Executive Summary

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Scope

Agreements between First Nations and the provincial government, covering the North and Central Coast of British Columbia, document the intention to fully implement Ecosystem-Based Management (EBM) over time. A key goal over the short term is to ensure land and habitat management does not create high levels of risk for selected focal species, including: mountain goats, grizzly bears, northern goshawks, tailed frogs, and marbled murrelets.

Each of these focal species has unique habitat requirements. This creates a complex and data-limited planning setting, which can only be addressed through a three-step process

1. Elicit information from species experts.
2. Package the resulting information for communication with planners.
3. Establish on-going collaborative processes to support case-by-case implementation.

This report is intended to inform: 1) completion of a conservation gap analysis for each focal species, and 2) decision making about potential amendments to current land use objectives.

Process

For each focal species, a facilitated 1-day workshop was held with 3 species experts. All 5 workshops followed the same process:

- reviewed the EBM risk assessment approach and terminology
- developed a concept map describing the factors affecting the population,
- identified an appropriate habitat indicator
- drew a hypothesized relationship showing risk to the population versus habitat abundance,
- identified high- and low-risk habitat thresholds based on EBM definitions of these terms,
- described assumptions and sources of uncertainty related to the hypothesized relationship.

Summary reports for each workshop were drafted by the facilitators, revised by species experts, and then compiled into a single report *Influence of Habitat Abundance on Risk to Focal Species in BC's North and Central Coast*. A collective workshop with all species expert groups was then held to address information gaps in the reports, present the information to intended end-users, and address their questions. The report was revised to reflect discussions at the collective workshop.

Highlights

This workshop series and the resulting information are crucial building blocks for the sustainable management of these 5 focal species. The following are particularly noteworthy:

- A consistent framework, adapted from the EBM handbook, was applied to diverse species.
- Habitat requirements were succinctly summarized for each species, and threats to those habitats were indentified.
- Habitat indicators were clearly defined for each species.
- Workshops included detailed discussion of sources of uncertainty and produced a short-list of specific recommendations.

Habitat Risk Curves – Concepts, Definitions, and Interpretation

For each species, the expert groups also went through a facilitated exercise to identify a low-risk threshold and a high-risk threshold along the habitat indicator, based on a hypothesized cause-and-effect curve (i.e. the expected response of the focal species to changes in habitat supply). Each group of species experts started with the same definitions for the thresholds and the same background materials from the EBM handbook.

Each group then adapted these general tools to their particular focal species as needed. Subtle, but potentially important, differences were introduced as a result of these adaptations, which led to intensive discussions regarding the appropriate representation and across-species interpretation of the threshold estimates developed by species experts.

Species Summaries

The next 10 pages of this Executive Summary consist of a 2-page summary for each of the five focal species:

- The first page of each summary establishes the context for habitat considerations, shows how a single key habitat indicator was defined for each species, and provides a brief paragraph describing each of the risk thresholds.
- The second page of each summary reproduces the hypothetical habitat-risk curves developed by species experts. Due to the complexity of the issues under consideration, these diagrams contain a lot of information and are challenging to interpret at first. Three supplementary diagrams were developed to highlight key aspects:
    A. Highlight uncertainty in location of the thresholds
    B. Highlight uncertainty in risk associated with a specific % of natural habitat
    C. Highlight confidence at which point the system has crossed a threshold

Note that uncertainty bands in these figures are intended to capture the "Sources of Uncertainty" and "Quality of Knowledge" considerations summarized in the first page, and discussed in detail in the report.

The 2-page summaries went through numerous revisions to find a balance between the intent of a high-level summary and the details crucial for informed interpretation. This material is intended to summarize, but cannot replace, all of the material in the body of the report. Readers need to consider the habitat risk curves and resulting thresholds in the context of the full report, with a particular focus on definitions, management assumptions, and sources of uncertainty!

Cross-Species Summary

This Executive Summary concludes with a 3-page table that contrasts the summary information across species. This is intended as a reference for quick comparisons; much of the information in this table is simply reorganized from the individual species summaries (e.g. Information about spatial scale is included on Page 1 of each species summary under *Habitat Indicator* and on Page 3 of the cross-species summary.)

The last row of Page 3 in the Cross-Species Summary outlines "What's needed to estimate current status?", outlining the information used to define the natural state at the starting point of the hypothesized cause-and-effect curves. The appendix on "Implementation" contains a detailed discussion of the necessary steps for estimating natural and current habitat abundance for each of the five focal species.

Species: **MARBLED MURRELET** *(Brachyramphus marmoratus)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

1 Overview of factors affecting population

Where do habitat factors fit in? (ranked by influence)

1 Loss of terrestrial (nesting) habitat
2 Decline in marine environment (forage↓, mortality↑)
3 Increased fragmentation/habitation (nest predation ↑)
4 Increased power lines (collisions and mortality ↑)

Terrestrial habitat degradation is the highest-ranked threat because murrelets rely on this habitat to provide nesting platforms, and population trends are likely influenced mainly by nesting success, due to estimated low adult mortality. In the current marine environment, oil spills and gill net by-catch do not seem to be major causes of mortality. Food supply does not appear to be limiting, but effects are not well studied in the region. Nest predation can limit populations in fragmented areas near people.

Which land uses affect habitat? (ranked by influence)

1 Logging of habitat
2 Fragmentation of habitat
3 Nearby human habitation

Logging is the highest-ranked threat because it can remove or degrade (fragment) nesting habitat - large mossy limbs in old forests. Logging is assumed to preferentially remove good murrelet habitat, because good habitat has higher timber value. Fragmentation due to logging reduces nearby forest cover, increasing a nest's exposure to weather and predators, and possibly increasing predator abundance.

2 Risk to populations versus habitat

Components of Habitat (ranked by influence)
1 Area of old forest habitat (Class I, II,III)
2 Proximity (< 30 km) of old forest to fjords
3 > 140 yr old

Habitat Indicator: % Remaining of Natural Habitat
Defined here as the area of habitat classes I, II an III that are more than 140 yr old and within 30 km of fjords, within a sub-region. This was used as the horizontal axis on risk curves developed in the workshop. (Class I = Very high quality, Class III = Moderate quality, see def'n in Sec 4.3)
Scale = Sub-region, because murrelets are sufficiently mobile to movve among landscape units.

Management Assumptions
1 Habitat Class I, II logged preferentially
2 Little forest fragmentation
3 Little harvest of Class IV and V habitat

Sources of **Knowledge** Uncertainty (ranked by influence)
1 Response to marine environment
2 Nesting density per habitat class (I to VI)
3 Map accuracy
4 Future fragmentation and human presence
5 Effects of nest predation
6 Impacts of variable retention on nesting density/success
7 Population genetics
8 Uncertainty related to climate change was not considered

Sources of **Management** Uncertainty (ranked by influence)
1 Changes in logging practices (e.g. retain best habitat)
2 Substantial increases in human presence

3 Habitat-Risk Thresholds

Definitions of low- and high-risk thresholds used in workshop
LRT = noticeable change from natural abundance and distribution is likely
HRT = serious ecol. impacts likely begin (~ minimum viable population)

Hypothesized threshold habitat abundance

LRT identified around **88%** remaining habitat based on estimated historic natural variation in murrelet habitat abundance.

HRT identified around **33%** remaining habitat due to a combination of lost high-quality nesting habitat and increased edge effects associated with fragmentation (e.g. predation). Further loss of nesting habitat accelerates risk to viability, considering genetics and uncertainty in reproduction and survival due to uncertain at-sea conditions.

Thresholds only apply if management assumptions are met!

Quality of Knowledge: LOW to MODERATE (rated 2.5 out of a possible 5) (see Sec 8.4 in report for definitions)

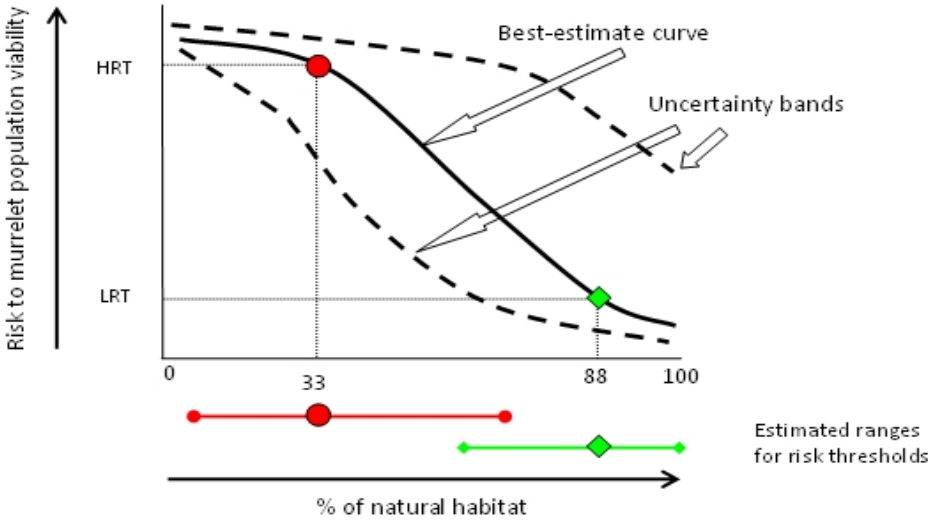
Key References: (1) Habitat maps for each sub-region more recent than 2002 (2) Aerial surveys and air photo interpretation of nesting habitat (3) Radar surveys and other large-scale data on distribution (4) Nesting vs. habitat quality data - South BC & Haida Gwaii (5) Reports of the EBM Working Group Focal Species Project (6) Population viability analysis Steventon et al. 2006

Species: **MARBLED MURRELET** *(Brachyramphus marmoratus)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

4 Habitat-Risk Curve

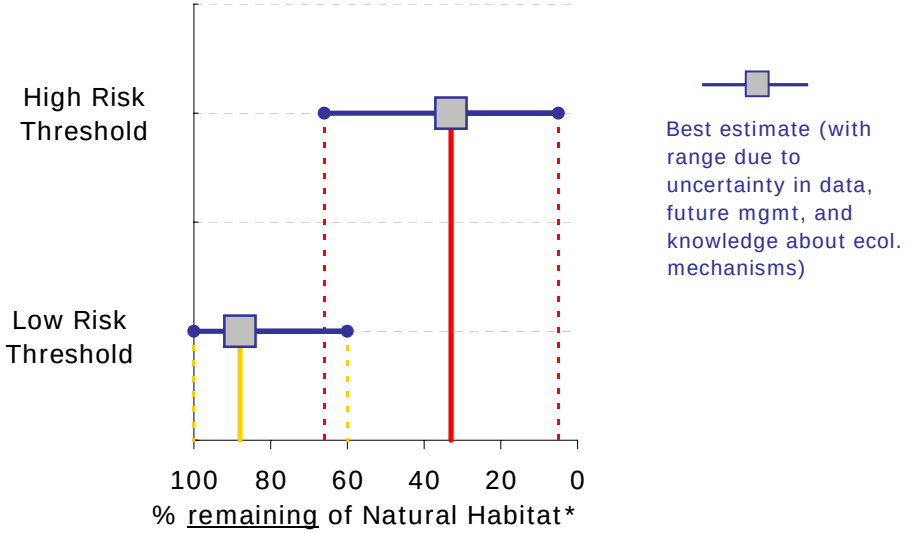
Main Figure (Figure 4-4 in report)

Hypothesized relationship based on expert opinion



Supplementary Figure A

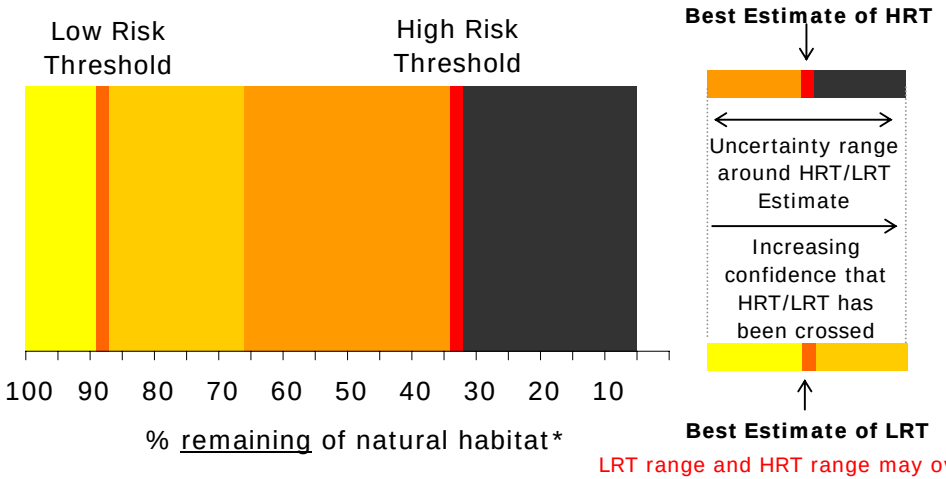
Highlights uncertainty in location of the thresholds



Supplementary Figure C

Highlights confidence that the system has crossed a threshold

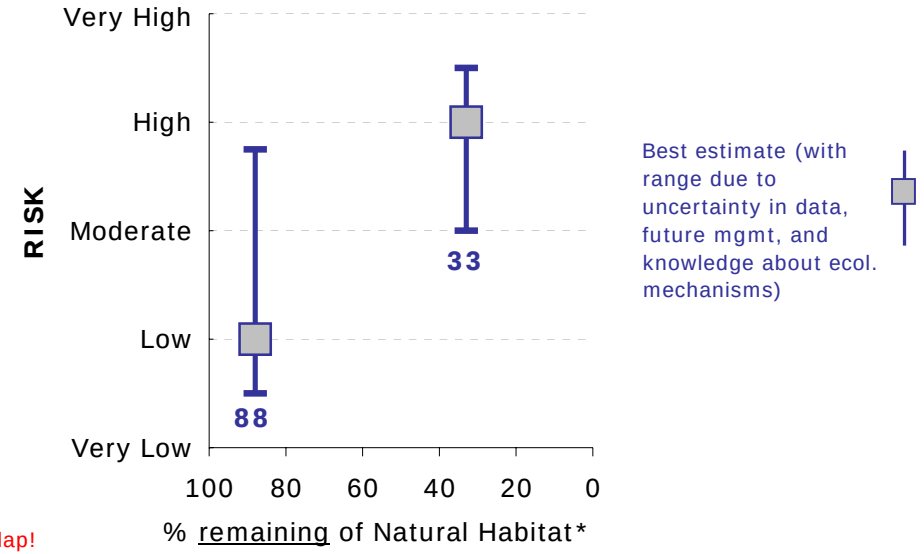
(Risk increases from left to right, even if exact location of LRT and HRT are are uncertain. Colours reflect increasing risk. Ranges may overlap - see Fig A)



LRT range and HRT range may overlap!

Supplementary Figure B

Highlights uncertainty in risk associated with a specific % of habitat



* see definitions on previous page (Note that x-axis is flipped on supplementary figures)

Species: **COASTAL TAILED FROG** *(Ascaphus truei)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

1 Overview of factors affecting population

Where do habitat factors fit in? (ranked by influence)

1 **Habitat (aquatic and terrestrial)**
2 Stochastic mortality (flash flood,low flow,debris, torrents)
3 Local climate (stand microclimate,weather,climate change)
4 Predation mortality

Degradation of habitat quality and quantity is the highest ranked threat because condition of stream buffers and basins affects multiple life stages. Quantity and quality of terrestrial habitat affects aquatic conditions for larvae, streamside living habitat for adults, and dispersal habitat. High quality habitat can ameliorate effects of adverse weather and buffer against impacts of some stochastic events. Connectivity is important to allow dispersal among the metapopulation.

Which land uses affect habitat? (ranked by influence)

1 **Roads (especially stream crossings & sediment management)**
2 Logging (treatment of buffers and ECA)
3 Independent power production (run-of-the-river installations)

Roads and logging are the highest-ranked threats because they affect frog habitat both at the basin level (stream and forest conditions) and at the reach level (e.g. stream flow, riparian buffer, canopy closure, channel condition, riparian routes). IPPs (aproximately 500 approved and 8,200 proposed) also affect channel riparian habitat and have the potential to isolate populations via diversion reaches.

2 Risk to populations versus habitat

Components of Habitat (ranked by influence)

1 Local climate (e.g. windward/leeward)
2 Physiography (geology, relief, ruggedness)
3 Stream reach characteristics
4 Riparian buffers (structure/microclimate)
5 Connectivity (and proximity of old growth to streams)
6 Equivalent clearcut area (ECA) in basins
7 Basin size and quality

Habitat Indicator: % Remaining of Natural Habitat

Defined here as streams suitable for frogs (Class 1 and 2) that are effectively buffered along their entire length, within a basin. Basin condition is a secondary habitat indicator and considers the disturbed area in the basin (see Figure 6-3 in report). This was used as the horizontal axis on risk curves developed in the workshop. **Scale = Basin**

Management Assumptions

1 Best management practices (BMP; see references)
2 Sufficient buffer (stream protection, adult habitat)
3 Basin cond. good (low ECA and slides, good hab.distr.)
4 Connectivity within and betwen basins
5 No Independent Power Production (IPP)

Sources of **Knowledge** Uncertainty (ranked by influence)

1 Actual suitable streams vs. stream classes
2 Assumptions about population response/resilience
3 Dispersal habitat; dispersal rate

Sources of **Management** Uncertainty (ranked by influence)

1 Logging practices (BMP or no BMP)
2 Partial logging of buffers (buffer width)
3 Management of stream crossings

3 Habitat-Risk Thresholds

Definitions of low- and high-risk thresholds used in workshop

LRT = noticeable change from natural abundance and distribution is likely
HRT = serious ecol. impacts likely begin (~ minimum viable population)

Hypothesized threshold habitat abundance

LRT identified as at least **80%** of suitable frog streams buffered, because natural variability of stream habitat was probably low historically and more than a 20% change in habitat may result in populations that can be detected beyond natural variability

HRT identified around **50%** of suitable frog streams buffered. Tailed frogs have low reproductive output and poor dispersal so impacts of predation and stochastic events on small poulations, all become greater threats than when populations are larger.

Thresholds only apply if management assumptions are met!
Effects of climate change have not been accounted for!

Quality of Knowledge: Expert group rated knowledge about tailed frogs as very low to low, but didn't rate quality of threshold estimates. Assumed to be very low (see Sec 8.4 in report for definitions)

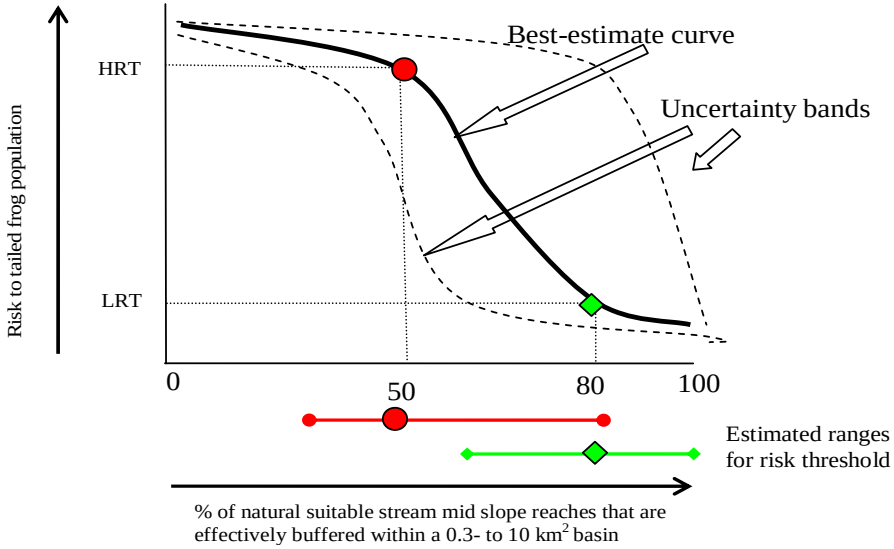
Key References: (1) Surveys in 135 coastal basins in the EBM area (2) Previous analyses of risk thresholds for tailed frogs (3) Reports of the EBM Working Group Focal Species Project (4) Literature on tailed frogs from other areas (5) about 15 local references (6) Best Management Practices described in Dupuis and Freile (2003)

Species: **COASTAL TAILED FROG** *(Ascaphus truei)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

4 Habitat-Risk Curves

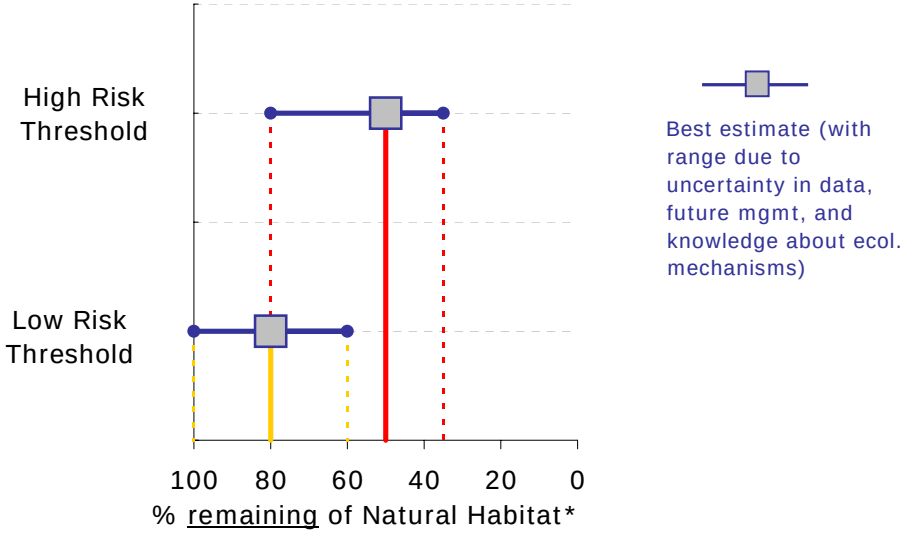
Main Figure (Figure 6-2 in report)

Hypothesized relationship based on expert opinion



Supplementary Figure A

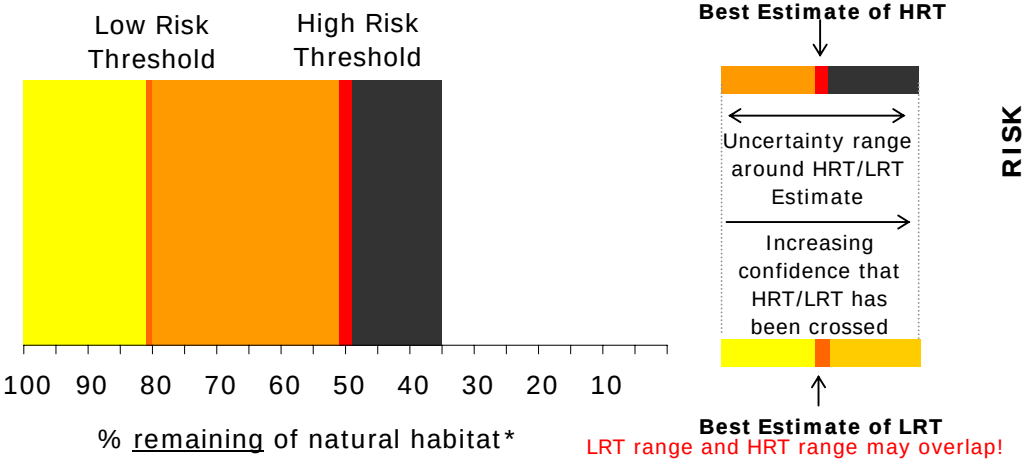
Highlights uncertainty in location of the thresholds



Supplementary Figure C

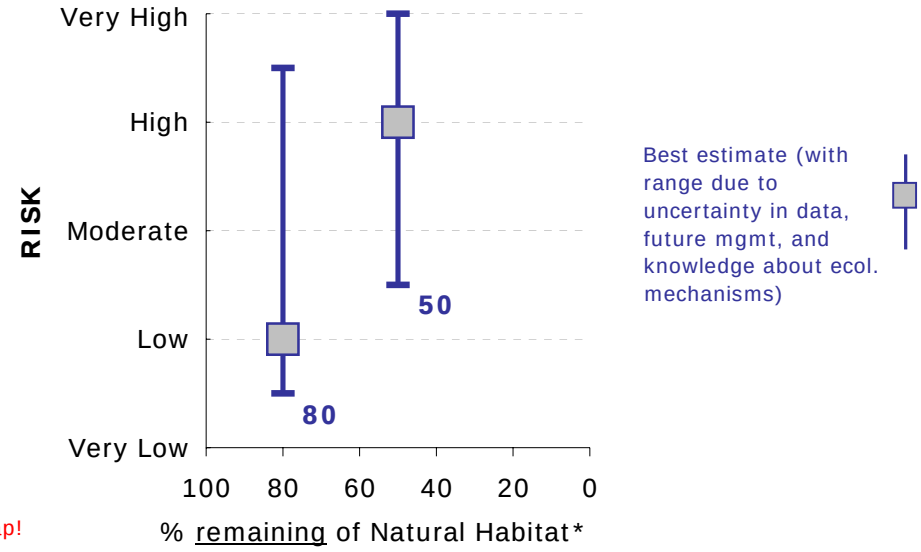
Highlights confidence that the system has crossed a threshold

(Risk increases from left to right, even if exact location of LRT and HRT are are uncertain. Colours reflect increasing risk. Ranges may overlap - see Fig A)



Supplementary Figure B

Highlights uncertainty in risk associated with a specific % of habitat



* see definitions on previous page (Note that x-axis is flipped on supplementary figures)

Species: **COASTAL MOUNTAIN GOAT** *(Oreamnos americanus)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

1 Overview of factors affecting population

Where do habitat factors fit in? (ranked by influence)

1 **Loss of winter ranges (overwinter habitat)**
2 Increased mortality risk associated with access
3 Disturbance that limits habitat use
4 Stochastic environment (weather, food)
5 Predation and disease

Goats have a low recruitment rate and live in relatively isolated sub-pop'ns that can limit re-colonisation and possibly gene transfer. Loss of winter range habitat is the highest-ranked threat because goats depend on it for overwinter survival and also because natal areas and nursery areas overlap substantially with winter ranges. Roads and powerline corridors can increase accessibility for predators and hunters.

Which land uses affect habitat? (ranked by influence)

1 **Logging**
2 Repeated, sporadic noise disturbance (heli-skiing, snowmobiles)
3 Fire suppression reduces summer range forage

Logging is the highest-ranked threat because it directly affects winter ranges (i.e. escape terrain intermixed with suitable forest cover - mature and old forest), which are a key seasonal habitat requirement for coastal goats. Goats are sensitive to noise disturbance and can be displaced from habitats. Note that many activities affect both habitat effectiveness and mortality risk (e.g. roads fragment habitat, increase hunting and predation, and increase short-term disturbances that lead to falls). Fire suppression allows trees to encroach in summer range, reducing forage.

2 Risk to populations versus habitat

Components of Habitat (ranked by influence)

1 Number of intact winter ranges
2 Relative quality of winter range
3 Summer, natal, and nursery ranges
4 Displacement risk

Habitat Indicator: % Remaining of Natural Habitat

Defined here as % of naturally-occurring winter range patches that remain intact in each mountain block. This was used as the horizontal axis on risk curves developed in the workshop.

Scale = Mountain block, because of limited connectivity between mountain blocks due to predation or terrain.

Management Assumptions

1 Other seasonal habitats are intact
2 Intact winter ranges are not partly harvested
3 Constant ratio of good/poor quality winter ranges
4 Mortality and displacement do not increase
5 Disease, predation, etc remain within RONV
(RONV = Range of natural variation)

Sources of **Knowledge** Uncertainty (ranked by influence)

1 Response of predators and hunters to access
2 Lack of field verification for habitat maps
3 Reponse of population connectivity to development

Sources of **Management** Uncertainty (ranked by influence)

1 Partial logging of winter ranges
(including negotiated boundary changes)
2 Preferential logging of best or worst winter ranges
3 Future level of watershed development (noise, access)

Effects of climate change have not been accounted for!

3 Habitat-Risk Thresholds

Definitions of low- and high-risk thresholds used in workshop

LRT = noticeable change from natural abundance and distribution is likely
HRT = serious ecol. impacts likely begin (~ minimum viable population)

Hypothesized threshold habitat abundance

LRT identified around **90%** remaining habitat based on estimated detectable difference from natural variation in population distribution and abundance and considering changes to the landscape associated with development.

HRT identified around **60%** remaining habitat because goats are likely more sensitive to habitat loss than many other species for two reasons: they have a low recruitment rate and they live in relatively isolated sub-populations that can limit re-colonisation and possibly gene transfer. Winter ranges are essential for overwinter survival.

Thresholds only apply if management assumptions are met!

Quality of Knowledge: LOW - rated 2 out of a possible 5 (see Sec 8.4 in report for definitions)

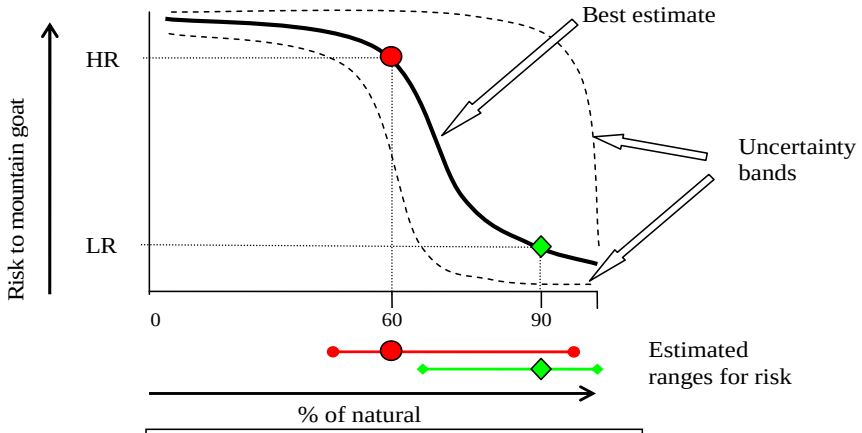
Key References: (1) Regional population and habitat inventories (2) Mountain Goat Management Plan for British Columbia (3) Reports of the EBM Working Group Focal Species Project (4) Anecdotal information from resident hunters, First Nations and Guide Outfitters

Species: **COASTAL MOUNTAIN GOAT** *(Oreamnos americanus)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

4 Habitat-Risk Curve

Main Figure (Figure 3-2 in report)

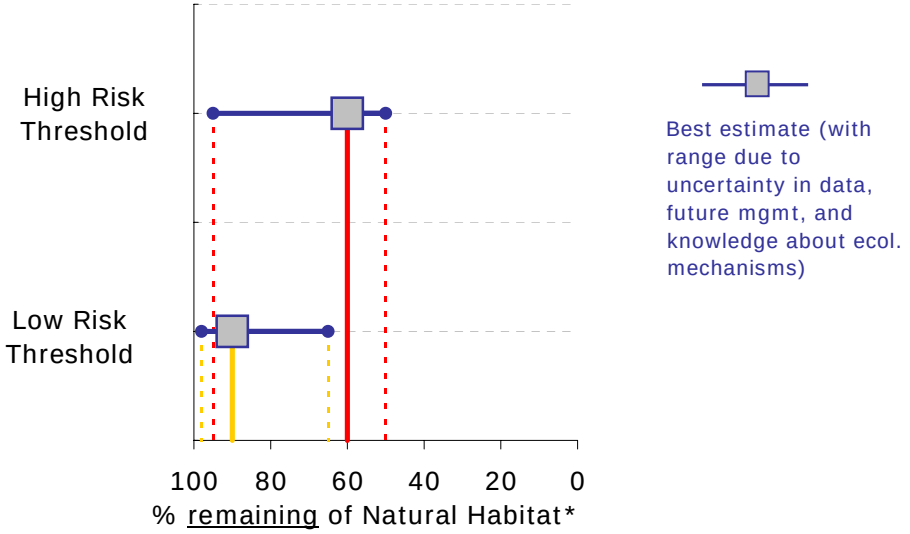
Hypothesized relationship based on expert opinion



Habitat means % of naturally occurring winter ranges that remain intact per mountain block

Supplementary Figure A

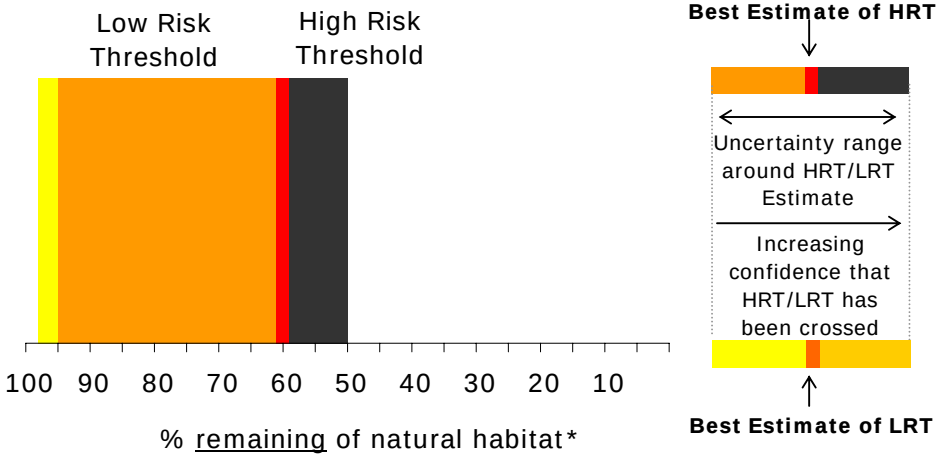
Highlights uncertainty in location of the thresholds



Supplementary Figure C

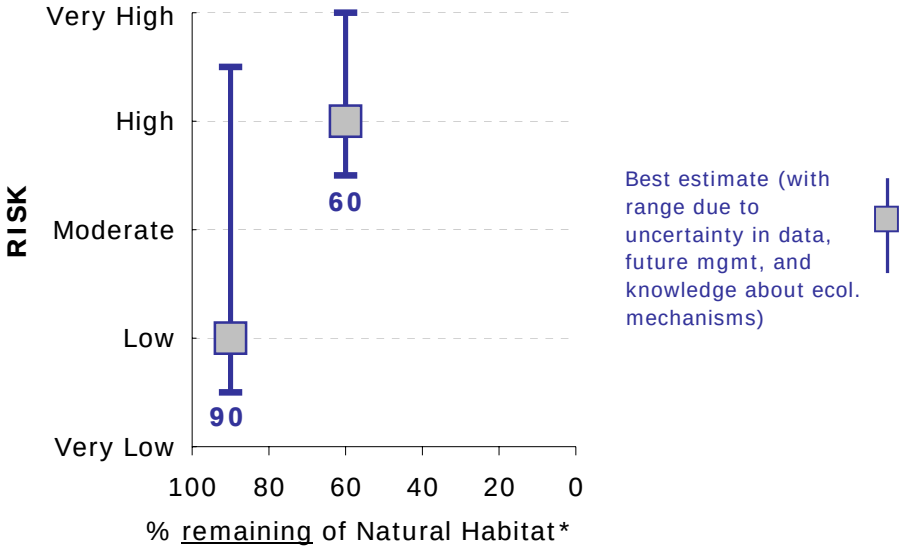
Highlights confidence that the system has crossed a threshold

(Risk increases from left to right, even if exact location of LRT and HRT are are uncertain. Colours reflect increasing risk. Ranges may overlap - see Fig A)



Supplementary Figure B

Highlights uncertainty in risk associated with a specific % of habitat



* see definitions on previous page (Note that x-axis is flipped on supplementary figures)

Species: **GRIZZLY BEARS** *(Ursus arctos)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

1 Overview of factors affecting population

Where do habitat factors fit in? (ranked by influence)

1 Direct human-caused mortality
(e.g. hunting, poaching, control kills)
2 Changes in salmon availability to bears
3 Loss of habitat effectiveness
4 Reduced population-scale connectivity (i.e.fragmentation)

Loss of habitat is the third highest threat. Anthropogenic mortality (e.g. hunting, poaching, control kills) is typically the largest threat and is influenced by access development. Coastal bears depend greatly on salmon runs, but will probably persist at lower densities if stocks crash. Habitat conservation is necessary but usually not sufficient to conserve bears: access should be managed also.

Which land uses affect habitat? (ranked by influence)

1 Logging in and near Class I habitat
2 Logging in and near Class II habitat
3 Development activity causing displacement

Logging of Class I habitat is the highest-ranked habitat threat, because full retention is considered necessary, but not sufficient, to avoid high risk. Logging of Class II habitat is the second highest habitat threat because retaining a substantial portion of class II habitat can reduce risk to low. Development activity (e.g. road construction, harvesting, hauling) is the third highest threat because it can prevent bears from using intact habitats. Salmon management is treated as an uncertainty but could be considered here.

2 Risk to populations versus habitat

Components of Habitat (ranked by influence)

1 Amount of Class I habitat (assume 100% protected)
2 Amount of Class II habitat
3 Landscape context
4 Displacement

Habitat Indicator: % Remaining of Natural Habitat
Defined here as the area of Class II habitat in each sub-region, assuming that all class I habitat is protected. This was used as the horizontal axis on risk curves developed in the workshop.
Scale = Sub-Region (Social interactions, but topographical limitations to connectivity

Management Assumptions

1 100% of Class I habitat protected
2 Representative range Class II habitats
(e.g. seasonally-limited vs abundant)
3 EBM creates moderate to good seral stage distribution
4 Current level of pop'n connectivity (i.e. fragmentation)
5 Current level of human/bear interaction (access, etc.)
6 Current salmon stocks

Sources of **Knowledge** Uncertainty (ranked by influence)

1 Future salmon abundance
2 Landscape context (e.g., need for forage supply)
3 Social interactions (e.g. displacement, mortality risk)
4 Habitat capability (i.e. natural level) not yet mapped

Sources of **Management** Uncertainty (ranked by influence)

1 Future magnitude of human/bear interaction

Effects of climate change have not been accounted for!

3 Habitat-Risk Thresholds

Definitions of low- and high-risk thresholds used in workshop
LRT = noticeable change from natural abundance and distribution is likely
HRT = serious ecol. impacts likely begin (~ minimum viable population)

Hypothesized threshold habitat abundance

LRT identified around **100%** remaining Class II habitat based on estimated natural variation in population distribution and abundance and considering changes to the landscape associated with development.

HRT identified around **0%** remaining Class II habitat because Class I habitat provides forage and security cover. The HRT estimate, and more generally the value of habitat, depends greatly on the non-habitat context--particularly salmon availability and human-bear interaction.

Thresholds only apply if management assumptions are met!

Quality of Knowledge: MODERATE - rated 3 out of a possible 5 (see Sec 8.4 in report for definitions)

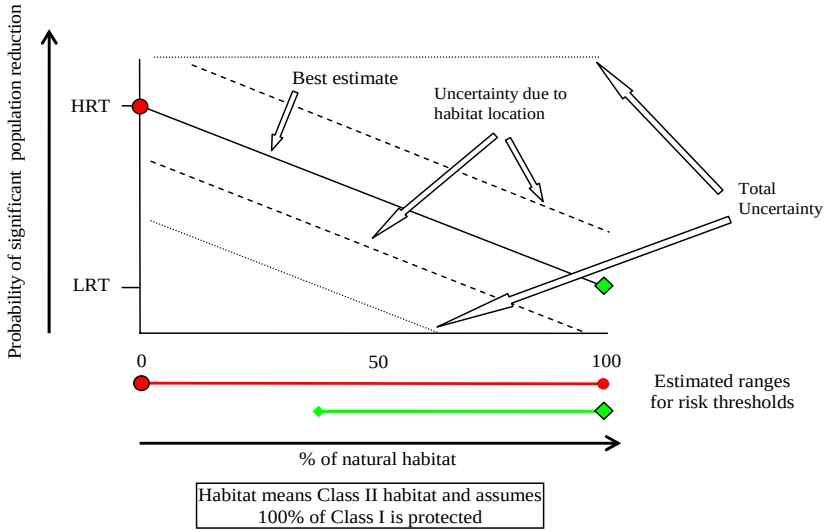
Key References: (1) Seasonal Class I and II habitat maps - 1:20k (2) Reports of EBM Working Group Focal Species Project.

Species: **GRIZZLY BEARS** *(Ursus arctos)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

4 Habitat-Risk Curve

Main Figure (Figure 2-2 in report)

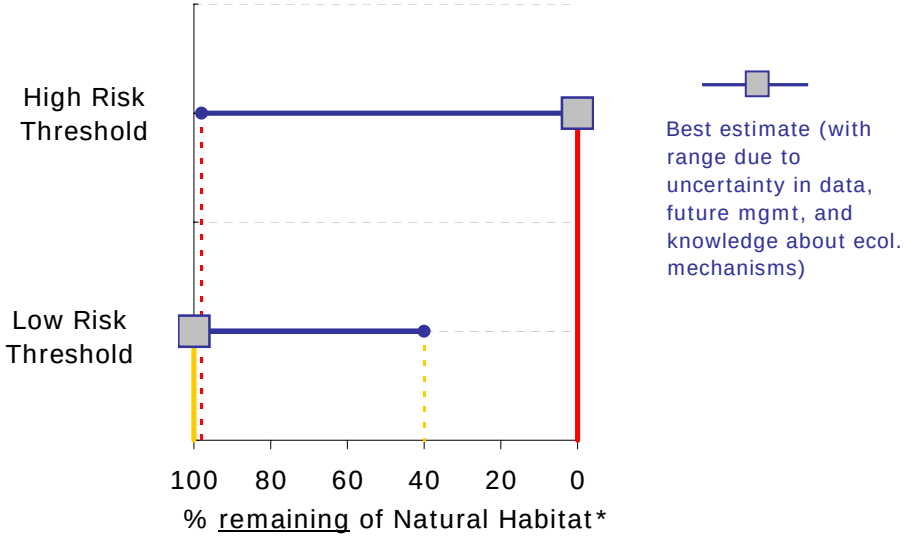
Hypothesized relationship based on expert opinion



Habitat means Class II habitat and assumes 100% of Class I is protected

Supplementary Figure A

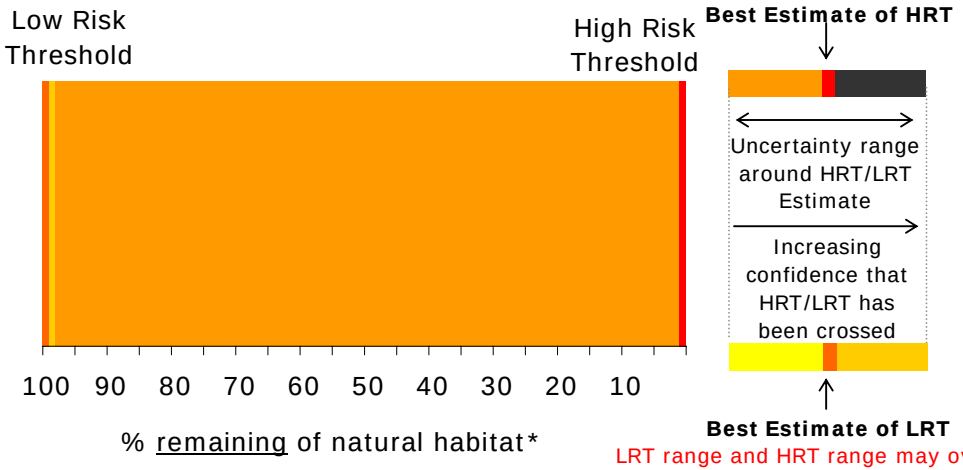
Highlights uncertainty in location of the thresholds



Supplementary Figure C

Highlights confidence that the system has crossed a threshold

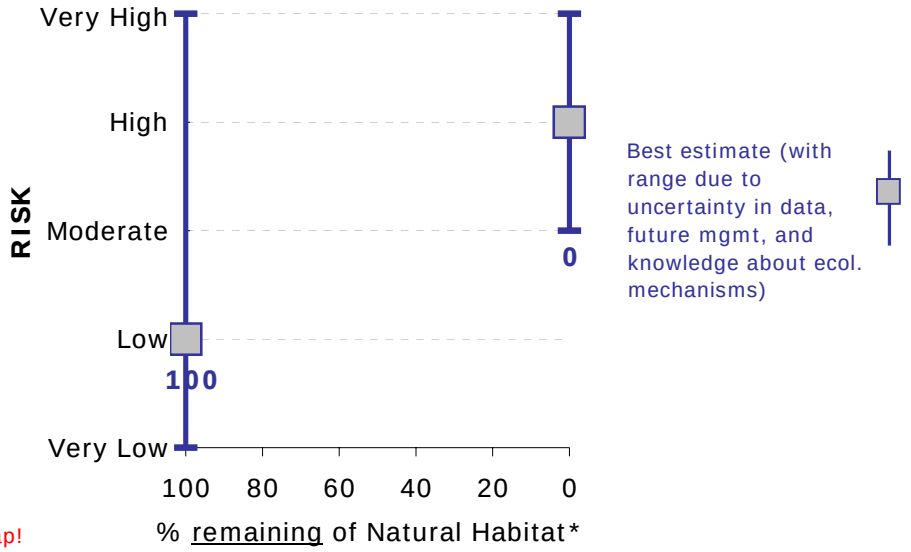
(Risk increases from left to right, even if exact location of LRT and HRT are are uncertain. Colours reflect increasing risk. Ranges may overlap - see Fig A)



LRT range and HRT range may overlap!

Supplementary Figure B

Highlights uncertainty in risk associated with a specific % of habitat



* see definitions on previous page (Note that x-axis is flipped on supplementary figures)

Species: **NORTHERN GOSHAWKS** *(Accipiter gentilis laingi)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

1 Overview of factors affecting population

Where do habitat factors fit in? (ranked by influence)

1 Loss of habitat (suitable territories)
2 Natural variation in breeding success
3 Natural variation in mortality

Loss of suitable habitat is the highest-ranked threat because it directly affects breeding success, foraging success and mortality risk. Habitat provides cover from predators and thermal cover. Habitat is considered to be the primary factor limiting the population. Reproductive rates are not well known but may be low and are subject to high yearly variation. Starvation is believed to be the primary source of mortality.

Which land uses affect habitat? (ranked by influence)

1 Logging
2 Disturbance associated with logging (e.g. noise)

Logging of habitat is the highest-ranked threat because it directly affects the suitability and occupancy of potential territories. Goshawks occupy territories that have > 40 to 70% foraging habitat. Foraging habitat consists of mature and old-growth coniferous forest with closed (>50%) canopies, relatively large diameter trees and open understories. If disturbances are persistent during the sensitive timing window and if they result in permanent changes to habitat characteristics of the breeding area, goshawks may relocate nest sites, or abandon territories.

2 Risk to populations versus habitat

Components of habitat (ranked by influence)
1 Habitat density at the territory scale
2 Stand age (**B**reeding,**F**oraging)
3 Tree height and species (B,F)
4 Biogeoclimatic variant (B,F)
5 Slope and elevation (B,F)
6 Patch size and edge (Breeding only)

Habitat Indicator: % Remaining of Natural Habitat
Defined here as number of suitable territories (i.e. more than 70% foraging habitat) in a sub-region. Territory suitability based on existing models of breeding habitat suitability, foraging habitat suitability and territory suitability. This was used as the horizontal axis on risk curves developed in the workshop. **Scale = Sub-region**, because sufficiently mobilee to move among landscape units.

3 Habitat-Risk Thresholds

Definitions of low- and high-risk thresholds used in workshop
LRT = noticeable change from natural abundance and distribution is likely
HRT = serious ecol. impacts likely begin (~ minimum viable population)

Hypothesized threshold habitat abundance

LRT identified identified around **80%** remaining habitat due to small population. Not higher because of high mobility that allows interactions among breeding individuals at relatively low densities as well as floater populations that help buffer population impacts.

HRT identified around **60%** remaining habitat because goshawks may not be able to locate mates for breeding, negative genetic consequences would be likely and stochastic events would have a large impact on populations, putting these small populations at a significant risk of extirpation.

Management Assumptions
1 Range of territory qualities represented
2 Territories are well-distributed (natural spacing)
3 Little silviculture to enhance habitat

Sources of **Knowledge** Uncertainty (ranked by influence)
1 Population response to territory abundance
2 Response of breeding success to territory suitability
3 Poorly known reproductive and mortality rates
4 Influence of habitat abundance on floater density
5 Influence of floater density on population processes
6 Poor understanding of gene flow

Sources of **Management** Uncertainty (ranked by influence)
N/A

Effects of climate change have not been accounted for!

Thresholds only apply if management assumptions are met!

Quality of Knowledge: low to moderate - rated 2.5 out of a possible 5
(see Sec 8.4 in report for definitions)

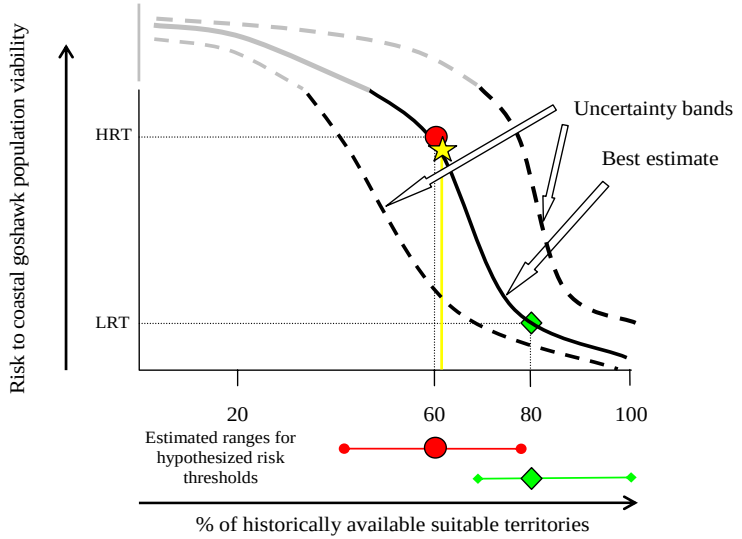
Key References: (1) Breeding, foraging and territory models (2) Breeding densities and home range sizes on Haida Gwaii (3) Report of the Northern Goshawk Recovery Team (4) Reports of the EBM Working Group Focal Species Project (5) Published analyses of goshawk-habitat interactions

Species: **NORTHERN GOSHAWKS** *(Accipiter gentilis laingi)*
Area: EBM study area which coincides with the North Coast and Central Coast LRMP
Source: *Focal species risk thresholds for BC's North and Central Coast - workshop proceedings*

4 Habitat-Risk Curves

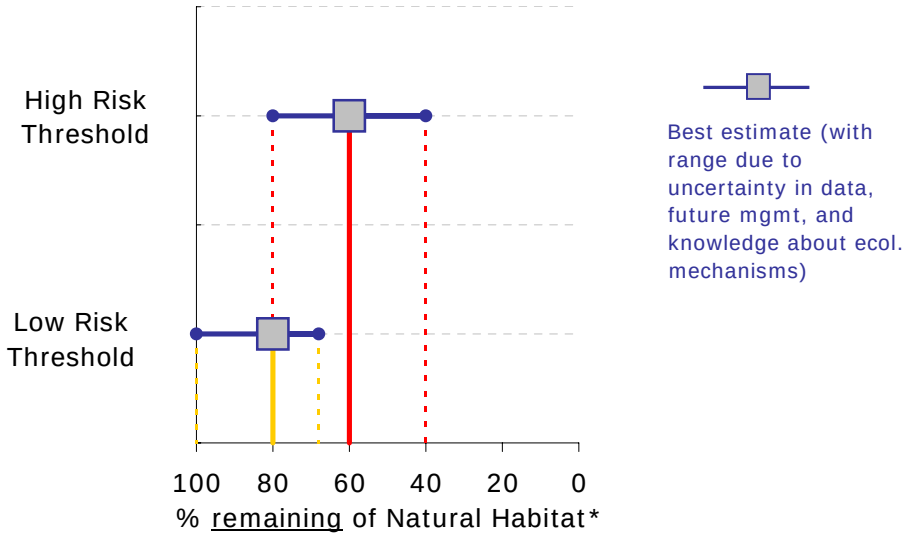
Main Figure (Figure 5-3 in report)

Hypothesized relationship based on expert opinion



Supplementary Figure A

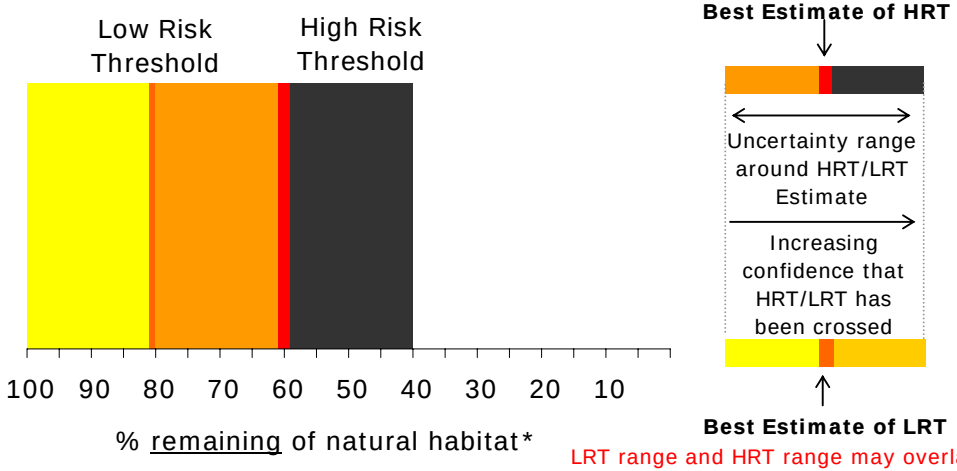
Highlights uncertainty in location of the thresholds



Supplementary Figure C

Highlights confidence that the system has crossed a threshold

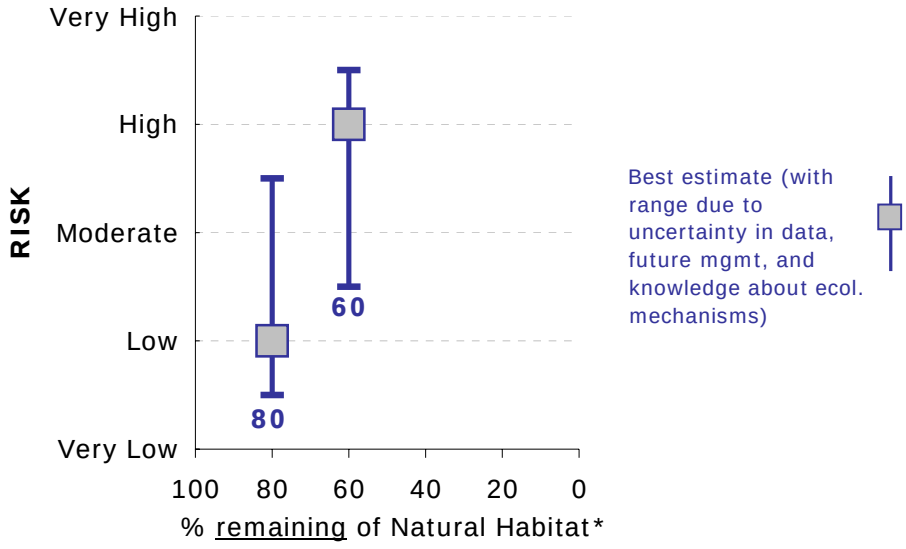
(Risk increases from left to right, even if exact location of LRT and HRT are are uncertain. Colours reflect increasing risk. Ranges may overlap - see Fig A)



LRT range and HRT range may overlap!

Supplementary Figure B

Highlights uncertainty in risk associated with a specific % of habitat



* see definitions on previous page (Note that x-axis is flipped on supplementary figures)

Conceptual Model	MARBLED MURRELET	TAILED FROG	MOUNTAIN GOAT	GRIZZLY BEAR	NORTHERN GOSHAWK
Key Factors Affecting Populations	(1) Terrestrial nesting habitat (2) influence of marine environment on adult mortality and reproductive rate (3) fragmentation (4) power lines	(1) Habitat - aquatic and terrestrial (2) Stochastic mortality - flash flood,low flow,debris, torrents (3) Local climate - stand microclimate,weather,climate change (4)Predation mortality	(1) Habitat (winter range) effectiveness, (2) Mortality risk (starvation, disease, predation, hunting, poaching) (3) Stochastic environmental factors	(1) Direct human-caused mortality(2) Changes in salmon availability (3) Habitat (Class I and II) effectiveness (4) Pop'n-scale connectivity	(1) Loss of habitat (suitable territories) (2) Natural variation in breeding success (3) Natural variation in mortality
Land-use impacts on habitat	Terrestrial nesting habitat: Logging removes and fragments habitat and tends to remove better habitats because they correlate with higher timber values.	(1) Roads - especially stream crossings & sediment management (2) Logging - treatment of buffers and ECA (3) Independent power production - run-of-the-river installations	Winter ranges: (1) Small amounts of logging within winter ranges can substantially reduce suitability (2) Repeated sporadic noise causes displacement	Habitat effectiveness: (1) Logging in and near Class I habitat (2) Logging in and near Class II habitat (3) Development that causes displacement	Logging, because it directly affects the suitability and occupancy of potential territories
Other impacts	Reproductive and mortality rates are influenced by marine environment. Nest predation risk increases with habitat fragmentation and nearby human habitation		Mortality risk: over-winter starvation, predation, hunting, avalanches and falls. Summer range: forage reduced by fire suppression	Direct human-induced mortality: Human/bear interact'ions, displacement Declining salmon stocks: a major pre-hibernation food source	Disturbance (e.g. noise and activity from logging)
Management assumptions used to identify risk thresholds	(1) Habitat Class I, II logged preferentially (2) Limited forest fragmentation (3) Limited harvest of Class IV and V habitat (Habitat classes are defined in Section 4.3, I = very high quality, III = moderate)	(1) Best management practices (2) Sufficient buffer - stream protection, adult habitat (3) Basin cond. good low ECA and slides, good hab.distr. (4) Connectivity within and betwen basins (5) No Independent Power Production (IPP)	(1) Other seasonal habitats are intact (2) Intact winter ranges are not partly harvested (3) Constant ratio of good/poor quality winter ranges (4) Mortality and displacement do not increase (5) Disease, predation, etc. remain within rangee of natural variation	(1) All Class I habitat protected (2) Repres. range Class II habitats (3) EBM creates moderate to good seral stage distr. (4) Current level of pop'n connectivity (i.e. fragmentation) (5) Current level of human / bear interaction (access, etc.) (6) Current salmon stocks	(1) Territories are harvested equally across their range of habitat quality (2) Territories are well distributed, i.e., maintained across the sub-region in a manner that reflects natural spacing patterns. (3) little to no silvicultural enhancement of habitat

Sources of Uncertainty	MARBLED MURRELET	TAILED FROG	MOUNTAIN GOAT	GRIZZLY BEAR	NORTHERN GOSHAWK
Data	Habitat mapping and classification (forest cover maps, air photo interpretation, aerial surveys) have limited accuracy. Maps may miss small patches of good habitat within poor habitat polygons.	Stream classifications (vs. actually suitable habitat)	(1) Habitat maps may have been modified due to other objectives or may lack field verification.	(1) Habitat capability (i.e. natural level) not yet mapped.	(1) Inputs into the breeding, foraging, and territory models (e.g. estimates of habitat quality / breeding density)
Management	Possible changes in logging practices (e.g. do not take best habitat first) or substantial increases in human presence (e.g. power development)	(1) Logging practices -BMP or no BMP (2) partial logging of buffers (3) management of stream crossings (4) old growth present? (5) connectivity of old growth and riparian	(1) Partial logging of winter ranges (2) Preferential logging of best/worst winter ranges (3) Future levels of watershed development (noise, access)	(1) Level of human/bear interactions (2) Level of consideration of context and value when selecting Class II habitat patches to reserve	(1) Preferential harvesting of better habitat (2) Silvic. to create mature stand structure
Knowledge - General	Effects of habitat class on murrelet density and recruitment rate. Effects of marine environment on mortality and recruitment.	(1) Effects of aquatic conditions (2) Effects of logging in each basin (sedimentation, flow) (3) effects of forest age (4) life history and limitations	(1) Response of predators and hunters to access. (2) Effects of development on connectivity.	(1) Future changes in salmon abundance (2) Influence of landscape context (e.g., need for forage supply) (3) Social interactions (e.g. habitat use, mortality risk)	(1) Population dynamics, including mortality, predation and dispersal rates (2)Territory size and required habitat density within territories (3) number of floaters and their effect on population dynamics
Knowledge - High Risk Thresholds	Estimates of (1) habitat effect on rates of reproduction and mortality, (2) murrelet density by habitat class (particularly percent using Class IV and V), (3) ratio of adults to breeding pairs, (4) viable populations size	(1) Assumptions about population resilience, (2) effects of isolation on genetic fitness, (3) frog dispersal capability, (4) critical frog densities below which there are large effects on gene flow, recolonization, etc	(1) Estimate of increased sensitivity of goats to habitat loss, given low recruitment rate and isolated sub-populations	(1) Relative magnitude of other threats (e.g., human-bear interaction and salmon abundance)	(1) Relationships between number of suitable territories and goshawk population viability (2) Influence of high quality individuals or territories on population viability.
Quality of knowledge supporting threshold estimates?	LOW to MODERATE - rated 2.5 out of a possible 5	Expert group rated knowledge about tailed frogs as VERY LOW to LOW, but didn't rate quality of threshold estimates. Assumed to be very low	LOW - rated 2 out of a possible 5	MODERATE - rated 3 out of a possible 5	LOW to MODERATE - rated 2.5 out of a possible 5

Habitat Thresholds	MARBLED MURRELET	TAILED FROG	MOUNTAIN GOAT	GRIZZLY BEAR	NORTHERN GOSHAWK
Spatial Scale	Sub-Region: Murrelets are sufficiently mobile to move among landscape units.	Basin: Start at the stream and basin levels, then scaled up (LRT/HRT developed at each level!)	Mountain blocks: Limited connectivity between mountain blocks due to predation or terrain.	Sub-Region: Social interactions, but topographical limitations to connectivity	Sub-Region: Goshawks are sufficiently mobile to move among landscape units.
Definition of habitat	Area of habitat classes I, II an III that are 140+ years old and within 30 km of ocean (i.e. ends of fjords)	In a basin: Number of streams suitable for frogs that are effectively buffered along their entire length	Proportion of intact naturally-occurring winter range patches in each mountain block	Area of Class II habitat in each sub-region; 100% of existing Class I habitat protected	Number of suitable territories (i.e. sufficient size and more than 70% foraging habitat)
Low Risk Threshold	About **88%** (range 60 to 100%) remaining habitat based on estimated historic natural variation in murrelet habitat abundance.	At least **80%** (range 60 to 100%) of suitable frog streams buffered, because natural variability of stream habitat was probably low historically and more than a 20% change in habitat may result in populations that can be detected beyond natural variability	About **90%** (range 65 to 100%) remaining habitat based on estimated detectable difference from natural variation in population distribution and abundance and considering changes to the landscape associated with development.	About **100%** remaining Class II habitat based on estimated natural variation in population distribution and abundance and considering changes to the landscape associated with development.	About **80%** (range 68 to 100%) remaining habitat due to small pop'n; not higher due to high mobility (breeding occurs at low densities) and floater pop's that buffer impacts.
High Risk Threshold	About **33%** (range 5 to 66%) remaining habitat due to a combination of lost high-quality nesting habitat and increased edge effects associated with fragmentation (e.g. predation). Further loss of nesting habitat accelerates risk to viability, considering a wide range of at-sea conditions.	About **50%** (range 35 to 80%) of suitable frog streams buffered. Tailed frogs have low reproductive output and poor dispersal so impacts of predation and stochastic events all become greater threats to small poulations than when populations are larger	About **60%** (range 50 to 95%) remaining habitat because goats are likely more sensitive to habitat loss than many other species: they have a low recruitment rate and they live in relatively isolated sub-populations that can limit re-colonisation and possibly gene transfer. Winter ranges are essential for overwinter survival.	About **0%** (range 0 to 100%) remaining Class II habitat because Class I habitat provides forage and security cover. The HRT estimate, and more generally the value of habitat, depends greatly on the non-habitat context--particularly salmon availability and human-bear interaction.	About **60%** (range 40 to 80%) remaining habitat because goshawks may not be able to locate mates for breeding, negative genetic consequences would be likely and stochastic events would have a large impact on populations, putting these small populations at a significant risk of extirpation.
What does the uncertainty range capture?	Uncertainty bands: data, future mgmt, and knowledge about ecol. mechanisms and sensitivity analysis	Uncertainty bands: Data, future mgmt, and knowledge about ecol. mechanisms (esp population exchange rates and locations)	Uncertainty bands: data, future mgmt, and knowledge about ecological mechanisms	Inner unc. bands: diff. value of Class II habitat retention Outer bands: data, mgmt, ecol mech., other threats)	Uncertainty bands: pop. response to loss of territories (incl. data, mgmt, ecol. mech.) Note: uncert. about territory suitability is not included
What's needed to estimate current state?	Rough estimate included in report: Current is **roughly 80%** of natural	For each basin, develop and field-verify habitat inventories. Est. numbers of suitable basins in EBM area, est. suitable streams; check occupancy with field work	For each mountain block, develop and field-verify maps of habitat suitability (current) and habitat capability (natural)	Habitat suitability maps are complete, but habitat capability maps are needed	Estimate of **60%** for EBM area based on documented, but unpublished, territory model