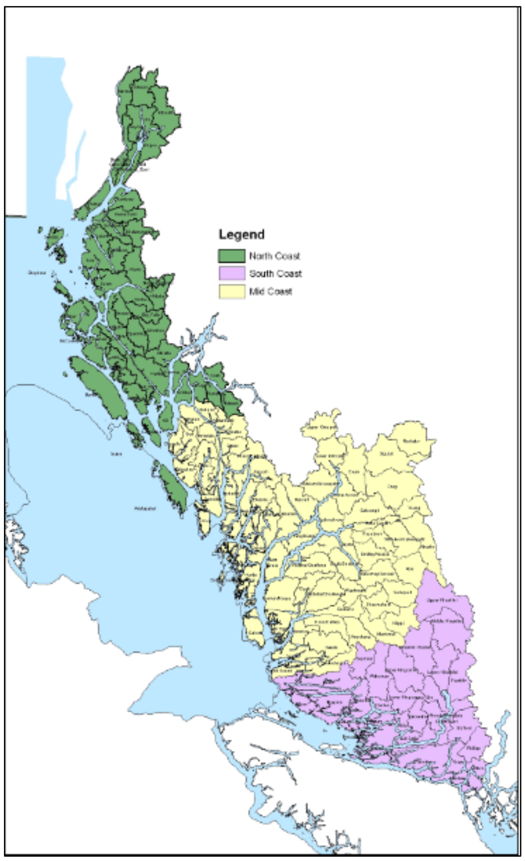
EBM Working Group Focal Species Project

Part 4:

Summary of Habitat Mapping to Support EBM Implementation



Prepared for

Ecosystem-Based Management Working Group

by

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April 2009

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.

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Acknowledgements

Many thanks to John Sunde, Scott Allen and the hard-working team at ILMB for their support with mapping for the Focal Species Project. Thanks also to Ministry of Environment staff and others who put so much time and effort into updating map projects within the EBM Working Group timelines and in providing resources to ensure projects were completed. Particular thanks to Kim Brunt, Dave Donald, Tanya Dunlop, Ken Dunsworth, Steve Gordon, Troy Larden, Volker Michelfelder, Kathy Paige and Buck Tanner. Thanks also to Sally Leigh-Spencer, Dave Leversee, Glenn Sutherland, Pierre Friele, Mark Hafer, Brad Pollard and Shawn Taylor for providing expertise into completing map products and to all domain experts for their knowledgeable input concerning habitat mapping.

1.0 Introduction

1.1 Background

One of the key tasks of the EBM Working Group EI02c Focal Species Project was to review and update habitat mapping to support EBM implementation, in particular the co-location of focal species habitat within areas of old growth retention.

Habitat models for each of seven focal species were completed and peer reviewed in 2004 to use as inputs into Coast Information Team Ecosystem Spatial Analysis (CIT ESA). Most of the mapping at the time was based on GIS algorithms that were relatively coarse but that provided useful inputs to the CIT ESA. Mapping and data gathering has continued in the years since the CIT ESA was completed. By March 2009, updated mapping was available for six of the seven focal species. Domain experts for the Focal Species Project reviewed the most current habitat mapping, provide input into mapping updates and have recommended additional improvements to ensure that the best available spatial information is available on each species.

The following biologists reviewed habitat mapping to support the EI02c Focal Species Project and provided guidance in updating habitat layers:

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

1.2 Document Outline

This document provides a summary of the current status of habitat mapping in the coastal planning region as of March 2009. A list of the currently recommended data layers is provided in Appendix 1. This list is subject to ongoing change as mapping is updated.

This report is Part 4 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

1.3 Description of study areas

The coastal planning region comprises the boundaries of the North and Central Coast Land and Resource Management Plans (LRMPs). For the purposes of the Focal Species Project, the region is divided into three sub-regions that are referred to in this report: North Coast, Mid Coast and South Coast (Figure 1). The boundaries of each sub-region are defined by the landscape units that are in each.

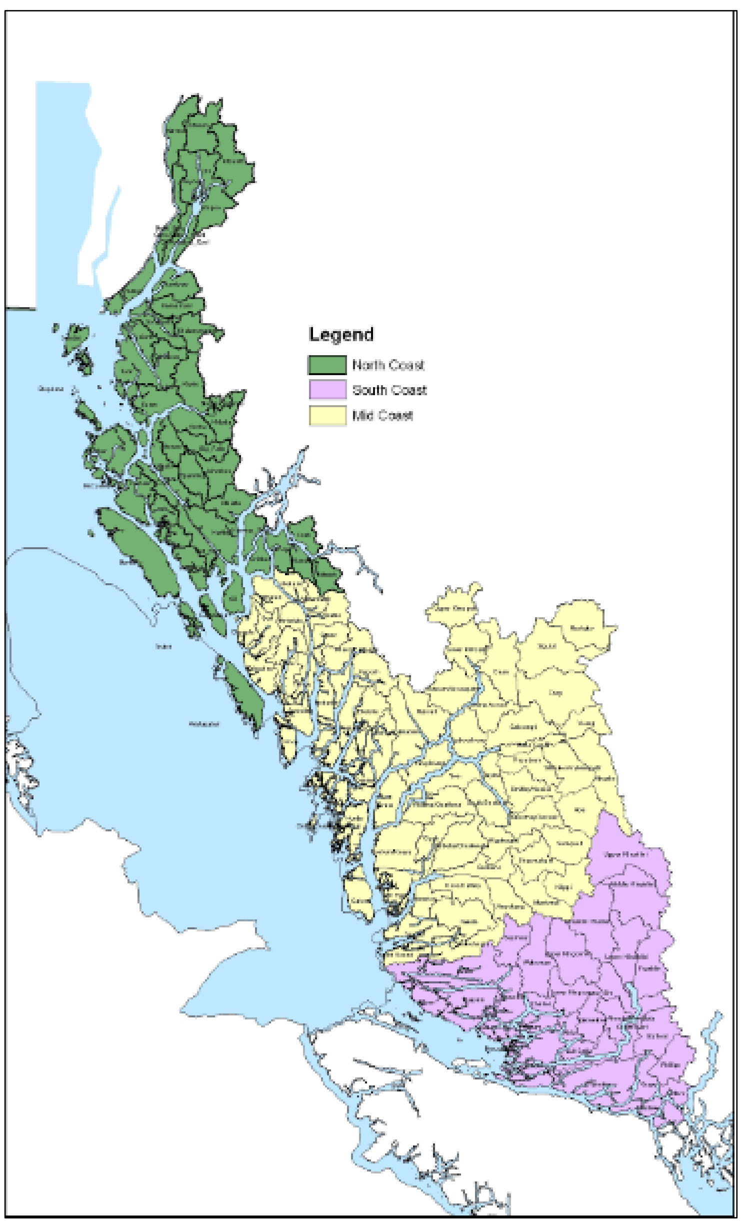

Figure 1. Sub-regions for coastal planning

2.0 Black Bear

Domain experts:

Helen Davis, Artemis Wildlife Consultants

Tony Hamilton, B.C. Ministry of Environment

Grant MacHutchon, A. Grant MacHutchon Consulting

2.1 Status of mapping of black bear habitats

The existing black bear habitat suitability layer, based on 1:250,000 Broad Ecosystem Inventory (BEI), was considered by domain experts and rejected for the following reasons:

- The maps were small scale, i.e., 1:250,000, therefore each map unit covers a large area on the ground. Typically this scale of mapping has minimum polygons of approximately 40 ha. This means any habitat ratings assigned are necessarily generalized across a large area, whereas the habitat within those polygons that is actually high suitability may only make up a small percentage of the polygon area. Conversely, since the BEI assignment to each polygon is based on the most common unit within a polygon, habitats that may be high suitability for black bears are not necessarily “captured” by the mapping, therefore effectively lost in the suitability map.
- The scale of mapping is so much smaller for black bear habitat than other species, therefore it would make it difficult to compare among species, particularly when comparing black bear with grizzly bear habitat.
- In specific areas examined, the habitat maps did not match with known (field-assessed) high-quality habitats.

Given the above:

- The black bear habitat suitability map does not adequately reflect the habitat requirements of black bears in the study area at the scale of OGRA planning.
- Both from a scale perspective and a habitat representation perspective, any scenarios considering the influence on black bears will be misleading, whether considered in the initial modelling or post-hoc.

Comprehensive mapping has been completed of Class 1 and 2 grizzly bear habitats. These have some use as a proxy for black bear habitats as they comprise important habitat elements such as wetlands and avalanche chutes. However, black bears, in particular females with cubs, have been shown to use habitats poorer in forage and salmon abundance where there is overlap with grizzly bears or male black bears (MacHutchon et al. 1998, Fortin et al. 2007).

A black bear habitat model should consider the following (Davis et al. 2006, Powell et al. 2007):

- Seasonal food abundance and distribution (vegetation and salmon);
- Denning habitat;
- Security cover;
- Habitat effectiveness (distance from roads and human activities);
- Mortality risk (from all human causes) ; and
- Connectivity/corridors.

It is important to capture habitats such as wetlands, estuaries, and foreshore areas. Mapping of black bear habitat has already been completed for Princess Royal Island based on interpretations of 1:50,000 TEM (Norecol, Dames & Moore, Inc. 1997). There has also been mapping completed for TFL6 where habitat rankings for black bear have been identified based on BEC variant, seral stage, and site series groupings in terms of forage and den value (Kremsater et al. 1999). Black bear mapping for the coast might be improved by using a resource selection function based on Davis et al. (2006) and existing den data.

Canadian Forest Products has developed a den model for the Nimpkish Valley (Manning, Cooper and Assoc. 2003). Due to the limited amount of data on actual den sites on the coastal mainland, it would be useful for strategic planning to estimate potential denning sites based on structural stage and site series. Western Forest Products has a den catalogue and has completed work on coastal black bears (contact: John Deal). A denning model is also under development for Princess Royal Island and mainland areas (McCrory et al. 2008). This model needs to be tested with a telemetry study.

2.2 Recommendations to improve mapping

- Assemble all existing mapping projects for black bear from coastal B.C., including data from studies that have been completed to date (e.g., TFL 6, Princess Royal Island).
- Complete coast-wide habitat suitability mapping for black bears, using available den data and based on resource selection function or an expert-based approach, to be used as an input to future MARXAN co-location efforts. The most useful base layer for mapping of black bear habitat is TEM. If future mapping is based on TEM, then a specific model can be applied for black bears rather than basing mapping on the current grizzly bear classifications.

  Two different TEM-based habitat models are required for black bears:

  - Black bear habitats outside of grizzly-occupied areas (e.g., in hypermaritime areas).
  - In areas where there is overlap with grizzly bears, mapping to provide interpretation of all habitat classes within landscape units (currently only Class 1 and 2 grizzly bear habitats have been comprehensively mapped).
- Ranking of BEC or TEM unit habitat values should be based on telemetry data or field surveys by bear experts in as many study areas as possible.
- Model den potential based on age class, structural stage and site series.

2.3 References

Davis, H., R. D. Weir, A. N. Hamilton, and J. A. Deal. 2006. *Influence of phenology on site selection by female American black bears in coastal British Columbia*. Ursus 17:41-51.

Kremsater, L., H. Davis, and D. Byng. 1999. *Developing GIS algorithms to predict black-tailed deer winter range, elk winter habitat, marbled murrelet nesting habitat and black bear habitat in TFL #6*. Western Forest Products. Vancouver, B.C..

Manning, Cooper and Associates. 2003. *2002 Black Bear Winter Den Inventory: TFL37, North*

McCrory , W. P. , P. Paquet and B. Cross. 2008. *An evaluation of winter den ecology of grizzly and black bears on the B.C. Coast: Development of den habitat models as a tool for conservation planning.* Draft report.

Norecol, Dames & Moore, Inc. 1997. *Terrestrial ecosystem mapping for Princess Royal Island: wildlife interpretations.* Prepared for the B.C. Ministry of Environment, Lands and Parks and B.C. Ministry of Forests, North Coast Forest District.

Powell, R. A., J. W. Zimmerman, and D. E. Seaman. 1997. *Ecology and behaviour of North American black bears: Home ranges, habitat and social organization*. Chapman and Hall, London, United Kingdom.

3.0 Coastal Black-tailed Deer

Domain experts:

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

Sally Leigh-Spencer, International Forest Products

Description of mapping parameters:

Brunt et al. 2009

3.1 Status of mapping of coastal black-tailed deer habitats

There are two coverages of winter range for black-tailed deer:

1. A modelled estimate of winter range suitability for deer in the South Coast sub-region
2. A legal ungulate winter range layer (UWR) showing polygons of habitat designated under the Government Actions Regulation.

The deer model for the Mid Coast sub-region was not completed due to uncertainties in the map outputs.

The deer model for the North Coast sub-region was also not completed for two reasons: (1) a lack of knowledge about deer winter habitat attributes in the North Coast; and (2) a low priority for managing the species in the sub-region.

3.1.1 Modelled winter range: South Coast

Mapping of deer winter range suitability for the entire coastal planning area was completed by Coastal Resources Mapping in 2009 to support the EBMWG focal species project. This report describes the model for the South Coast.

Although results of this mapping exercise have not been ground-truthed, the outputs of this habitat model have been reviewed for the South Coast sub-region and are believed to provide a reasonable approximation of deer winter range for the purposes of strategic planning, with the clear proviso that users be aware of its' limitations (see section 3.2). This model will be refined and improved over time.

3.1.1.1 Model parameters

Model variables include: slope/aspect, elevation, BEC variant, and solar index. BEC variant was used as a surrogate for snowpack. These variables are not independent of one another. Domain experts consider that, collectively, this combination of variables provides better predictability than if independent variables were used.

Each variable had four potential values depending on its contribution to deer winter range from 1 (best) to 4 (worst). A Habitat Rating for each map cell was then established as the sum of the ratings for each variable at that cell with the result varying from highest quality (4) to lowest quality (16) habitat.

The following were excluded from the final layer:

- Stands with leading species of western redcedar, yellow cedar and mountain hemlock;
- Forested stands less than 140 years in age; and
- Non-productive and non-forested areas.

- Habitat patches <40 ha in size were excluded (smaller patches within 50 m of each other that collectively exceeded 40 ha were included).

3.1.1.2 Habitat ratings

The following cut-offs for habitat values (high, moderate and low) were based on a review of model output by domain experts compared against a coarse estimate of a 25% – 50% – 25% distribution of High – Moderate – Low value habitats across each sub-region.

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

3.1.2 Mapping of designated Ungulate Winter Ranges

Legally designated UWRs represent well-defined habitats that have received some field-truthing. They are a subset of all deer winter range habitat available, having been selected, in part, to minimize impacts to timber supply. Legal UWRs have been approved in the Mid and South Coasts but not for the North Coast.

3.2 Limitations and uncertainties associated with deer mapping

- 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.

  There is a specific issue about the reliability of model output for the Klinaklini. For example, there is no Mountain hemlock leading species identified in the TSA area, but there are large areas labelled as Douglas-fir leading species not noted in the TFL area indicating inconsistencies in forest cover information between the two tenure areas.
- The coastal deer model used BEC subzones as a surrogate for snow zones. BEC is a coarse surrogate for snow zones. It is a better integrator than elevational range as it takes into account shading and slope/aspect influences on vegetative cover, but the results may nonetheless be unreliable, especially at finer scales. TEM would provide a higher level of confidence in model output.

3.3 Recommendations to improve mapping

3.3.1 South Coast model

- There is a large amount of variability in deer habitats that is impossible to capture using GIS. The deer habitat model should be field-truthed to confirm model veracity. On-site assessment is particularly important for deer, as they select suitable habitat based on site specific habitat attributes, which may not be well-represented through modeling. Testing a winter range suitability model requires consideration of the interactions between the extent and location of forest development and its likely effect on deer behaviour patterns, the severity of winter weather during the period of sampling and its likely effect on deer behaviour patterns and input data error.

- Evidence of use by deer can also be used to confirm winter range suitability, but current population levels need to be known to infer habitat quality related to levels of use. A lack of use does not necessarily indicate poor habitat quality. For example an area may be high quality habitat but not show evidence of current or recent use due to local predation or some other population limiting factor.

3.3.2 Mid Coast model

The initial map outputs from the Mid Coast mapping indicated a fifty-fold difference in the amount of high value deer habitat compared to the South Coast. This raised a flag with domain experts and a decision was made to not use the Mid Coast deer layer until this anomaly could be looked into.

Unlike the South Coast model, the habitat model for the Mid Coast did not exclude cedar-leading stands (Cw and Yc). This is because, in the Mid Coast, cedar stands dominate the landscape, including many of the areas where deer are wintering on the Outer Coast. A proposed next step is to test the model against changes in one or more variables (e.g., removing cedar-leading stands) to assess the final product in terms of its capture of critical deer winter range.

Model outputs should be carefully reviewed by biologists with knowledge of the local area to ensure that the final habitat polygons reflect known information.

3.4 References

Brunt, K., K. Dunsworth and S. Leigh-Spencer. 2009. Coastal Black-tailed Deer Mapping Report. Prepared for the EBM Working Group. ILMB, Nanaimo, B.C.

4.0 Grizzly Bear

Domain experts:

Grant MacHutchon, A. Grant MacHutchon Consulting

Tony Hamilton, B.C. Ministry of Environment

Description of mapping methods:

Leigh-Spencer 2003; 2007

MacHutchon 2007; 2008

Palfrey 2003

4.1 Status of mapping of grizzly bear habitats

4.1.1 Overview

Comprehensive mapping of grizzly bear habitat suitability has been completed in three coastal sub-regions as follows:

- <u>South-Central Coast:</u> There were four projects completed between 1999 and 2006 using a variety of mapping methods and ratings of habitat quality (suitability and capability) These different projects were amalgamated by Grant MacHutchon in 2006-07 and additional air photo mapping undertaken in 2007 to provide coverage of the entire South-Central Coast planning area (MacHutchon 2007, Leigh-Spencer 2007) with the exception of the Smith Sound, Smokehouse, Mid Klinaklini, and Upper Klinaklini LUs.

  Three of the six projects mapped grizzly bear habitat complexes with forested buffers, one project mapped grizzly bear habitat complexes without forested buffers, and two projects assigned suitability ratings to Terrestrial Ecosystem Mapping (TEM) polygon ecosystem units.

- <u>Mid Coast:</u> There was one major project to map grizzly bear habitat complexes with forested buffers in the Mid-Coast portion of the South-Central Coast and North and Central Coast planning areas (Palfrey 2003). Mapping of the Green LU was subsequently completed in fall 2008. Suitability ratings were also assigned to TEM units for blocks of TFL 39 and a large number of WHAs for grizzly bears have been approved for the Mid Coast.

  The various Mid Coast map layers were consolidated into a single layer in November 2008. The TFL39 layer was not included in this consolidated layer as the two layers had a different data structure. Grizzly bear habitat mapping has not been completed for the Atnarko, Kynoch, east Sheep Passage, Khutze, Aaltanhash, and Klekane LUs.

- <u>North Coast:</u> Air photo interpretive mapping was completed for the entire North Coast Land and Resource Management Planning (LRMP) area in 2008 (MacHutchon 2008).

A 'seamless layer' has been created for the entire coastal planning region that combines all of the above mapping.

Grizzly bears mainly occur east of a defined 'line of grizzly bear occupation' which is based on known occupancy by adult females. Mapping of grizzly bear habitat suitability was within the line of known grizzly bear occupation.

4.1.2 Air photo interpretive mapping

The best available mapping is considered to be that which specifically identified grizzly bear habitat polygons using air photo interpretation and some field verification. Highest value (Class 1 and 2) grizzly bear habitats have been mapped for the entire coastal planning area at

1:20,000 and their suitability to bears ranked according to the provincial 6-class system (RIC 1999).

The emphasis of grizzly bear habitat mapping was on polygons considered to be Class 1 or 2 in at least one season. However, occasionally habitat polygons were mapped and provisionally classed as 3 or 4 pending field assessment as the person doing the mapping was uncertain of their suitability for grizzly bears from air photo interpretation alone. Some of these polygons were subsequently upgraded to Class 2 or remained as Class 3 or 4 following field assessments. In some cases, polygons originally mapped as Class 2 were downgraded to Class 3 or 4 based on field assessments. Nevertheless, these few Class 3 or 4 polygons were retained in the database. Other than this incidental mapping of Classes 3 and 4 habitats, no other mapping of Classes 3 – 5 exists outside of TEM-interpreted areas.

The focus of air photo mapping in the South-Central Coast and Mid-Coast was spring and summer habitats, although habitat ratings were given for all four seasons (MacHutchon 2007). For the purposes of this project, it was assumed that fall habitats would be adequately addressed through management of aquatic habitats under the Coastal Orders. However, because there is overlap in seasonal habitats, most of the habitats used across seasons were captured, including fall habitat (e.g., floodplain forest is valuable as both summer and fall habitat). All seasons were considered during the North Coast mapping.

The widths of forested buffers were determined based on terrain and the type of forest adjacent to the feeding habitat (MacHutchon 2007).

4.2 Limitations and uncertainties associated with grizzly bear mapping

The following limitations in map inputs to the co-location necessitate careful scrutiny of co-location outcomes for completeness of coverage e.g., of all seasonal requisites.

- The mapping for the Mid and South Coast sub-regions comprises several different projects using a variety of methods to identify and rate habitat suitability. Each method yielded outputs adequately reliable for the purposes of habitat management, but the approaches different enough that the end products are not always completely comparable. Some of the outputs have been field verified.

  One key difference is that mapping in some areas of the South Coast did not include buffering of habitat complexes. In this case, the delineation of buffers was deferred to operational planning (Leigh-Spencer 2003).

- Mapping in the South-Central Coast and Mid Coast did not specifically consider fall salmon spawning habitat, although it was likely included as a result of overlap with summer feeding habitats. All seasons of use were considered during the North Coast mapping.

  Delineation of the actual spawning reaches where bears fish can be problematic. These stream sections may be quite small and the number of fish variable (R. Flynn. Alaska Department of Fish and Game, pers. comm.). Several projects are underway to refine known distribution of spawning reaches in coastal B.C.

- Mountain hemlock habitats were not mapped for South-Central Coast and Mid Coast but were included in the North Coast.

- Mapping did not include consideration of habitat alienation adjacent to high traffic roads and human settlements (effectiveness mapping). The majority of coastal B.C. grizzly bears occupy landscapes with few high traffic roads and settlements so this is not considered a major limitation.

- While TEM provides a reliable and effective land classification for rating habitat values, there are challenges with its use for spatially explicit assessments. Each TEM polygon can have up to three ecosystem units; the minimum being 10% of the polygon.

  For presentation purposes, the overall polygon rating for grizzly bears used the rating of the highest suitability ecosystem unit within the polygon during each season, regardless of what percentage of the polygon that unit made up. Consequently, in many cases a larger area appears to be Class 1 or 2 than actually occurs in the polygon and there is no way to tell where the Class 1 or 2 habitat is located within the larger polygon. For this reason, the TEM mapping has not proved as useful as the grizzly bear-specific air photo mapping for the purposes of co-location.

- Small and isolated pockets of habitat might be missed in the air photo mapping. The mapping occurred over a large geographic area and some habitats were not of large enough aerial extent to be mapped or were possibly overlooked.

- Polygon boundary line-work for grizzly bear habitat mapping projects in the South-Central Coast and Mid Coast were transferred by hand from air photos to 1:20,000 TRIM before being digitised in a GIS so there may be considerable spatial error in the resulting digital line-work at operational scales (e.g., 1:5000). This is a minor issue for co-location planning at the strategic scale.

- In some mapping projects, little or no field verification of polygon line-work, ecosystem unit classification or habitat suitability ratings was done.

4.3 Recommendations to improve mapping

- Refine the single consolidated map layer of habitat suitability for the coastal planning area as follows.
  - Where necessary, adjust data structures to allow all map layers to be amalgamated.
  - Several LUs in the South-Central and Mid Coast do not have any grizzly bear habitat mapping, including Smith Sound, Smokehouse, Mid Klinaklini, Upper Klinaklini, Atnarko, Kynoch, east Sheep Passage, Khutze, Aaltanhash, and Klekane. However, this mapping was underway at the time of preparing this report.
  - Undertake air photo-interpreted grizzly bear habitat mapping for the Phillips and Fulmore LUs to use as an alternative to the existing TEM-interpreted mapping to make these map layers compatible with other LUs in the coastal planning area.
- The Scott Paper license area in the Klinaklini River has had grizzly bear habitat mapped, but is missing other spatial data for the co-location efforts. This is a gap in the forest cover/ vegetation resource inventory.
- At the landscape scale, identify nodes of (a) highest quality and concentration of habitats and (b) highest densities of overlapping home ranges that anchor the regional population. These nodes can be identified using broad scale population distribution modelling and should be prioritized for conservation. Some of these areas have been identified in the southern Coast Ranges.

4.4 References

Leigh-Spencer, S. 2003. *Grizzly bear habitat mapping, Clyak, Neil, Young, Milton, and Ingrig drainages*. International Forest Products, Campbell River, B.C.

Leigh-Spencer, S. 2007. *Grizzly bear air photo habitat assessments, Klinaklini Glacier, Franklin and Estero Landscape Units within the CCLRMP*. B.C. Ministry of Environment, Black Creek.

MacHutchon, A.G. 2007. *Mapping Methods for Important Coastal Grizzly Bear Habitat. Ministry of Environment.* Victoria, B.C.

MacHutchon, A.G. 2008. *North Coast, B.C. grizzly bear habitat mapping*. B.C. Ministry of Environment, Smithers and Ecosystem Based Management Working Group.

Palfrey, N. 2003. *Grizzly bear habitat mapping, Central Coast, B.C., 2003*. B.C. Ministry of Environment, Lands and Parks, Williams Lake, B.C.

RIC (Resources Inventory Committee). 1999. *British Columbia wildlife habitat rating standards. Version 2.0*. Terrestrial Ecosystems Task Force, Resources Inventory Committee, Victoria, B.C.

5.0 Marbled Murrelet

Domain experts:

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

Alan Burger, Alan Burger Consulting and University of Victoria

Peter Arcese, University of British Columbia

Description of mapping methods:

Burger 2004

Burger et al. *In press*

Donaldson 2004

Hobbs 2003

Waterhouse et al. 2008

5.1 Status of habitat mapping

There are four different habitat layers of marbled murrelets in the coastal planning region:

5.1.1 CMMRT habitat suitability mapping

As of August 2008, there was seamless coverage of CMMRT habitat mapping for the entire study area based on stand age, height class, crown closure and elevation, done by the Ministry of Environment (M. Mather and T. Chatwin, MoE, Nanaimo). The CMMRT layer uses a bimodal classification i.e., habitat is classed as being either Habitat or Not Habitat with Habitat being most or moderately likely to provide suitable nesting habitat. Based on the review by the recovery team (CMMRT 2003), suitable habitat is defined as forest with a combination of age class >140 years (age class 8+), height class ≥ 28.5 m (height class 4+) and elevation.

5.1.2 Hobbs suitability mapping

The 'Hobbs model" uses a more detailed algorithm than the CCMRT model, using stand age, height class, crown closure, elevation, slope and dominant tree species (details in Hobbs 2003). The product is a 4-level ranking of habitat quality (Superior, Good, Fair and Nil).

5.1.3 Air photo interpretive mapping

Recent methods using air photo interpretation or low-level aerial surveys have been developed to map potential nest habitats based on known habitat features (Burger 2004). These methods of mapping use a 6-level ranking system to assess the suitability of forest stands as murrelet nesting habitat (Burger 2004). The ranking gives 1 to the highest rank (key habitat features area present in abundance; nesting is highly likely), 2 – 5 for lower ranked habitats and 6 for nil habitats (all key habitat features are absent and nesting is impossible).

Air photo interpretation mapping is being completed for the entire coastal planning area (completion date March 2010). Forest structural attributes important to nesting marbled murrelets are assessed from air-photos using a standard protocol (Donaldson 2004; Waterhouse et al. 2008, Burger et al. in press). The method allows an analysis of the structure and complexity of the forest canopy, tree size, micro-topography and other features that are not always accurately captured in forest cover data (Donaldson 2004). Thus habitat mapping is not constrained by elevation or slope but focuses on forest structure. This qualitative habitat classification follows the recommendations of the CMMRT (2003) with assessed attributes including tree height, crown closure, vertical complexity, canopy complexity (Donaldson 2004).

As of February 2009, air photo mapping is completed for the Mid and South Coasts. Mapping of the North Coast will be completed in the 2009/ 10 fiscal year. Most air photos used in the South Coast were less than 5 yrs old although older photos were used to fill some gaps. All of the Mid Coast the northern portion of the South Coast was based on digital images that were captured in 2007.

5.1.4 Low-level aerial assessment

Low-level aerial surveys following a standard protocol are undertaken to field verify the presence and relative abundance of the micro-habitat features important for nesting murrelets (Burger 2004). Surveys are useful for field identifying the presence and abundance of potential nest platforms and epiphyte cover, which are not detectable from air photos and forest cover layers (Burger 2004, Burger et al. in press). As for air photo interpretation, habitats are ranked according to a 6-level system.

In the South Coast, low-level aerial assessment has been completed for six landscape units (Stafford, Phillips, Fulmore, Estero, Gray, and Gilford). Low-level aerial surveys are also being used to verify the air photo interpretation habitat mapping by MoE (D. Donald, MoE, pers. comm.).

5.2 Comparison of map layers

Of the various map layers for marbled murrelets on the Coast, air photo interpretive mapping is currently the best available habitat layer for strategic planning purposes. While low level aerial assessment is a more accurate method of habitat mapping (Waterhouse et al. 2008), it is expensive and is not available over extensive areas within sub-regions.

Air photo interpretation has greater accuracy and resolution than mapping based on GIS algorithms. It allows a specific focus on attributes important to marbled murrelets and is not reliant on the availability and accuracy of forest cover data (MoE 2004; MoFR 2007; Waterhouse et al 2008, Burger et al in press). Air photo mapping also allows habitat to be ranked into six classes, providing greater resolution of habitats than the bimodal classification (suitable and non-suitable) applied to GIS algorithms. The air photo interpreted layer for the Coast, once completed, will provide seamless coverage and will not be limited to areas covered by forest cover or VRI data.

Where air photo or low-level aerial mapping is not available, domain experts recommend the use of the Hobbs model for the purposes of MARXAN analysis. This is because the Hobbs model, with its four habitat ranks, provides greater flexibility for habitat representation than the bimodal CMMRT model. In addition, the Hobbs model has been applied to the Mid and North Coast sub-regions and, therefore, can provide continuous coverage in these two sub-regions for the purposes of the analysis.

Field surveys in the North Coast have verified that both the Hobbs model and CMMRT model perform well in predicting suitable nesting habitat but are less successful at predicting when habitat is not suitable or Nil (Burger et al. 2005).

5.3 Limitations and uncertainties of marbled murrelet mapping

- Aerial surveys indicate that Biogeoclimatic Ecosystem Classification (BEC) variants in the hypermaritime (Coastal Western Hemlock (CWH) vh, vh1, vh2 variants) appear to be less suitable for marbled murrelet nesting than suggested by GIS algorithms or air photo interpretation (Burger et al. 2005, D. Donald, MOE, pers. comm.). Overestimates may occur because there are big trees in these areas but they have little moss for nesting platforms and are subject to a wind shear effect closer to the ocean creating more closed canopies.

- There has not been a comparison of maps created using air photo interpretation and low level aerial assessment, therefore it is not known if similar polygon units are produced by both methods and how habitat rankings differ. Ministry of Environment is undertaking comparisons of polygons resulting from these two methods of classification (contact: D. Donald, MoE, Vancouver Island Region).

5.4 Recommendations to improve mapping

- Field verify habitat quality in the hypermaritime (i.e., CWHvh1 and vh2) with the possibility of down-ranking air photo interpretations by one class e.g., from Class 2 to a Class 3. An assessment is underway on the South Coast (Contact: D. Donald, MoE, Vancouver Island Region).
- Undertake low level aerial surveys of areas mapped using air photo interpretation to test and verify the habitat rankings applied. In particular, verify Class 1 - 3 habitats as these are to be used to drive the MARXAN co-location scenarios.
- Use recent satellite imagery to remove any recent cutblocks that might still show as habitat in older forest cover data or air photos.

5.5 References

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5.0 Mountain goat

Domain experts:

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Brad Pollard, McElhanney Consulting Services, Ltd.

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

***Description of mapping methods*:**

Pollard and Keim 2006

Taylor et al. 2004

Each coastal sub-region has a different habitat suitability layer for mountain goats. These are described below.

5.1.1 Habitat suitability models by sub-region

5.1.1.1 North Coast

Mapping of mountain goat winter range in the North Coast sub-region was completed in 2006 using a resource selection probability function (RSPF) model to predict areas with a high probability of use (Pollard and Keim 2006). The variables used in the RSPF were elevation, slope, heat load index, and access to escape terrain. Heat load index was a function of latitude, longitude, slope and aspect at a given location. Access to escape terrain was defined as the distance to the nearest 45 - 60° slope.

Mapping was verified using helicopter surveys in 2005 and 2006. 80% of all observations during the surveys were located within goat winter range and 86% of nursery group and high density observations, 80% of medium density observations and 77% of low density observations were within 50 metres of predicted goat winter range (Pollard and Keim 2006).

5.1.1.2 Mid Coast

The modelled goat winter range layer for the Mid Coast ranks habitat as suitable or not suitable based on specific slope, aspect and elevation criteria. The coverage was updated in 2008 to only include those polygons that meet the sun shade requirements (shaded areas were removed). (K. Dunsworth, pers. comm.)

5.1.1.3 South Coast

A resource selection function (RSF) model described in Taylor et al. (2004) was applied by ungulate domain experts in 2008 and 2009 to assess winter habitat suitability. The RSF model used the environmental variables of stand age, elevation, slope, solar loading, and distance to escape terrain.

To address insolation, the model used a digital elevation model (DEM) and position of the sun to estimate how much solar radiation a slope would receive. In coastal areas, solar loading received on a given aspect varies due to the influence of topography and shading. Solar loading models can be more informative than aspect alone for ungulate models.

Relative probability of goat use:

$$y = \frac{\exp(-1.634 - 0.008x_1 - 0.002x_2 - 0.002x_3 + 0.146x_4 + 0.002x_5)}{1 + \exp(-1.634 - 0.008x_1 - 0.002x_2 - 0.002x_3 + 0.146x_4 + 0.002x_5)}$$

where:

x_1 = distance (m)

x_2 = elevation (m)

x_3 = slope (degrees)

x_4 = insolation (kj/m2/day)

x_5 = forest age (years)

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.

Habitat for final co-location was limited to forest age classes of 8 and 9. Age class 7 was not included because stands of that age class do not typically achieve snow interception cover, except occasionally on high growing sites (K. Brunt, pers. comm.).

Separate models were run for females and males. The female model will typically incorporate natal and some of the nursery areas, and includes a larger area than the male model. All goat habitats are contained within the Pacific Ranges Ecoregion minus the Outer Fjordland Ecosection.

Habitat mapping was validated against GPS data of mountain goat locations in the Stafford and Kingcome Landscape Units (Taylor and Brunt 2007). There is a good correlation between the habitat mapping and occurrence data in these areas.

5.1.2 Legally designated ungulate winter ranges

Ungulate winter ranges (UWRs) designated under the *Forest and Range Practices Act* (FRPA) are a subset of the modelled habitat layers described above. Legal UWRs represent a negotiated set of winter range polygons that have been defined within a provincial policy limit on impact to timber supply and therefore may not capture all of the highest quality habitats.

Almost all of the polygons identified and submitted for legal ungulate winter range designation have been field verified through helicopter survey flights over the last decade. There is a high level of confidence in the locations designated.

5.2 Limitations and uncertainties associated with habitat mapping

- A professional review of any computer-generated habitat model is needed to verify that the selected parameters and assumptions result in a habitat layer that reliably approximates actual areas of habitat use. Professional interpretation is also needed to remove unsuitable habitats identified by the resource selection probability function. As ever, human understanding and error is a potential source of uncertainty.
- Where forest cover is used as an input to habitat mapping there are limitations resulting from inconsistencies and inaccuracies in the forest cover layer.
- One of the biggest uncertainties with the use of habitat models is whether the modelled habitats are actually occupied. Field verification is recommended to confirm the use of

modelled habitats. Verification surveys are limited by the weather conditions at the time of surveying, as mountain goats will use habitats in milder winters that may not be accessible in more severe winters (Pollard and Keim 2006). Surveys may also miss goats where visibility is limited due to dense canopy cover.

5.3 Recommendations to improve mapping

- Age class is a broad category (age class 8 = 140 – 250 yrs; age class 9 = 250+ yrs). Habitat models based on specific ages will provide a finer resolution of map product.
- Field verification of modelled habitats should be undertaken in the Mid Coast and South Coast sub-regions. Some field verification of modelled goat winter ranges has occurred in the North Coast sub-region (Pollard and Keim 2006).

5.4 References

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6.0 Northern goshawk

Domain experts:

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Todd Mahon, Wildfor Consultants

Frank Doyle, Wildlife Dynamics Consulting

Description of mapping methods:

Mahon et al. 2008

Smith and Sutherland 2008

6.1 Status of mapping of northern goshawk habitats

The Northern Goshawk *A. g. laingi* Recovery Team and Habitat RIG have developed habitat suitability models for nesting and foraging throughout four conservation regions in coastal B.C.: 1) Haida Gwaii; 2) North Coast B.C.; 3) South Coast B.C.; and 4) Vancouver Island (Mahon *et al.* 2008, Smith and Sutherland 2008). These habitat models were based on the habitat suitability index (HSI) methodology (US Fish and Wildlife Service 1981). This methodology is commonly used in habitat assessment and has been successfully used in several goshawk habitat mapping and supply analyses in B.C. (e.g. North Coast LRMP (Mahon *et al.* 2003), Morice LRMP (A. Edie and Associates 2004), see review of others by Mahon (2005)).

Nesting and foraging habitat suitability models combine to form a territory model which generates potential goshawk territories (home ranges) across portions of the study area that have adequate amounts, and suitable configurations, of nesting and foraging habitat (Mahon *et al.* 2008, Smith and Sutherland 2008). The territory model was designed as a strategic-level analysis tool to estimate relative numbers of breeding pairs that could be supported within each conservation region. The territory model was not used in this co-location exercise because of limited time and funding. Therefore, the nesting and foraging habitat layers were used as stand-alone products to estimate the amount and distribution of different qualities of goshawk habitat across the south-coast B.C. planning unit.

6.2 Limitations and uncertainties of northern goshawk mapping

Although these standardized habitat suitability models are considered the best available information for this project at this time, models within each conservation region are in various stages of ground-verification, accuracy assessment and revision. Therefore, there are specific caveats that Northern Goshawk Recovery Team requests data users to consider when using these models as a planning tool (see Box 6.2).

Box 6.2: Caveats for the use of the Northern Goshawk Recovery Team habitat models

The Northern Goshawk *A. g. laingi* Recovery Team has been working with the Habitat Recovery Implementation Group (RIG) to develop nesting and foraging habitat suitability models that combine to form a territory scale model. These models represent the best available predictive habitat supply models for Northern Goshawk in coastal B.C. and they are specific to different Conservation Regions (Haida Gwaii, North Coast, South Coast and Vancouver Island) and so ensure that you are using the correct habitat models for your area.

These habitat models are **DRAFT** at this time and the Recovery Team/Habitat RIG will continue to refine these models through ground-verification and sensitivity analyses. Therefore, please acknowledge that as with any model, there is uncertainty associated with its predictions. As models are refined and updated, employ the adaptive management framework and ensure you re-examine your outputs using the most current models.

The models were designed to be applied for strategic planning to predict generalized patterns of habitat supply and configurations at landscape scales, not at an operational cutblock/reserve scale. Therefore, if the results will be used at scales finer than this intended use, ground-verification work is required. As well, the territory model is not meant to predict exact locations of Northern Goshawk territories, but to predict approximate densities of territories that may be supported across landscapes, under different habitat supply and distribution scenarios.

Please ensure that all users of this model obtain their own data-sharing agreements with licensees for the underlying forest cover data required to run these models.

6.3 Recommendations to Improve Mapping

a) Quality of forest cover data: Model output is only as good as the inputs. The quality of forest cover data varies throughout coastal B.C. Models were developed on the assumption that forest cover data is adequate to use at a strategic level but poor at a stand level. There is a high level error rate for stand level polygons unless field verified.

   There are major differences and biases in data quality depending on sources (TFLs, TSAs, private lands, Parks and Protected Areas). These discrepancies should be considered when comparing landscapes as different outputs between areas may only reflect underlying data quality differences, not actual habitat quality differences.

b) The Northern Goshawk Recovery Team/Habitat RIG did not include some forest cover attributes in models because either they were unavailable within portions of conservation regions or it was impossible to use the parameter in time series models (e.g. canopy closure). Crown closure estimates may be derived through air photo interpretation but this would be a huge undertaking for the entire coastal range of goshawks. If habitat models are being applied in portions of conservation regions that have missing data, or if habitat models are only being used to predict current habitat supply and distribution, model accuracy may be improved upon by including additional forest attributes (see Mahon *et al.* 2008).

6.4 References

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7.0 Tailed frog

Domain experts:

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Volker Michelfelder, Ministry of Environment

Glenn Sutherland, Cortex Consultants

Description of mapping methods:

Leversee 2009

7.1 Status of Mapping and Inventory of Tailed Frogs

7.1.1 Mapping

Mapping of tailed frog habitat was completed for the entire coastal planning area in 2008 as part of the Focal Species Project. The previous model, which was developed by the Coast Information Team, only identified optimal *A. truei* streams. Hundreds of potentially suitable streams were eliminated from consideration because rules were applied additively, so that each successive application limited the number of selected creeks. The CIT approach to mapping is good for selecting WHA candidates but is not suitable for the subject co-location exercise.

The 2008 Tailed Frog Model used 1:20,000 scale Corporate Watershed Base (CWB) streams and watersheds. The goal of the model was to identify watershed and stream systems with a total drainage area between 0.3 km^2 (30 ha.) and 10 km^2 (1,000 ha.) and assign a “ruggedness” class to each system (as described in Leversee 2009).

Drainage area:

The CWB watershed polygon area was used as the *de facto* drai*nage are*a and a tracing routine was used on the stream network to determine the total upstream drainage area for each watershed polygon.

Basin ruggedness

“Ruggedness” was calculated using the TRIM Digital Elevation Model (DEM). The definition used for “relief” was the change in elevation from the highest and lowest points in the stream for each tailed frog sub-basin. A simple min/max analysis was used to calculate the “relief” value for each sub-basin stream and this was then divided by the square root of the drainage area to get the “ruggedness” value. Each tailed frog basin polygon received the ruggedness value of its main stem sub-basin.

For basins and sub-basins, tailed frog habitat was assigned to 4 classes based on ruggedness.

- Not rugged enough < 30%
- Class 1 30 to 70%
- Class 2 70 to 120%
- Too Rugged > 120%

For streams, additional non-habitat classes were identified, including stream segments in lakes or under glaciers, and headwater streams that drain less than 30 hectares.

Tailed frog habitat streams (Class 1 and Class 2) were buffered by 50 metres on each side.

7.1.2 Inventory

Tailed frogs are widely distributed on the Coast between the B.C. - Washington border and Portland Canal (Dupuis and Bunnell 1997; Dupuis and Friele 2003; Frid et al 2003; Michelfelder and Dunsworth 2007). The inventories cited suggest that tailed frogs occur in about 60-70% of suitable creeks sampled (though a 30% occurrence is more likely at the extreme limit of their range; Dupuis and Bunnell 1997). The data cited was amalgamated as part of the focal species project.

7.2 Limitations and Uncertainties of Tailed Frog Mapping

The previous tailed frog model relied on 1:50,000 Watershed Atlas data. The updated model used 1:20,000 TRIM data and this is viewed as a vast improvement, as TRIM streams are a fairly good representation of actual streams in the landscape.

The limitations of the model are primarily related to the CWB data itself. By its nature, there is no way to identify the total drainage area of a stream until it crosses into a new watershed polygon. This means that the entire length of a stream within a single watershed polygon gets the same drainage area. A raster-based method was tested to calculate cumulative watershed drainage area using a Digital Elevation Model (DEM), but it was too difficult to spatially match the flow results to the CWB stream lines. This problem only affects the stream portion of the model results (Leversee 2009).

7.3 Recommendations to Improve Mapping

The co-location effort could be improved by developing a 'dispersal nodes' layer that could be used as an input to MARXAN to drive the spatial configuration of OGRA solutions to assess linkages between meta-populations. The identification of dispersal nodes could be automated, but this has not yet been accomplished. In the exercises where dispersal nodes have been identified nodes were identified manually (e.g., Friele and Dupuis 2004). This technique is suitable for small areas, but not for regional assessments.

Automate the identification of dispersal nodes might involve a combination of the following rules (L. Gyug, pers. comm.):

1. Point at the upstream end of every 1st order 20K TRIM stream, and zero-order basins which have no TRIM streams, to develop theoretical zero-order stream lines from the ArcView Hydrology Extension;
2. These would be joined to nearest such points in adjacent basins;
3. "Passability" would be some function of slope, aspect, moisture, soils, and/or surficial geology;
4. This would then be overlaid with forest cover as a final "passability" assessment.

The resulting links between watersheds could either be treated as "nodes" (point file), or better yet, as lines that were a subset of the basin boundary, so that lengths could be attached. Developing the GIS rules in Step 3 could be the challenge and would highly depend on what data layers are available. Slope and aspect are available everywhere, but not necessarily the others.

7.4 References

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Friele, P. and L.A. Dupuis. 2007. *Species Account and Habitat Model for Coastal Tailed Frog (Ascaphus truei) in the Lillooett Forest District.* Ministry of Environment. Kamloops,B.C.

Gyug, L. 2005.

Leversee, D. 2009. *EBMWG Tailed Frog Habitat Model Summary, January 2009.* Ministry of Agriculture and Lands, Land Information. Nanaimo 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.

Appendix 1. Recommended habitat layers for co-location

Table 11 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.

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 1. 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 2. Deer Winter Habitat Suitability Ratings

Slope (degrees)	
1	0-10º
2	11º-20º
3	21º-30º
4	31º-50º
5	>50º

Aspect		
1	N	337°-22°
2	NE	22°-67°
3	E	67°-112°
4	SE	112°-157°
5	S	157°-202
6	SW	202°-247°
7	W	247°-292°
8	NW	292°-337°

Elevation (meters)		Snowpack
1	0-300	shallow
3	300-800	moderate & deep
4	>800	very deep

BEC Variants	Snowpack
BAFAun	very deep
BAFAunp	very deep
CMA un	very deep
CMA unp	very deep
CWH dm	shallow
CWH ds 2	moderate
CWH mm 1	moderate
CWH ms 2	deep
CWH vh 1	shallow
CWH vh 2	shallow
CWH vm	moderate
CWH vm 1	moderate
CWH vm 2	deep
CWH vm 3	deep
CWH wm	moderate
CWH ws 1	moderate
CWH ws 2	deep
CWH xm 2	shallow
ESSFmc	very deep
ESSFmcp	very deep
ESSFmk	very deep
ESSFmkp	very deep
ESSFmw	very deep
ESSFmwp	very deep
ESSFwv	very deep
ESSFxv 1	very deep
ESSFxvp	very deep
IDF dw	moderate
IDF ww	moderate
IMA unp	very deep
MH mm 1	very deep
MH mm 2	very deep
MH mmp	very deep
MH wh 1	very deep
MH whp	very deep
MS un	very deep
SBPSmc	very deep
SBS mc 2	deep

Slope	Aspect	Rating		Elevation	Rating		Subzone-variant	Rating		Solar Index Value (Kj/m^2)	Rating
1	1	4		0-300	1		BAFAun	4		0 - 3,997	4
1	2	4		300-800	3		BAFAunp	4		3,998 - 7,561	3
1	3	3		>800	4		CMA un	4		7,562 - 10,710	2
1	4	3					CMA unp	4		10,711 - 16,600	1
1	5	3					CWH dm	4			
1	6	3					CWH ds 2	1			
1	7	3					CWH mm 1	2			
1	8	4					CWH ms 2	2			
2	1	4					CWH vh 1	1			
2	2	4					CWH vh 2	1			
2	3	3					CWH vm	2			
2	4	2					CWH vm 1	2			
2	5	2					CWH vm 2	3			
2	6	2					CWH vm 3	3			
2	7	2					CWH wm	2			
2	8	4					CWH ws 1	2			
3	1	4					CWH ws 2	3			
3	2	3					CWH xm 2	1			
3	3	2					ESSFmc	4			
3	4	1					ESSFmcp	4			
3	5	1					ESSFmk	4			
3	6	1					ESSFmkp	4			
3	7	2					ESSFmw	4			
3	8	4					ESSFmwp	4			
4	1	4					ESSFwv	4			
4	2	4					ESSFxv 1	4			
4	3	2					ESSFxvp	4			
4	4	1					IDF dw	2			
4	5	1					IDF ww	2			
4	6	1					IMA unp	4			
4	7	2					MH mm 1	4			
4	8	4					MH mm 2	4			
5	1	4					MH mmp	4			
5	2	4					MH wh 1	4			
5	3	4					MH whp	4			
5	4	2					MS un	4			
5	5	2					SBPSmc	4			
5	6	2					SBS mc 2	3			
5	7	3									
5	8	4									