios for habitat retention

a. Habitat mapping

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

Known nest 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; 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.

The Northern Goshawk Recovery Team has insufficient information at this time to set measurable habitat and population goals for recovery (Northern Goshawk *A. g. laingi* Recovery Team 2008). However, for the purpose of this co-location work, domain experts identified low risk scenarios associated with amounts of nesting and foraging habitat recommended for retention within old growth reserves.

These low risk scenarios 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. <u>Nest areas + PFAs</u>

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

Due to the species' strong territoriality and high fidelity to their nest areas goshawk nest areas/PFAs should be included in all old-growth reserve area solutions.

ii. <u>Modelled nesting habitat</u>

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

iii. <u>Modelled foraging areas</u>

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

b. Designated habitat areas

The approved WHA for goshawks forms a legal requirement for consideration in the focal species co-location project and should be 'locked into` the MARXAN solution.

Assign a 100% retention target to proposed WHAs for goshawks.

c. Upper limits of change

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

2.2.6.7 Rationale for scenarios

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 Horn 2009a). 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 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

2.2.6.8 Parameters to incorporate into Spatially Explicit Landscape Event Simulator (SELES)

Northern goshawks require large areas of mature and old forest over time. This requires maintaining habitat inside and outside of OGRAs. To properly assess the overall functionality of goshawk habitat across the landbase it is necessary to (a) assess OGRAs in the context of the overall landscape; and (b) look at estimated changes in forest cover (distribution and total amounts of mature & old) over time. Time series should be run in 10 year increments (an approximate goshawk lifespan; Squires and Reynolds 1997) over a 50 year planning horizon.

The Northern Goshawk Recovery Team/Habitat RIG territory model should be used to estimate the potential number and distribution of goshawk pairs that could be supported at each time step over the next 50 years.

2.2.6.9 Uncertainties and limitations

We are unable to assess how much goshawk high and moderate nesting and foraging habitats would be captured in other focal species low risk target scenarios at this time (because some species models are incomplete and we haven't reviewed these outputs).

The cost layer is modelled over a 400 year time frame whereas focal species models are reflections of current suitability. Therefore, it is difficult to determine how our objective to minimize cost, may affect our overall OGRA strategy, over time.

Table 6. Summary of recommended habitat retention targets for northern goshawks

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
Northern goshawk **Objective:** Maintain sufficient habitat to maintain viable breeding territories and, therefore, populations	NGRT modelled foraging habitat	M habitat = [0.5 - 1.0]; H habitat = [0.75 - 1.0]	LU	60% of M or H [= 0.5 - 1.0]; at least half of this to be H [= 0.75 - 1.0]	33% of low risk solution (20% foraging habitat overall)		Domain experts were unable to set an upper limit of change at this time, due to lack of knowledge around factors influencing populations at the upper limits.
	NGRT modelled nesting habitat	M habitat = [0.5 - 1.0]; H habitat = [0.75 - 1.0]	LU	60% of M or H [= 0.5 - 1.0]; at least half of this to be H [= 0.75 - 1.0]	100% of low risk solution		
	Known nest sites buffered by 800m mature/old forest	nest area polygons = nest site + 800m buffer		100% of 800m-buffered nest area polygons (all age classes)	All known nest sites and surrounding nest area	All known nest sites and surrounding nest area	

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
	Approved and proposed WHAs	WHA polygon		The approved WHA in the North Coast has been 'locked into' the MARXAN solution as 100% retention. Proposed WHAs in the North Coast have a target of 100% retention but are not locked in.	All approved and proposed WHAs	All approved and proposed WHAs	

2.2.7 Coastal tailed frog

2.2.7.1 Assumptions

- The tailed frog habitat model captures close to all suitable tailed frog streams. There may be occurrences in gentle (<30%) basins and very steep (>120%) basins, but these will be few. In gentle basins it is likely that fisheries management will offer protection; while very step basins may be largely inoperable.
- Stream buffers are more important than protecting the remainder of a tailed frog basin.
- More rugged tailed frog basins (the basin surrounding the buffered stream) are more sensitive to disturbance than less rugged basins.
- Both mature (>100 years of age) and old growth forests are equally important for retention.

- The spatial configuration of retention areas is important at the scale of basins and landscape units.
- As the Central North and South Central Coastal Orders do not provide direct protection to tailed frog streams via streamside buffers, the objectives for upland streams (s12) are assumed to not contribute to *A. truei* habitat.

2.2.7.2 Existing Management Designations and Objectives

Wildlife Habitat Areas

Mid Coast: A number of areas proposed as 'Tier 1 specified areas' for tailed frogs (formerly proposed WHAs) are to be designated as no-harvesting areas. These areas consist of a core area (Class 1 and 2 stream segment) and buffer.

South Coast: Nine WHAs are established, each consisting of a core area (100% netdown) and buffer area (80% netdown).

Coastal Orders

Section12 in the Central & North and South Central Coastal Orders (Objectives for Upland Streams) requires the maintenance of "70% or more of the forest, in the portion of the watershed where upland streams occur, as functional riparian forest". There may be quite different outcomes for upland stream management, depending on whether this objective is applied to the stream buffer or the entire contributing sub-basin.

There are no defined buffers for S5 and S6 streams under the Coastal Orders. The co-location of tailed frog stream segments within OGRAs is even more important in the absence of defined stream buffers.

2.2.7.3 Pre-analysis

To prepare the tailed frog map layer for co-location:

- Buffer all suitable tailed frogs streams by 50m to either side.
- Separate the basins associated with each stream into the buffered reaches and the remaining basin.
- Remove habitat having forest cover of age class = 0 to drive the capture of forested habitats.

2.2.7.4 Map inputs

Modelled habitat

MARXAN used a tailed frog model that was developed in 2008 based on basin size and ruggedness class (see section 7.3.1). The model has been applied to the entire coastal planning area.

Designated habitat areas

WHAs or equivalent for the Mid and South Coasts

2.2.7.5 Habitat definition

These habitat definitions are based on the assumptions listed in section 7.5.1. There are two habitats that are treated separately in the analysis: tailed frog streams and the contributing basins to those streams.

Class 1 habitat = buffered streams, ruggedness 30 - 70%;

Class 2 habitat = buffered streams, ruggedness 71 - 120%;

Class 3 habitat = remaining basin area, ruggedness 30 - 70%;

Class 4 habitat = remaining basin area, ruggedness 71-120%

2.2.7.6 Targets for habitat retention

a. Biological habitat layer

Experimental low risk scenario:	Retention: 50% Class 1; 45% Class 2; 30% Class 3; 40% Class 4.
	Fragmentation: low
Experimental high risk scenario:	Retention: 20% Class 1; 20% Class 2; 20% Class 3; 20% Class 4.
	Fragmentation: moderate
Analysis unit:	Landscape unit

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-location. Targets will be better defined as inventory and research improves understanding of coastal tailed frogs and their response to changes in habitat.

b. Designated habitat areas

WHAs are treated as follows in the MARXAN analyses:

- Approved WHAs in the South Coast are locked in their entirety (core + buffer area) as part of the designated 'reserve' layer.
- Proposed Tier 1 Specified Areas on the Mid Coast are assigned a 100% retention target within core areas.

2.2.7.7 Rationale for co-location targets

- 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 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).
- 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. In addition, these basins harbour lower tailed frog densities and populations are more vulnerable to stream impacts.
- 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 too 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).

2.2.7.8 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.

As the co-location experiments in Phase 2 (Horn and Rumsey 2009b) did not appropriately capture tailed frog habitats, domain experts were unable to assess the different targets for risk and their implications. As a priority, future efforts at spatial design should include an assessment of the implications of different targets for co-location of tailed frog habitat.

Table 7. Summary of recommended habitat retention targets for coastal tailed frogs

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
Tailed frog **Precautionary objective:** To capture the full range of habitat variability across each landscape unit	Updated tailed frog model - based on basin size and ruggedness class. Streams are buffered by 50m to each side	There are two habitats that are treated separately in the analysis: tailed frog streams and the contributing basins to those streams. Class 1 habitat = buffered streams, ruggedness 30 - 70%; Class 2 habitat = buffered streams, ruggedness 71 - 120%; Class 3 habitat = remaining basin area, ruggedness 30 - 70%; Class 4 habitat = remaining basin area, ruggedness 71-120%	LU	Experimental low risk scenario: 50% Class 1 45% Class 2 30% Class 3 40% Class 4 Capture 100% of Class 1 and 2 streams that overlap know tailed frog occurrences. Fragmentation: moderate The more overall area that is captured within a watershed (stream buffers and basins), the greater the potential conservation value for tailed frogs and the greater the dispersal capability between watersheds.	100% of low risk solution for Class 1 and 2 habitats (stream buffers)	100% of buffered streams having known tailed frog occurrences	Experimental high risk scenario: 20% Class 1 20% Class 2 20% Class 3 20% Class 4 Fragmentation: moderate

Focal species	Description of layers	Description of habitat for analysis	Analysis Unit	Low risk goal	Best Habitats	100% capture in OGRAs or other reserves	Upper limit of change
Tailed frog	Approved and proposed WHAs	WHA polygon		Approved WHAs in the South Coast are 100% retention (core + buffer area). Core areas of proposed WHAs in the Mid Coast have a target of 100% retention	All approved WHAs Core areas of proposed WHAs in the Mid Coast	All approved WHAs Core areas of proposed WHAs in the Mid Coast	-

3.0 Spatial Considerations

The MARXAN co-location tool spatially defines potential areas of old growth retention at a strategic level. The final solutions will be optimal for focal species to the extent that they meet targets for retention of high value habitats and also in there spatial configuration (patch size, amount of edge) and distribution across the landbase. The requirement to meet representation of old growth within site series surrogates results in a dispersed pattern of polygons across the landbase. Domain experts have identified preferred spatial parameters to be considered during the co-location exercise (Table 8). At this time, spatial considerations do not drive MARXAN; rather they are considered *post hoc* and can also be used as guidance to detailed landscape unit design.

Table 8. Spatial consideration related to co-location of focal species`` habitats in old growth reserves.

Focal species	Spatial Considerations	Post Hoc Assessment
Black bear	Both of the following are important to provide security for dominant and sub-dominant bears. : • 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.	• Assess how all of the various components of EBM contribute to the requirements of black bears over time. This includes conservancies, OGRAs and focal species co-location, riparian areas, forested swamps, limits on mid-seral forest, and within-stand retention • Connectivity and the affect of roads should also be assessed post-hoc.

Focal species	Spatial Considerations	Post Hoc Assessment
Coastal black-tailed deer	• Patches of winter habitat should be ≥ 40ha. • Winter ranges should be placed a maximum of 5 km apart. • Under current management assumptions, critical UWRs are not designated in the hypermaritime in the Mid and North Coast areas, so there is no mapping of winter range for deer in these areas. This may represent a gap in the provision of suitable winter habitat in this zone in these areas. • Mortality risk factors need to be considered as well as habitat suitability in managing habitat for deer. For example, the size and location of winter range patches can influence the risk of mortality from predation, and location of roads can influence risk of mortality from predation and hunting (Farmer et al 2006). • There is likely a need for cross-elevational connectivity between habitat patches in some areas, but more research is needed determine appropriate habitat types, and amounts, to satisfy deer requirements.	Post-hoc assessment of deer winter range would involve consideration of: total amount of habitat, patch size, distribution of patches, and dispersion (in context of seasonal ranges).

Focal species	Spatial Considerations	Post Hoc Assessment
Grizzly bear	• Co-locate a range of well-distributed seasonal habitats to meet the food requirements of bears throughout their active period. This can be achieved for food plants by stratifying habitat types by BEC variant and LU and setting targets by season. • Using BEC variants as an analysis unit will also ensure that solutions are distributed across elevations, including important lower elevation habitats. • Consider the distribution of habitats within LUs. For example, the capture of Class 2 habitat should be a higher priority in LUs where there is not a lot of Class 1 habitat available. In general, with regard to configuration of OGRAs: • Link old growth reserves together along riparian corridors. Large contiguous reserve areas are preferable to small disjointed areas. Watersheds that are more intact (less fragmented) may provide better habitat in the long term. • Many essential habitats are in valley bottoms, including estuaries, spawning channels, wetlands, and forested swamps. Embed these habitats in the hydroriparian network that is part of an overall reserve network. In addition, consider cross elevational linkages, e.g. to avalanche chutes through Ungulate Winter Ranges and along beach fringes.	Assess the capture of habitat requirements in the context of all EBM zoning and objectives, including conservancies, old growth reserves, hydroriparian management, mid-seral targets, and within-stand retention. Consider: • the adequacy of amounts and spatial distribution of habitats within OGRAs, • the distribution of habitats over the four active seasons (early spring, late spring, summer and fall), and • the quality of the matrix and its contribution to linkage between seasonal habitats. Ensure that (a) nodes of highest habitat quality and concentration of habitats and (b) highest densities of overlapping home ranges are represented in the OGRA solutions.

Focal species	Spatial considerations	Post Hoc Assessment
Marbled murrelet	***Distance to ocean*** Seek to achieve targets by two separate distance-to-ocean classes: 0 – 30 km and 30 – 50 km. This stratification is to prevent MARXAN making trade-offs between the higher quality habitats closer to the ocean and those further inland. This is particularly important in large watersheds where there are large valleys that go a long way (>30 km) inland. Treat the 30-50 km zone separately to the 0-30 km zone (to avoid having most of the selected habitat >30 km inland) but apply the same scenarios and rationale to each. Habitats > 50 km from the coast have a relatively low value and should be excluded from the MARXAN analyses. Do not exclude habitats within 500m of the ocean, as is recommended in some applications of the CMMRT (2003) guidelines. In the Central and Northern Conservation Regions, habitats within 500m of the ocean appear to be suitable unless there are obvious negative marine influences (less moss, windshorn canopy) in some of the hypermaritime subzones (A. Burger, pers. comm.). ***Distribution among landscape units*** An analysis of the distribution of suitable marbled murrelet habitats in the South Coast showed that there is a clustering of habitat, so that almost all suitable murrelet habitat occurs in only one-third of the 29 landscape units	• Consider proximity to known aggregations at sea with respect to marine foraging potential. OGRAs selected in areas that are not proximal (within ~ 50 km) to high value marine foraging areas will be of lower habitat value. A challenge is that there is not good information about at-sea feeding at this time; there has been very little marine sampling in the central coast and not all marine concentrations of marbled murrelets are known. • Compare old growth reserves to areas known to have high marbled murrelet counts e.g., using radar counts at selected watersheds (database maintained by Dr Doug Bertram of the Canadian Wildlife Service). • Adjust outputs in the hypermaritime to account for overestimation of habitat quality in those BEC variants for the air photo and Hobbs map products. • Seek to achieve a range of patch sizes and soft edges. Hard edges are a concern.

Focal species	Spatial considerations	Post Hoc Assessment
	in the sub-region. Other landscape units in the South Coast have only small amounts suitable habitat. This skewed distribution needs to be taken into consideration when planning for distribution of Old Growth Reserve Areas. Domain experts state in section 5.4.8 that the priority is to capture existing high quality habitat and that existing habitat should not be traded-off against future recruitment. Future MARXAN scenarios should compare the effect of meeting targets by LU versus sub-region to test the effect on distribution of habitats within OGRAs. ***Spatial configuration*** To reduce edge effect, a clumping of reserves is preferable to dispersed polygons; few large contiguous areas are preferred over several small areas. Maintain a mix of large (>200 ha), medium (50–200 ha), and small (<50 ha) patches (MOE 2004).	• Determine the area harvested since 2002 and assess the implications for meeting targets for meeting CMMRT goals and, correspondingly, targets for co-location.

Focal species	Spatial considerations	Post Hoc Assessment
Mountain goat	Manage all habitats where goats are known to occur or have a high probability of occurring (as opposed to ensuring a general distribution of suitable habitat characteristics across the landbase). The preferred spatial configuration of OGRAs depends on the location of goat habitats and other focal species habitats. In general, the preference is to not concentrate protection measures in any one area and focus on capturing the most productive goat habitats within OGRAs. Both horizontal and cross-elevational connectivity is very important. In particular, contiguous forest cover is required across elevations, anchored in winter ranges, to allow goats to respond to varying winter conditions.	• Assessment of cross-elevational and horizontal connectivity. • Distribution of OGRAs relative to habitats within mountain blocks (metapopulations)

Focal species	Spatial considerations	Post Hoc Assessment
Northern goshawk	A good distribution of OGRAs across the landbase that includes all known nest areas/post-fledging areas, combined with the low risk target for modelled nesting habitat, should provide an adequate fine-filter level of habitat protection for goshawks within the planning area. Design OGRAs to be distributed across landscape units in relatively large patch sizes (100-200 ha). Capture foraging habitat in close proximity to large patches of nesting habitat.	What happens outside of the OGRAs proposed by this project is critical to goshawk viability because very little habitat overall, within breeding home ranges, is captured within MARXAN scenario outputs. Post hoc analysis should look at old growth reserves within the context of the overall landbase. Domain experts would like to be able to use the outputs of the SELES (Fall and Fall 1996) runs to assess changes in total habitat availability over time. As part of post hoc analysis, overlay the goshawk territory model with MARXAN outcomes to estimate how many goshawk territories are supported by the outcomes of each scenario. As well, overall patch size representation of OGRAs should be examined.

Focal species	Spatial considerations	Post Hoc Assessment
Tailed frog	Establish stream buffers on the entire length of selected streams. An adequate riparian buffer is large enough to moderate stream temperature and riparian microclimate conditions, and be resilient to extensive windthrow. Capture entire streams segment polygon (valley bottom to headwater) within class 1 and 2 habitats rather than short reaches. Link buffered streams with old growth in the contributing basin. especially old forest that coincides with moist sites (seepages, depressions) and forested areas in or near low passes	Entire basins should be evaluated for their contribution to the quality of *A. truei* habitat. The value of old growth protection over the entire basin will vary by basin. For example: • Sedimentation effects: basins with steep smooth slopes descending into creeks will benefit greatly from retention, while basins with irregular topography and limited slope to creek connectivity may benefit less. • Microclimate effects: basins with extensive areas of mesic to hydric sites will benefit less than basins dominated by xeric sites. The contribution of OGRAs to landscape connectivity should be maximized by: • Mapping the stream networks within watersheds. • Linking these stream networks to other forests within basins, particularly upland forests that are conducive to potential meta-population exchange across traversable passes. • Considering the effects of existing roads and road density on the functionality of the solutions. OGRAs should be followed up by site-specific evaluations to assess stream network complexity: dendritic stream networks and channels with complex long profiles offer a greater recolonization potential in the event that channel events locally extirpate a segment of the population.

4.0 Other Considerations for Strategic Co-Location

This section provides additional considerations for co-location of habitats in areas of old growth retention.

4.1 Connectivity

Connectivity has been identified as an important issue for three of the seven focal species: coastal black-tailed deer, mountain goat and tailed frogs (Table 9). Domain experts have indicated that, at the landscape scale, connectivity is not an issue of concern for bears (black and grizzly), marbled murrelets and northern goshawk.

Table 9. Connectivity during co-location

Species	Connectivity strategy	Connectivity strategy
Coastal black-tailed deer	Connectivity is vital component of winter range. Deer require horizontal and vertical connectivity to support movement between cover and foraging areas and to respond to changing winter snow conditions. ***a. Horizontal connectivity: Juxtaposition of forage areas and forested cover*** Deer require the ability to readily move between cover and forage areas on both daily and seasonal time frames. Juxtaposition between foraging areas (open-canopied habitats) and forested cover areas allows deer to satisfy their life requisites on a daily basis. Seasonally, spring forage areas within 2.5 km of a winter range, with traversable habitat between them, is most desirable. ***b. Vertical connectivity: Elevational movement in response to snow conditions*** To facilitate elevational movement within a winter range, continuous forest cover across elevational gradients is required. While deer may have a preferred elevation range, adequate cover is needed both above and below this elevation to facilitate movements in response to changing snow conditions throughout the winter. During the winter, deer tend to occur as high on the hill as they can, given the snow pack conditions. During periods of deep, soft snow, deer move to lower elevations and then	There is likely a need for cross-elevational connectivity between habitat patches in some areas, but more research is needed determine appropriate habitat types, and amounts, to satisfy deer requirements.

Species	Connectivity strategy	Connectivity strategy
	return to higher elevations once a supportive crust forms; a pattern of movement that can be repeated many times in a winter. Continuous forest cover throughout the elevational range of the winter range is required to enable these movements. Facultative migratory deer encountering conditions of deep snow may also move horizontally out of a valley as well as vertically (down in elevation) (S. McNay, pers. comm.). Roads may present a barrier to elevational movement of deer in winter ranges, particularly on –steep slopes. Side case and banks limit the ability of deer to move across roads; this impediment to movement is exacerbated in winter due to snow berms along road sides.	
Mountain goat	Goats require good vertical (cross-elevational) and horizontal (lateral) connectivity within their habitats. ***a. Lateral connectivity*** Winter range typically consists of a series of connected rock bluffs and goats move along contours from bluff to bluff. Goats appear to require forested cover to provide connectivity between bluffs to reduce energy expenditures and predation risk (B. Pollard pers. comm.). They generally disperse in stages e.g., to a rock bluff in the middle of a forested patch and then beyond. ***b. Cross-elevational connectivity*** Cross-elevational connectivity is important to mountain goats. Goats can move 500m – 600m per day vertically depending on the weather (B.Pollard, pers. comm.). Goats migrate up and down hillsides between seasonal habitats (Taylor et al. 2004, Rice 2008). They move up elevation in the spring, post-kidding, following the trailing edge of the snow and emerging vegetation. Higher elevations provide summer forage and cooler microclimates (snow patches) to avoid insects. In winter, goats descend to lower elevations.	Contiguous forest cover is required across elevations, anchored in winter ranges, to allow mountain goats to respond to varying winter conditions. This connectivity is inherent in the mapping of winter ranges but could be expanded to increase resiliency e.g., to climate change effects. Factors affecting the connectivity of mountain goat habitats include: • Snow interception cover connecting escape terrains across elevations. • Connectivity from lower elevations to the alpine to provide security cover during seasonal migrations. • High density forests (>5000 stems per hectare) or young (20 – 50 year old) forest may

Species	Connectivity strategy	Connectivity strategy
	Connectivity that allows within-season movement can be linked to winter survival. Goats will move up and down in elevation in response to snow conditions. Goat surveys have shown that, during heavy snowfall years, there is very little forage for mountain goats and they are forced down to lower elevations to avoid deep snow (Gordon and Reynolds 2000, Jex 2004). Once the snow forms a crust that facilitates easy movement (usually mid- late winter) they move up in elevation again to forage on surface litterfall (MELP 2000).	be an impediment to movement. Early seral forest, post-harvesting, may present difficult conditions for mountain goats to move through due to logging residue. • Where possible, roads should be planned to avoid bisecting connectivity corridors for mountain goats and deer. More research is needed regarding management for connectivity for mountain goats.
Tailed frog	It is important to provide within-basin dispersal as well as to provide opportunities for migration between watersheds. • Within-basin dispersal is critical because *A. truei* needs to be able to move from one part of a stream network to another. Dispersal occurs upstream (frogs) and downstream (tadpoles), and within moist landscapes frogs disperse across the hillslope between streams (Wahbe et al 2004). • Dispersal over drainage divides provides linkages between populations. These are passes linking ephemeral headwater streams that the frogs can navigate through.	• Good hydroriparian management will contribute to connectivity along riparian areas. In addition, moist microsites that are at a distance from streams can be protected to facilitate dispersal across the hillslope. • 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. • At lower elevations, connectivity is addressed through hydroriparian objectives and management of salmon habitat.

4.2 Habitat Recruitment

In landscape units where there is not enough old forest to meet targets for ecosystem representation, MARXAN is instructed to acquire younger forest based on a rule of `oldest first`. Domain experts have provided species-specific guidance for recruitment of habitats which could be considered during detailed landscape design. Table 10 provides strategies for recruitment of habitats within OGRAs in landscape units where there is a shortfall of old growth to meet retention targets in the Coastal Orders.

Table 10. 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 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

Species	Recruitment strategy
	relatively high and debris loading low (see MoF 2001).
Marbled murrelet	The priority is to capture existing high quality habitat. Existing habitat should not be traded-off against future recruitment. This is because the time required to recruit suitable trees is too long (~200 years).
Mountain goat	Recruit from oldest forest first in areas that provide juxtaposition to geological formations that provide suitable escape terrain.
Northern goshawk	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 (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 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.

4.3 Promoting resilience to climate change

Although climate change predictions vary, the general prediction for coastal BC is warmer and wetter winters and warmer and drier summers (Rodenhuis et al. 2007). Although greater precipitation is predicted in the winters, average snowlines will migrate north in latitude and higher in elevation, snow accumulation will decrease and the spring snowmelt will occur earlier in the season. At the same time, coastal areas are expected to continue experiencing an increased frequency and magnitude of storm events with heavy winds and precipitation intensity (Pike et al. 2008).

Although it is difficult to predict future climate scenarios with certainty, steps can be taken to increase the resilience of reserve areas to large-scale changes (Table 11).

Table 11. Strategies to promote resiliency to climate change in reserve design

<table>
<tr><th>Species</th><th>Climate Change Strategies</th></tr>
<tr><td>Black bears</td><td>Key changes predicted under climate change that are of concern to bears (black and grizzly) are:

Reduced salmon populations (at-sea survival and reduced recruitment in temperature sensitive streams),
Increased snowload and potential scouring of productive avalanche chutes,
Increased frequency of peak streamflow events resulting in impacts to stream environments,
Late snowpack at high elevations resulting in poor pollination and fewer berries, and
Changes to ocean levels resulting in impacts to important coastal estuary habitat for bears.

Windstorms may increase in intensity making old growth reserves areas more vulnerable to blow-down. The more forest left standing the greater the resiliency to change (Wilson and Hebda 2008). If given the capability, black bears will adapt but resiliency can be promoted by providing diversity at the landscape and stand level, over a range of habitats as well as a distribution of important habitat types. This approach will allow for changes over time.</td></tr>
<tr><td>Coastal black-tailed deer</td><td>Resiliency might be built into old growth reserves as follows:

Expand the elevational extent of winter ranges to lower and higher elevations overall to account for shifts in climatic envelopes. This will help maintain options for deer movement in response to changing winter conditions.
Maintain a wide distribution of habitats to provide options to satisfy a wide range of habitat requirements.
</td></tr>
<tr><td>Grizzly bear</td><td>The following are potential issues related to climate change with some associated strategies to promote resiliency (note: not all of the effects listed here will apply to the Coast).
a. <u>Avalanching</u>
Effects:

more avalanches (higher snow loads, more violent changes in temperature, too much vegetative change, scouring to rock substrates); or
fewer avalanches (lower snow loads, less snow movement, gradual succession changes in important plant communities)

Resiliency strategy: integrity of buffering to either side of avalanche chutes</td></tr>
</table>

Species	Climate Change Strategies
	b. <u>Spawning salmon</u> Effects: • higher frequency and intensity of fall storms (e.g., rain on snow) leading to stream scouring and gravel removal post spawning. • higher stream temperatures in the late summer and early fall - leading to no spawning • higher stream temperatures in the rearing period (e.g., coho) *Resiliency strategy:* hydrological / hydroriparian management meets EBM objectives; manage human fishing levels within sustainable limits. c. <u>Changing hydrology – effect on wetlands</u> Effects: shrinking wetlands *Resiliency strategy:* hydrological / hydroriparian management meets EBM objectives; manage watershed level cut / flow regime d. <u>Weather during berry shrub pollination</u> Effects: • A number of factors can affect the berry crop, including weather being too cold, too wet, too cloudy (less sun and warm weather for pollinating insects) and growth occurring too late in the year because of higher snowpacks at elevation. All can lead to fewer berries, and / or an unnatural spatial and temporal distribution of berries. • There is a risk of increased bear–human conflict as a result of reduced berry production. *Resiliency strategy:* maintain berry production as a priority food resource. If salmon populations decline berries will become an important alternative. Manage landscape seral stage distribution at the landscape scale; consider stand tending and/or cluster planting as per guidelines (L'Anson 1996, MoF 2001); use variable retention to promote shrub production in understories. e. <u>Disease</u> - none are known, but even some of the endemics may get worse, e.g., increased incidence of mange. f. <u>Drought</u> Effects: • too dry for insects that bears use (e.g., ants) • too dry, combined with Mountain pine beetle, wide spread, hot fires that burn down to mineral soil, taking out the berry shrubs, and not allowing "normal" post-fire vegetation recovery as a strategy to promote resilience. g. <u>Insect pest outbreaks e.g., Mountain Pine Beetle</u>

Species	Climate Change Strategies
	Effects: • vegetative change too rapid and extensive; and • increased access due to construction of roads as pine-damaged stands are harvested. h. <u>Change in timing of phenology</u>, resulting in earlier spring emergence, later den entry Effects: • increased vulnerability to bear–human conflict; and • unnatural food supply / food distribution / temporal food availability i. <u>Direct effect on food plants</u> • Example: Mountain pine beetle affecting Whitebark pine in the Coast-Interior transition (a major food in some places) j. <u>Spread of alien and weedy invaders, enhanced or enabled by climate change</u> k. <u>Artificial plant communities replacing important natural forage</u>
Marbled murrelet	Marbled murrelets are vulnerable to changes in both terrestrial and oceanographic conditions. Murrelets are sensitive to changing conditions at sea, with evidence of lower number in some areas and reduced breeding recruitment during El Nino years or years with unusually low marine productivity (Burger 2002, Piatt et al. 2006, Ronconi 2008). More information is needed of marine distributions and how these might change with global climate change e.g., if there is a change in food types or decline in food abundance. If there is a northward shift of ecosystems as a result of climate change, it may have a negative effect on marbled murrelets. The bulk of marbled murrelet populations are in B.C. and Alaska; populations are not as healthy in Washington, Oregon and California (McShane et al. 2004, Piatt et al. 2006). To build resiliency, provide a diversity of habitat across the landbase to accommodate future unpredictable changes in forests and in environmental conditions on land. One way to do this is to retain a range of site series / forest types and habitats for marbled murrelet in reserves distributed across the planning area
Mountain goat	• Functional winter ranges and opportunities for cross-elevational movement become even more critical under unpredictable climate conditions. • Snow interception becomes even more important if increased precipitation is predicted. Increased forested areas to buffer escape terrain in mountain goat habitat complexes will provide additional snow interception cover (do not manage to the minimum 100m width; manage to greater than or equal to 400m). Regardless of climate change effects, bigger buffers will always be the safest approach, although at

Species	Climate Change Strategies
	some point the incremental gain will be insignificant. Due to the risk to goat population viability and the long time spans required to re-establish effective winter range habitat, a precautionary approach is merited. • Expand the elevation extent of winter range habitats into lower and higher elevations to account for shifts in climatic envelopes and maintain options for distribution i.e., allow animals to move up and down in response to changing winter conditions. • Low elevation habitat becomes more important if climate change results in deeper and more persistent snow. • Maintain a distribution of habitats in each landscape unit (including some Type 2 habitats in the South Coast).
Northern goshawk	Reserves should be designed to capture a diversity of habitat complexes, in different elevation bands, that are spatially distributed throughout the planning unit to increase resiliency to climate change. As well, reserves should be designed to be resilient to windthrow; this may occur by considering patch size, shape and orientation. The changing climate has the potential to change (or is changing now) the environment in which goshawks live. One way we can try to mitigate these impacts is to ensure an adaptive management feedback loop is maintained which will identify conditions that provide for successful breeding in goshawks, and, by default, the coarse filter environment (forest structure and prey) on which they depend. Mechanisms must be in place to allow modification of forest management to respond to these changes and promote continued health of the wildlife community. Integral to this adaptive approach to understanding the impacts of climate change; systematic monitoring of known nest areas should be implemented to determine under what conditions goshawks continue to breed successfully.
Tailed frog	Due to its strong link to lotic environments, and the immediate implications of climate change on hydrologic conditions, *A. truei* will likely be immediately responsive to climate change. Winters are to become wetter and warmer, with more extreme storm events, and summers drier and warmer. Snowpacks will melt earlier and summer freshet will end earlier. Thus, due to more severe winter conditions, streams may become more disturbed by flash floods and landslides, and in summer, perennial headwater streams may contract and the density of perennial streams may diminish. These conditions could lead to habitat loss, restricted dispersal, and local extirpation. Application of the cautionary principle is warranted, protecting as much habitat as possible. • Forested buffers should be increased to

Species	Climate Change Strategies
	– help maintain cooler climatic conditions as summer temperatures increase; and – offset winter disturbance effects. • Based on the view that a population is a network of upland stream segments within a greater watershed unit, protection should focus on preservation groups of interconnected streams (Wahbe et al 2004). • Resiliency to change at the regional level can be promoted by distributing reserves across physiographic and climatic gradients, resulting in a diversity of habitat conditions.

5.0 Guidance to detailed landscape unit design

The outputs from the MARXAN tool are not intended to provide a final set of old growth retention areas; the MARXAN scenarios provide spatial outputs to assist technical experts in designing OGRAs within landscape units during more detailed design and planning. In addition, domain experts have summarized a number of important considerations when applying the MARXAN results at a more detailed scale.

5.1 Black bear

Until such time as habitat mapping for black bears is completed, 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.

5.2 Coastal black-tailed deer

5.2.1 Spatial vs aspatial reserve design

There are pros and cons to both spatial and aspatial reserves.

- *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.

5.3 Grizzly bear

If only 50% of Class 2 habitats are to be captured in OGRAs it is important that the most important of these habitats are selected. Priorities for capture of Class 2 habitats are listed in Table 3. In addition, habitat retention within OGRAs should address recommendations for habitat distribution and spatial configuration, as described in section 3.0.

5.4 Marbled murrelet

The main considerations for co-location of marbled murrelet habitat in OGRAs are:

Habitat quality and amount: This analysis assumes the number of marbled murrelets is correlated with the amount of nesting habitat by watershed, therefore as habitat area is reduced, the number of nesting murrelets goes down. The birds will not increase their density into remaining patches as habitat is depleted.

Location of habitat: Amount of suitable habitat within flying range of where marbled murrelets are feeding. Murrelets will not fly far over land but may fly up river drainages that extend more than 50km inland (e.g., Whiting River). The nesting habitats most likely to be used by murrelets generally occur within 30 km of the ocean. Proximity to potential marine foraging areas should be considered, where possible.

Distribution of habitat: Representation of marbled murrelet habitat should accommodate the uneven distribution of high quality habitats across landscape units in the South Coast. However, to the extent possible, there should be a distribution of habitats throughout each subregion.

Specifically:

- Class 1 and 2 habitats have the highest value for marbled murrelets and should be retained on the landbase wherever possible. The loss of any Class 1 and 2 habitats in a landscape unit constitutes a move away from low risk and to a higher risk scenario.
- Class 3 habitats are less important than Class 1 and 2 habitats and there is flexibility as to their location and amount in a given landscape unit.
- The hypermaritime should not be over-represented in OGRAs due to variability in the suitability of marbled murrlet habitats. This situation is being assessed by Ministry of Environment (Contact: D. Donald, MOE Vancouver Island Region).
- Where possible, cluster Class 3 habitats within proximity of Class 1 and 2 habitats to reduce the amount of edge.

5.5 Mountain goat

Any loss of winter range habitat is considered a risk and the amount of risk increases with the amount of alteration. 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 survivorship of populations (Côté and Festa-Bianchet, 2001).

5.6 Northern goshawk

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' that change over time and are linked to landscape-unit wide targets for habitat retention.

5.7 Tailed frog

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.

Outside of stream segments, the priority is to identify OGRAs within basins that contribute to stream segments located in OGRAs.

6.0 References

Burger, A. E. 2002. *Conservation Assessment of Marbled Murrelets in British Columbia: Review of the Biology, Populations, Habitat Associations, and Conservation (Marbled Murrelet Conservation Assessment, Part A)*. Technical Report Series No. 387, Canadian Wildlife Service, Delta, B.C.. URL: http://www.sfu.ca/biology/wildberg/bertram/mamurt/links.htm

Burger, A.E., J. Hobbs and A. Hetherington. 2005. *Testing Models of Habitat Suitability for Nesting Marbled Murrelets, using Low-Level Aerial Surveys on the North Coast, British Columbia*. Report to the Ministry of Water, Land and Air protection. Smithers, B.C.

Burger, A. E. and F. L. Waterhouse. In press. *Relationships between habitat area, habitat quality and populations of nesting Marbled Murrelets*. B.C. Journal of Ecosystems and Management. Accepted Feb 2009.

Burger, A.E., F. L. Waterhouse, A. Donaldson, C. Whittaker and D. B. Lank. In press. *Applications of new methods for assessing nesting habitat of Marbled Murrelets in coastal forests: air photo interpretation and low-level aerial surveys*. B.C. Journal of Ecosystems and Management. Accepted 1 Dec 2008.

CIT (Coast Information Team). 2004. *Coast Information Team Ecosystem-Based Management Planning Handbook.* Integrated Land Management Bureau, Nanaimo, B.C. http://ilmbwww.gov.bc.ca/citbc/

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

Doyle, F. 2006b. When do Naturally Regenerating and Pre-commercially Thinned Second Growth Forests Attain Attributes that will Support Northern Goshawks (*laingi* subspecies) and Marbled Murrelets on Haida Gwaii? Parks Canada, Haida Gwaii, B.C.

Dupuis, L.A. and P. Friele. 2003. *Watershed-level Protection and Management Measures for the Maintenance of Ascaphus treui Populations in the Skeena Region.* Ministry of Water, Land and Air Protection. Smithers B.C.

Dupuis, L.A. and D. Steventon. 1999. *Riparian management and the tailed frog in northern coastal forests.* Forest Ecology and Management 124: 35 – 43.

Fall, A. and Fall, J. 1996. SELES: A Spatially Explicit Landscape Event Simulator. In Proceedings of the 3rd International Conference on Integrating Geographic Information Systems and Environmental Modeling. Santa Fe, New Mexico. Proceedings also available on CD-ROM and the Internet at: www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/main.html.

Frid, L. P. Friele and L.A. Dupuis. 2003. *Defining Effective Wildlife Habitat Areas for Tailed Frog (Ascaphus truei) Populations in Coastal British Columbia.* Ministry of Water, Land and Air Protection. Nanaimo, B.C.

Gordon, S.M. and D.M. Reynolds. 2000. *The use of video for mountain goat winter range inventory and assessment of overt helicopter disturbance.* Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 12:26 – 35.

Hobbs, J. 2003. *Marbled Murrelet Nesting Habitat in the Mid Coast Forest District: An Assessment of the Mid Coast Model*. Unpublished report, Ministry of Water, Land and Air Protection, Habitat Branch, Victoria, B.C. Available from Jared Hobbs (Jared.Hobbs@gov.B.C..ca).

Horn, H.L and Rumsey, C. 2009a. *Management recommendations for focal and fine filter species under Ecosystem-Based Management* (Part 1 of the Focal Species Project report series). Prepared for the Ecosystem-Based Management Working Group.

Horn, H.L and Rumsey, C. 2009b. *Review of Phase 2 Co-Location Scenario Outputs* (Part 5 of the Focal Species Project report series). Prepared for the Ecosystem-Based Management Working Group.

Horn, H.L. 2009a. *Knowledge Base for Focal Species and their Habitats in Coastal B.C.* (Part 3 of the Focal Species Project report series). Prepared for the Ecosystem-Based Management Working Group.

Horn, H.L. 2009b. *Summary of Habitat Mapping to Support EBM Implementation.* (Part 3 of the Focal Species Project report series). Prepared for the Ecosystem-based Management Working Group.

Jex, B. 2004. *Analysis of the Topographic Habitat Attributes for Mountain Goat (Oreamnos americanus) Winter Ranges on the Southern Mainland Coast of British Columbia*. Ministry of Water Land and Air Protection, Chilliwack, B.C.

Lewis, T. and L.K. Kremsater. 2009. *Design Concepts for Landscape-level Reserves: A Comparison of Methods*. Prepared for the Ecosystem-based Management Working Group. 51 pp.

McShane, C., T. Hamer, H. Carter, G. Swartzman, V. Friesen, D. Ainley, R. Tressler, K. Nelson, A. Burger, L. Spear, T. Monagen, R. Martin, L. Henkel, K. Prindle, C. Strong, and J. Keany.

2004. *Evaluation Report for the 5-year status Review of the Marbled Murrelet in Washington, Oregon, and California*. Unpublished report, prepared for U.S. Fish and Wildlife Service, Region 1. Portland Oregon. EDAW, Inc., Seattle, WA. URL: http://www.earthjustice.org/library/background/marbled_murrelet_status_review_pdf.html

MELP (Ministry of Environment, Lands and Parks). 2000. *Mountain Goat in British Columbia: Ecology, Conservation and Management.* Victoria, B.C.

Michelfelder, V. and K. Dunsworth. 2007. *Proposed Wildlife Habitat Ares for the Coastal Tailed Frog (Ascaphus truei) on the Central Coast of British Columbia*. Ministry of Environment. Hagensborg, B.C.

MOE (Ministry of Environment). 2004. *Identified Wildlife Management Strategy, Version 2004: Procedures for Managing Identified Wildlife.* Victoria. B.C.¸

MoF (Ministry of Forests). 2001. *Grizzly Bear Habitat in Managed Forests: Silviculture Treatments to Meet Habitat and Timber Objectives*. Extension Note No. 54. Ministry of Forests Research Program. Victoria, B.C.

Northern Goshawk *Accipiter gentilis laingi* Recovery Team. 2008. Recovery strategy for the Northern Goshawk, laingi subspecies (*Accipiter gentilis laingi*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 56 pp.

Nyberg, J.B. and D.W. Janz (eds). 1990. *Deer and elk habitats in coastal forests of southern British Columbia*. Min. of Forests, Victoria, B.C. Rep. Series 5.

Piatt, J.F., K.J. Kuletz, A.E. Burger, S.A. Hatch, V.L. Friesen, T.P. Birt, M.L. Arimitsu, G.S. Drew, A.M.A. Harding, and K.S. Bixler. 2006. *Status Review of the Marbled Murrelet (Brachyramphus marmoratus) in Alaska and British Columbia.* U.S. Geological Survey Open-File Report 2006-1387. Available at: http://pubs.usgs.gov/of/2006/1387/

Pike, R.G., D.L. Spittlehouse, K.E. Bennett, V.N. Egginton, P.J. Tschaplinski, T.Q.. Murdock, and A.T. Werner. 2008. *A Summary of Climate Change Effects on Watershed Hydrology*. Ministry of Forests and Range, Forest Sciences Program. Extension Note 87

Pollard, T.B and J. Keim. 2006. *Identifying Mountain Goat Winter Ranges in the North Coast of British Columbia.* Ministry of Environment, Skeena Region. Smithers, B.C.

Rodenhuis, D., K.E. Bennett, A.T. Werner, T.Q., Murdock, and D. Bronaugh. 2007. *Climate Overview 2007: Hydro-climatology and Future Climate Impacts in British Columbia*. Pacific Climate Impacts Consortium. University of Victoria. Victoria, B.C.

Ronconi, R. A. 2008. *Patterns and Processes of Marine Habitat Selection: Foraging Ecology, Competition and Coexistence among Coastal Seabirds*. Ph.D. dissertation, Department of Biology, University of Victoria, Victoria, B.C., Canada.

Rumsey, C. 2009. *Co-location Modelling to Inform Old Growth Reserve Selection: EBMWG Project DS04a, Final Report.* Prepared for the Ecosystem-based Management Working Group.

Taylor, S., W. Wall and Y. Kulis. 2004. *A GPS-Telemetry Study of Mountain Goat Habitat Use in South Coastal B.C.* International Forest Products. Campbell River, B.C.

Wahbe, T.R., F.L. Bunnell, and R.B. Bury. 2004. *Terrestrial movements of juvenile and adult tailed frogs in relation to timber harvest in coastal British Columbia*. Canadian Journal of Forest Research 34: 2455–2466.

Waterhouse, F. L., A. Donaldson, and D. B. Lank. 2004. *Using airphotos to interpret Marbled Murrelet nesting habitat in British Columbia: application of a preliminary classification scheme*. Research Section, Coast Forest Region, BC Ministry of Forests. Nanaimo, BC. Technical Report TR-029. 37 pp. http://www.for.gov.bc.ca/rco/research/vanpublicat.htm

Waterhouse, F.L., A.E. Burger, A. Cober, A. Donaldson, and P.K. Ott. 2007. *Assessing habitat quality of Marbled Murrelet nest sites on the Queen Charlotte Islands/Haida Gwaii, by algorithm, air photo interpretation, and aerial survey methods*. B.C. Ministry of Forests and Range, Coast Forest Region, Nanaimo, B.C. Technical Report TR-035. URL: http://www.for.gov.bc.ca/rco/research/vanpublicat.htm

Waterhouse, F. L., A. Donaldson, D. B. Lank, P. K. Ott, and E. A. Krebs. 2008. *Using air photos to interpret quality of Marbled Murrelet nesting habitat in south coastal British Columbia*. B.C. Journal of Ecosystems and Management 9:17–37. URL: http://www.forrex.org/publications/jem/ISS47/vol9_no1_art3.pdf

Waterhouse, F. L., A. E. Burger, D.B. Lank, P.K. Ott, E.A. Krebs, and N. Parker. In press. *Using the low-level aerial survey method to identify Marbled Murrelet nesting habitat*. BC Journal of Ecosystems and Management. Accepted Feb 2009.

Wilson, S.J. and R.J. Hebda. 2008. *Mitigating and adapting to climate change through the Conservation of Nature*. Report to Land Trust Alliance of B.C.. 58 pp.

Appendix 1. List of peer reviewers

The following people recommended co-location methods for each focal species and provided peer review comments. These comments and responses will be summarized in Part 6 of the Focal Species Project reports.

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

Appendix 2. Recommended habitat layers for co-location

Table 6 lists the data layers that are recommended for use in co-location of habitats within OGRAs. With the exception of the northern goshawk data, these data layers are located on the EBM ftp site and can be accessed by contacting ILMB Coast Region. As the file names are in the process of being cleaned up, the current and future file names are both shown. Discussion is still needed as to the custodianship of the new habitat layers developed to support the Focal Species Project; for the time being ILMB is shown as the data custodian. More detailed descriptions of habitat mapping to support co-location is provided in *Part 4: Summary of Habitat Mapping to Support EBM Implementation* (Horn 2009).

This data list is current to March 2009 but is frequently updated. Please contact ILMB Coast Region (Contact: John Sunde) for the most up-to-date information.

Table 12. Recommended habitat layers for use in co-location, as of March 2009.

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
Grizzly Bear	Consolidated GB habitat suitability layer	NC, MC, SC	Class 1 - 6	Various: 2003 - 2007	ILMB	J. Sunde	griz_suit_ncmcsc_20090205.zip	griz_suit_ncmcsc_20090205.zip	Some LUs remain unmapped; entire layer stratified by BEC
	Schedule 2 to the Central & North Coastal Order	NC and MC	Legal polygons	2008	ILMB	LRDW	griz_schedule2_cnc_order_dec1_08.zip	griz_suit_leg_luo_cnc_20081201.zip	
	Schedule 2 to the South Central Coastal Order	MC and SC	Legal polygons	2008	ILMB	LRDW	griz_schedule2_scc_order_dec3_08.zip	griz_suit_leg_luo_scc_20081203.zip	
	Approved SC WHAs 2-073 to 2-075	SC	Legal polygons	2001	MoE VI	D. Donald	griz_wha_phillips_sc.zip	griz_wha_leg_sc_20010913.zip	Field verified
	Approved MC WHAs 5-003 to 5-541	MC	Legal polygons	2006	MoE Cariboo	V. Michelfelder	GB_twha_5-003to541.zip	griz_wha_leg_mc_20060825.zip	Some field verification

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
Tailed Frog	2008 tailed frog model	SC	Class 1 - 4	2008	ILMB	J. Sunde	frog_suit_basins&streams_sc_20081018.zip	tfrg_suit_basins&streams_sc_20081018.zip	Not field verified
	2008 tailed frog model	NC and MC	Class 1 - 4	2008	ILMB	J. Sunde	frog_suit_subbasinsWithHabBuffers_ncmc_20090116.zip	tfrg_suit_subbasinsWithHabBuffers_ncmc_20090116.zip	Not field verified
	Approved SC WHAs	SCC	Legal polygons	2005	MoE - VI	D. Donald	tailed_frog_wha_scc.zip	tfrg_wha_leg_scc_20050214.zip	Field verified
	Proposed MC WHAs (=Tier 1 specified areas):	MC	Core + buffer areas	2007	MoE-Cariboo	V. Michelfelder	Tailed_Frog_basin_CC_fieldverified.zip	tfrg_wha_prop_mc_20071017.zip	Subject to change until approved
	Proposed MC WHAs (=Tier 1 specified areas)	MC	Core areas + basins	2009	MoE - Cariboo	V. Michelfelder	Not yet uploaded and named	Not yet uploaded and named	Subject to change until approved
	Shapefile of tailed frog occurrences	NC, MC, SC	Data points(spatial file)	2006	ILMB	J. Sunde	1225_tailed_frog_locations.zip	tfrg_dta_spat_ncmcsc_ 200671123.zip	

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
Marbled Murrelet	Habitat suitability mapping: air photo interpretation	MC and SC	Class 1 - 6	2006 - 2009	MoE-VI	D. Donald	MAMU_airphotointerp_mcsc_xxxxxx.zip (date updated as new files added)	mamu_suit_ap_mcsc_2009xxxx (date updated as new files added)	Stratified by BEC and distance to ocean class
	Habitat suitability mapping: low level aerial assessment – Estero, Broughton, Gilford and Gray LUs	SC	Class 1 - 6	2008	Interfor	Sally Leigh-Spencer	MAMU_IFP	mamu_suit_flt_sc_ifp_20080122.zip	Stratified by BEC and distance to ocean class
	Habitat suitability mapping: low level aerial assessment – Stafford and Phillips LUs	SC	Class 1 - 6	2008	WFP	John Deal	MAMU_WFP	mamu_suit_flt_sc_wfp_20080429.zip	Stratified by BEC and distance to ocean class
	Habitat suitability mapping: low level aerial assessment – Fulmore LU	SC	Class 1 - 6	2008	MOE-VI	D. Donald	MAMU_flight_data_FulmoreLU.zip	mamu_suit_flt_sc_fulmore_20080311.zip	Stratified by BEC and distance to ocean class
	Consolidated MM air photo interpreted	MC	Class 1 - 6	2009	MOE-Cariboo	V. Michelfelder	Not yet uploaded and named		Stratified by BEC and distance to ocean class

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
	layer								
	Approved MC WHAs	MC	Legal polygons	2006	MOE	V. Michelfelder	MAMU_WHA_new.zip	mamu_wha_leg_mc_20061123.zip	Field verified
	Proposed MC WHAs	MC	Proposed polygons	2008	MOE	V. Michelfelder	MAMU_wha_prop_08_mc.zip	mamu_wha_prop_mc_20080502.zip	Subject to change until approved
	Habitat suitability mapping, Hobbs method	NC	Four class ranking (S,G,F,P)	No date	MOE - Skeena	A. Hetherington	mamu_suit_hobbs_bec_dto_nc_20090209.zip	mamu_suit_hobbs_bec_dto_nc_20090209.zip	Stratified by BEC and distance to ocean class
	Proposed NC WHAs for MM and NG	NC	Proposed polygons	2008	MOE- Skeena	A. Hetherington	mamu_wha_nc.zip	mmng_wha_prop_nc_20080903.zip	Subject to change until approved
Northern Goshawk	NG Recovery Team foraging and nesting model	NC, MC, SC	H value habitat: HSI 0.75 – 1; M + H value habitat: HSI 0,5 – 1	2008	NG Recovery Team	E. McClaren	nogo_hab_ccnc.zip (content files: cc_fhsi_dta.e00 (foraging layer) and cc_nhsi_dta.e00 (nesting layer)	-	Sensitive data. Permission required from the NG RecoveryTeam
	Known NG nest sites, buffered by 800m	NC, MC, SC	Nest area polygons	2008	NG Recovery Team	E. McClaren	NCCC_geoav_800_buff.dbf	-	Sensitive data. Permission required from the NG RecoveryTeam
	Approved NC WHAs	NC	Legal polygons	2005	MOE- Skeena	A. Hetherington	twha_6-003.zip	nogo_wha_leg_nc_20050214.zip	Field verified
	Proposed NC WHAs for MM and NG	NC	Proposed polygons	2008	MOE-Skeena	A. Hetherington	mamu_wha_nc.zip	mmng_wha_prop_nc_20080903.zip	Subject to change until approved

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
Mountain Goat	Habitat suitability: RSF of female MG habitat	SC	Type 1 (VH) = RSF 0.185 – 1; Type 2 (H): RSF 0,024 – 0,185	2008-9	MOE-VI	K. Brunt	goat_uwr_mod_fem_sc_20090127.zip	goat_uwr_mod_fem_sc_20090127.zip	Not field verified, , except where overlaps legal UWRs and goat inventories
	Habitat suitability: MC algorithm	MC	Suitable/ Not suitable	2008	MOE-Cariboo	V. Michelfelder	goat_nosunhi_mc.zip	goat_uwr_mod_mc_20081009.zip	Not field verified, except where overlaps legal UWRs
	Habitat suitability: NC RSPF model	NC	Suitable/ Not suitable	2006	MOE-Skeena	L. Vanderstar	goat_nc_uwr.zip	goat_uwr_mod_nc_20060403.zip	Some field verification
	Approved SCC UWR (deer, goat and elk)	SCC	Legal polygons	No date	MOE-VI	D. Donald	uwr_scc not incl Phillips.zip	ung_uwr_leg_scc_nophillips_nodate.zip	Field verified
	Proposed SC UWR (Phillips LU)	SC	Proposed polygons	May 2008	MOE-VI	D. Donald	gwr_phillips_May2_08.zip	goat_uwr_prop_sc_phillips_20080502.zip	Subject to change until approved
	Approved MC UWR	MC	Legal polygons	2006	MOE	V. Michelfelder	Goat_wr.zip	goat_uwr_leg_mc_20061123.zip	
	Proposed NC UWR	NC	Proposed polygons	2007	MOE-Skeena	L. Vanderstar	Goat_uwr07_nc.zip	goat_uwr_leg_nc_20070719.zip	Subject to change until approved

Focal species	Description of data	Sub-region	Habitat definition	Year developed	Data custodian	Contact	Current file name	Proposed corrected file name	Issues
Coastal Black-tailed Deer	2008-9 coastal deer habitat model – SC layer	SC	See section 3.1.1.2	2009	ILMB	J. Sunde	deer_suit_mod_sc_20090120.zip	deer_suit_mod_sc_20090120.zip	Acceptable for strategic use; not field verified
	2009 coastal deer habitat model – MC layer	MC	See section 3.1.1.2	2009	ILMB	J. Sunde	deer_suit_mod_mc_200903xx.zip	deer_suit_mod_mc_200903xx.zip	Acceptable for strategic use; not field verified
	2009 coastal deer habitat model – NC layer	NC	See section 3.1.1.2	2009	ILMB	J.Sunde	deer_suit_mod_nc_200903xx.zip	deer_suit_mod_nc_200903xx.zip	Acceptable for strategic use; not field verified
	Approved SCC UWR (deer, goat and elk)	SCC	Legal polygons	2003 - 2006	MOE	D. Donald	uwr_scc not incl Phillips.zip	ung_uwr_leg_scc_nophillips_nodate.zip	Field verified
	Approved MC UWR	MC	Legal polygons	2007	MOE	V. Michelfelder	Deer_WR_Mid_Coast.zip	deer_uwr_leg_mc_20070302.zip	Field verified
Moose	Habitat suitability mapping	NC	Suitable/ Not suitable	No date	MOE-Skeena	L. Vanderstar	moose_nc.zip	moos_uwr_prop_nc_nodate.zip	Not used for co-location – has been included here for completeness
	Proposed MC UWR	MC	Proposed polygons	No date	MOE	V. Michelfelder	Moose_combined.zip	moos_uwr_prop_mc_nodate.zip	
Other WHAs	Proposed MC WHAs for sandhill cranes	MC	Proposed polygons	2008	MOE-Cariboo	V. Michelfelder	crane_propwha_mc.zip	sacr_wha_prop_mc_20080416.zip	

Appendix 3. Habitat Cut-offs for Coast-wide Deer Mapping

The following are the habitat cut-offs define moderate and high value habitats for the purposes of co-location:

i. North Coast

Classification	Habitat Rating
MOUNTAINS	
High	4 to 7
Moderate	8 to 9
Low	10 to 16
COASTAL AREAS	
High	4 to 6
Moderate	7 to 9
Low	10 to 16

North Coast Ecosections

<u>Coastal areas:</u>

Hecate Lowland

Dixon Entrance

Hecate Strait

North Coast Fjords

Queen Charlotte Sound

<u>Mountains:</u>

Kitimat Range

Southern Boundary Range

Nass Mountains

Southern Boundary Range

Meziadin Mountains

c. Mid Coast

Classification	Habitat Rating
MOUNTAINS	
High	4 to 7
Moderate	8 to 9
Low	10 to 16

COASTAL AREAS	
High	4 to 6
Moderate	7 to 9
Low	10 to 16

Mid Coast Ecosections

Coastal areas:

Hecate Lowland

Queen Charlotte Sound

Mountains:

Kimsquit Mountains

Kitimat Ranges

Nazko Upland

Nechako Upland

Northern Pacific Ranges

Western Chilcotin Ranges

Central Pacific Ranges

iii. South Coast

Note: the cut-offs for the South Coast were different to those applied in the co-location experiments described in Appendix 2).

Classification	Habitat Rating
MOUNTAINS AND COASTAL AREAS	
High	4-6
Moderate	7
Low	8-16