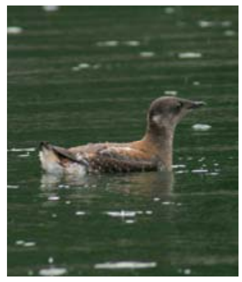
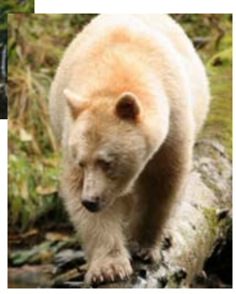
EBM Working Group Focal Species Project

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

Prepared by:

Hannah Horn

P. Arcese

K. Brunt

A. Burger

H. Davis

F. Doyle

K. Dunsworth

P. Friele

S. Gordon

T. Hamilton

G. MacHutchon

T. Mahon

E. McClaren

V. Michelfelder

B. Pollard

G. Sutherland

S. Taylor

L. Waterhouse

March 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.

Acknowledgements

Huge thanks to the many people who put so much time and effort into this document, reviewing and re-reviewing the content and verifying and clarifying the details. The document is much improved because of your diligence.

Cover photographs:

Northern goshawk: Ian Jacobs

Marbled murrelet: Alan Burger

Kermode and grizzly bears and black-tailed deer: Grant MacHutchon

Mountain goat: Steve Gordon

Tailed frog: Alex Brandt

Recommended Citation

Horn, H.L., P. Arcese, K. Brunt, A. Burger, H. Davis, F. Doyle, K. Dunsworth, P. Friele, S. Gordon, Hamilton, G. MacHutchon, T. Mahon, E. McClaren, V. Michelfelder, B. Pollard, G. Sutherland, S. Taylor, L. Waterhouse. 2009. *Part 3: Knowledge Base for Focal Species and their Habitats in Coastal B.C.* Report 3 of the EBM Working Group Focal Species Project. Integrated Land Management Bureau, Nanaimo, B.C.

Table of Contents

1. Introduction

1.1 The Purpose of this Document

This document provides a synopsis of the knowledge related to the habitat requirements of the five focal species named in the Central & North and South Central Coastal Orders (grizzly bear, marbled murrelet, mountain goat, northern goshawk, and tailed frog) and two additional species: black bear and coastal black-tailed deer. This information was assembled to support the co-location of habitats for these species within areas of old growth retention as part of the implementation of Ecosystem-Based Management (EBM).

This report is Part 3 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

Several documents provide more detailed accounts of the ecology, management and conservation of the seven focal species. For detailed background information, refer to the Recommended Readings listed in each focal species chapter.

1.2 Overview of the legal and planning context

The EBM Working Group Focal Species Project is associated with the implementation of the Central & North and South Central Coastal Orders. These legal orders define the minimum legal requirements that must be met by forestry tenure holders during their development activities under ecosystem-based management.

Co-location is enabled under Section 14 of the Coastal Orders. Section 14 (objectives for landscape level biodiversity) requires the retention of a specified amount of old forest within each site series. Subsection (7) states:

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

(a) mountain goats;

(b) grizzly bears;

(c) northern goshawks;

(d) tailed frogs; and

(e) marbled murrelets".

Section 17 in both Coastal Orders (Objective for grizzly bears) and Section 18 (Objectives for Kermode bear habitat) in the Central and North Coastal Order provide species-specific objectives for the fine filter management of habitats. Fine filter management for other focal species is formally addressed through the designation of wildlife habitat areas (WHAs) under the Identified Wildlife Management Strategy and ungulate winter ranges (UWRs) under the *Forest and Range Practices Act*. Under provincial government policy, WHAs and UWRs are not to exceed a pre-defined impact to timber supply.

1.3 Approach to information assembly

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

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

Steps:

1. Each domain expert provided information about habitat quality, quantity, spatial configuration and distribution, and connectivity. They also provided a list of key literature references relevant to the species in a coastal context.
2. The combined interview notes for each species were assembled into chapters describing the knowledge base to support the co-location exercise.
3. Domain experts reviewed and edited the chapter for their species.
4. The chapters were sent to multiple peer reviewers, selected for their own expertise in the species. A list of peer reviewers is provided in Appendix 1.
5. Domain experts reviewed peer reviewer comments and final text was adjusted, as appropriate. The response to peer reviewer comments is provided in Part 6.

2.0 Selection of focal species

Species for the Focal Species Project were selected by the Focal Species Project steering committee at the commencement of the project. A full assessment of choices for species to include was not undertaken at the time due to time limitations. This section provides a *post-hoc* review of the species selected for the project.

2.1 Rationale for focal species selected

Focal species are, by definition, those most influenced by threatening processes (Lambeck 1997). Five species are identified in the Coastal Orders as focal species: grizzly bear, marbled murrelet, mountain goat, northern goshawk, tailed frog. These species, all of which are of conservation concern, were specifically included in the legal orders because they are responsive to changes in mature and old forest cover and they represent different types of habitats.

Two additional species were added to broaden the representation of habitats during co-location. Both of the additional species are of strong social, cultural and economic interest in the coastal planning area. They also represent habitats not addressed by the other species.

Table 1 provides a summary of the ecological rationale for each focal species being identified for focal or fine filter management under EBM. These rationales are described in detail in the chapter for each focal species. Other reasons include:

1. Each are wide-ranging species, whose habitats can be represented by habitat suitability polygons applied across the planning sub-regions. This makes them well-suited to strategic co-location.
2. Each of these species has been of management concern for many years and, therefore, there is existing data and habitat mapping available, with habitat coverage of the entire planning region.
3. Focal species have been identified to represent a spectrum of habitats across the landbase. Specifically, this includes representation of
   - Habitats at different elevational ranges:
     - Lower elevation, valley bottom habitats: grizzly bears, marbled murrelets, northern goshawks
     - Mid-elevation habitats: mountain goats, tailed frogs
     - Higher elevation habitats: tailed frogs
   - Hydroriparian ecosystems
     - Lower elevation riparian ecosystems (estuaries, floodplains, alluvial fans): grizzly and black bears
     - High value fish habitats: grizzly and black bears
     - Upland streams: tailed frogs
   - Steep forested terrain: mountain goats and black-tailed deer
   - Mixed early and old seral forest: black-tailed deer
   - Lowland to upland connectivity: mountain goats, black-tailed deer
   - Habitats outside of grizzly bear-occupied areas: black bear

The Coast Information Team Ecosystem Spatial Analysis (CIT ESA) represented the habitats of these same seven species.

Table 1. Rationale for selection of focal species

Species	Rationale for selection
Black bear	• Black bears have habitat requisites that can be addressed through reserve design and forest management at multiple scales. • Requirements for denning and security habitat may not be adequately addressed by managing for those other species. • Black bears replace grizzly bears as a focal species in the hypermaritime subzones of the Coastal Western Hemlock (CWH) zone. • Black bears are a good barometer of ecosystem health because they are responsive to changes in vegetation and availability of large forest structure for den sites and are likely affected by the size of salmon runs. • Within ranges of subspecies (such as *kermodei)* black bears exhibit considerable genetic diversity and isolation such as between islands or between islands and the mainland. • Black bears are socially, economically and culturally important on the Coast: - Bear viewing is potentially a large source of revenue for some coastal communities, particularly for Kermode bears (Davis 2008). - They are culturally important to First Nations. - Spirit (Kermode) bears have important cultural and social value to First Nations and non-First Nations. Kermodes are a B.C. icon; they are the Provincial Mammal.
Coastal black-tailed deer	• Black-tailed deer represent a habitat mosaic of open and forested habitats, concentrating activity near the ecotone between open- and closed-canopied forests. These habitat combinations are not always captured by other focal species. • The limiting habitat features for deer are often the availability of old-growth forests with desirable topographic characteristics for winter survival. • Managing for deer will help to ensure a healthy predator-prey system. • There is a strong human interest in maintaining deer populations at levels that are self-sustaining (e.g., for hunting, viewing, and First Nations interests).
Grizzly bear	• Grizzly bears are wide-ranging omnivores that require planning considerations at a hierarchy of spatial scales, from regional to site-specific. • Grizzly bears occur at relatively low densities compared to other species and have slow reproductive and dispersal rates. As a consequence they are less resilient than other species to human activities and changes to the land base. • The grizzly bear is an *umbrella* species, that is, protection of the wide range of habitats they use benefits an array of other plants and animals. . • The grizzly bear is also a *keystone* species, meaning that grizzly bears contribute to important ecosystem functions.

Species	Rationale for selection
	• The grizzly bear is a useful *indicator* species. The abundance and distribution of grizzly bears in an ecological community reflects ecosystem health at lower levels of organization. • The grizzly bear is Blue-listed by the B.C. Conservation Data Centre (CDC), a COSEWIC species of Special Concern, and an Identified Wildlife species under FRPA. It is a Priority 2 species under Goal 2 of the B.C. Conservation Framework.
Marbled murrelet	• Marbled murrelets are old-growth dependent. • They are dependent on specific features of forested habitats that have been well-defined through recent research. • Habitat requirements need to be considered at multiple spatial scales. • Their habitat can be lost or be reduced in quality (e.g., edge creation and increased predators) by development activities (e.g., forestry, energy production, and mining). • The species is listed as Threatened under the *Species-at-Risk Act*, is Red-listed by the CDC and is an Identified Wildlife Species under FRPA. It is a Priority 1 species under Goals 1 and 3 of the B.C. Conservation Framework.
Mountain goat	• As B.C. supports over half of the world's mountain goat population, the Province has a global responsibility to conserve the species. • Mountain goats show very predictable use of winter habitat. On the Coast, some female goats use very small areas of winter habitat and they show strong site fidelity. • Old growth forests play an important role in the survival of mountain goats, providing critical snow interception cover, particularly during winters of heavy snowfall. • Mountain goats represent wilderness to the public. They are not often seen in front country areas. As such, they provide a visible sense of wilderness to an area. • The mountain goat is a Priority 1 species under Goal 2 of the B.C. Conservation Framework.
Northern goshawk	• Northern goshawks are a top avian predator within mature and old forests. As such, they likely play a complex ecological role. Goshawks are often considered to be an indicator of mature forest ecosystem health because they depend on the presence of prey species that are themselves dependent on the structural complexity of these forests. • Goshawks can regulate prey populations, especially in areas where they select a few key prey species. • Goshawks function as a primary nest builder for other birds such as large forest owls, Common Ravens, and Great Blue Herons. • As a large, territorial forest raptor, goshawks likely influence the spacing and

Species	Rationale for selection
	distribution of other forest raptors (Krüger 2002). • *Laingi* subspecies is Red-listed by CDC and is listed as Threatened by COSEWIC. It is an Identified Wildlife Species under FRPA. Under the B.C. Conservation Framework it is a Priority 1 species under Goal 3 and a Priority 2 species under Goal 1.
Tailed frog	• Tailed frogs have specialized habitat requirements, being adapted to perennially flowing upland streams with stable bedforms, low sedimentation rates and cool water temperatures. • Since they are highly philopatric (remains in, or habitually returns to a specific location in order to breed or feed), long-lived and have relatively stable populations, their relative abundance can be an indicator of habitat quality in upland streams. • Upland streams lacking fish are not protected under the *Forest and Range Practices Act* and management for other focal species will not adequately protect these headwater stream habitats. • As a dominant grazer, tailed frogs are an umbrella species and protecting their habitat will serve to protect other inhabitants of upland streams. • For the purpose of old seral retention, *A. truei* has life history characteristics that are directly responsive to forestry practices. Most research points to *A. truei* being highly associated with old forest. • *A. truei* is Blue-listed by the CDC and is listed on the Species at Risk Act [SARA] Registry. Tailed frogs are a Priority 1 species under Goal 2 of the B.C. Conservation Framework.

2.2 Additional species for consideration

2.2.1 A process for selecting focal species

As mentioned in section 2.1, there are ecological and practical reasons for selecting the focal species considered in this project. The list of species could readily be expanded to include occurrences or habitats of other species of conservation concern, including Identified Wildlife and CDC-listed species, consistent with the Coastal Orders (see below). Species not at risk, but of conservation concern might also be included, such as B.C. Conservation Framework priority Goal 2 species and species of social, cultural and economic concern, such as hunted or trapped species.

A more systematic approach might be applied to identify a broader range of species for the coastal planning area, although there may not be the data or mapping to warrant the effort. Nature Conservancy Canada uses an expert-based approach to selecting features species for its Ecoregional Assessments based on a set of conservation-based criteria (TNC 2000). Gillingham (2003) has developed a classification system based on ‘lifeform groupings’ to identify representative species that, when considered together, represent the structural needs for all species within a given lifeform.

Another approach might be to be guided by traditional and local knowledge in the selection of focal species. Garibaldi and Turner (2004) describe “cultural keystone species” that are integral to the cultures of indigenous communities.

The following sections contain examples of other species that might be considered for the purposes of co-location and broader implementation of EBM.

2.2.2 Species of conservation concern

2.2.2.1 Identified Wildlife

Section 14 (7) of the Coastal Orders requires that habitat elements important for species at risk ungulate winter range and regionally important wildlife be co-located within old forest retention areas, to the extent practicable. Species at risk and regionally important wildlife established under GAR are referred to as Identified Wildlife and are managed under the Identified Wildlife Management Strategy (IWMS). Procedures for the delineation and establishment of wildlife habitat areas and general wildlife measures for Identified Wildlife are outlined in the IWMS (MOE 2004).

The IWMS lists the following Identified Wildlife whose range includes the coastal planning region:

Taxon	Species	Habitats to be addressed within WHAs
Amphibian	Red-legged frog (*Rana aurora aurora*)	Aquatic and riparian breeding habitats not addressed by riparian objectives or through landscape level planning.
Bird	Great blue heron (*Ardea herodias*)	Nesting sites and adjacent foraging areas
Bird	Sandhill crane (*Grus canadensis*)	Nesting areas and breeding wetlands and staging areas
Fish	Bull trout (*Salvelinus confluentus*)	Aquatic habitat features, migration corridors. Riparian areas on S4 - S6 streams known or suspected to have bull trout or feed into a bull trout stream. Bull trout are generally an interior species but are known to occur in tributaries to the lower Skeena River (D, Atagi, MOE, pers. comm.)
Mammal	Fisher (*Martes pennanti*)	Resting and maternal den sites
Mammal	Keen's long-eared myotis (*Myotis keenii*)	Known colonies (maternity or hibernacula), roosting sites as well as adjacent foraging areas and movement corridors.
Mammal	Wolverine (*Gulo gulo*)	Seasonal foraging areas, denning sites, movement and dispersal corridors.

2.2.2.2 Species listed by the B.C. Conservation Data Centre

Birds:

Canada goose occidentalis subspecies (*Branta Canadensis occidentalis*) is Red-listed by the CDC (NatureServe conservation ranking S1N). The *occidentalis* subspecies is considered threatened because of declines along the Pacific Flyway and incursion by other Canada goose species.

Peregrine falcon pealei subspecies (*Falco peregrinus pealei*) is Blue-listed by the CDC (NatureServe conservation ranking S3B) and is a COSEWIC species of Special Concern. Breeding sites have been recorded on islands off the central mainland coast but not on the coastal mainland, although there are numerous non-breeding occurrences (Campbell et al. 1990).

Pine grosbeak carlottae subspecies (*Pinicola enucleator carlottae*) is Blue-listed by the CDC (NatureServe conservation ranking S3B). It occurs on Vancouver Island and Haida Gwaii and is believed to occur on the coastal mainland. Exact boundaries of its range are unknown (Fraser et al. 1999).

Western screech owl, coastal subspecies (*Ottus kennicottii kennicotti*) is Blue-listed by the CDC (NatureServe conservation ranking S3) and is a COSEWIC species of Special Concern. Screech owls breed along the mainland coast as far north as Kitimat, including coastal islands (Campbell et al. 1990). They are considered an indicator of healthy riparian ecosystems, requiring intact contiguous riparian areas with reasonably large cottonwoods or birch for nest cavities (COSEWIC 2002).

Fish:

Coastal cutthroat trout (*Oncorhynchus clarki clarki*) is Blue-listed by the CDC (NatureServe ranking S3S4). They occur in gravelly lowland streams and lakes along the Coast. They may be resident or anadromous (B.C. Ministry of Fisheries).

Dolly Varden (*Salvelinus malma*) is Blue-listed by the CDC (NatureServe ranking S3S4). Resident fish occur in streams and lakes can be found in steep small streams (>20% gradient). Anadromous Dolly Varden remain close to shore during their time away from freshwater streams (B.C. Ministry of Fisheries).

Eulachon (*Thaleichthys pacificus*): Eulachon is Blue-listed by the CDC (NatureServe conservation ranking S2S3). The species is found in shallow coastal habitats and spawn near the ocean on the shores of medium and large-sized rivers.

2.2.2.3 B.C. Conservation Framework

The B.C. Conservation Framework ranks species of conservation concern according to priority for management action, for each of three goals:

Goal 1: Contribute to global efforts for species and ecosystem conservation

Goal 2: Prevent species and ecosystems from becoming at risk

Goal 3: Maintain the diversity of native species and ecosystems

Goal 1 and 3 species that are a high priority under the Conservation Framework are already captured as focal species or are mentioned in the preceding sections (2.2.2.1 and 2.2.2.2). Goal 2 species that are a high priority for conservation and that that are not already mentioned above include:

Barrow’s goldeneye	(*Bucephala islandica*)
Common goldeneye	(*Bucephala clangula*)
Harlequin Duck	(*Histrionicus histrionicus*)

2.2.2.4 Important Bird Areas

An Important Bird Area (IBA) is a site providing essential habitat for one or more species of breeding or non-breeding birds. These sites may contain threatened species, endemic species, species representative of a biome, or highly exceptional concentrations of birds. One of the main goals of the IBA program is to ensure the conservation of sites through the development and implementation of conservation plans in partnership with local stakeholders for priority IBAs. There are a number of IBAs within the coastal planning area at www.bsc-eoc.org/iba/IBAsites.html

2.2.3 Other potential focal species

Moose (*Alces alces*): Domain experts requested that moose be added to the list of focal species for the Mid and North Coasts. Ungulate Winter Ranges for moose have been designated in the Mid Coast. Skeena Region MOE did not put moose forward as a focal species, stating that the habitats of other species were of higher priority for conservation, including black-tailed deer because of the habitat dependency of deer on old-growth.

Elk (*Cervus spp*): Domain experts also requested that elk be included to the list of focal species for the Mid Coast. Habitat mapping for elk is still under development.

Marten (*Martes americanus*): Biologists in Southeastern Alaska recommend marten as an indicator species as they are very sensitive to removal of old growth, fragmentation and roaded access (R.Flynn, Alaska Department of Fish and Game, pers. comm.; Baltensperger 2006).

2.3 References

Baltensperger, A. 2006. *American Marten: A Global Barometer of Global Climate Change*. U.S. Fish and Wildlife Service Kenai National Wildlife Refuge website http://kenai.fws.gov/overview/notebook/2006/june/30june2006.htm

B.C. Ministry of Fisheries. No date. B.C. *Fish Facts: Coastal cutthroat trout Oncorhynchus clarki clarki.* Victoria, B.C. http://wlapwww.gov.bc.ca/wld/documents/fishfacts/cutthroattrout.pdf

B.C. Ministry of Fisheries. No date. B.C. *Fish Facts: Dolly Varden Salvelinus malma .* Victoria, B.C. http://wlapwww.gov.bc.ca/wld/documents/fishfacts/cutthroattrout.pdf

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990 The *Birds of British Columbia, Volume 2. Non-Passerine. Diurnal birds of prey through woodpeckers*. Royal British Columbia Museum / Canadian Wildlife Service. Victoria, B.C. pp 54 – 57.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. *Assessment and Update Status Report on Western Screech-owl Otus kennicottii macfarlanei subspecies, kennicotti subspecies in Canada*. URL:www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_western_screech_owl_e.pdf

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. *Pine Grosbeak carlottae species subspecies* In Rare birds of British Columbia. B.C. Ministry of Environment. Victoria, B.C.

Garibaldi, A. and N. Turner. 2004. Cultural keystone species: implications for ecological conservation and restoration. Ecology and Society 9(3): 1. [online] URL: http://www.ecologyandsociety.org/vol9/iss3/art1

Gillingham, M.P. 2003. *Report on the Lifeform Classification Project (1 August 2002 to 30 March 2003)*. University of Northern B.C., Prince George. http://www.for.gov.bc.ca/hfd/library/FIA/2003/FIA-03-04-0016.pdf

Tamblyn, G.C. and H. Horn. 2001. *Current Conditions Report: North Coast Land and Resource Management Plan.* Prince Rupert Interagency Management Committee. Smithers, B.C.

TNC (The Nature Conservancy). 2000. *Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning.* Volume 1 (2nd edition).

3.0 American Black bear (*Ursus americanus*)

Domain experts:

Helen Davis, Artemis Wildlife Consultants

Tony Hamilton, B.C. Ministry of Environment

Grant MacHutchon, A. Grant MacHutchon Consulting

3.1 Species Overview

3.1.1 Introduction

Photos: G. MacHutchon

American black bears are ubiquitous throughout British Columbia and much of North America. There are five subspecies of black bears recognized in B.C., two of which are common to the coastal planning region:

- *U. americanus altifrontalis* is a coastal subspecies of primarily black-phase bears occurring from Bella Coola to Oregon (Hatler et al. 2008);
- *U. americanus kermodei* (Kermode or Spirit bear) is primarily restricted to the north central part of the coastal mainland, with concentrations of the rare white-phase bears on Princess Royal, Gribbel and Roderick Islands (Marshall and Ritland 2002).

Home ranges consist of seasonal feeding habitats connected by travel corridors. Home ranges of female black bears on the coast average 7.83 km^2 (Davis et al. 2006). There is not a lot of overlap between home ranges of females, but home ranges of males overlap home ranges of numerous females. Females have high fidelity to their home ranges, with daughters inheriting home ranges from their mother or establishing a home range adjacent to their mothers (Powell et al. 1997). The home range of male black bears is generally larger than for female bears (Koehler and Pierce 2003; H. Davis, pers. comm.).

British Columbia provides habitat for approximately 25% of the black bears in Canada. The estimated population is 80,000 to 100,000 (T. Hamilton, pers. comm.). The density of black bears in the coastal planning region is estimated at 1 bear per 5 km^2, or 3000 – 3500 in the region (T. Hamilton, pers. comm.).

Scales for planning and management of black bear habitat include:

Landscape scale:	landscape level forage supply; provision of a supply of dens, forage habitats, and security habitats throughout landscape units; linkages between lowland and upland areas.
Stand scale:	important forest structural elements (trees for denning and security, stumps, coarse woody debris).

3.1.2 Conservation status and legal designations

3.1.2.1 Conservation status

Black bears are yellow-listed in B.C. because none of the subspecies are considered to be at risk and populations are considered stable.

3.1.2.2 Existing management designations

Coastal Land Use Orders

Section 18 of the Central and North Coastal Order (Section 18), has the following objectives within defined Kermode stewardship areas:

- Maintain a maximum of 30% early-seral and 40% mid-seral within identified watersheds;
  - Maintain a maximum 70% crown closure within managed stands by the end of the free-growing period;
  - Do not alter critical black bear habitat; and
  - Establish windfirm reserves adjacent to known black bear dens.

Other EBM objectives in the Central & North and South Central Coastal Orders that will contributed to black bear habitat include:

- Objectives for grizzly bear habitat (Section 17)
- Objectives for landscape level biodiversity (Section 14):
  - Retention of old forest within each site series (or site series surrogate) in each landscape unit
  - Maintain less than 50% mid-seral of each site series (or site series surrogate) by LU.
- To the extent practicable, co-location include within areas of old growth retention, habitat elements for species at risk, ungulate winter range, regionally important wildlife and focal species.
- Objectives for stand level retention (Section 16): Minimum 15% stand level retention.
- Objectives for hydroriparian areas, including active fluvial units and fans and forested swamps (Sections 10 – 13).
- Objectives to manage the rate of harvest in mapped 'important fisheries watersheds' (Section 8) and to apply reserve zones along streams having high value fish habitat (Section 9).

3.1.3 Threats to black bears

Aside from considerations of human-induced mortality, black bears are generally adaptable and are able to occupy poorer quality habitats more successfully than grizzly bears. Due to their ubiquity and adaptability, black bears generally receive less specific management attention but they are nonetheless vulnerable to the effects of land management practices.

- Some of the biggest threats to black bears are mortality as a result of roaded access and its consequential effect on hunting and poaching, increased human-bear interaction and human-bear conflict over garbage and other non-natural food sources. There are, on average, 876 conflict kills of black bears reported in B.C. each year (T. Hamilton, pers. comm.).
- Roads and concentrations of people can be barriers to bears. Loss of connectivity is an issue in places with a high level of human activity and concentrated development, particularly if every major valley bottom is developed. There is a need for proactive planning in areas of sizeable human settlement (e.g., along Highway 16).
- In heavily logged areas, black bears, unlike grizzly bears, will particularly have a problem with lack of suitable den sites. This is a problem where the volume of large standing live and dead trees and downed wood is diminished over several rotations, especially where the

ratio of operable land base to total forested land area is high. Second growth may include denning opportunities, but these are typically old growth legacies that will eventually decay and cease to exist.

- There is also a concern about a reduction in food availability over time in managed forests. Black bears need berries and succulents. Timber harvesting and subsequent silviculture practices that promote 'boom and bust' forage conditions will impact bears.
- It is not clear that forage regeneration after clearcutting second growth will equal the volume, quality and diversity that remains after old growth harvesting. There is a risk of an incremental and detrimental loss of forage capacity in managed stands over future rotations.
- Habitats may be lost as a result of natural and logging-generated landslides/debris torrents. Historic logging may accelerate the rate of mass wasting events on the wetter, outer coast.
- Climate change also has the potential to reduce food availability through poor salmon returns and reduced berry production.
- There may be considerable impacts on coastal bears from declining wild salmon stocks (e.g., as a result of sea lice contamination caused by commercial fish farms; Krkošek et al. 2007)
- There may be impacts associated with bear viewing. Bear populations need to be stable enough to accommodate disruptions associated with viewing. Bears need access to seasonally important resources such as salmon and those bears unwilling, or unable, to habituate to bear viewing activities will be disproportionately displaced from these critical food sources (Davis 2008).
- Researchers have shown that grizzly bears are exposed to persistent organic pollutants (POPs) in their diet and that these chemicals accumulate and concentrate during hibernation (Christensen et al. 2005, Christensen et al. 2007). There is concern that this exposure to toxic chemicals may contribute to disruption of endocrine processes, increasing the risk of adverse health effects in grizzly bears and their cubs (Christensen et al 2007). This situation may also apply to black bears, although this has not been researched.
- Hunting is not considered a threat to black bear populations on the Coast. Very few black bears are legally harvested. Illegal killing of individual bears (poaching) is a concern and is generally facilitated by increased human access and use. Additionally, many more bears than necessary are killed as a result of conflicts with humans.

3.1.4 Black bears as a focal species

Black bears are a suitable focal species on the B.C. Coast because:

- They have habitat requisites (e.g., large, old trees and coarse woody debris for denning; security cover adjacent to foraging areas; seral stage distribution over time) that can be addressed through reserve design and forest management at multiple scales.
- Their requirements for denning and security habitat do not always overlap with other focal species and, therefore, may not be adequately addressed by managing for those other species. There is a reasonably high degree of overlap in critical habitat with grizzly bears, as both species of bears require habitats such as wetlands, other non-forested habitats, and forested swamps. However, their habitat requirements differ, e.g., black bears use habitat elements that grizzly bears do not use, such as large cottonwood trees that rot out in the core for dens. Denning also occurs at different elevations.

- Black bears replace grizzly bears as a focal species in the hypermaritime subzones of the Coastal Western Hemlock (CWH) zone, west of the grizzly bear occupied line (i.e., in habitats where grizzly bears are uncommon).
- Black bears are a good barometer of ecosystem health because they are responsive to changes in vegetation, like that seen when large areas are logged and become sources of berries. Black bears are also responsive to changes in availability of large forest structure for den sites (Davis 1996) and, like grizzly bears (Robbins et al. 2004), are likely affected by the size of salmon runs. As omnivores and occasional predators, their existence near the top of the food chain reflects ecosystem health at lower levels of organization.

  Black bears may be better able to adapt to changes in food availability (e.g., relying more on vegetation as a primary food source; Welch et al. 1997) than grizzly bears. Reasons include smaller body size, a higher reproductive rate and a greater adaptability to human influence.
- Within ranges of subspecies (such as *kermodei)* black bears exhibit considerable genetic diversity and isolation such as between islands or between islands and the mainland (Ritland and Marshall 2001).
- Black bears are socially, economically and culturally important on the Coast:
  - Bear viewing is potentially a large source of revenue for some coastal communities, particularly for Kermode bears (Davis 2008).
  - They are culturally important to First Nations.
  - Spirit (Kermode) bears have important cultural and social value to First Nations and non-First Nations. Kermodes are a B.C. icon (e.g., they are the Provincial mammal).

3.2 Habitat Quality

Key factors affecting the quality of habitat supply for black bears are:

- food availability,
- availability of den structures,
- availability of escape and thermal cover,
- proximity to roads and human activity.

The highest quality forested black bear habitats provide structural diversity (horizontal and vertical) with a diversity of age classes, species and canopy openings. This diversity provides greater food availability and an ongoing supply of the requisite structural elements for black bear survival. Good black bear habitat is composed of big trees in open forest with canopy gaps that allow understory forage to develop and is in close proximity to salmon-bearing streams. Large trees provide existing and future den sites, serve as escape trees and afford shelter from inclement weather.

> Horizontal structure provides security cover and forage.
>
> Vertical structure, provided by a variety of age classes and tree sizes, allows sunlight to reach the forest floor which promotes understory growth. A higher density of trees means a denser canopy, reduced light and therefore reduced forage values.

Old forests on the coastal mainland typically contain horizontal and vertical diversity as a result of small gap disturbance dynamics (Lertzman et al. 1996). Changes to this historic structure affect the availability and security of habitat for black bears.

Important non-forested habitats include beaches, estuaries, wetlands (fens) and avalanche chutes. Bear habitats often occur in a complex of non-forested habitat and adjacent forested buffer, both of which are considered necessary for habitat to be fully functional (H. Davis, pers. comm.). The forest adjacent to non-forested habitats provides thermal cover for bedding, security cover, marking behaviour trees and travel trails.

Within grizzly-occupied areas, black bears co-exist with grizzly bears by adjusting their behaviour and habitat selection to avoid the more dominant grizzly bears (MacHutchon et al. 1998, Fortin et al. 2007).

Hypermaritime (CWH vh1 and vh2) areas are used by black bears but there is little use by grizzly bears, possibly due to a lower overall abundance of forage. Black bears may be relegated to these habitats because they are less dominant than grizzly bears (Mattson et al. 2005) and may have their nutritional needs met by vegetation and fruit sources (Welch et al. 1997), while most grizzly bears likely require the intake of salmon due to their larger body size (Robbins et al. 2004). Denning opportunities for grizzly bears are perhaps also reduced in the hypermaritime Hecate Lowlands and Outer Fjordlands ecosections (T. Hamilton, pers. comm.).

Photo: G. MacHutchon

3.2.1 Food availability

Black bears are opportunistic omnivores. Coastal back bears take advantage of a wide variety of vegetative and non-vegetative food sources, depending on what is locally and seasonally available (Davis et al. 2006, Michelfelder and Lertzman 2006). Most of their diet is composed of herbaceous vegetation and fruit (MacHutchon 1999, Davis et al. 2006, Fortin et al. 2007). The availability of these resources is directly linked to reproductive output (Rogers 1976).

Prime vegetative foraging areas throughout bear active seasons include wetlands (fens and bogs), meadows, wet seepage areas, estuaries, intertidal zones, riparian fringes along creeks and rivers, beach fringes (vegetated areas above the high tide line), open canopy floodplain forests, lower slope moist to wet and nutrient rich to very rich forests, and avalanche chutes (Unsworth et al. 1989, MacHutchon 1999, Koehler and Pierce 2003). In managed forests, black bears also forage in early successional clearcuts (< 15 years old) and cleared and hydroseeded roadsides (Davis et al. 2006; Hanson 1988).

Black bears also utilize non-vegetative food sources. Where available, bears feed on intertidal animals (MacHutchon 1999) and spawning salmon (Reimchen 2000). They also eat insects and will kill and eat small mammals throughout the year (MoELP 2001). Black bears can be significant predators, eating deer fawns and elk and moose calves, where available (T. Hamilton pers. comm.).

Sedge fen habitat Photo: G. MacHutchon

Habitat use by black bears differs between seasons (Davis et al. 2006). Black bears have been shown to make extensive movements to areas of seasonal food abundance. Davis et al. (2006) showed that black bears will choose areas to feed based on their seasonal forage value, selecting berries and succulents at their peak and moving to spawning streams when fish are present. Coastal black bears are known to make seasonal vertical migrations, for example, as *Vaccinium* ripening progresses bears follow the ripening to higher and higher elevations eventually ending up in the Mountain Hemlock (MH) zone in September (T. Hamilton, pers. comm.).

- For black bears, foraging habitat should be addressed inside and outside of old growth reserves. Critical bear habitat complexes should be captured within reserves. In order to adequately manage for black bears, old growth reservs should include non-forested critical habitats. Mapping of habitat complexes for black bears will allow these habitats to be included in the co-location solution.
- Outside of old growth reserves, forest management should ensure that the functional quality of complexes of forested and non-forested habitats (wetlands, riparian areas, and avalanche chutes) are maintained and functionally linked across the operable landbase.

In addition to conserving or maintaining habitat, forestry activities outside of old growth reserves should be timed and located to avoid boom and bust habitat conditions. Where large areas of early seral are created through logging, there is an initial flush of high quality forage (for up to 15 years in fully stocked stands), but the growing forest quickly reaches closed canopy with a depauperate understory with little foraging opportunity for bears. Forest harvesting can be planned to ensure ongoing forage supply across the land base over time (e.g., by distributing openings over space and time as well as retaining openings in selected site series through cluster planting and stand tending.

3.2.2 Availability of den structures

Coastal black bears rely on old-growth structures for winter denning (Davis 1996; Hanson 1988; Manning Cooper and Assoc 2003). In a study of denning in the Nimpkish River Valley on Vancouver Island (Davis 1996), black bear dens were found in the cavities of hollow standing trees or under the root masses of wind-thrown trees or inside and under large logs, with few dens inside the base of high-cut stumps and under the roots of standing trees. The average diameter of trees with dens was 1.43m (n = 67) (Davis 1996). On the B.C. coast, black bears den at low – mid elevations, whereas grizzly bears typically den from mid to high elevations (e.g., CWH/ MH transition). Dens are critical habitats that provide protection from inclement weather and protection from predation, particularly for females and cubs. Dens used by pregnant females also provide safe, sheltered structures necessary for birthing and early rearing of young in late winter – early spring. A sufficient supply of winter dens is essential for stable black bear populations. This is particularly true on the coast where cold and wet conditions require den structures that keep bears warm, dry and secure (Davis 1996). Harvesting exerts a downward pressure on den supply with long return intervals for habitat recovery that typically exceed normal managed forest rotations.

There is some supporting evidence from a radio-telemetry study of coast black bear on Mitkof Island in Southeast Alaska. Hanson (1988) found 16 dens using 15 radio-collared black bears and 26 probable dens though field research. Of these 42 den structures, the majority (n = 32) involved cavities associated with trees in old stands of western hemlock and mountain hemlock situated in “upland” commercial old-growth forests. Seven were in clearcuts (mostly in downed logs), one in a bole in a living hemlock on a stream terrace, one in a living hemlock at the base of an avalanche chute, and one in a hemlock in the muskeg.

Dens are such sporadic and uncommon elements that they are difficult to proactively manage for except at the stand level. At this time, there is no proven way to predict where they will occur using habitat modelling; the only reasonable approach at the watershed level is to identify and retain stands with large, old trees. However, a project is underway to model coastal denning habitat (McCrory et al. 2008).

Currently, dens are mainly identified during timber cruising and harvest layout and are then retained in wildlife tree patches. Predictive mapping of black bear dens can be unreliable unless it is supported by adequate field sampling that demonstrates the regular occurrence of large, suitable cavities. Where den information is lacking at broader scales, within-stand structural retention becomes very important. Western redcedar and yellow cedar are favoured as den trees (Davis 1996) due to the nature of their growth and decay.

Overall it is necessary to maintain a source of dens inside and outside of old growth reserves. The EBM objective for ≥ 15% stand level retention will contribute to current and future den supply, as long as efforts are made to retain large structural elements with known den sites within harvested stands in combination with the suite of EBM objectives (section 4.4).

The EBM objective to retain monumental cedars will not necessarily address bear den supply as monumental cedars are selected for their soundness and den trees must have an internal cavity to be functional.

3.2.3 Forested buffers

- Escape trees

  Black bears bed under forested cover and close to escape trees that provide security from other bears. Females with cubs rarely go beyond 200 m into a cutblock if there are no escape trees to run to (H. Davis, pers. comm.). They will skirt the edge of a clearcut to get to the other side, rather than cross large openings and make themselves vulnerable. Security trees become even more important where black bears and grizzly bears overlap or where black bears congregate at high value food sources such as along salmon streams. Escape trees need to be at least 10 m in height (Davis et al. 2006). The bigger these trees are the better. Outside of old growth reserves, escape trees can be provided through within-stand retention of large trees.

- Thermal cover

  Black bears utilize many types of structures for thermal cover. Bears will seek shelter from precipitation under forested cover or rock overhangs (Boulanger and MacHutchon 2005), they will also seek shelter from the heat by bedding in cool, shady areas, and they will wallow in small water bodies and creeks or streams to stay cool.

- Bedding sites

  During periods of inactivity, bears bed under forested cover adjacent to feeding areas (Boulanger and MacHutchon 2005). They select dry sites to stay warm and moist sites to stay cool. Bed sites adjacent to well-used feeding areas, such as estuaries, may be used repeatedly and are essential habitats.

3.2.4 Effect of roads

Where a road is proximal to an old growth reserve, the habitat quality of the reserve is reduced as there is an increased risk of hunting and poaching and some possibility of displacement of warier bears. Bears also risk being hit by vehicles on higher traffic roads.

The effect of roads is compounded since bears can be attracted to roads, especially if they are hydro-seeded, as they provide vegetative forage early in the spring and are easy movement corridors for both bears and people (Davis et al. 2006). This issue is potentially more problematic in second growth-dominated landscapes where alternative spring habitat is rare and bears have fewer alternatives (T. Hamilton, pers. comm.). The effect of roads can be reduced through permanent deactivation or debuilding following completion of harvesting and silviculture activities.

3.2.5 Security as a driver of habitat selection

Security is an important issue for black bears and drives habitat selection and resource use. Studies of bear activity have documented the significance of security cover as an element of habitat selection by black bears for security from predatory attacks (Davis and Harestad 1996).

3.2.5.1 Security from grizzly bears

- Black bears use temporal and spatial avoidance to coexist with grizzly bears where there is overlap between the species (MacHutchon et al. 1998). Grizzly bears typically exploit the best quality habitats. Black bears are better able to exploit lower quality habitats, for example, lower productivity sites or lower quality fishing areas (i.e., it is harder to fish or there are fewer fish). In Alaska, Fortin et al. (2007) found that there was minimal dietary overlap between sympatric black bears and grizzly bears. Grizzly bears were found to have a diet high in salmon and terrestrial animal matter, while male black bears ate minimal amounts of salmon and female black bears did not feed on salmon at all.
- Mainland hypermaritime habitats (CWHvh1 and vh2) provide secure habitat for black bears because these areas are rarely used by grizzly bears. Where grizzly bears are not present (i.e., west of the grizzly bear occupied line) those habitats that would normally be considered Class 1 and 2 for grizzly bears are also likely the best habitats for black bears.
- Black bears are prevalent on coastal islands through all three coastal planning areas, with grizzly bears only occasionally occurring on these islands. There are different theories as to the cause of this distribution, including competitive exclusion by black bears (Mattson et al. 2005). However, it is likely that some of the islands on the British Columbia coast that are occupied almost exclusively by black bears do not have large enough salmon runs to support the nutritional needs of grizzly bears (Robbins et al. 2004). For example, on Princess Royal Island there is only one river with an escapement > 10,000 salmon (DFO unpublished data) and it is the only river on Princess Royal with regular sightings of grizzly bears (T Hamilton pers. comm.).

3.2.5.2 Security of females from males

There are demonstrated differences in habitat selection by age class and sex. Security-conscious black bears (especially females with cubs) will use lower quality habitats than adult males (e.g., higher elevation side slope forests, bog forests with shore pine nutrient poor areas with poor drainage, and more closed canopy forests; Powell et al. 1997). Most black bears den away from areas used by other bears to increase security; they tend not to den near spawning reaches of fish-bearing rivers or near high-use areas or foraging areas (H. Davis, unpublished data).

Females with cubs are highly vulnerable to infanticide and cannibalism**.** A recent paper on population demography in Ontario (Obbard and Howe 2008) describes a 10-fold increase in the risk of cannibalism by male bears on females with cubs compared to females with no cubs. Cannibalism may be linked to increased interaction between bears in areas where they are concentrated in a few foraging areas (small food-rich clearcuts surrounded by food-poor, closed canopy second growth forests; Davis and Harestad 1996). Similarly, Czetwertynski et al. (2007) found lower cub survival in an unhunted, high-density study area than in a lower-density, hunted area.

3.3 Habitat Distribution, Spatial Configuration and Connectivity

3.3.1 Distribution

There should be dispersion of important habitats and habitat elements and a distribution of age classes within each landscape unit. While the best foraging habitats are at lower elevations, it is also necessary to capture mid-elevation habitats for females, as they do not always use the best habitats that may be set aside in old growth reserves for security reasons.

3.3.2 Spatial configuration

Black bears continue to eat berries and succulents during the fishing season. The ideal configuration of old growth reserves that are for supplying foraging habitat is near to fish streams for bedding but spatially adjacent to clearcuts for berries and other forage. Reserves that are protecting denning habitat should occur on well-drained mid-slope areas with large trees.

3.3.3 Connectivity

Connectivity at the sub-regional scale for both black and grizzly bears is primarily addressed by conservancies and other large reserve areas and the linkages between them. Large, heavily used human travel corridors are also an issue for bears as these can fragment populations. This is not as much of an issue on the Coast as there are few such corridors, other than Highway 16.

At the landscape scale, the main issue is lowland to upland connectivity (e.g., along riparian corridors). This is mainly a concern with respect to clearcuts, roads and mortality risk.

The contribution of old growth reserves to connectivity is best assessed post-hoc and should be considered during more detailed reserve design.

3.4 Habitat Quantity

For black bears, the appropriate spatial supply of black bear habitat within old growth reserves should be assessed as part of overall land base conditions, including food supply, den supply and security and thermal cover inside and outside of reserves.

The challenge is how to measure adequacy. It is difficult to say that x% of habitat will result in y black bears. The key is to ensure a reasonable mix of habitats over space and time so that whatever is left post-harvest represents a variable mix of old and newer forest, distributed and linked in a reasonable way. The *quality* of the forest matrix is the issue.

There is not enough information to define upper and lower thresholds of habitat availability for black bears. In general, black bears are adaptable and the species is unlikely to be extirpated from areas under today’s standards for forest management. However, there is a limit to what they will adapt to, particular with respect to the availability of structures associated with denning and security and the amount and proportion of closed canopy forest in a landscape.

When assessing the adequacy of habitat supply, there is a need to distinguish between preferred and essential habitats. There are a range of habitat types suitable for black bears, but the key considerations are those habitats that directly meet life requisites. Research has shown that black bear populations respond positively to early seral habitats created by forest harvesting, at least in the short term until re-growth reaches the closed canopy stage (Davis et al. 2006, Lindzey and Mezlow 1977). Conversely, if there are widespread decreases in habitat quality there will likely be a lower density of bears that have larger home ranges. More research is needed in this area.

3.5 Research and inventory gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

3.5.1 Research questions

1. How well do EBM objectives contribute to habitat needs of black bear at the stand and landscape scale?
2. What are the critical habitat elements for black bears? What happens if they are lost?
3. What are the limiting habitat elements for black bears? What happens if they are lost?
4. How does the distribution of harvesting affect black bears (e.g., spatial configuration of openings and security cover, amount of area harvested, etc.)?
5. What are the implications of not managing for lower class habitats to subdominant black bears and females with cubs? Typically higher quality (Class 1 and 2) grizzly bear habitats are the focus of conservation efforts and these may not be as suitable for all black bears in areas where the two species overlap.

   Female black bears with cubs may choose to use lower quality habitats for security reasons – are the bears therefore more vulnerable if that habitat is lost?
6. What is the home range size, habitat selection and behaviour of black bears in unharvested areas where there is overlap with grizzly bears? Many wildlife studies focus on single species; but it would be useful to know what black bears are doing around grizzly bears.
7. What are the effects on forage quality, quantity and diversity following second growth harvesting?
8. What is the impact for black bears of a reduction in salmon returns? Will it increase predation of black bears by grizzly bears, or increase cannibalism amongst black bears?
9. What is the impact of forest harvesting on the strength of the *kermodei* genotype, especially on smaller near-shore islands?
10. What are the impacts of bear viewing on black bear behaviour?

3.5.2 Inventory gaps

1. A better overall inventory of black bears is needed in B.C.
2. Monitoring at viewing sites should be conducted to detect if there is a decrease in the number of bears at a site or a shift in the age or sex classes of bears using a viewing site.
3. The Kermode Bear Scientific Panel (2007) recommends the following to better understand the distribution of Kermode bears and trends over time:
   - Systematic DNA sampling to more precisely estimate the frequency of the white-phase gene and ascertain whether this frequency is changing over time.
   - Monitoring of Kermode bear populations on Princess Royal Island, Gribbell, Roderick, and Pooley islands (the 4 main “Kermode islands”) using indices.
   - Monitoring the number of Kermode and black bears, as well as grizzly bears, in the Green River (index of numbers and frequencies as opposed to a total count) (the Green River has been an area of contention re harvesting and effects on Kermode populations; see KBSP 2007).

3.6 References and Recommended Readings

Boulanger, J. and A. G. MacHutchon. 2005. *Black Bear Inventory Plan for Haida Gwaii, B.C.* Ministry of Water, Land and Air Protection, Biodiversity Branch. Victoria, B.C.

Christensen, J.R., M. MacDuffee, R.W. MacDonald, M. Whiticar, and P.S. Ross. 2005. *Persistent Organic Pollutant exposure in B.C. grizzlies: the consequence of divergent diets.* Environmental Science and Technology. 39: 6952-6960

Christensen, J.R., M. MacDuffee, M.B Yunker, and P.S. Ross. 2007. *Hibernation associated changes in persistent organic pollutants (POP) levels and patterns in British Columbia grizzly bears.* Environmental Science and Technology. 41: 1834-1840

Czetwertynski, S. M., M. S. Boyce, F. K. Schmiegelow. 2007. *Effects of hunting on demographic parameters of American black bears*. Ursus 18:1-18.

Davis, H. 1996. *Characteristics and Selection of Winter Dens by Black Bears in Coastal British Columbia*. M.Sc. Thesis, Simon Fraser University, Burnaby, B.C..

Davis, H. and A.S. Harestad. 1996. *Cannibalism by Black Bears in the Nimpkish Valley, British Columbia*. Northwest Science 70: 88 – 91.

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.

Davis, H. 2008. *Kitasoo Spirit Bear Conservancy Viewing Strategy*. Prepare for B.C. Parks, Hagensborg, B.C..

Deal, R.L. and J. C. Tappeiner. 2002. *The effects of partial cutting on stand structure and growth of western hemlock-Sitka spruce stands in southeast Alaska*. Forest Ecology and Management 159: 173-186.

Fortin, J. K., S. D. Farley, K. D. Rode, and C. T. Robbins. 2007. *Dietary and spatial overlap between sympatric ursids relative to salmon use*. Ursus 18: 19-29.

Hanson, M.B. 1988. H*abitat use and den ecology of black bears on Mitkof Island, southeast Alaska*. MSc Thesis. Univ. of Wash. Dept. of Fisheries, Seattle, WA

Hatler, D.F, D.W. Nagorsen, and A.M. Beal. 2008. *Carnivores of British Columbia*. Royal B.C. Museum Handbook Vol. 5: Mammals of British Columbia. Royal B.C. Museum. Victoria, B.C.

Kermode Bear Scientific Panel. 2007. *Potential for Gene Swamping in Kermode Bears on Princess Royal Island: Scientific Panel Workshop Summary Report, February 15, 2007.* Ministry of Agriculture and Lands, Victoria, B.C..

Koehler, G. M., and D. J. Pierce. 2003. Black bear home-range sizes in Washington: climatic, vegetative, and social influences. Journal of Mammalogy 84:81-91.

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..

Krkošek, M., J. S. Ford, A. Morton, S. Lele, R. A. Myers, and M. A. Lewis. 2007. *Declining wild salmon populations in relation to parasites from farm salmon*. Science 318: 1772-1775.

Lertzman, K. P., G. D. Sutherland, A. Inselberg, and S. C. Saunders. 1996. *Canopy gaps and the landscape mosaic in a coastal temperate rain forest*. Ecology 77:1254-1270.

Lindzey, F. G., and E. C. Meslow. 1976. *Characteristics of black bear dens on Long Island, Washington*. Northwest Science 50:236-242.

Lindzey, F. G., and E. C. Meslow. 1977. *Home range and habitat use by black bears in southwestern Washington*. Journal of Wildlife Management 41:413-425.

MacHutchon, A.G. 1999. *Black bear inventory, Clayoquot Sound, B.C. Volume I: habitat inventory*. B.C. Ministry of Environment, Lands and Parks, Nanaimo, B.C..

MacHutchon, G. 2000. *Proposed method for delineating important black bear habitat polygons within planning units of Clayoquot Sound.* Provided by the author.

MacHutchon, A.G., S. Himmer and C.A. Bryden. 1993. *Khutzeymateen Valley Grizzly Bear Study*. Wildlife Habitat Research Report No. 31. Ministry of Forests Research Program. Victoria, B.C..

MacHutchon, A. G., S. Himmer, H. Davis, and M. Gallagher. 1998. *Temporal and spatial activity patterns among coastal bear populations*. Ursus 10:539-546.

Manning, Cooper and Associates. 2003. *2002 Black Bear Winter Den Inventory: TFL37, North Vancouver Island, B.C..* Canadian Forest Products, Limited, Woss, B.C..

Marshall, H.D. and K. Ritland. 2002. *Genetic diversity and differentiation of Kermode bear populations*. Molecular Ecology 11: 685 – 697.

Mattson, D. J., S. Herrero, and T. Merrill. 2005. *Are black bears a factor in the restoration of North American grizzly bear populations?* Ursus 16:11-30.

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.

Michelfelder, V. and K.P. Lertzman. 2006. *Community Structure of Forage Plants Consumed by Black Bears in the Nimpkish Valley, British Columbia*. Ministry of Forests and Range, Forest Science Program. Victoria, B.C..

Ministry of Environment, Lands and Parks. 2001. *Black Bear in British Columbia: Ecology, Conservation and Management.* Victoria, B.C.

Noble, W. O., Meslow E. Charles, and M. D. Pope. 1990. *Denning habits of black bears in the central coast range of Oregon*. Oregon State University. 97331-3803. Corvallis, Oregon, USA.

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.

Obbard, M. E., and E. J. Howe. 2008. *Demography of black bears in hunted and unhunted areas of the boreal forest of Ontario*. Journal of Wildlife Management 72:869-880.

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.

Reimchen, T. E. 2000. *Some ecological and evolutionary aspects of bear-salmon interactions in coastal British Columbia*. Canadian Journal of Zoology 78:448-457.

Ritland, K., C. Newton, and D. H. Marshall. 2001. *Inheritance and population structure of the white-phased "Kermode" black bear.* Current Biology 11:1468-1472.

Robbins, C. T., C. C. Schwartz, and L. A. Felicetti. 2004. *Nutritional ecology of ursids: a review of newer methods and management implications*. Ursus 15:161-171.

Rogers, L. L. 1976. *Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears*. Transactions of the 41st North American Wildlife and Natural Resources Conference 41:431-438.

Unsworth, J. W., J. J. Beecham, and L. R. Irby. 1989. *Female black bear habitat use in west-central Idaho*. Journal of Wildlife Management 53:668-673.

Welch, C. A., J. Keay, K. C. Kendall, and C. T. Robbins. 1997. *Constraints on frugivory by bears*. Ecology 78:1105-1119.

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

4.0 Coastal Black-tailed Deer (*Odocoileus hemionus*)

Domain experts:

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

Photo: G. MacHutchon

4.1 Species Overview

4.1.1 Introduction

Coastal black-tailed deer are ubiquitous throughout the B.C. Coast, west of the divide of the Coast and Cascade ranges and including the coastal islands. There are two closely related subspecies of black-tailed deer on the Coast: Columbia black-tailed deer (*O. hemionus columbianus*) and Sitka black-tailed deer (*O. hemionus sitkensis*). The Columbia sub-species occurs in the southern part of the coastal planning area and the Sitka sub-species to the north and into Southeast Alaska. A third subspecies, Mule deer (*O. hemionus hemionus*), typically occurs east of the Coast Ranges. The three sub-species interbreed where their ranges overlap, resulting in deer with hybrid characteristics.

Black-tailed deer are fundamental to the ecology, economy and culture of the Coast. They are an integral part of coastal predator-prey systems, providing food for a number of different predators, in particular wolves and cougars (MoF 1996d; McNay and Voller 1995). Deer are an important source of game for subsistence and recreational hunters. A limited commercial hunt (guide outfitting) also occurs. The species is important to First Nations for cultural and subsistence purposes.

Black-tailed deer tend to live alone or in small family groups most of the year. Home range sizes vary widely and are directly correlated with availability of food, water and cover and their distribution across the landbase (Kie et al 2002). Deer have high fidelity to their home ranges, which are usually within proximity of their natal area (MoF 1996a).

There are three behavioural types related to seasonal movement patterns of black-tailed deer: facultative migratory, obligate migratory, and non-migratory residents (McNay and Doyle 1987).

- *Obligate migratory and non-migratory residents* are restricted in their migration movements. Resident deer do not migrate between seasonal ranges and obligate migrators move between seasonal ranges but only at specific times and regardless of snow conditions (MOF 1996b, McNay 1995).
- By comparison, *facultative migratory* deer appear to behave similar to residents until habitat conditions change (usually weather related) at which time they make a migration to a different seasonal range.

These behavioural types invoke different strategies for survival. Resident (non-migratory) deer remain within the same low elevation home range throughout the year. In managed landscapes, resident deer mostly inhabit the matrix of early- and young-seral forests. In snow-free or low snow conditions, forage resources in early seral openings tend to be abundant relative to the mature/old forest stands. In years when the snowpack is moderate to deep, very little forage is available in clearcuts but forage biomass continues to be available in old forests (Farmer 2002) and deer will move into older stands for winter survival.

Migratory deer take advantage of nutritious alpine meadows and other higher elevation foraging habitats, and lower risk of predation during spring, summer and fall. In mild winters, facultative migrators continue that protection from predation by remaining in forest stands at higher elevations and on steeper slopes. In severe winters, they move into lower elevation habitats where they overlap with resident and obligate migratory deer (D. Person, Alaska Dept. of Fish and Game, pers. comm.).

Survival of individual black-tailed deer may be correlated to movement behaviour. Survival rates for resident black-tailed deer have been noted to be lower than for migrants in some instances (MoF 1996d; McNay and Voller 1995). Deer are, in general, vulnerable to rapid and large-scale changes in their habitat, as behavioural influences may limit the mobility of individual deer and their freedom to choose other habitats (MoF 1996a, McNay and Bunnell 1994).

Hunting of deer in the study area is managed as a general open season with bag limits set by Management Unit

Deer habitat should be planned and managed at two scales:

Landscape scale: Management of habitat distribution (seral stage and patch size) and dispersion (distance between seasonal ranges).

Stand scale: Management of food and cover through forest stand characteristics.

4.1.2 Conservation status and legal designations

4.1.2.1 Conservation status

Black-tailed deer have a global conservation rank of G5 and a subnational rank of S5, meaning that they are not a species of conservation concern. They are also considered a species with a low priority for conservation in the B.C. Conservation Framework. However, the species is a key component of coastal ecosystems and, like all ungulates, is vulnerable to the loss of suitable winter habitat characteristics. Ungulate Winter Ranges (UWRs) for deer are able to be established under the Government Actions Regulation (GAR) enacted through the *Forest and Range Practices Act*.

4.1.2.2 Existing management designations

Ungulate Winter Ranges for deer have been legally established under GAR for the Mid Coast and South Coast:

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

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

North Coast: There are no UWRs proposed for the North Coast. Deer are not thought to be at risk from forestry activities and are a low priority for habitat management in the region.

4.1.3 Threats to coastal black-tailed deer

- Removing old forests from the landscape threatens black-tailed deer by:
  - diminishing opportunities to find sanctuary during moderate and severe winter weather; and
  - promoting proportionally more resident (conversely, proportionally less migratory) behaviour in the population. The possible consequences are reduced over-winter survival and reduced population resiliency; the latter due to having more of the population exposed to higher risk of predation (McNay 1995; McNay and Voller 1995).
- Delayed onset of spring snowmelt will also increase mortality risk. Higher quality winter range provides deer with added resiliency to wait out a late snowmelt.
- Boom and bust patterns of timber harvesting have been shown to affect deer population dynamics (Ministry of Forests 1996b). When timber harvesting results in a significant portion of the landscape in early seral stage, deer populations may reach high numbers for some years but will oscillate wider than would be expected under conditions of natural disturbance. In extreme cases, the degree of population oscillation may affect long-term population viability.
- While young clearcuts may provide abundant forage, it is often of poorer nutritional quality (Hanley et al. 1989; Hanley and McKendrick 1983). In particular, digestible protein may be low per kilogram of forage, which could influence reproduction and lactation in females.
- The main causes of mortality among black-tailed deer are malnutrition, predation, and hunting (McNay and Voller 1995). Predation by wolves and cougars, in particular, is a significant source of deer mortality, particularly in low elevations and gentle terrain (MoF 1996d; Farmer et al 2006).

  Managed landscapes give rise to linear corridors (roads) which are known to increase predator search rates and extents (McNay and Voller 1995) thereby putting resident deer at greater risk of dying from predation. Hunting pressure is also greater along linear corridors.

  Fragmentation of landscapes and the isolation of forest patches may also result in greater risk of predation while simultaneously reducing resilience of habitat to support deer.

  Where predation is a factor, habitat should be managed to ensure that deer populations will be resilient to interacting pressures of weather, predation, and hunting.
- Range expansion of white-tailed deer has resulted in this species moving towards coastal areas. White-tailed deer are more aggressive and may out-compete black-tailed. This issue is part of a continent-wide colonization of new habitats by some species and retraction by others in response to habitat alteration and global factors such as climate change.

4.1.4 Coastal black-tailed deer as a focal species

- Severity of winter weather notwithstanding, black-tailed deer are a species that do well with a habitat mosaic of open and forested habitats, concentrating activity near the ecotone between open- and closed-canopied forests (Kremsater and Bunnell 1992). These habitat combinations are not always captured by other focal species.
- The limiting habitat features for deer are often the availability of old-growth forests with desirable topographic characteristics for winter survival. Migratory deer predominantly

choose these places as winter range (McNay 1995). Old growth reserves can provide the food and cover combination that is critical to deer in high and moderate snow pack zones during moderate and severe winter conditions. There is a strong human interest in maintaining deer populations at levels that are self-sustaining (e.g., for hunting, viewing, and First Nations interests).

- Managing for deer will help to ensure a healthy predator-prey system.

4.2 Habitat Quality

Habitat managers tend to generalize the life requisites of black-tailed deer into requirements for food and cover. The juxtaposition of food and cover is a fundamental factor in managing habitat for deer (Parker et al. 1996; Parker et al 1999).

- Food occurs in open-canopy habitats with highly digestible and nutritious forbs and shrubs. Forest edges have particularly high species richness of vegetation but valuable forage resources can also be found within early- and old-seral forests; and
- Cover, which typically occurs in forested habitats of suitable age and species composition, provides security and moderation of climatic conditions (thermal cover ameliorates the effects of wind, temperature, and rainfall, providing deer with a warm dry, secure places to bed). Snow interception cover is a key component of critical winter habitat.

There are four conditions considered critical to functional deer habitat:

1. Topographic and vegetative characteristics that reduce the accumulation of snow while simultaneously allowing for the provision of winter forage (rooted and/or litterfall, including conifer branches and arboreal lichens) during moderate and severe winters.
2. Access to emergent vegetation early in the spring (steep, southerly aspect, no overstory).
3. Adjacency of, and/or connectivity within and between, winter and spring ranges.
4. Security cover to reduce risk of predation.

With proper forest harvesting, these conditions can be managed to maintain or enhance deer populations.

4.2.1 Winter habitat

Deer will select different habitats in response to winter conditions. Winter range becomes a critical habitat requirement during moderate or severe winters, allowing deer to forage and move within habitats in conditions that might otherwise result in high levels of mortality due to malnutrition and physical exhaustion.

Highest levels of snow interception cover occur in within forested stands having larger and older trees (150 years and over). The physical characteristics of the trees and canopy in these stands are important. Older trees have stronger limbs, and wider branches, that can hold large quantities of snow in the canopy to reduce ground-level snow depths (McNay and Doyle 1987)[1]. Snow interception cover is important for reducing the depth of snow, thereby reducing the cost of movement when conditions do not allow travel on the snow crust. It takes a large amount of

[1] Not all old growth provides suitable winter range. In some locations near coasts where southeastern exposures are frequently exposed to severe storms, even-aged or multicohort stands of mature timber may dominate the landscape. Windprone forests tend to have closed canopies and depauperate understories much like dense, closed canopied stands, 40-80 yrs. They may provide winter cover but very little forage.

energy to wade through deep snow (> 30 cm) at a time when food conditions are marginal (Parker et al 1984). Mature and/or old-growth forests that offer good snow interception cover are particularly important during deep snowpack periods. In areas with low snow accumulation, the availability of old-growth as winter range is typically less critical and older age class second-growth forests may suffice.

Important foods in the winter can be terrestrial based (rooted shrubs) or arboreal (litterfall - lichens and broken conifer branches deposited following windstorms). During deep snowpack conditions, deer cannot access rooted forage so litterfall on the snow crust becomes a critical component of survival (Bunnell 1990). In coastal areas, thawing and rain-on-snow events followed by freezing often produces a crust that can support deer allowing them to survive on litterfall regardless of the depth of snow on which they are walking.

Litterfall is typically much more abundant in old-growth stands. Slow-growing lichens are not as abundant in young forests as physical conditions are changing too quickly for them to become established. (Nyberg and Janz 1990).

Response to different winter climatic conditions

As the regional climate of the Coast transitions inland toward a more continental climate of interior ecosystems, snow conditions change from being relatively deep, dense, and intermittent to snow that is shallower, less dense, and more persistent. The effect of varying snow conditions (known as the 'continentality effect') is more pronounced in the Mid and North Coasts than in the South Coast. Most of the Mid and North Coast sub-regions exist in the 'Coastal Gap' between the top of Vancouver Island and southern end of Haida Gwaii. Winter storms in the Coastal Gap flow directly from the Pacific, resulting in heavy snowfall in the hypermaritime and maritime ecosystems. Particularly in the hypermaritime, this deep snow is not long-lasting; rains typically reduce it in a few days. Further inland, in the dry submaritime, precipitation may be lower but the snow does not melt and the snowpack deepens over the winter (Demarchi et al 1990).

Deer respond to these varying winter conditions by moving up and down in elevation to the most suitable habitat for both forage and cover at any particular time (thermal and snow interception).

- The hypermaritime tends to be boggy with small trees that do not provide suitable snow interception cover. During heavy snowfall events, deer will move up in elevation to well-drained hillslopes with trees that shed snow well and provide good snow and thermal interception cover. When the rain reduces the snow, they will move down again.
- In the dry submaritime, up to a certain elevation, periodic rain-on-snow events, followed by colder high pressure systems, result in the formation of snowcrust, which allows deer to walk on top of the snowpack rather than wading through it. Deer will move down in elevation following a heavy snowfall and then up again when they are able to walk on the snowcrust, a pattern that occurs throughout the winter.
- At higher elevations, the snow does not regularly crust and remains too deep for deer to travel.

According to traditional and local knowledge, deer make increasingly heavy use of hypermaritime areas in the winter as one moves north. Deer may respond to enduring, deep snow at mid- to low-elevations by moving all the way to valley bottoms, estuaries, or beaches (Nelson et al. 2008).

In hypermaritime conditions, timber harvesting occurs on hillsides with higher timber volume. Consequently, deer may have no refuge during heavy snowfall events in these areas. Scattered large cedars and sometimes hemlocks offer cover and the snow free well surrounding the boles of large trees enable deer to bed down and find forage. Selective logging of large trees may limit the value of these stands for deer (D. Person, Alaska Dept. of Fish and game, pers. comm.).

4.2.2 Spring habitat

By the end of winter, deer have very limited body fat reserves. Because winter forage is typically low in both quality and quantity, by spring, deer have survived several months of energy and protein deficits (Bunnell 1990). It is critical for deer survival to have access to spring forage when winter ends. They have to be able to move out of their winter habitat and access areas that have early spring green-up with minimum energy expenditure (Bunnell 1990; McNay and Voller 1995).

Spring range that is adjacent to winter range provides the highest quality spring habitat, because the snow melts earlier than within forested stands. The availability of high quality spring range is particularly important following a severe winter. Delayed spring green-up or the lack of adequate spring range can significantly affect deer survival.

The emergence of vegetation growth in spring typically occurs first on steep, southern aspects where solar input is not shaded by adjacent mountains or closed-canopy forests.

4.2.3 Spring and summer forage

Photo: G. MacHutchon

The quality and abundance of forage plays an essential role in deer survival, productivity and ecological carrying capacity. There is increasing evidence of the importance of good quality forage in spring and summer in allowing deer to increase fat reserves and survive the winter (Bunnell 1990; Farmer et al 2006).

A key factor in forage supply is the management of the closed canopy mid-seral “green desert” (typically age class 40 – 80 years). Mid-seral forests may provide security cover, but are typically devoid of foraging opportunities. Mid-seral forests are at stem exclusion stage with dense stems, and little or no understory forbs, herbs, and shrub layers. Logging activities should be planned in space and time so that satisfying deer seasonal range habitat requirements can occur in perpetuity.

4.3 Habitat Distribution, Spatial Configuration and Connectivity

4.3.1 Habitat distribution

Winter ranges should be dispersed across snowpack zones in each landscape unit. The coastal deer habitat model used BEC subzones (hypermaritime, submaritime and maritime) as a surrogate for snowpack zone mapping, which classifies the landbase according to the average depth of the snow pack (shallow, moderate, deep, very deep). Snowpack zones are described in Nyberg and Janz 1990.

A goal should be to place deer winter ranges a maximum of 4 – 5 km apart. This distance is based on documented deer movement distances between spring and winter ranges (McNay and Doyle 1987). An unsatisfactory solution would be to have all the deer winter range in some landscape units and none in others. It may be necessary to locate winter ranges in lower quality habitat to get a suitable distribution, but, at the same time, it is always preferable to select the best habitats that are available.

4.3.2 Spatial configuration

4.3.2.1 Elevation

Black-tailed deer tend to have a 'core use range of elevation' or preferred range of elevations that are used most heavily in the winter although they use habitats above and below this elevation band in response to changing snow conditions. Mapped winter ranges should be anchored in the core use range, which will vary by latitude (regional climate i.e., temperature, precipitation) and solar input (time of year, latitude, slope, aspect and adjacent topography). There may be two or three different preferred elevation ranges in the overall coastal planning region (K. Dunsworth pers. comm.).

4.3.2.2 Patch size and edge

The size and shape of winter range affects their function. Patches of old growth retained for winter range need to be wide enough and large enough to moderate the effect of wind and snow blowing into the stand adjacent to clearcuts or natural openings ('edge effect'). Microclimatic effects associated with edges penetrate into the forest to varying distances depending on the site and the variables measured, but effects begin to diminish within 50m and little effect is seen after 100 - 200m (Ministry of Environment 1995). A minimum patch width of 600m is recommended to supply a 200m section of interior habitat (Voller 1998). 40 hectares is considered a minimum patch size to manage for deer winter range. Larger (≥ 40 ha) patches also decrease vulnerability to predation.

While the size of a patch affects its function in providing interior forest conditions for deer, the shape of a patch affects the amount of edge for foraging. Harvest patterns that maximize edge (a convoluted shape) are preferable when the objective is to increase effective foraging habitat.

Management strategies for patch size vary between coastal planning regions.

- On Vancouver Island and the South Coast, areas of high quality winter range (typically >40 ha) are legally designated as UWR. These UWRs occur in discrete polygons based on habitat characteristics that have typically been confirmed through site assessment. Douglas-fir dominated old-growth forests typically produce large quantities of arboreal lichens and trees have brittle branches that break off in the wind and provide abundant litterfall forage in the winter.
- On the Mid Coast where less logging has occurred compared to the South Coast, legal UWR polygons ('specified areas') are very large and may comprise the entire south-sloping ridge from valley bottom to height of land. The legal order (#U5-005) sets out different age classes to be retained as deer winter range habitat within each specified area in the short term, by landscape unit. The long-term goal for all landscape units is to designate a minimum of 25% of each specified area as deer winter range habitat of age class 8 or greater. The timeline for achieving this goal is specified in the order (immediately or over 80 years, depending on the landscape unit). Designated deer winter ranges may move within a specified area over time as long as they are consistent with the terms of the general wildlife measures.
- There are no legally designated UWR for deer in the North Coast.

4.3.3 Horizontal and vertical connectivity

4.3.3.1 Horizontal connectivity: Juxtaposition of forage areas and forested cover

Deer require the ability to readily move between cover and forage areas on both daily and seasonal time frames. Juxtaposition between foraging areas (open-canopied habitats as discussed in Section 4.2) and forested cover areas allows deer to satisfy their life requisites on a daily basis. Seasonally, spring forage areas within 2.5 km of a winter range, with traversable habitat between them, is most desirable.

4.3.3.2 Vertical connectivity: Elevational movement in response to snow conditions

To facilitate elevational movement within a winter range, continuous forest cover across elevational gradients is required. While deer may have a preferred elevation range (see section 4.3.1), adequate cover is needed both above and below this elevation to facilitate movements in response to changing snow conditions throughout the winter. During the winter, deer tend to occur as high on the hill as they can, given the snow pack conditions. During periods of deep, soft snow, deer move to lower elevations and then return to higher elevations once a supportive crust forms; a pattern of movement that can be repeated many times in a winter. Continuous forest cover throughout the elevational range of the winter range is required to enable these movements.

Facultative migratory deer encountering conditions of deep snow may also move horizontally out of a valley as well as vertically (down in elevation) (S. McNay, Wildlife Infometrics, pers. comm.).

Roads may present a barrier to elevational movement of deer in winter ranges, particularly on steep slopes. Side case and banks limit the ability of deer to move across roads; this impediment to movement is exacerbated in winter due to snow berms along road sides.

4.4 Habitat Quantity

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

Deer are generalists; they are plastic in their ability to adapt and will persist under a variety of habitat scenarios. A group of deer will exhibit distinct behaviour patterns associated with a specific habitat. Although biologists recognize stratification of deer habitat quality, indicators of deer abundance have not proven precise enough to draw direct correlations between deer density and habitat quality. Research to date has not provided a basis for estimating the quantity of habitat required to sustain deer populations at any particular desired level.

The goal is to manage landscapes that sustain deer populations that are resilient to variable factors such as weather, predation, habitat change, and climate change. By default this means it is difficult to fine tune habitat guidelines and determine the minimum habitat requirements for deer. However, general guidelines have included: 1) retention of 10% of all deer habitat in the form of winter range (Nyberg and Janz 1990) and 2) in the Mid and North Coasts, managing forests for equal amounts of early-, mid-, and old-seral stage forests. Recently, biologists consider the latter recommendation should be revised to increase the proportion of old forest (K. Dunsworth, pers. comm.).

4.5 Research and inventory gaps

4.5.1 Research questions

- How much habitat is enough? The current guidelines are only for deer and are based on rough estimates of deer densities during winter in DWRs vs. across the landscape. They have not been tested on the ground. This is a significant unknown that would require new research in all three sub-regions.
- What are the differences in habitat quality and use by deer in the hypermaritime compared to the submaritime and maritime? What kind of management is needed to maintain habitat conditions in the hypermaritime? What areas should and should not be harvested?

- More research is needed about how to manage for ungulate winter range under a variety of habitat conditions e.g., what is the difference in habitat conditions and management approaches for Vancouver Island and the Mid Coast? This includes research into how deer use low-volume stands.
- Effectiveness monitoring is needed to track how well management approaches are working. Researchers in Alaska are developing a tool to estimate deer populations using DNA extracted from pellets. The project has been very successful and should be an excellent tool for monitoring (D. Person, pers. comm.).
- Research is needed to define the connectivity requirements of deer in coastal forests e.g., with respect to width and composition of corridors to maintain movement between habitats while minimizing risk of predation. The impedance of deer movement e.g., by roads or dense second growth, is also poorly understood.

4.5.2 Inventory gaps

- Ongoing inventory is required to monitor responses to habitat changes. This is both a gap and a priority.
- Update GIS-derived habitat maps and ground truth for errors.

4.6 References and Recommended Readings

Brunt, K.R. 2001. *Vancouver Island Deer Winter Range (DWR) Assessment Variables*. Ministry of Environment, Nanaimo.

Bunnell, F.L. 1990. *Ecology of Black-tailed Deer. Pages 31 – 64 in* J.D. Nyberg, J.D. and D.W. Janz (eds). Deer and Elk Habitats in Coastal Forests of Southern British Columbia. Special Report Series 05. Ministry of Forests and Range Research Branch. Victoria, B.C.

Bunnell, F.L., F.W. Hovey, R.S. McNay and K.L. Parker. 1990. *Forest cover, snow conditions and black-tailed deer sinking depths.* Canadian Journal of Zoology 68: 2403 – 2408.

Deal, R.L. 2001. *The effects of partial cutting on forest plant communities of western hemlock-Sitka spruce stands in southeast Alaska*. Canadian Journal of Forest Research 31: 2067 – 2079.

Demarchi, D.A., R.D. Marsh, A.P. Harcombe and E.C. Lea. 1990. *The Environment*. In The Birds of British Columbia, Volume One: Non-Passerines, Introduction, Loons through Waterfowl (R. Wayne-Campbell, N.K. Dawe, I. MacTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNeill, eds), Royal British Columbia Museum, Victoria, B.C.

Farmer, C.J. 2002. *Survival and habitat selection of Sitka black-tailed deer (Odocoileus hemionus sitkensis) in a fragmented coastal temperate rainforest*. Dissertation, College of Environmental Sciences and Forestry, State Univesity of New York, Syracuse, New York.

Farmer, C.J., D.K. Person and R.T. Bowyer. 2006. *Risk factors and mortality of black-tailed deer in a managed forest landscape.* Journal of Wildlife Management 70(5): 1403 – 1415.

Hanley, T.A., C.T. Robbins, and D. E. Spalinger. 1989. *Forest habitats and the nutritional ecology of Sitka black-tailed deer: a research synthesis with implications for forest management*. U.S.D.A. Forest Service General Technical Report PNW-GTR-230. Portland, Oregon.

Hanley, T.A. and J.D. McKendrick. 1983. *Seasonal changes in chemical composition and nutritive value of native forages in a spruce-hemlock forest, Southeastern Alaska*. U.S.D.A Forest Service Pacific Northwest Forest and Range Experiment Station, Palmer, Alaska.

Kie, J.G., R.T. Bowyer, M.C. Nicholson, B.B. Boroski, and E.R. Loft. 2002. *Landscape heterogeneity at differing scales: effects on spatial distribution of mule deer*. Ecology 83(2) 530 – 544.

Kirchhoff, M.D. and S.R.G. Thomson. 1998. *Effects of selection logging on deer habitat in Southeast Alaksa: a retrospective study.* Alaska Department of Fish and Game, Federal Aid in Wildlife Restoration Final Research Report W-24-4 to W-271, Study 2.11, Juneau, Alaska.

Kremsater, L.L., and F.L. Bunnell. 1992. *Testing responses to forest edges: the examples of black-tailed deer*. Canadian Journal of Zoology 70: 2426 – 2435.

McNay, R.S. and D.D. Doyle. 1987. *Winter Habitat Selection by Black-tailed Deer on Vancouver Island: A Job Completion Report.* Integrated Wildlife Intensive Forestry Research (IWIFR) Report. Ministry of Forests and Lands

McNay, R.S., and F.L. Bunnell. 1994. *Behavioural limits to movement: The effect on habitat choices for Columbian black-tailed deer.* Proceedings of the 21st International Union of Game Biologists (IUGB) Congress, Halifax, Nova Scotia.

McNay, R.S. 1995. *The Ecology of Movements made by Columbian Black-tailed Deer*. University of B.C. Vancouver, B.C. PhD Thesis. 194 pp.

McNay, R.S. and J.M. Voller. 1995. *Mortality causes and survival estimates for adult female Columbian black-tailed deer*. Journal of Wildlife Management 59: 138 – 146.

MoELP (Ministry of Environment, Lands and Parks). 2000. Mule and Black-tailed Deer in British Columbia: Ecology, Conservation and Management. Victoria, B.C.

Ministry of Forests. 1996a. *Decoding deer movement patterns.* Report No. 1: Coastal Black-tailed Deer Study. Ministry of Forests Forest Science Program. Victoria, B.C.

Ministry of Forests. 1996b. *Clarifying habitat use.* Report No. 2: Coastal Black-tailed Deer Study. Ministry of Forests Forest Science Program. Victoria, B.C.

Ministry of Forests. 1996c. *How black-tailed deer react to logging in their winter habitat..* Report No. 3: Coastal Black-tailed Deer Study. Ministry of Forests Forest Science Program. Victoria, B.C.

Ministry of Forests. 1996d. *Habitat and predator concerns.* Report No. 4: Coastal Black-tailed Deer Study. Ministry of Forests Forest Science Program. Victoria, B.C.

Ministry of Forests. 1996e. *Habitat assessment and planning.* Report No. 5: Coastal Black-tailed Deer Study. Ministry of Forests Forest Science Program. Victoria, B.C.

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

Nelson, J., D. Cottam, E.W. Holman, D.J. Lancaster, S. McCorquodale, and D.K. Person. 2008. *Habitat Guidelines for Black-tailed Deer: Coastal Rainforest Ecoregion*. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies. Cheyenne, Wyoming.

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

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984**.** *Energy expenditures for locomotion by mule deer and elk.* Journal of Wildlife Management 48: 474-488.

Parker, K.L., M.P. Gillingham, T.A. Hanley, and C.T. Robbins. 1996. *Foraging efficiency: energy expenditure versus energy gain in free-ranging black-tailed deer*. Canadian Journal of Zoology 74: 4442 – 450.

Parker, K.L., M.P. Gillingham, T.A. Hanley, and C.T. Robbins. 1999. *Energy and protein balance of free-ranging black-tailed deer in a natural forest environment*. Wildlife Monographs. 143.

Robertson Environmental Services Ltd. 2002. *North Coast Forest District Black-tailed Deer Winter Range Inventory*. Ministry of Forests, Prince Rupert.

Schoen, J.W. and M.D. Kirchhoff. 1990. *Seasonal habitat use by black-tailed deer on Admiralty Island, Southeast Alaska.* Journal of Wildlife Management 54: 371 – 378.

Voller, J. 1998. *Biodiversity and Interior Habitats: The Need to Minimize Edge Effects. Part*

5.0 Grizzly bear (*Ursus arctos*)

Domain experts[2]:

Grant MacHutchon, A. Grant MacHutchon Consulting

Tony Hamilton, B.C. Ministry of Environment

Photos: G. MacHutchon

5.1 Species Overview

5.1.1 Introduction

The distribution of grizzly bears in North America once extended from Mexico to Alaska and from B.C. to Manitoba. This distribution is now limited to Alaska, the Yukon Territory and British Columbia, with small populations in Alberta, the Northwest Territories, Nunavut, and the northwestern United States (Banci 1991). Approximately half of the Canadian population and one quarter of the North American population is estimated to occur in B.C. The 2008 population estimate for B.C. is 16,000 (Hamilton 2008), which is thought to be about half the historic population in the province (NCGBRT 2004).

The natural abundance of grizzly bears is driven by the productivity of their habitat (MoWLP 2001). Increased food availability, particularly salmon and other meat, results in higher reproductive success, larger body mass, higher population density and higher cub-of-the-year survival (Hildebrand et al. 1999). Survival is also strongly influenced by the level of mortality risk associated with human use and development (Ciarniello et al. 2007).

Home range sizes are reflective of habitat quality, with smaller home ranges on the Coast where habitats are generally more productive than in the Interior (MacHutchon et al. 1993, McLoughlin et al. 1999). Home ranges include a mix of seasonal habitats that provide access to a range of primary food sources (MoWLP 2001, Gyug et al. 2004, MacHutchon 2007). Male home ranges tend to be larger, on average, than female home ranges, partly because of their larger body size and greater energy requirements (McLoughlin et al. 1999) but also to maximize their access to females. Grizzly bears, particularly females, demonstrate an inherent fidelity to their maternal home ranges (McLellan and Hovey 2001) however, some bears, particularly sub-adult males, may be forced to disperse away from their natal home range. Grizzly bears are not territorial and individual home ranges frequently overlap, particularly on the Coast and in other food-rich environments. Grizzly bears use a variety of marking behaviours as a means of social communication. A higher frequency of marking is thought to indicate a higher frequency of social interaction.

There are few grizzlies within hypermaritime ecosystems. Possible reasons include limited denning potential, less habitat diversity, and greater food competition with black bears. Poor demographic connectivity may also influence observed patterns of grizzly bear distribution and abundance. It is also likely that many of the islands on the B.C. Coast that are occupied by black

[2] Clayton Apps, Aspen Wildlife Research, also provided input into the Knowledge Base (sections 3.1 and 3.2).

bears do not have large enough salmon runs (H. Davis, Artemis Wildlife Consultants, pers. comm.) to support the nutritional needs of grizzly bears (Robbins et al. 2004).

Hunting of grizzly bears in B.C. is managed under limited entry for resident hunters within Management Units and Limited Entry zones and under guide outfitter quota with allocations set within defined guide territories for non-resident hunters (MoE 2007).

Grizzly bear habitats are planned and managed at four spatial scales: regional, sub-regional, landscape and stand.

a. Regional and sub-regional scales – conservation planning

At the *regional scale,* grizzly bears in B.C. are managed within Grizzly Bear Populations Units (GBPUs), which are based on known occupancy by adult females within geographically distinct areas. These are meta-populations that are connected through genetic exchange. In general, GBPUs encompass contiguous populations but the units may not always be well-connected to each other. Connectivity is provided at this scale by conservancies and other protected areas.

At the sub-regional scale, it is important to identify and manage for connected and semi-connected population nodes (i.e., areas where multiple female and male home ranges overlap). These overlapping nodes can be considered core areas/ strongholds/ anchors typically associated with excellent foraging habitat and low levels of human activity. This sub-regional connectivity also allows bears that spend the majority of their time and den in the Interior of B.C., to make seasonal movements to coastal areas to forage for salmon.

b. Landscape scale

The landscape scale is the key management scale to address habitat issues that are core to grizzly bear population integrity, as this scale best reflects individual animal home ranges. Consequently, this is the most important scale for the design of old growth reserves outside of conservancies and other protected areas.

Management at this scale focuses on retaining a diversity of habitats by managing for seral stage distribution according to Natural Disturbance Type and protecting essential habitats in reserves.

c. Stand scale (scale of operational level forest management)

Operational management involves identifying and managing for site specific habitat attributes.

Stand-level cutblock treatment for grizzly bears includes within-stand retention of old forest features, including coarse woody debris, variable retention, delayed replanting, broadcast burning to encourage berry production, and minimal use of herbicides.

5.1.2 Conservation status and legal designations

5.1.2.1 Conservation status

The grizzly bear has been identified as a species of Special Concern by COSEWIC and is Blue-listed by the B.C. Conservation Data Centre. The B.C. Conservation Framework identifies grizzly bears as a priority 2 species under the goal of "preventing species and ecosystems from becoming at risk" (Goal 2). Under the Identified Wildlife Management Strategy of the *Forest and Range* Practices Act, Wildlife Habitat Areas can be established for grizzly bears to protect provincially significant areas or for seasonally important habitats (Gyug et al. 2004).

Each GBPU in the province has been assigned a conservation status of threatened or viable. This conservation status reflects the difference between the current population estimate for the GBPU and the estimated inherent capability of each population unit to support a specific density of grizzly bears. There are ten GBPUs on the B.C. Coast; eight are considered viable and two south of Phillips Arm, outside of the coastal planning area, are considered threatened. Other than in the CWHvh1 and CWHvh2 (Coastal Western Hemlock Very Wet Hypermaritime subzone, Southern and Central variants), grizzly bears occur at higher densities in the eight GBPUs within the coastal planning area relative to most other population units in B.C.. The threatened status of southern coastal populations is likely a result of historically high human-caused mortality and extensive habitat loss and alteration.

5.1.2.2 Existing management designations

Coastal Land Use Orders

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

- Section 17 in the South Central Coast Order is to maintain 100% of grizzly bear habitats as identified in the Schedule 2 map associated with the Order.
- Section 17 in the Central and North Coast Order is to maintain 100% of Class 1 and 50% of Class 2 grizzly bear habitats as identified in the Schedule 2 map associated with the Order.

Designated habitat areas

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

Grizzly Bear Management Areas

There are three Grizzly Bear Management Areas (GBMAs) in the coastal planning area. These areas, negotiated as part of the coastal strategic planning exercises, will be designated under the B.C. Grizzly Bear Conservation Strategy for the purpose of securing the long-term survival of grizzly bear populations (B.C. MELP 1995). GBMAs are closed to hunting of grizzly bears. Resource development within and outside of GBMAs is as per existing zoning and management direction, including ecosystem-based management as set out in the Central & North and South Central Coastal Orders and as reflected in Government-to-Government Agreements between coastal First Nations and the Province of B.C..

5.1.3 Threats to grizzly bears

- Industrial development activity, recreation, and settlement are the greatest threats to grizzly bears (McLellan 1990, Gyug et al. 2004). In particular, the development and use of roads increases bear mortality risk, can displace bears from preferred habitats, and may contribute to population fragmentation.
- The recent dramatic increase in hydroelectric development has the potential to significantly increase human access in coastal environments. Roads to service these developments are permanent, unlike most road networks associated with logging (many of which become active or inactive according to market conditions).
- Loss or alteration of essential habitats may affect bears, particularly at lower elevations. Loss of low-elevation habitat is a concern throughout the active season of bears, but particularly during spring and early summer when they are seeking succulent and high nutrient vegetation following den emergence, and seasonal alternatives are limited.
- Researchers have shown that grizzly bears are exposed to persistent organic pollutants (POPs) from the salmon in their diet and that these chemicals accumulate and concentrate during hibernation (Christensen et al. 2005; Christensen et al. 2007) There is concern that

this exposure to toxic chemicals may contribute to disruption of endocrine processes, increasing the risk of adverse health effects in grizzly bears and their cubs (Christensen et al 2007).

- Commercial and recreational bear viewing activities (land-based and water-based) are increasing on the Coast without a coordinated viewing strategy to identify and address negative impacts to bears. Adult males may avoid viewing areas, leaving them to females, cubs and sub-adults (Nevin and Gilbert 2004). Bears unwilling, or unable to, habituate to bear viewing activities need alternative options for accessing seasonally important resources such as salmon.
- Improper solid waste management or food storage can lead to human food conditioning among bears, which typically leads to bears being shot as a result of conflicts with humans.
- The legal harvest of grizzly bears is managed (MoE 2007) to ensure that all human-caused mortalities (including conflict and estimated illegal kills) do not exceed a maximum 6% of each population. This level of human-caused mortality is assumed to be within the limits of sustainable population growth, therefore, the contribution of the legal hunt is not considered a threat to grizzly bear conservation.

  However, illegal killing of individual bears (poaching) is a concern and is generally facilitated by increased human access and use. Additionally, in areas where people live, work and recreate in close proximity to bears, animals are commonly destroyed in reaction to bear-human conflicts that often could be prevented. Some coastal communities are known to have relatively high levels of grizzly bear-human conflicts and resulting mortalities are concentrated in these areas.

5.1.4 Grizzly bear as a focal species

The grizzly bear is a suitable focal species for the identification of Old Growth Retention Areas for the following reasons:

- Grizzly bears are wide-ranging omnivores whose home ranges include a diversity of plant/ecological communities during their active seasons. Consequently, grizzly bears require planning considerations at a hierarchy of spatial scales, from regional to site-specific.
- Grizzly bears occur at relatively low densities compared to other species and have slow reproductive and dispersal rates. As a consequence they are less resilient than other species to human activities and changes to the land base that (a) increase morality risk (e.g., roads and other forms of human access) and/ or (b) reduce the reproductive success and survivorship of populations (e.g., extensive habitat loss and/or alteration and displacement from preferred habitats).
- The grizzly bear is an *umbrella* species, that is, protection of the wide range of habitats they use benefits an array of other plants and animals. The range of habitats on the Coast include:
  - low to high elevation areas (primarily the CWH & MH BEC zones);
  - early to old seral forests;
  - nutrient-rich to nutrient-medium habitats; and
  - wet to dry habitats.
- The grizzly bear is also a *keystone* species, meaning that grizzly bears contribute to important ecosystem functions. Examples include:

- Nutrient transport: bears transport salmon carcasses into riparian forests, contributing to movement of nutrients from the aquatic to the terrestrial environment.
- Frugivory: seeds are ingested and dispersed by bears. Scarification during digestion promotes seed germination.
- Soil mixing: they substantially till the soil when they dig in estuaries and other habitats.
- Predation: like other top predators, grizzly bears potentially influence prey species in terms of the behaviour of individuals and the composition of prey populations.

- The grizzly bear is a useful *indicator* species. The abundance and distribution of grizzly bears in an ecological community reflects ecosystem health at lower levels of organization. If an ecosystem is pushed to its limits in terms of functionality, such as a significant loss of Pacific salmon or landscape dominance of mid-seral coniferous forest, the effect on occupancy and productivity of grizzly bears is expected to be profound (T. Hamilton pers. comm.). For this reason, the abundance and distribution of grizzly bears are good indicators of the effects of climate change, changes in salmon abundance and distribution, and changes in forest biodiversity and ecosystem productivity (e.g., forage supply) at the landscape scale.

5.2 Habitat Quality

Grizzly bears require a sufficient spatial distribution and abundance of habitat to provide for their nutritional, security, thermal, reproductive, and seasonal needs. To meet these varied requirements, bears use an array of habitats, ranging from valley bottom to subalpine, old growth to non-forested, and wetlands to dry areas.

With the exception of denning areas, high elevation berry or forb-dominated habitats, and avalanche chutes, prime habitats are below treeline concentrated in valley-bottom ecosystems and are often associated with salmon streams (Hamilton 1987, MacHutchon et al. 1993, Flynn et al. 2007). A study in the Kimsquit Valley has shown that approximately 75% of the collared bears' active season was spent below 500m in elevation but bears denned under deep snow at higher elevations to maximize insulation and minimize humidity (Hamilton 1987). Another study on the North Coast found that > 85% of aerial locations of radio-collared grizzly bears in all seasons were in the Coastal Western Hemlock (CWH) BEC zone even though it comprised only 26% of the study area. The Coastal Mountain Heather Alpine (CMA) (formerly Alpine Tundra) zone was almost half the study area, but radio-collared grizzly bears were never located there (MacHutchon et al. 1993).

5.2.1 Essential habitat complexes

Important habitats for grizzly bears often consist of a complex of foraging habitat and adjacent forest used for bedding, security and thermal cover, and/ or travel (MacHutchon et al. 1993). Protection of the entire habitat complex (foraging habitat and forested buffer) is important for the habitat to be optimally functional.

1. *Essential habitat*

   Essential habitats are considered requisites for individual bear survival. These areas typically have high foraging value, but may also be high-value bedding or denning areas. Patches of these habitats are particularly important when they are relatively uncommon within a watershed or landscape unit (LU).

Class 1 floodplain habitat Photo: G. MacHutchon

Essential feeding habitats may be forested or non-forested. Forested habitats include forested swamps with skunk cabbage, open canopy forest with berry species on floodplains or alluvial fans, and riparian forest adjacent to rivers and creeks where salmon are available to bears. Non-forested habitats include beaches and beach margins, estuaries, rich non-forested fens, edges of bogs, marshes, and shallow ponds, herb and fruit-bearing shrub dominated patches on avalanche chutes (particularly south-facing), herb-dominated sub-alpine parkland meadows, and early seral floodplains.

2. *Forested buffers*

Adjacent forest cover is important to the integrity of essential non-forested or open-forested habitats. Forested buffers provide the following functions for bears:

Bedding habitat: Grizzly bears use forested areas adjacent to feeding sites to bed during periods of inactivity.

Thermal cover: Rain interception when conditions are wet and cold
and sun interception when conditions are hot and dry.

Security cover: There are two types of security cover: screening from humans and security from other bears. Mortality risk is reduced and bears are less likely to be displaced if they are screened from human activity. Forested buffers also provide escape trees for females and cubs; family groups will stay closer to large trees so that cubs can climb to escape threat from other bears.

Forested buffers also have an important role in maintaining the ecological integrity of non-forested or open forested patches e.g., moderating the effects of wind, sun, surface and sub-surface water movement and flow. Buffers also help to control snow movement (channelling) through avalanche chutes; if the buffer is removed, the avalanche may have a wider, less directed path.

Buffer widths vary depending on the terrain and the type of forest adjacent to the feeding habitat (MacHutchon 2007). Buffers can be delineated using a combination of (a) ecological boundaries e.g., changes in forest type, (b) determinations of windfirmness, and (c) the presence of permanent and recent grizzly bear sign e.g., mark trees, beds.

5.2.2 Foraging habitat

Coastal grizzly bears are omnivores and generalists, using a variety of food sources. Habitat use is season specific and, typically, bears will actively select the highest quality habitats in each season (Hamilton 1987; MacHutchon et al. 1993). However, some bears may be excluded from the highest quality habitats because of social interaction (e.g., females with cubs, and sub-adults), particularly in highly altered landscapes (Flynn et al. 2007). In areas of human influence, adult male bears have been observed to avoid high value habitats at viewing sites (Nevin and Gilbert 2004) and along high traffic road corridors (Archibald et al. 1987).

MacHutchon (2007) described five grizzly bear seasons on the coast as early spring, late spring, summer, fall and winter (denning). Foraging habitat use during the four active seasons is as follows:

a. Early and late spring (April – May): Grizzly bears forage on emergent green vegetation, as is found in estuaries, ocean foreshores (Smith and Partridge 2004), wetlands, forested swamps, wet seepage sites and riparian areas. Food plants consist mainly of sedges, grasses and forbs, which provide digestible protein to replace body mass lost during hibernation (Rode et al. 2001). Skunk cabbage and the shoots of fruiting shrubs, such as salmonberry and Devil's club, are also eaten. As spring progresses, bears will follow the receding snow, feeding on emerging vegetation in upper valleys and avalanche chutes. Bears will also take advantage of winter killed ungulates when available.

b. Summer (June – August): In summer, coastal grizzly bears feed on a number of berry species in valley bottoms and side slopes, depending on local and annual variation in berry availability and concentration. Key foraging habitats in summer are open canopy floodplain and alluvial fan forests as well as forest edges bordering avalanche chutes and other natural openings. Early seral clearcuts can also provide an abundant source of berries. Bears may move to higher elevations in late summer to access black huckleberry.

Skunk cabbage habitat Photo: G. MacHutchon

c. Mid-summer to late fall (August – October) coastal grizzly bears primarily feed on live salmon and post-spawning carcasses or a mixture of berries and salmon. Once salmon availability declines late in the season, they will resume eating various types of vegetation and late ripening berries.

Throughout their active seasons, grizzly bears will also eat intertidal invertebrates (e.g., softshell clams, barnacles and mussels), insects in rotting downed wood, small mammals, and carrion. Some predation and scavenging of deer, moose, mountain goats and seals occurs opportunistically.

Factors influencing the quality of foraging habitat

- The abundance and availability of salmon is very important to the health of coastal bear populations. The value of local salmon populations to grizzly bears is related to:
  - The abundance of Pacific salmon in the stream (escapement);
  - The availability of the salmon to bears, that is, factors that influence a bear's ability to catch the salmon e.g., water depth, turbidity and velocity; and
  - The security of bears from people while feeding on salmon. Mortality risk to bears and the risk of human–bear conflict may increase when humans are active in salmon feeding areas, particularly when human behaviour is random and unpredictable.

  Grizzly bears will travel considerable distances to access salmon and will congregate at salmon-bearing streams during spawning. Female grizzly bears have been shown to consume significantly less salmon in watersheds where riparian buffers have been significantly altered compared to those that are relatively intact, possibly because females are avoiding open areas to achieve security (Flynn et al. 2007). However, a study in Knight Inlet indicated that females used an altered artificial spawning channel more than adult males while humans were present in a neutral way i.e., passively viewing the bears (Nevin and Gilbert 2004). This suggests that females faced with the choice may forego vegetative screening cover for the security humans can provide from adult male bears.

  Because access to high quality forage is strongly linked to reproductive success, the Alaska Department of Fish and Game considers it a priority to manage landscapes to ensure that secure access to salmon by female bears is maintained. This includes ensuring a minimum buffer of all stream segments with salmon of 150m and, where the management objective is for abundant, healthy brown bear populations, to provide enhanced buffering of productive salmon streams or complete watershed protection (Flynn et al. 2007).

- Growth of preferred bear food plants is influenced by forest structure and productivity. Old forests with variable density canopies on relatively rich sites provide openings for berry growth and other forage in the understory. Closed canopy forests (mid-seral forest) are relatively non-productive for understory growth or exclude important forage species completely.

5.2.3 Specific old forest habitat attributes

The highest quality forested stands for grizzly bears have structural diversity (horizontal and vertical) in landscapes with a diversity of age classes and canopy openings typically as a result of small gap disturbance dynamics.

> *Horizontal structure* is provided by canopy gaps and downed trees that provide for forage production in the understory. A denser canopy or a higher density of trees results in reduced forage value because understory productivity declines with lower light availability.
>
> *Vertical structure* is provided by a variety of age classes and tree heights that provide structural elements as well as allowing sunlight to reach the forest floor to promote understory growth.

This structural diversity supports greater food plant diversity and abundance and provides for an ongoing supply of the requisite structural elements for thermal and security cover. Large trees provide existing and future denning sites, escape trees, and shelter from weather.

a. Structural attributes

Grizzly bears are not considered to be old growth dependent, *per se*, provided they are able to use younger seral forests for movement, bedding, and security and have alternate foraging habitat available. However, they do have requisites with regard to old growth structure e.g.,

- For denning:
  - Dens are more typically in old growth, using old growth structures (inside hollows in trees and logs or beneath root wads) or dug underneath standing live old trees. Denning occurs in steep terrain at elevations in the transition of the CWH and MH, high enough that temperatures remain below freezing in the winter and snow persists and provides insulation value (Hamilton 1987, MacHutchon et al. 1993; Himmer and Power 2003).
- For bedding:
  - under the thick canopies of large, old trees (e.g., low growing branches of Sitka spruce on floodplains) when it is wet and cold; and
  - cool, sandy areas under a variety of cover for bedding in hot weather.

Bedding habitat Photo: G. MacHutchon

b. Foraging habitat features

Within old forest, important habitat features are open-canopy rich sites with an abundance and diversity of fruit-bearing shrubs and wet seepage or swampy microsites with skunk cabbage and other forbs.

5.3 Habitat Distribution, Spatial Configuration and Connectivity

5.3.1 Distribution

A key aspect of habitat distribution is the interspersion of seasonally important habitats at a scale that will support female bears within their home ranges. Social dynamics among bears encourages interspersed use of important habitats by individual bears (exceptions are concentrations of bears at highly productive salmon spawning areas or on estuaries). The primary driver in this context is the security of adult females with young cubs who are wary of other bears that may kill their cubs. Interspersion allows security-conscious females access to essential habitats while avoiding other bears. If the habitat needs for females are addressed, then it is assumed that the habitat needs of males will also be addressed (Hamilton 1987).

Females will select habitats and establish home ranges based on the availability of food resources and other life requisites. Intraspecific and interspecific interactions, particularly bear-human interactions, may also influence habitat use at multiple scales. On the Coast, populations are unevenly distributed due to high inherent variability in landscape conditions. The expected average size of a female home range on the Coast (approximately 75 km^2) is smaller than in the Interior because habitats are more concentrated spatially along valley bottoms and are more productive as a result of greater rainfall, higher food plant species diversity, longer growing season and salmon availability.

5.3.2 Spatial Configuration

The number and distribution of old growth reserves needs to be considered within the context of land uses and management outside of reserves. The preferred configuration of habitats reflects a combination of the following needs:

i. Interspersion of seasonally important habitats within old growth reserves, dispersed across elevations and landscapes; and

ii. Forestry activities that are planned over space and time in a manner that tends to concentrate harvesting and road development and leave entire tributary valleys (approximately 5000 ha in size) and entire landscape units, without human disturbance for prolonged periods.

Under this arrangement, areas of old growth retention become particularly important during periods when forestry activities are occurring in a valley.

5.3.3 Connectivity

Habitat connectivity is important and functions across scales, leading to occupied landscapes and connected populations. Connectivity for grizzly bears at a *regional* scale should consider barriers or deterrents to movement such as terrain constraints (extreme slopes, extensive areas of rock and ice), major inlets, lakes and reservoirs, areas with concentrated human use (e.g., communities) and linear developments (e.g., high traffic highways and rail lines). This "demographic connectivity" is important for continuous or periodic augmentation of marginal populations / landscapes through immigration of bears from more productive source areas. In addition, maintaining opportunities for gene flow and genetic health is important for population resilience (Allendorf and Servheen 1986).

At the landscape scale, connectivity for bears is driven by foraging habitat distribution as well as the need for security cover. Connectivity of forested cover allows bears to move between habitats with a reduced risk of harmful interaction with other bears or humans. Conservation design should connect one existing 'secure area' (old growth reserve or other reserves) to another 'secure area' to create a larger contiguous reserve network, particularly in highly altered landscapes.

Old growth reserves should be linked together along riparian corridors, where possible. Many essential habitats are in valley bottoms, including estuaries, spawning channels, wetlands, and forested swamps. These essential habitats should be embedded in the valley bottom hydroriparian network that is part of an overall reserve network. Cross-elevational linkages, e.g. to avalanche chutes through Ungulate Winter Ranges, should also be considered. Additional linkage may be provided by contiguous beach and beach fringe habitats, particularly along steep-sided inlets.

Management outside of old growth reserves also contributes to connectivity across the landbase.

5.4 Habitat Quantity

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

Flynn et al. (2007) defines a healthy grizzly bear population as follows: "[It] should be relatively stable and sustainable given desired human use, able to maintain its organization and function over time, and resilient to stressors, including human impacts and stochastic environmental and demographic events". This population objective is driven largely by societal choice and is set to a higher level than 'population viability', which infers long-term persistence of a population but does not allow for significant human use.

Grizzly bears will occupy highly modified landscapes (large areas of unsuitable habitat; high levels of human activity), but densities are expected to be much lower than in less modified landscapes. To meet population objectives, rates of human-caused mortalities must be minimized through proactive efforts to prevent bear-human conflicts before they occur and reproductive rates maximized through the maintenance of adequate habitat quality, quantity, distribution and linkages. Currently, however, there is no reliable method to determine the appropriate abundance and distribution of habitat required to support the desired population objectives. The impact on bears as a result of development activity depends on the type and amount of changes to habitats and their spatial configuration and whether or not there is also direct mortality risk from humans.

Thresholds of habitat quality and quantity

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). A limited portion of this mapping is based on interpretation of standard ecological mapping (e.g., TEM) but most has been direct air photo interpretation (MacHutchon 2007).

- Class 1 habitats are the highest suitability and all Class 1 habitats are considered essential to the health of individual grizzly bears or local grizzly bear populations.
- Class 2 habitats are also high value but are not considered to have quite the same habitat suitability as Class 1 habitats. Class 2 units are primarily foraging habitats and they vary in

seasonal abundance and distribution. For example, Class 2 avalanche chutes in the CWH vm2 and MH are often common, have a relatively large area, and are spaced close together. Conversely, Class 2 alluvial fans or non-forested wetlands at lower elevations are often less common, are smaller, and are disparate within a landscape unit.

Domain experts consider it more important to protect the less common, lower elevation Class 2 habitat types for grizzly bears. Class 2 early and late spring habitats are the least common of any of the seasonal habitats, and are also very important to bears as they provide necessary nutrient-rich forage post-denning. Therefore, these habitats are considered more vulnerable than Class 2 summer and fall habitats.

Domain experts consider the lowest risk target for grizzly bears is to conserve the functional integrity of all Class 1 and 2 habitats. If only a portion of Class 2 habitats are to be conserved, then these habitats need to be stratified and the rarest and most seasonally important habitats retained in reserves.

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

Other important considerations are:

- Hydroriparian management. Functional hydroriparian buffers that provide habitat for food, cover (security and thermal), and travel are fundamental to the overall quality and quantity of grizzly bear habitat. It is assumed that EBM objectives for aquatic habitats will contribute to the maintenance of grizzly bear habitat suitability and effectiveness.
- Adequate within block retention. Objectives in the Coastal Orders require 15% within-stand retention. The contribution of within stand retention is dependent on the habitat elements retained. For example, are security trees inside or adjacent to the block being retained for bears? Are understories kept intact?

5.5 Research and Inventory Gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

5.5.1 Research questions

1. Undertake finer scale research to fill knowledge gaps re local ecology of grizzly bears. For example, further work is needed regarding the suitability and effectiveness of habitats in highly altered landscapes, particularly regarding security for adult females with cubs.
2. Effect on food quality, quantity and diversity following second growth harvesting.
3. Impacts of bear viewing on grizzly bears.
4. Predictive studies to estimate and assess the effects of climate change, including the risks and uncertainties associated with food quality, quantity and diversity.

5.5.2 Inventory gaps

- A comprehensive population monitoring program for coastal grizzly bears is a high priority for the Ministry of Environment.

- Extend work in the South Coast ranges using non-invasive hair snagging techniques for population sampling to assess and monitor the distribution and abundance of the existing populations as well as connectivity between populations. Systematic sampling is needed over very large areas.
- Establish permanent vegetation monitoring plots in association with a variety of restorative silviculture activities designed to mitigate longer term impacts of forestry-related activities on grizzly bear habitats.

5.6 References and Recommended Readings

Allendorf, F.W., and C. Servheen. 1986. *Genetics and conservation of grizzly bears*. Trends in Ecology and Evolution 1:88-89.

Archibald, W.R., R. Ellis, and A. N. Hamilton. 1987. *Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley.* Ursus 7: 251 - 257.

Banci, V. 1991. The *status of the grizzly bear in Canada in 1990*. Committee on the Status of Endangered Wildlife in Canada, Ottawa. 170 pp.

B.C. MELP. 1995. A *future for the grizzly: British Columbia grizzly bear conservation strategy*. B.C. Ministry of Environment, Lands and Parks, Victoria.

Christensen, J.R., M. MacDuffee, R.W. MacDonald, M. Whiticar, and P.S. Ross. 2005. *Persistent Organic Pollutant exposure in B.C. grizzlies: the consequence of divergent diets.* Environmental Science and Technology. 39: 6952-6960

Christensen, J.R., M. MacDuffee, M.B Yunker, and P.S. Ross. 2007. *Hibernation associated changes in persistent organic pollutants (POP) levels and patterns in British Columbia grizzly bears.* Environmental Science and Technology. 41: 1834 - 1840

Ciarniello, L. M., M. S. Boyce, D. C. Heard, and D. R. Seip. 2007. *Components of grizzly bear habitat selection: density, habitats, roads, and mortality risk.* Journal of Wildlife Management 71:1446-1457.

Flynn, R.W., S.B. Lewis, L.R. Beier, and G.W. Pendleton. 2006. *Abundance, Spatial Relationships and Transboundary Movements of Brown Bears on the Mainland Coast of Southeast Alaska*. Unpublished progress report. Division of Wildlife Conservation, Alaska Department of Fish and Game, Juneau.

Flynn, R.W., S.B. Lewis, L.R. Beier, and G.W. Pendleton. 2007. *Brown Bear Use of Riparian and Beach Zones on Northeast Chichagof Island: Implications for Streamside Management in Coastal Alaska.* Alaska Department of Fish and Game, Southeast Regional Office. Douglas, Alaska.

Gyug, L., T. Hamilton, and M. Austin. 2004. *Grizzly bears, Ursus arctos, in Accounts and measures for managing identified wildlife: version 2004*. B.C. Ministry of Water, Land and Air Protection, Victoria, British Columbia.

Hamilton, A.N. 1987. *Classification of coastal grizzly bear habitat for forestry interpretations and the role of food in habitat use by coastal grizzly bears*. M.Sc. Thesis. University of British Columbia, Vancouver, British Columbia.

Hamilton, A.N. 2008. *2008 Grizzly Bear Population Estimate for British Columbia.* Ministry of Environment, Ecosystems Branch. Victoria, B.C.

Hilderbrand, G.V., S.G. Jenkins, C.C. Schwartz, T.A. Hanley, and C.T. Robbins. 1999. *Effect of seasonal differences in dietary meat intake on changes in body mass and composition in wild and captive brown bears*. Canadian Journal of Zoology 77:1623-1630.

Himmer, S. and D. Power. 2003. *A Guidebook for Grizzly Habitat Features in Coastal British Columbia*. Ministry of Water, Land and Air Protection, Williams Lake, B.C.

L'Anson, B. 1996. *Saving Berries for the Bears*. Ministry of Environment. Victoria, B.C.

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. 2001. *Grizzly Bear Habitat Mapping, Central Coast, B.C. – 2000*. Ministry of Environment, Lands and Parks. Nanaimo, B.C.

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.

MacHutchon, A.G, S. Himmer, and C.A. Bryden. 1993. *Khutzeymateen Valley Grizzly Bear Study: Final Report.* Wildlife Habitat Research Report No. 31. Ministry of Forests Research Program. Victoria, B.C.

McLellan, B.N. 1990. Relationships *between human industrial activity and grizzly bears*. International Conference on Bear Research and Management 8:57-64.

McLellan, B.N., and F.W. Hovey. 2001. *Natal dispersal of grizzly bears*. Canadian Journal of Zoology 79:838-844.

McLoughlin, P.D., R.L. Case, R.J. Gau, S.H. Ferguson, and F. Messier. 1999. *Annual and seasonal movement patterns of barren-ground grizzly bears in the central Northwest Territories*. Ursus 11:79-86.

MoE (Ministry of Environment). 2007. *British Columbia Grizzly Bear Harvest Management Procedure*. Victoria, B.C.

http://www.env.gov.bc.ca/wld/documents/grizzlybear_harvest_mgmt_proc_2007.pdf

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

MoWLP (Ministry of Water, Land and Air Protection). 2001. *Grizzly Bears in British Columbia: Ecology, Conservation and Management.* Victoria, B.C.

NCGBRT, North Cascades Grizzly Bear Recovery Team. 2004. *Recovery plan for grizzly bears in the North Cascades of British Columbia*. North Cascades Grizzly Bear Recovery Team, Victoria, British Columbia. 54 pp.

Nevin, O.T. and B.K. Gilbert. 2004. *Perceived risk, displacement and refuging in brown bears: positive impacts of ecotourism?* Biological Conservation 121(4): 611 – 622.

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.

Robbins, C. T., C. C. Schwartz, and L. A. Felicetti. 2004. *Nutritional ecology of ursids: a review of newer methods and management implications*. Ursus 15:161-171.

Rode, K. D., C. T. Robbins, and L. A. Shipley. 2001. *Constraints of herbivory by grizzly bears*. Oecologia 128:62-71.

Smith, T.S., and S.T. Partridge. 2004. *Dynamics of intertidal foraging by coastal brown bears in southwestern Alaska*. Journal of Wildlife Management 68:233-240.

6.0 Marbled Murrelet (*Brachyramphus marmoratus*)

Domain experts[3]:

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

Alan Burger, Alan Burger Consulting and University of Victoria

Peter Arcese, University of British Columbia

Photo: A. Burger

6.1 Species Overview

6.1.1 Introduction

The marbled murrelet is a small diving seabird from the alcid family. Its range includes coastal areas from Alaska to central California, with the largest population in Alaska. B.C. is thought to have approximately 27% of the global population with an estimated 106,600 birds (D. Bertram, Canadian Wildlife Service, pers. comm.).

These birds are both marine and terrestrial. They spend approximately 90% of their time in nearshore marine waters, coming onto land only during the spring and summer breeding season, where they nest on mossy branches in large conifers (Nelson 1997, Burger 2002). There is a demonstrated correlation between the distribution of the birds and the distribution of old-growth and late-successional forests that provide the structural features required for nesting (Burger 2002, Raphael 2006). As such, they are considered to be old growth dependent.

Marbled murrelets eat small schooling fish and large crustaceans, generally preferring sand lance (*Ammodytes hexapterus*) and juvenile herring (*Clupea harengus*) during breeding season. They typically forage in sheltered waters that are less than 30 metres in depth or within 500m of exposed shores (Burger 2002). In B.C., they prefer marine waters with sandy substrates that provide habitat for sand lance. They will travel up to 100 km between their nests and marine foraging areas, but, on average, the distance travelled does not exceed 30 km (Whitworth et al. 2000, Hull et al. 2001).

Planning for marbled murrelets occurs at three scales:

1. *Regional scale*

There are regional differences in the ways that marbled murrelets use inland habitats for nesting, and differences among regions in the availability of suitable nesting habitat (CCMRT 2003). Where applicable, the CMMRT provides regionally specific habitat criteria in addition to its province-wide standards and habitat criteria e.g., as outlined in the Identified Wildlife Management Strategy (IWMS) (MOE 2004).

2. *Landscape or watershed scale*

The CCMRT focus at the landscape scale is to identify clusters of landscape units that provide larger proportions of suitable habitat associated with known foraging aggregations in nearby marine areas.

3. *Within managed forests at the stand level*

The marbled murrelet is considered an old-growth dependent species because of its requirement for old forest structure. The IWMS (MOE 2004) contains guidelines for the management of marbled murrelet habitat features within and outside of Wildlife Habitat

[3] Stephanie Hazlitt, University of British Columbia, also provided input into the Marbled Murrelet chapter

Areas. EBM objectives for within-stand retention may also contribute to the conservation of old forest structures suitable for murrelet nesting, so long as suitable habitat elements are retained.

6.1.2 Conservation status and legal designations

6.1.2.1 Conservation Status

In 1990, the marbled murrelet was designated as a threatened species by COSEWIC and this status was confirmed in 2000. It became a Schedule 1 species under the *Species At Risk Act* in June 2003. In B.C. the species was Red-listed by the B.C. Conservation Data Centre. It is one of the Identified Wildlife species under the *Forest and Range Practices Act* (FRPA), enabling Wildlife Habitat Aras (WHAs) to be established to protect suitable nesting habitat. Marbled murrelet and their nests and eggs are protected under the federal

In the U.S. the marbled murrelet is listed as Threatened under the *Endangered Species Act* in California, Oregon and Washington, and is a Species of Concern in Alaska. *Migratory Birds Convention Act, 1994,* and the provincial *Wildlife Act* (Section 34).

The conservation status of the species in B.C. is due to a low reproductive rate of the birds[4] combined with a declining population, even though marbled murrelets are still considered relatively common along the Coast. Researchers estimate that there has been an overall population decline of 70% in Alaska over the past 25 years (Piatt et al., 2006). Rates of decline in B.C. are thought to be similar (*Ibid*) although there are few data to assess population trends in B.C. (Burger 2002, Piatt et al. 2006). Population models indicate that changes in the survival of adult murrelets potentially have greater effects on populations than changes in the survival of immature birds or nesting success, although adult survival is not currently limiting murrelet populations (*Ibid*).

6.1.2.2 Existing and proposed management designations

Designated habitat areas:

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

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

6.1.2.3 Marbled Murrelet Recovery Strategy

The Canadian Marbled Murrelet Recovery Team (CMMRT) has worked together for the past 18 years. Their Marbled Murrelet Conservation Assessment was published 2002 - 2004 (Part A: Burger 2002; Part B: CMMRT 2003; Part C: Steventon et al. 2003). A draft Recovery Strategy for the marbled murrelet was presented to the federal government in 2007 for consideration. The strategy in draft format is unavailable until posted, therefore Recovery Team goals and strategies are referenced to Part B of the published Conservation Assessment.

The goals of the published Conservation Assessment, Part B (CMMRT 2003) are:

1. *To down-list the species from Threatened to Special Concern, by creating conditions that will limit the decline of the B.C. population and its nesting habitat to less than 30% over three generations (30 years), during the period 2002 to 2032.*

---

[4] Marbled murrelets do not begin to breed until 2 – 3 years of age and have a low reproductive output (1 egg/year and low breeding success) (Burger 2002)

2. *The CMMRT recognizes that the population in 2002 is likely reduced from historical levels, but the available data on past population size, distribution, and population trends before 2002 are too incomplete to use past populations for setting future minimum acceptable populations. The CMMRT believes that dealing with future declines is more realistic than trying to estimate and manage for past declines across the entire province.*
3. *To ensure that, by maintaining sufficient suitable nesting habitat (see definition below), and by reducing other threats, the species will have a low risk of reduced viability after 2032. This goal will allow the species to be considered for down-listing to Special Concern and eventually de-listed.*

The guiding principles for the conservation of marbled murrelets include the following (from CMMRT 2003):

1. The present range of marbled murrelets in B.C. should be maintained.
2. Marbled murrelets should remain a relatively abundant bird in B.C.
3. Conservation goals should be aimed at acceptable, not minimal standards.
4. Marbled murrelets should be managed according to both coast-wide and regional criteria.
5. Uncertainties should be addressed by applying an adaptive management approach.

6.1.3 Threats to marbled murrelets

On land:

- Loss of nesting habitat. The CCMRT recognizes loss of nesting habitat due to logging and agricultural and urban development as the primary threat to marbled murrelets (CMMRT 2003). It is a priority of the CMMRT to set aside enough habitat to conserve populations (See the Species at Risk Public Registry website: http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=39#ot10).
- Nest predation is the greatest cause of nest failure. Predators at nest sites include accipiters (e.g., northern goshawk), owls and corvids (crows, ravens and jays). Squirrels and other arboreal mammals are also suspected of preying on nestlings (Burger 2002).

  Outdoor recreation, logging, activity, road building and other human activities can impact nesting murrelets if corvids (ravens, crows and jays) and squirrels are attracted to campsites, lodges, picnic sites or remote work camps. Such human settlements and activities have been shown to increase predation risk (Marzluff and Neatherlin 2006).
- Windfarms and run-of-river projects have also been identified as potential threats to marbled murrelets. Both result in loss of nest habitat, the creation of a high density of 'hard edges' as a result of road and powerline development, and a risk that adult birds will be killed by flying into powerlines.
- Climate change may impact marbled murrelets on land but the effect on nesting habitat is not known at this time.

At sea:

- At sea threats from human activity include fishing-related mortality (getting caught in gill nets and angler's hooks as well as competition for prey), aquaculture (which results in loss of shallow water foraging), oil spills (Burger 2002), Offshore wind farms create a risk of collision and possibly loss of foraging habitat for marbled murrelets and loss of habitat for their prey (A. Harfenist, pers. comm.).

- Birds are vulnerable to at-sea predation by falcons, bald eagles, large gulls, sea lions and whales.
- Research in the Georgia Basin (Norris et al. 2007) suggests that marine habitat quality is a factor in breeding success. This is supported by studies in Alaska that suggest that declines in marbled murrelet numbers are a result of ocean conditions being unfavourable for forage fish (Piatt et al. 2006).
- Climate change and variability in ocean climate may also influence murrelet populations by influencing prey populations (Piatt et al. 2006).

6.1.4 Marbled murrelets as a focal species

Marbled murrelets are an appropriate focal species because:

- They are old-growth dependent.
- They are dependent on specific features of forested habitats that have been well-defined through recent research.
- Habitat requirements need to be considered at multiple spatial scales.
- Their habitat can be lost or reduced in quality (e.g., edge creation and increased predators) by development activities (e.g., forestry, energy production, and mining).
- The species is listed under the Species-at-Risk Act, is Red-listed by the B.C. Conservation Data Centre and is an Identified Species under FRPA.

6.2 Habitat Quality

The health of marbled murrelet populations is affected by the condition of habitats in their terrestrial and marine environments. This document focuses on the quality and quantity of terrestrial habitats.

6.2.1 Terrestrial Habitat Quality

Marbled murrelets nest high in large trees, often in inaccessible areas, which makes them difficult to detect. The first marbled murrelet nest was not discovered until 1974 and fewer than 300 nests have been identified since that time (reviews by Ralph et al. 1995, McShane et al. 2004, Piatt et al. 2006). Murrelet nesting habitat requirements are reviewed for the B.C. population in Burger (2002) and CMMRT (2003).

6.2.1.1 Stand structural attributes

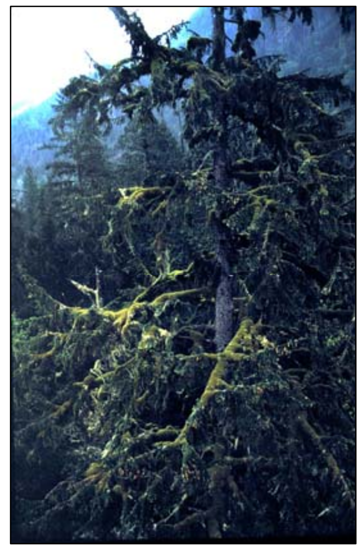
Marbled murrelets occur primarily in the Coastal Western Hemlock zone on moister, productive forested stands at lower elevations (<900 m on the southern coast and <600 m in more northern areas) (Burger 2002, CMMRT 2003).

Forested stands acquire suitable structural characteristics for nesting at approximately 200 years (Burger 2002). Large trees with large branches, and well-developed epiphytic mosses associated with these stands, provide mossy platforms for nests. There are five key structural features of marbled murrelet habitat (Burger 2002, 2004):

1. Nest tree height (usually >30 m; size class 4+)
2. High vertical complexity, which provides openings in the canopy next to nest areas
3. Large branches or limb deformities > 15 cm in diameter.
4. Moss/ epiphytic growth (although duff and litter may be used in drier areas)
5. Overhead cover of branches to provide shelter and protection from predators.

Nests are generally found in large conifer species with no consistent preferences for tree species, although nests are not found in Lodgepole pine (Burger 2002, Piatt et al. 2006). A small number of nests have been found on limbs without moss or on mossy inaccessible ledges with overhead cover (Burger 2002), however, management of marbled murrelet habitat in B.C. focuses on old seral forests.

Riparian areas provide important habitat, as they are moist and productive and provide the important structural features of nesting habitat. Montane riparian forests often support a greater abundance of epiphytic mosses (Rodway and Regehr 2002, Zharikov et al. 2006).



Nesting tree Photo: A. Burger

Marbled murrelets require a suitable balance between accessibility to their nests and security cover (Waterhouse et al. 2008). The complex vertical canopy structure and gappiness typical of old seral stands on the coast provides the birds with breaks in the forest canopy to access their nests (Manley 1999). Cover is important for protection from predators such as northern goshawks and corvids (ravens, crow and jays) (Burger 2002).

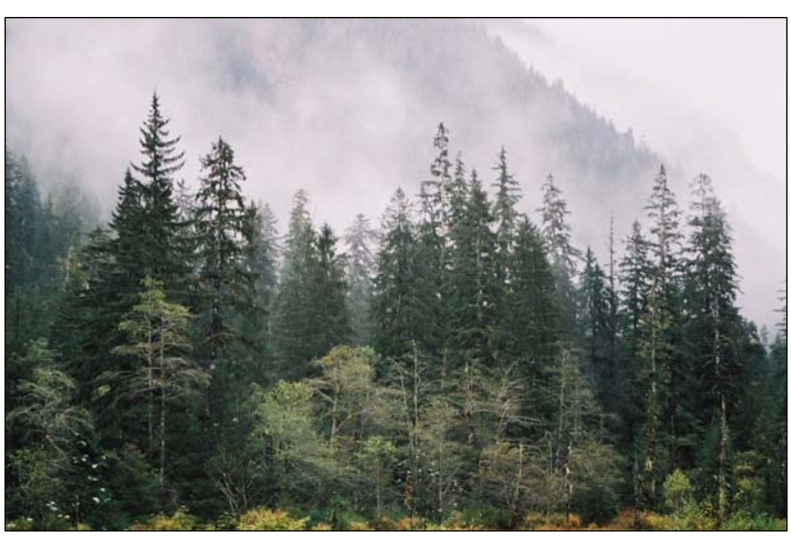
6.2.1.2 Locational factors

Elevation

Nesting murrelets prefer lower elevation forests (<900 m on the southern coast and <600 m in more northern areas) (Burger 2002, Zharikov et al 2006). This may occur because habitat features important for nesting such as large trees, presence of platform limbs and epiphyte cover, tend to be found at lower elevations and decline as elevation increases (review by Burger 2002).

Slope

Marbled murrelets nest on both steep or moderate slopes and valley bottoms. Waterhouse et al. (2008) identified on air photos that murrelets selected lower meso-slope positions of local catchments (i.e., 5 - 300 m). The birds may avoid upper meso-slopes if wind exposed and less habitable. Marbled murrelets will nest on steep slopes (30 - 70°) under suitable conditions. Steeper slopes provide a security advantage (fewer predators; Bradley 2002) and make it easier for marbled murrelets to access the mid-to lower crowns of trees where larger branches occur. This is likely for the same reasons that variable canopy structure and gappiness are preferred habitat features (Burger 2002).



High value marbled murrelet habitat Photo: A. Burger

Distance from the ocean

Most marbled murrelet nests are found within 30 km of the coast and any habitat within this range is likely to be used if suitable (Ralph et al. 1995, Burger 2002). On the exposed outer west coast of Vancouver Island nests tend not to occur within 500 m (Burger 2002). Analysis of nests located using telemetry in Desolation Sound and Clayoquot Sound showed a negative relationship with proximity to coastal zones for both nest site location and breeding success but did not specifically test the use of the 500 m coastal strip (Zharikov et al. 2007a).

Distance from the coast is related to energy expenditure (Hull et al. 2001). Some nests occur 30 – 50 km from the coast but these areas are not used to the same extent. It is rare (probably <1% of nests) to find nests at a distance of more than 50 km (Ralph et al. 1995, Burger 2002)).

Nest locations are also affected by geographic barriers; for example murrelets tend to stay on the coastal side of high mountains, unless river corridors facilitate access to interior sites.

Proximity to marine foraging areas

An important factor in selecting conservation areas for marbled murrelet is the juxtaposition of nesting areas with high quality feeding areas at sea (Ronconi 2008). Murrelet will fly up to 100 km to productive marine foraging (Whitworth et al. 2000, Hull et al. 2001), however, they are believed to prefer nesting areas within 30 km of marine foraging areas. For example, marbled murrelet densities tend to be low in habitats at the ends of long inlets in the Central Coast e.g., Bella Coola and the Kimsquit (Burger et al. 2004).

In southern B.C., marbled murrelet distribution at sea can be estimated based on sea floor substrates (e.g., sandy bottoms to support sand larvae; eel grass beds), the rate and preference for food capture and cost of flying in between feeding and nesting areas (Burger 2007, Ronconi 2008). Murrelets avoid areas with low salinity glacier water; these areas are not productive and there is a lot of silt on the bottom. They also avoid rocky areas (Ronconi 2008).

The EBMWG and University of B.C. are partnering on a project to study the marine-terrestrial interface of marbled murrelet habitats on the Central Coast and assess the most suitable areas for conservation of murrelet habitat (a project outline is provided in Appendix 2).

6.2.1.3 Influence of terrestrial habitat quality on nesting density

It is not known how habitat quality affects nest density. Radar studies indicate likely nest density on the B.C. mainland coast is 0.05 ± 0.04 birds per hectare of apparently suitable nesting habitat as defined by the CMMRT algorithm (Burger et al. 2004) which is approximately 1 bird per 20 ha or one nest per 60 ha of suitable habitat (assuming approx. 1 nest per 3 birds taking into account non-breeders). Newer radar data suggests somewhat higher densities in the coastal planning area (Doug Bertram, unpublished data) but the density is unlikely to be higher than one nest per 30 ha (A. Burger pers. comm.). Marbled murrelets are not using every suitable tree and many apparently suitable trees have no nests. Conroy et al. (2002) reported only five nests (some from previous years) in 467 apparently suitable trees climbed in Clayoquot Sound and similar low densities have been reported from other parts of B.C. (Burger 2002).

The density of nests does not change if a watershed is logged. Radar studies indicate that marbled murrelets will not inhabit remnant old-growth patches in higher densities than in areas of contiguous old-growth to compensate for reduced habitat availability (Burger 2001).

Territoriality may also be a factor in nest density but remains speculative (Burger 2002).

6.2.2 Marine Habitat Quality

Recent isotope studies by Norris et al. (2007) in B.C. and Beissinger and Peery (2007) in California suggest that the quality of marine habitat (i.e., prey availability) can affect the breeding success of marbled murrelets. In studying the quality of habitat in the Georgia Basin over 40 years, Norris et al. (2007) observed a close relationship between the proportion of fish in the murrelet diet and abundance. They speculate that, at some point, diet quality becomes a limiting factor in marbled murrelet viability and that the marine habitat quality in the Georgia Basin has declined to the point that murrelets can no longer breed at rates needed to recover their populations. In a more restricted time scale, Ronconi and Burger (2008) showed that juvenile recruitment was reduced in a year when oceanic factors greatly reduced prey abundance off Vancouver Island.

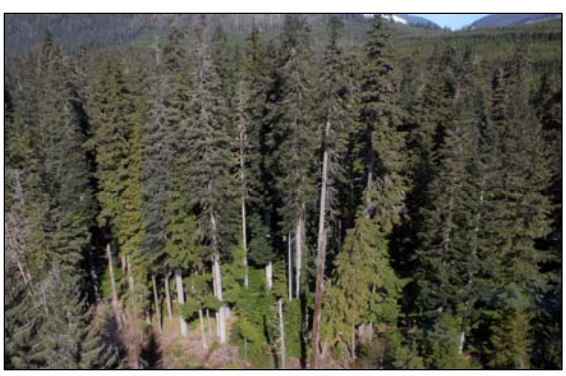
Analysis is underway on areas outside of the Georgia Basin. In the coastal planning region, where there is less fishing impact and lower industrial and urban-rural development, a decline in the quality of marine habitat has been observed, but it is thought to be less severe than in areas further south (P. Arcese pers. comm.).

6.3 Habitat Distribution, Spatial Configuration and Connectivity

6.3.1 Habitat distribution

Geographic isolation of habitat has been shown to be a factor in habitat selection (Raphael et al. 2002a). Studies in highly fragmented areas in California and Oregon suggest that very isolated patches of suitable forest might not be used (Meyer et al. 2002, Meyer & Miller 2002) but this is not true of all fragmented landscapes (Zharikov et al. 2007a). However, to date there are no data to indicate a minimum distance between used patches.

6.3.2 Spatial configuration


High value habitat Photo: A. Burger

Marbled murrelets use habitat in proportion to availability; there is no obvious selection for or against small patches (CMMRT 2003). However, risk of predation is likely higher in small patches with hard edges e.g., e.g., forested stands less than 40 years in age, roads (Burger 2002, Raphael et al. 2002b, Malt and Lank 2007). Some studies have shown that nests near forest edges are less successful, possibly due to increased risk of predation (Manley and Nelson 1999), but Zharikov et al. (2006) reported no negative effects near edges and higher success near natural edges. Once a clearcut bordering old growth has regenerated to 40 years it is no longer considered to increase predation risk within the old growth nesting habitat (Malt and Lank 2007).

Human activity near hard edges can increase risk of predation. A study in Washington State has shown that campsites and logging camps attract corvids which increases predation (Marzluff and Neatherlin 2006).

The CMMRT (2003) and IWMS (MOE 2004) recommend a representative range of patch sizes across the landscape.

6.3.3 Connectivity

Contiguity of forested cover between patches of old forest is not a concern for the management of marbled murrelet habitat as the birds will fly over clearcuts and openings.

6.4 Habitat Quantity

Objectives:

- To achieve the CCMRT goal of retaining 69% of suitable habitat within the sub-region over the long term
- To provide a preferred distribution of Class 1 - 3 habitats.

The CMMRT divided the marbled murrelet range into six conservation areas. Conservation efforts are not evenly distributed across these. A goal of 69% retention of 2002 habitat area was the minimum recommended for the Central and Northern Mainland regions, which overlap the coastal planning region (see CMMRT 2003 for details on the 69% retention goal). The lower retention target for the Central and Northern Mainland regions is to balance higher retention in regions with smaller populations (Vancouver Island and Southern Mainland).

A relationship between habitat quality and marbled murrelet density has not been determined but researchers do know that marbled murrelet are more likely to select Class 1 and 2 air photo-classed habitats than Class 3 habitats on air photos (Waterhouse et al. 2007, 2008, *In press*). Studies have shown that approximately 10% of marbled murrelet nests occur in poorer habitats in forest greater than 140 years (Class 4 and 5) (Waterhouse et al. 2004, 2007, 2008, *In press*; Burger and Waterhouse *In press*).

6.5 Research and inventory gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

6.5.1 Research questions

Arcese et al (2008) have designed an adaptive monitoring program to test hypotheses associated with the effect of timber harvesting on populations of marbled murrelets using radar surveys. This program has been endorsed by the CMMRT and could be applied in the coastal planning area. The program recommends experimental areas to be intensively managed and monitored. Suitable watersheds have been identified through simulation modelling using SELES (Spatially Explicit Landscape Events Simulator) (Contact: P. Arcese, University of B.C.).

- What is the link between perceived quality of nesting habitat (from algorithms, air photo interpretation or low-level aerial surveys) and density of marbled murrelets? (Currently a research project at Simon Fraser University [Dr. David Lank] is investigating this)
- What is the link between perceived quality of nesting habitat and nesting success?
- What is the link between the quality of terrestrial habitat and the quality of marine foraging habitat re marbled murrelet use?
- What factors limit marbled murrelet populations (nesting habitat limits carrying capacity, marine conditions affect recruitment)?
- What factors contribute to the quality of marbled murrelet habitat e.g., lower elevation, steep slope vs valley bottom? There are currently different views in the literature.
- What is the effect of commuting distance on likelihood of nesting successfully in suitable habitat (e.g., effects of long inlets and use of habitat >30 km inland)?
- At what age do second-growth stands begin to provide platforms and other attributes necessary for nesting, and how are these trends affected by regional, topographic & biogeoclimatic factors?

- What drives the spatial distribution of murrelet nests – are they territorial or do they use some other social spacing mechanism?
- What is the influence of forest edge and type of edge (hard vs. soft vs. natural) on habitat quality?
- Impact of developments other than timber harvesting e.g. independent power projects.
- How will murrelets in B.C. respond to global climate change?

6.5.2 Inventory gaps

Undertake ongoing inventories of the number and distribution of marbled murrelets on land and at sea. The Canadian Wildlife Service (CWS) has a multi-year program underway to monitor marbled murrelets in coastal watersheds using radar surveys. The data from this program is an important component of long-term monitoring of murrelets on the Coast (Contact: D. Bertram).

6.6 References and Recommended Readings

Arcese, P., A.E. Burger, C.L. Staudhammer, J.P. Gibbs, E. Selak, G.D. Sutherland, J.D. Steventon, S.A. Fall, D. Bertram. I.A. Manley, S.E. Runyan, W.L. Harper, A. Harfenist, B.K. Schroeder, D.B. Lank,, S.A. Cullen, J.A. Deal, D. Lindsay, and G. Jones. 2008. *Monitoring designs to detect population declines and identify their cause for the Marbled Murrelet*. Prepared for the Canadian Marbled Murrelet Recovery Team.

Beissinger, S.R., and M.Z. Peery. 2007. *Reconstructing the historic demography of an endangered seabird*. Ecology 88:296-305.

Bradley, R. W. 2002. Breeding ecology of radio-marked Marbled Murrelets (*Brachyramphus marmoratus*) in Desolation Sound, British Columbia. MSc Thesis, Simon Fraser University, Burnaby, BC. 86 pp

Bradley, R. W. and F. Cooke. 2001. *Cliff and deciduous tree nests of Marbled Murrelets in southwestern British Columbia.* Northwestern Naturalist 82:52-57.

Burger, A. E. 2001. *Using radar to estimate populations and assess habitat associations of Marbled Murrelets*. Journal of Wildlife Management 65:696-715.

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

Burger, A. E. (ed.) 2004. *Standard Methods for Identifying and Ranking Nesting Habitat of Marbled Murrelets (Brachyramphus marmoratus) in British Columbia using Air Photo Interpretation and Low-level Aerial Aurveys*. B.C. Ministry of Water, Land and Air Protection, Victoria, B.C., and Ministry of Forests, Nanaimo, B.C.. URL: http://wlapwww.gov.bc.ca/wld/documents/fia_docs/mamu_standard.pdf

Burger, A. E. 2007. *Preliminary Identification of At-Sea Aggregations to Support Regional Core Area Mapping for Marbled Murrelets in British Columbia*. Draft report to the Ministry of Environment, Nanaimo, B.C.

Burger, A. E., T. A. Chatwin, S. A. Cullen, N. P. Holmes, I. A. Manley, M. H. Mather, B. K. Schroeder, J. D. Steventon, J. E. Duncan, P. Arcese, and E. Selak. 2004. *Application of radar surveys in the management of nesting habitat of Marbled Murrelets Brachyramphus marmoratus*. Marine Ornithology 32:1-11. Available at: http://www.marineornithology.org

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

Burger, A. E. and R. E. Page. 2007. *The need for biological realism in habitat modeling: a reinterpretation of Zharikov et al. (2006)*. Landscape Ecology 22:1273-1281.

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

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

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

Conroy, C. J., V. Bahn, M. S. Rodway, L. Ainsworth, and D. Newsom. 2002. *Estimating nest densities for Marbled Murrelets in three habitat suitability categories in the Ursus Valley, Clayoquot Sound*. Pp. 121-137 i*n* Multi-scale studies of populations, distribution and habitat associations of Marbled Murrelets in Clayoquot Sound, British Columbia (A. E. Burger and T. A. Chatwin, eds.). Ministry of Water, Land and Air Protection, Victoria, B.C.. URL: wlapwww.gov.bc.ca/wld/documents/techpub/mamuwebs.pdf

Donaldson, A. 2004. Part Two: Air photo interpretation. In: Burger A. E. (ed.) *Standard methods for identifying and ranking nesting habitat of Marbled Murrelets (Brachyramphus marmoratus) in British Columbia using air photo interpretation and low-level aerial surveys*. Ministry of Water, Land and Air Protection, Victoria, B.C. and Ministry of Forests, Nanaimo, B.C.. URL: http://wlapwww.gov.bc.ca/wld/documents/fia_docs/mamu_standard.pdf

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

Hull, C. L., G. W. Kaiser, C. Lougheed, L. Lougheed, S. Boyd, and F. Cooke. 2001. *Intraspecific variation in commuting distance of marbled murrelets (Brachyramphus marmoratus): ecological and energetic consequences of nesting further inland.* Auk 118:1036-1046.

IWMS. 2004. *Identified Wildlife Management Strategy. Accounts and Measures for Managing Identified Wildlife: Marbled Murrelet Brachyramphus marmoratus.* Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, B.C.. Available at: http://www.env.gov.bc.ca/wld/frpa/iwms/accounts.html

Malt, J. M. and Lank, D. B. 2007. *Temporal dynamics of edge effects on nest predation risk for the marbled murrelet.* Biological Conservation 140: 160-173.

Manley, I. A. 1999. *Behaviour and Habitat Selection of Marbled Murrelets Nesting on the Sunshine Coast*. M.Sc. Thesis. Simon Fraser University, Burnaby, B.C.

Manley, I. A , and T. Jones. 2000. *Options for Managing the Nesting Habitat of Marbled Murrelets in the Sunshine Coast Forest District.* Unpublished report, Ministry of Environment, Lands and Parks, and International Forest Products, Surrey, B.C..

Manley, I. A. and S. K. Nelson. 1999. *Habitat characteristics associated with nest success and predation at Marbled Murrelet tree nests (Abstract)*. Pacific Seabirds 26:40

Marzluff, J. M. and E. Neatherlin. 2006. *Corvid response to human settlements and campgrounds: Causes, consequences, and challenges for conservation*. Biological Conservation 130 : 301 –314.

McShane, C., T. Hamer, H. Carter, G. Swartzman, V. Friesen, D. Ainley, R. Tressler, K. Nelson, A. Burger, L. Spear, T. Monagen, R. Martin, L. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. *Evaluation Report for the 5-year status Review of the Marbled Murrelet in Washington, Oregon, and California*. Unpublished report, prepared for U.S. Fish and Wildlife Service, Region 1. Portland Oregon. EDAW, Inc., Seattle, WA. URL: http://www.earthjustice.org/library/background/marbled_murrelet_status_review_pdf.html

Meyer, C. B and S. L. Miller. 2002. *Use of fragmented landscapes by Marbled Murrelets for nesting in Southern Oregon.* Conservation Biology 16:755-766.

Meyer, C. B. S. L. Miller, and C. J. Ralph. 2002. *Multi-scale landscape and seascape patterns associated with marbled murrelet nesting areas on the U.S. west coast*. Landscape Ecology 17:95-115.

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

MoFR (Ministry of Forests and Range). 2007. *Assessing Habitat Quality for Management of Marbled Murrelets*. Minutes of a workshop held on January 30 2007 in Nanaimo B.C..

Nelson, K. 1997. Marbled Murrelet (*Brachyramphus marmoratus*). In: Birds of North America, No. 276 (A. Poole and G. Gill, eds.). Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, DC.

Norris, D.R., P. Arcese, D. Preikshot, D.F. Bertram, T.K. Kyser. 2007. *Diet reconstruction and historic population dynamics in a threatened seabird.* Journal of Applied Ecology 44: 875 – 884.

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

Ralph, C. J., G. L. Hunt Jr., M. G. Raphael and J.F Piatt (eds.). 1995a. *Ecology and conservation of the Marbled Murrelet in North America.* Gen. Tech. Rep. PSW-GTR-152, Pacific Southwest Research Station, Forest Service, U.S. Dept. Agriculture, Albany, CA. Available at: http://www.fs.fed.us/psw/rsl/projects/wild/gtr152/

Raphael, M. G. 2006. *Conservation of the Marbled Murrelet under the Northwest Forest Plan*. Conservation Biology 20**:** 297-305.

Raphael, M. G., D. Evans Mack, and B. A. Cooper. 2002a*. Landscape-scale relationships between abundance of Marbled Murrelets and distribution of nesting habitat*. Condor 104:331-342.

Raphael, M. G., D. Evans Mack, J. M. Marzluff, and J. M. Luginbuhl. 2002b. *Effects of forest fragmentation on populations of the Marbled Murrelet*. Studies in Avian Biology 25:221-235.

Rodway, M. S., and H. M. Regehr. 2002. *Inland activity and forest structural characteristics as indicators of Marbled Murrelet nesting habitat in Clayoquot Sound.* Pp. 57-87 *in* Multi-scale Studies of Populations, Distribution and Habitat Associations of Marbled Murrelets in Clayoquot Sound, British Columbia (A. E. Burger and T. A. Chatwin, eds.). Ministry of Water, Land and Air Protection, Victoria, B.C..

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

Ronconi, R. A. and A. E. Burger. 2008. *Limited foraging flexibility: increased foraging effort by a marine predator does not buffer against scarce prey*. Marine Ecology Progress Series 366: 245–258.

Steventon, J.D., G.D. Sutherland and P. Arcese. 2003. *Long-term Risks to Marbled Murrelet (Brachyramphus marmoratus) Populations: Assessing Alternative Forest Management Policies in Coastal British Columbia.* Technical Report 012, Research Branch, British Columbia Ministry of Forests, Victoria, British Columbia.

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

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

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

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

Whitworth, D. L., S. K. Nelson, S. H. Newman, G. B. van Vliet, and W. P. Smith. 2000. *Foraging distances of radio-marked Marbled Murrelets from inland areas in southeast Alaska*. Condor 102:452-456.

Zharikov, Y., D. B. Lank, F. Huettmann, R. W. Bradley, N. Parker, P. P.-W. Yen, L. A. McFarlane-Tranquilla, and F. Cooke. 2006. *Habitat selection and breeding success in a forest-nesting Alcid, the marbled murrelet, in two landscapes with different degrees of forest fragmentation*. Landscape Ecology 21:107-120.

Zharikov, Y., D. Lank, and F. Cooke. 2007a. *Influence of landscape pattern on breeding distribution and success in a threatened Alcid, the marbled murrelet: model transferability and management implications.* Journal of Applied Ecology 44:748-759.

Zharikov, Y., D. Lank, F. Huettmann and F. Cooke. 2007b. *Interpreting habitat distribution models of an elusive species, the marbled murrelets: a response to Burger and Page*. Landscape Ecology 22:1283-1289.

7.0 Mountain goat (*Oreamnos americanus*)

Domain experts:

Steve Gordon, Ministry of Environment

Shawn Taylor, Goat Mountain Resources

Brad Pollard, McElhanney Consulting Services, Ltd.

Kim Brunt, Ministry of Environment, Nanaimo

Ken Dunsworth, Ministry of Environment, Hagensborg

7.1 Species Overview

7.1.1 Introduction

Mountain goats are endemic to North America. They are present in most mountain ranges throughout B.C., but are not found on Vancouver Island, Haida Gwaii and other coastal islands.

The species are superbly adapted to survive in steep terrain and severe winters. Mountain goats in B.C. exhibit behaviours associated with two ecotypes: Coastal and Interior (Hebert and Turnbull 1977). In the Interior, mountain goats will go to higher elevations in the winter and feed on windswept grasses. Such opportunities are limited on the Coast and goats generally use lower elevation, forested escape terrain in winter although they are observed at a range of elevations from sea level to upper elevations (Taylor et al. 2004). Mountain goats in areas of transition between coastal and interior habitat conditions will show variable patterns of winter elevation use (MELP 2000).

Mountain goats are matriarchal. Females (nannies) live apart from mature males (billies) with their kids and yearlings in nursery groups, except during the rutting period. Nannies are dominant and nursery groups occur in the highest quality habitats as they are most favourable for survival and reproduction (Fournier and Festa-Bianchet 1995). Billies are often solitary but do form small bachelor herds and, in a given area, will typically occupy more rugged and higher elevation habitats compared to nursery groups. Mountain goats show very high fidelity to their winter habitats and will often not move more than a few hundred metres in any direction during the winter periods (Taylor and Brunt 2007; Taylor et al., 2004; Keim 2003). This is particularly true of nursery groups.

Mountain goat meta-populations are defined as a number of discrete populations or sub-populations within topographically distinct mountain blocks within which goats can move between habitats without crossing a large valley. Summer range is connected by alpine/subalpine habitat. The highest density of use is always on the south side of the mountain block.

Little genetic interchange occurs between disjunct meta-populations; exchange between populations within a meta-population is mainly facilitated by the dispersal of adolescent billies which have been documented to travel large distances. Billies are thought to be at greatest risk of predation during such movements when they are away from escape terrain.

B.C. is estimated to support over half of the world's mountain goat population. The current population for B.C. is estimated at 39,000 – 67,000 (Festa-Bianchet and Côté 2008, Shackleton 1999). While the distribution of goat winter ranges and occupied habitats are relatively well known and data exists for individual herds, poor population inventories exist for the province as a whole.

In B.C., mountain goats are a game species for resident and non-resident hunters and are also harvested by First Nations for cultural, ceremonial and sustenance purposes. The annual allowable harvest (AAH) is currently based upon 4% of the population estimate. The mountain goat hunt in B.C. is managed predominantly as open season, with some areas managed by limited entry hunts. With the exception of some parts of Skeena Region, there is no winter hunt on the Coast. Even in more accessible areas of the Coast only 40 – 50% of the annual allowable harvest is achieved, on average (G. Schultze, MOE Skeena Region, pers. comm). A compulsory inspection if required of all mountain goats harvested to obtain management data related to area-specific age and sex composition.

In 2006, 721 mountain goats were taken under the regulated harvest in B.C. (577 male and 144 female). An average of eight goats is taken per year as part of the regulated harvest in the North Coast[5]. There is an extremely low harvest in the Mid and South Coast sub-regions (one goat has been harvested in each area in the last 5 years). These numbers do not include the First Nations harvest, which is not reported but may be substantial at the local population level.

Mountain goat habitat is planned and managed for at three scales: sub-region, watershed and stand.

Sub-region: Meta-populations = an assemblage of discrete / local populations (sometimes referred to as sub-populations) within distinct mountain complexes.

Watershed / landscape unit (1:50 000 to 1:20 000): Local populations (= a collection of herds). Watersheds that are known to support sizeable herds should be a priority for management.

Stand (1:10 000 to 1:5 000): Individual winter ranges provide critical habitat attributes for individual herds.

7.1.2 Conservation status and legal designations

7.1.2.1 Conservation status

Because mountain goats are widespread across B.C., and are thought to be stable in most areas of the province, they are not considered at risk and have been yellow-listed by the B.C. Conservation Data Centre (MELP 2000). Globally, they are not a species of conservation concern. However, localized declines have been reported and mountain goats are identified as a priority 1 Goal 2 species under the B.C. Conservation Framework, meaning that they are the highest priority for conservation under the goal of “preventing species and ecosystems from becoming at risk”.

7.1.2.2 Existing and proposed management designations

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

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

Mid Coast: General Wildlife Measures (GWMs) for approved UWRs in the Mid Coast state that up to 10% of a mountain goat UWR can be harvested, with restrictions on

[5] Based on data 1996 – 2008, estimating that the North Coast represents an estimate of 50% of MU 6-14 harvest, 50% of MU6-11 harvest, 10% of MU 6-10 harvest and 25% of MU6-03 harvest (G. Schultze, Ministry of Environment, Skeena Region, pers. comm.)

the nature and timing of activities and road development. As mountain goats appear to be on a declining trend, MOE Cariboo Region is considering amending the GWMs to prescribe no harvesting within UWRs (K. Dunsworth pers comm).

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

Management of goat natal areas (areas where nannies give birth to kids) may occur under the Identified Wildlife Management Strategy through the designation of wildlife habitat areas. These areas are generally small, as they only encompass the birthing areas themselves and not the larger area of habitat for other life requisites. Designation of mountain goats as Regionally Important Wildlife is also pending across the province, and this may provide opportunities for additional habitat protection measures to be implemented.

7.1.3 Threats to mountain goats

- Winter weather can result in high mortality for mountain goats. Mortality rates are highest in severe winters, often exceeding 50%. Between 40 and 60% of kids die in their first winter and many yearlings die in their second winter (MELP 2000). Mountain goats are typically in marginal condition over the winter and, even in unmodified habitats, an unusually deep and persistent snowpack may result in delays in spring green-up and cause substantial mortality.

- Due to their high fidelity to their winter ranges, the loss of effective winter habitat and associated natal habitats, may have a direct effect on population recruitment. The coastal mountain goat ecotype is particularly sensitive to removal of forest cover due to the heavier, wetter snow typical in coastal ecosystems. This emphasizes the importance of suitable snow interception cover for this ecotype.

- Demarchi et al. 2000 suggest that impacts to mountain goats may increase with second-pass logging (often heli-logging) if incremental areas of functional winter habitat are removed. If old-growth forest attributes have not recovered by the time the next pass of logging occurs, any further logging will result in even less habitat being available. At some point, there will be limits on the amount of habitat that can support a population through a severe winter.

- Industrial development can disrupt normal mountain goat behaviour, resulting in increased movement or displacement (Côté 1996, Wilson and Shackleton 2001, Gordon and Wilson 2004). It may also result in a higher mortality risk to goats due to increased human access The threat to mountain goats is magnified if increases in road density and habitat modification are occurring concurrently, which is typically the case with logging operations. As there are comparatively fewer accessible roads on the coastal mainland, this is not as much of a concern as in the Interior.

  Helicopter activity is an important management concern on the Coast where helicopter logging is increasing due to the inaccessibility of harvest areas. While the short-term acute responses of mountain goats to helicopter disturbance are relatively well known (Joslin 1986; Côté 1996; Gordon and Wilson 2004), the medium to long term effects are poorly understood and present an unknown risk to goats (Wilson and Shackleton, 2001; Toweill et al. 2004).

- Although designated winter ranges in the study area restrict forestry activities, they do not restrict the development of mining and power production projects. Forests near important escape terrain may therefore be at risk of removal or alteration from these developments.

- There is little hunting pressure on the Coast, compared to the Interior, because habitats are relatively isolated and inaccessible. However, there is still concern about impacts of over-harvest, especially of females. As mountain goats are matriarchal, the removal of the dominant nanny from a sub-group could result in a significant reduction in productivity and recruitment (Côté 2000). Unregulated hunting is a concern because there is no way to track impacts on local populations.
- Natural sources of mortality to adult mountain goats (other than winter kill) include predation, avalanches and falls from precipitous terrain. These are not considered major limiting factors to goat populations in B.C. (MELP 2000).

  Mountain goats avoid predation by occupying steep, inaccessible escape terrain. Grizzlies, wolves, golden eagles and, to a lesser extent, cougars and black bears have been documented to prey on mountain goats (Côté et al. 1997). Road development may result in predators becoming more efficient at accessing goat herds with a resulting increase in kill rates. The degree of risk posed by predation is herd-specific.
- Diseases and parasites have also been documented in mountain goats, some of which are associated with transmission from domestic animals. Goats however appear comparatively much less vulnerable to parasites, such as lungworms, than mountain sheep.

7.1.4 Mountain goat as a focal species

Mountain goats are a suitable focal species for the following reasons:

- As B.C. supports over half of the world's mountain goat population, the Province has a global responsibility to conserve the species.
- Mountain goats show very predictable use of winter habitat. On the Coast, some female goats use very small areas of winter habitat (as little as 7 ha of habitat over a winter, but ranging to 655 ha) (Taylor and Brunt 2007), and they show strong site fidelity (Taylor et al. 2004).
- Old growth forests play an important role in the survival of mountain goats, providing critical snow interception cover, particularly during winters of heavy snowfall.
- Mountain goats represent wilderness to the public. They are not often seen in front country areas e.g., highways except in areas where mineral licks occur in close proximity to transportation corridors. As such, they provide a visible sense of wilderness to an area.

7.2 Habitat Quality

Mountain goats are regarded as generalist herbivores but display rather narrow habitat preferences characterized by steep rugged terrain of open cliffs and rock bluffs intermixed with forest cover that provides food, shelter and escape from predators. Their preferred habitat includes a variety of microclimates for thermoregulation, including forested areas and south-facing rocky bedding sites. Thermal habitats are particularly important in winter to maintain body temperature and minimize energy expenditures. Foraging sites are in close proximity to rugged landforms that provide escape terrain in times of danger.

7.2.1 The importance of winter habitats

Mountain goats are most vulnerable during the winter months, when forage quality and quantity is at low levels and the cold and snow are energetically taxing. Coastal goats may use a wide variety of habitats during the winter, including a range of forest ages (Taylor and Brunt 2007; Jex 2004; Taylor et al. 2004). However, they show a strong selection for mature and old forest (80 years to over 250 years). In a coastal GPS collar study, Taylor et al. (2004) observed high winter use of mature and old forests by male (42%) and female (29%) goats. Use of these forest ages by goats was greater than twice their availability.

Field observations suggest that mountain goats preferentially select the warmest and driest ecosystems available. The preferred habitats to the south of the coastal planning area are Douglas-fir leading stands at low elevations with southerly aspects (Jex 2004; S. Gordon pers. comm.) As one moves north, there are fewer Douglas-fir stands, however, goats will continue to preferentially select dry, south-facing ecosystems as habitat. Habitat preference also changes with elevation. Preferred BEC variants for mountain goat winter range on the Coast vary with latitude but all are in the CWH zone.

Important winter range habitat occurs on southerly aspects, within slopes of 45 - 60%, particularly at the confluence of several drainage systems. This may be because these habitats tend to be more wind swept and may receive more solar radiation than surrounding areas (K. Brunt pers. comm.). These habitats are often occupied by nursery groups.

Mountain goats use different winter habitats, depending on the snow conditions. They have been observed from sea level to 3000 – 4000 feet depending on snow accumulation and the availability of suitable escape terrain.

During periods of low snowfall or in locations where there is high input of solar radiation, (e.g., open, south-facing slopes and steep burnt slopes) they will be able to access forage outside of the old-growth forest canopy (Taylor et al. 2004). When forage in more open areas is inaccessible due to snow cover, mountain goats will use old forest within and adjacent to escape terrain to access forage made available by snow interception.

Critical winter habitat

Heavy snowpack over the winter months is a critical period for mountain goat survival. Lack of suitable winter habitat may be associated with extirpation of local herds and population declines.

During times of heavy snow accumulation, old-growth forest cover becomes a critical habitat component. Crowns of large trees intercept snow by holding it in the canopy, resulting in reduced snow depth and increased availability of forage in the understory. Reduced snow depth also enables mountain goats to expend less energy during movement. The degree of canopy closure and ability of trees to intercept snow are important features. Older trees have stronger limbs, and species such as Douglas-fir hold snow well (Jex 2004). Where Douglas-fir is not uncommon or absent, as in the more northern parts of the Coast, it is the availability of forest adjacent to escape terrain that is important rather than the type of forest.

Litterfall lying on the top of the snow (e.g., fallen lichens and broken branches following a windstorm) is a major winter food source (Hjeljord 1973, Fox and Smith 1988, Fox et al. 1989). Litterfall is much more abundant in the understory of old stands. Slow-growing arboreal lichens are uncommon in younger stands and generally do not become established until old growth characteristics develop, such as slower growth rate, large crowns and fissured bark.

Under periods of heavy snowfall mountain goats may also use caves and shallow snow wells at the base of large trees in sparsely forested winter ranges (Shackleton 1999; S. Gordon, pers. comm.). Such shelters are temporary; while they provide snow interception they do not provide access to forage and are thus less desirable compared to conifer stands.

7.2.2 Escape terrain complexes

The preferred habitats of mountain goats occur in steep rocky terrain that is inaccessible to most predators. Functional escape terrain consists of complexes of forests and cliffs or rocky outcrops. Escape terrain complexes may exist as rocky bluffs adjacent to forest or as forested bluffs (i.e. bluffs scattered within a forest stand). The structure and quality of escape terrain varies greatly across the plan area; goats use escape terrain according to its availability.

The functionality of escape terrain complexes is very important, particularly in natal areas. The quality of forests within these complexes is essential to its function. Effective snow interception cover, as defined above, is critical in proximity to escape terrain.

7.2.3 Juxtaposition of forage and escape terrain complexes

Photo: S. Gordon

Goats require a juxtaposition of escape terrain complex and forage. The importance of forested cover within escape terrain complexes is discussed above. Access to forage is also very important within and adjacent to escape terrain complexes.

Mountain goats are generalists in their diet and can subsist on many foods in the winter and spring (Smith 1994). Habitat selection is directly related to the amount and quality of forage. Except for winters with deep snowpack, when they must relay on litterfall on the snow surface, goats will select habitats for their abundance and nutritional quality of grasses, shrubs and forbs. Open areas with little crown closure, particularly on sites that receive a lot of solar radiation, provide good forage during the winter in years with low snowpack, during melt periods and in the spring (S. Taylor, pers. comm.). Examples include burned areas and avalanche chutes. Ledges also provide early herbaceous and graminoid forage vegetation as the snow melts.

7.2.4 Specific habitat features: mineral licks

Mineral licks are considered a critical habitat feature in the Interior. However, the extent to which coastal mountain goats use mineral licks is unclear as there are few known mineral licks on the Coast.

7.3 Habitat Distribution, Spatial Configuration and Connectivity

7.3.1 Habitat Distribution

Goat habitats tend to be distributed in a disjunct fashion within a watershed depending on local topographic conditions. Provided that sufficient forested area around escape terrain is retained, it is preferable to provide spatially distributed habitat and not to concentrate protection measures in any one area. More productive winter range habitats should be identified for this purpose (using expert knowledge and ground-truthing).

7.3.2 Spatial configuration

The spatial configuration of each escape terrain complex (combined escape terrain and forested cover) influences its function. Habitat complexes need to be wide enough to moderate the effect of wind into the stand and to effectively change the depth of snow relative to clearcuts/ openings ('edge effect'). Microclimatic effects associated with edges penetrate into the forest to varying distances depending on the site and the variables measured, but effects begin to diminish within 50m and little effect is seen after 100 - 200m (Ministry of Environment 1995). In studies in the South Coast, the average area of mature and old forest within the average mountain goat winter home range was 30 ha in size (Taylor et al. 2004). However, the size of individual winter ranges may be much larger vary, depending on the topographic characteristics.

The larger the area of forested cover within an escape terrain complex, the greater the level of protection and likelihood that the viability of snow interception stands will be maintained. Most mountain goats are observed within 400m of escape terrain in winter (Taylor et al. 2004; Smith 1994) however, distances will vary with site conditions. For the purposes of management, forested cover of 150 – 400m in width may be needed to maintain the integrity of the complex (Fox 1983).

7.3.3 Connectivity

Goats require good vertical (cross-elevational) and horizontal (lateral) connectivity within their habitats.

7.3.3.1 Lateral connectivity

Winter range typically consists of a series of connected rock bluffs and goats move along contours from bluff to bluff. Goats appear to require forested cover to provide connectivity between bluffs to reduce energy expenditures and predation risk (B. Pollard pers. comm.). They generally disperse in stages e.g., to a rock bluff in the middle of a forested patch and then beyond.

7.3.3.2 Cross-elevational connectivity

Cross-elevational connectivity is important to mountain goats. Goats can move 500m – 600m per day vertically depending on the weather (B.Pollard, pers. comm.).

Goats migrate up and down hillsides between seasonal habitats (Taylor et al. 2004, Rice 2008). They move up elevation in the spring, post-kidding, following the trailing edge of the snow and emerging vegetation. Higher elevations provide summer forage and cooler microclimates (snow patches) to avoid insects. In winter, goats descend to lower elevations.

Connectivity that allows within-season movement can be linked to winter survival. Goats will move up and down in elevation in response to snow conditions. Goat surveys have shown that, during heavy snowfall years, there is very little forage for mountain goats and they are forced down to lower elevations to avoid deep snow (Gordon and Reynolds 2000, Jex 2004). Once the snow forms a crust that facilitates easy movement (usually mid- late winter) they move up in elevation again to forage on surface litterfall (MELP 2000).

Factors affecting the connectivity of mountain goat habitats include:

- Snow interception cover connecting escape terrains across elevations.
- Connectivity from lower elevations to the alpine to provide security cover during seasonal migrations.
- High density forests (>5000 stems per hectare) or young (20 – 50 year old) forest may be an impediment to movement. Early seral forest, post-harvesting, may present difficult conditions for mountain goats to move through due to logging residue.
- Where possible, roads should be planned to avoid bisecting connectivity corridors for mountain goats and deer.

7.4 Habitat Quantity

Population objective: To maintain existing populations and prevent localized extirpation.

The level of risk to mountain goats is directly associated with the availability of habitat. Mountain goats have a relatively quick response time to changes in their habitat due to their high habitat fidelity. The magnitude of risk depends on habitat conditions: in low-snowpack winters, goats may survive in areas where snow interception cover is compromised; however, a harsh winter in areas of inadequate cover could have severe population consequences. Therefore, reducing the functional effectiveness of winter range by removal of snow interception cover is thought to present a significant risk to the persistence of individual goat populations.

Photo: S. Gordon

The degree of natural disturbance within coastal ecosystems is relatively low (MoF/MELP 1999). To ensure sufficient habitat supply, a large proportion of habitat mapped as high suitability should be maintained. The degree of forest alteration that can occur within an individual ungulate winter range polygon has not been defined and the B.C. Ministry of Environment currently promotes a zero alteration approach as the low risk option. In the North Coast, 90% of habitat is outside of the Timber Harvesting Land Base (THLB), however much of the productive forest available for winter snow interception may be in the THLB, which could influence the risk rating.

Winter ranges encompass natal areas used by nannies during birthing in the spring (Geist 1964), adding to their importance as habitat. Natal areas on the Coast have been identified through field surveys of winter ranges. In the North Coast, all female winter range is assumed to be natal range since snows are still restrictive during the birthing season (L. Vanderstar, pers. comm.) and newborn kids have been observed within winter range polygons in coastal areas (S. Gordon, pers. comm.).

Nursery areas are habitats occupied by groups of nannies and kids after the solitary birthing (natal) period. Nursery areas may be occupied for a period of weeks to months (approximately mid June to late July). Because these habitats are used beyond the winter season, they cover a more extensive area than winter ranges.

Nursery groups typically occupy habitats most favourable for survival and reproduction (Fournier and Festa-Bianchet 1995). These are the most critical habitat areas for mountain goats and should be 100% protected as the health of nursery groups contributes to the reproductive success and survivorship of populations (Côté and Festa-Bianchet, 2001). This is particularly important as mountain goats have a low recruitment rate relative to other ungulates (Festa-Bianchet et al. 1993). An approach has been developed to assess the risk to available mountain goat habitats under different land management / conservation scenarios in the North Coast Forest District. The risk assessment is based on winter mountain goat Resource Selection Probability Function (RSPF) mapping combined with ratings for abundance of mountain goats (J. Keim pers. comm., work in progress). The method has not been tested on the co-location scenarios.

Where the amount of old forest habitat is inadequate, the recruitment potential of the forest needs to be maintained by retaining and managing second growth stands adjacent to escape terrain.

7.5 Research and inventory gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

7.5.1 Research questions

- In general, winter habitat is well described for the coastal mountain goat ecotype. What is needed is research that is more experimental and manipulative in design, with more experimental observations, (e.g., using collared animals), to see what happens when the habitat is altered. The long-term impacts of forest canopy removal are of particular concern in relation to population viability and habitat selection.
- What are the implications of loss of forested winter range at low elevations to mountain goat survival? Due to timber impact policies, legal UWRs tend to under-represent habitats in the contributing forest which may have a high importance to mountain goat survival.
- More information is needed about the effects of helicopter activity on mountain goat behaviour, habitat selection and rates of movement.
- What are the effects and the implications of potential climate change-related shifts?
- Spatial patterns of road development and risk to mountain goats. What are the effects of different road densities within varying distances from escape terrain?
- How do changes in land-use (including road building) affect predator-prey relationships?

7.5.2 Inventory gaps

- There are large information gaps on the Coast. The entire coastal planning area has been mapped for habitat suitability but this information is not suitable for population analysis. What is needed is an inventory program to measure vital rates (primarily productivity, recruitment and mortality). This should be continued on a regular frequency at a sub-regional level to monitor population trends and direct research gaps. A structured program would significantly add to our understanding for the species.
- The mountain goat harvest is currently assessed at the MU scale through monitoring of legal harvest and local inventories with sightability correction. There has been no comprehensive inventory of mountain goats on the Coast. With the current level of inventory, the probability of detecting localized loss of goats is low and local goat censuses are needed. However, the priority is to monitor population trends and vital rates.

7.6 References and Recommended Readings

Axys Environmental Consulting Ltd. 2005. *Identifying Mountain Goat Winter Ranges in the North Coast of British Columbia: Final Report*. Ministry of Water, Land and Air Protection, Skeena Region, Smithers, B.C.

Côté, S.D. 1996*. Mountain goat responses to helicopter disturbance.* Wildlife Society Bulletin 24: 681–685.

Côté, S.D., A. Peracino, and G. Simard, 1997. *Wolf, Canis lupus, predation and maternal defensive behaviour in mountain goats, Oreamnos americanus*. Canadian Field Naturalist 111: 389 – 392.

Côté, S.D. 1998. *Life history effects of chemical immobilisation and radio-collars on mountain goats.* Journal of Wildlife Management 62(2): 745 – 752.

Côté, S.D., and M. Festa-Bianchet, 2001. *Birthdate, mass and survival in mountain goat kids: effects of maternal characteristics and forage quality.* Oecologia (127): 230 – 238.

Côté, S.D. 2000. *Dominance hierarchies in female mountain goats: stability, aggressiveness and determinants of rank.* Behaviour 137(11): 1541 – 1566.

Demarchi, M.W. S.R. Johnson, and G.F. Searing. 2000. *Distribution and abundance of mountain goats, Oreamnos americanus, in westcentral British Columbia.* Canadian Field Naturalist 114:301-306.

Festa-Bianchet, M. and S.D. Côté. 2008. *Mountain Goats: Ecology, Behavior, and Conservation of an Alpine Ungulate*. Island Press, Washington, USA.

Festa-Bianchet, M., M. Urquhart and K.G. Smith 1993. *Mountain goat recruitment :kid production and survival to breeding age.* Canadian Journal of Zoology 72:22 – 27.

Fournier, F. and M. Festa-Bianchet. 1995. *Social dominance in adult female mountain goats*. Animal Behaviour 49: 1449 – 1459

Fox, J.L., 1983. *Constraints of Winter Habitat Selection by the Mountain Goat (Oreamnos americanus) in Alaska*. MSc. Thesis, University of Washington.

Fox, J.L. and C.A. Smith. 1988. *Winter mountain goat diets in southeast Alaska*. Journal of Wildlife Management 52: 362 – 365.

Fox, J.L., C.A. Smith and J.W. Schoen. 1989. *Relation between Mountain Goats and their Habitat in Southeastern Alaska.* General Technical Report PNW-GTR-246. USDA Forest Service, Portland, Oregon.

Geist, V. 1964. *On the rutting behavior of the mountain goat.* Journal of Mammalogy 45: 551 – 568.

Goldstein, M.I., Poe, A.J., Cooper, E., Youkey, D., Brown, B.A., and McDonald, T.L. 2005. *Mountain goat response to helicopter overflights in Alaska*. Wildlife Society Bulletin; 33: 688-699

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

Gordon, S. M. and S. F. Wilson. 2004. *Effect of helicopter logging on mountain goat behaviour in coastal British Columbia.* Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 14:49-63.

Hebert, D.M. and W.G. Turnbull, 1977. *A description of southern interior and coastal mountain goat ecotypes in British Columbia*. *In* W. Sammuel and W.G. MacGregor eds. Proceedings, First International Mountain Goat Symposium; 1977 February 19, Kalispell, MT. Ministry of Recreation and Conservation, Fish and Wildlife Branch, Victoria, B.C. pp.126-146

Hjeljord, O. 1973. *Mountain goat forage and habitat preference in Alaska.* Journal of Wildlife Management 37:353-362.

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

Joslin, G.L. 1986. *Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain front.* Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council 5: 253 – 271.

Keim, H. 2003. *Modeling Core Winter Habitats from Habitat Selection and Spatial Movements of Collared Mountain Goats in the Taku River Drainage of North-west British Columbia*. Ministry of Water, Land and Air Protection, Skeena Region. Smithers, B.C.

Ministry of Environment. 1995. *Forest Practices Code Biodiversity Guidebook*. Victoria, B.C.

MoF/MELP (Ministry of Forests and Ministry of Environment, Lands and Parks). 1999. *Landscape Unit Planning Guide*. Victoria, B.C.

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

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

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

Rice, C.G. 2008. *Seasonal altitudinal movements of mountain goats*. Journal of Wildlife Management 72(8): 1706 – 1716.

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

Schoen, J.W. and M.D. Kirchoff. 1982. *Habitat Use by Mountain Goats in Southeast Alaska.* Final Report, Federal Aid in Wildlife Restoration Projects W-17-10, W-17-11, W-21-1, and W-21-2, Job 12.4R. Alaska Department of Fish and Game, Juneau, Alaska.

Shackleton, D.M. 1999. *The Hoofed Mammals of British Columbia. Volume 3: The Mammals of British Columbia*. Royal British Columbia Museum, Victoria, and UB.C. Press, Vancouver.

Smith, B.L. 1977. *Influence of snow conditions on winter distribution, habitat use, and groups size of mountain goats.* In W. Sammuel and W.G. MacGregor (*eds.)*. Proceedings, First International Mountain Goat Symposium; February 19 1977. Ministry of Recreation and Conservation, Fish and Wildlife Branch. Victoria, B.C.:174-189.

Smith, C.A. 1986. *Habitat Use by Mountain Goats in Southeastern Alaska*. Federal Aid in Wildlife Restoration Project W-22-2; Final Report; Job 12.4R. Alaska Department of Fish and Game, Juneau Alaska.

Smith, C.A. 1994. *Evaluation of a multivariate model of mountain goat winter habitat selection*. Biennial Symposium of the Northern Wild Sheep and Goat Council 9:159-165.

Taylor, S., and K. Brunt. 2007. *Winter habitat use by mountain goats in the Kingcombe River drainage of coastal British Columbia*. Journal of Ecosystems and Management 8(1): 33 – 50.

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

Toweill, D.E., S. Gordon, E. Jenkins, T. Kreeger, and D. McWhirter. 2004. *A working hypothesis for management of mountain goats*. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:5 – 45.

Wilson, S. F. and D. M. Shackleton. 2001. *Backcountry Recreation and Mountain Goats: A Proposed Research and Adaptive Management Plan*. B.C. Ministry of Environment, Lands and Parks Wildlife Bulletin B-103.

Voyer, A.G., K.G. Smith, and M. Festa-Bianchet. 2003. *Dynamics of hunted and unhunted mountain goat Oreamnos americanus populations*. Wildlife Biology 9: 213 – 218.

Yazvenko, S.B., Searing, G.F. and M.W. Demarchi. 2000. *Wildlife Habitat Assessment in the Nass Wildlife Area*. Nisga'a Tribal Council. New Aiyansh, B.C.

8.0 Northern Goshawk (*Accipiter gentilis laingi*)

Domain experts:

Erica McClaren, Ministry of Environment

Todd Mahon, Wildfor Consultants

Frank Doyle, Wildlife Dynamics Consulting

Photo: E. McClaren

8.1 Species Overview

8.1.1 Introduction

Several documents provide detailed accounts of the ecology, management and conservation of the Northern Goshawk (*Accipiter gentilis*) internationally (Squires and Reynolds 1997, Kenward 2006, Squires and Kennedy 2006, U. S. Fish and Wildlife Service 2007), nationally (COSEWIC 2000), provincially (Northern Goshawk *Accipiter gentilis laingi* Recovery Team 2008) and regionally (Iverson *et al* 1996; Mahon and Doyle 2003; McClaren 2003). For detailed background information, refer to these documents. Below we provide a brief synopsis of key information used by the Northern Goshawk Recovery Team and Habitat Recovery Implementation Group (RIG) in the development of habitat suitability models (Mahon *et al.* 2008). These models were applied as base layers along with sets of rules to guide co-location of Northern Goshawk nesting and foraging habitats and other focal species habitats with site series surrogates within old growth reserves. Please note, opinions provided within this document are those of the authors and do not necessarily represent the views of the Northern Goshawk *A. g. laingi* Recovery Team.

Northern Goshawks are raven-sized raptors with short, rounded wings and long tails (Squires and Reynolds 1997). Two subspecies of Northern Goshawks are recognized in British Columbia based on morphological distinctions: *Accipiter gentilis atricapillus* and *Accipiter gentilis laingi* (AOU 1957, 1983; Palmer 1988; COSEWIC 2000). *A. g. laingi* has a darker plumage colour (Taverner 1940) and smaller size (Johnson 1989; Whaley and White 1994; Flatten and McClaren, in prep.) than *A. g. atricapillus*. Genetic analyses suggest that coastal populations of Northern Goshawks may not be panmictic, especially individuals from Haida Gwaii, which may be genetically isolated from adjacent populations (Talbot 2006). Microsatellite DNA analyses suggest individuals from Vancouver and the coastal mainland of B.C. are interbreeding but that these coastal populations are not interbreeding with interior B.C. populations (Talbot unpublished data). However, there is likely an area along the range boundary between these two subspecies where they hybridize.

In the United States, *A. g. laingi* occurs within coastal areas of southeast Alaska and Washington and possibly, Oregon and California (Jewett *et al.* 1953; Beebe 1974; Flatten and McClaren, in prep.). In Canada, 100% of *A. g. laingi* reside within B.C. In B.C., *A. g. laingi*, hereafter referred to as goshawk, inhabit Haida Gwaii, Vancouver Island, the coastal islands, and the B.C. mainland west of the Coast Mountains (AOU 1983; Campbell *et al.* 1990b; COSEWIC 2000; McClaren 2003). This coastal goshawk subspecies is listed as Threatened in Canada (COSEWIC 2000) and imperiled provincially (S2B) and globally (T2; B.C. Conservation Data Centre 2005; Natureserve 2007). *A. g. laingi* are a Category of Species at Risk under the B.C. Forest and Range Practices Act. The B.C. Conservation Framework identifies *A. g. laingi* within priority 1, Goal 3 “to maintain the diversity of native species and ecosystems” and also in priority 2, Goal 1 “to contribute to global efforts for species and ecosystems conservation" (http://www.env.gov.bc.ca/conservationframework/).

The goshawk is primarily adapted to breed and forage in mature and old-growth coniferous forests with closed (>50%) canopies, relatively large diameter trees and open understories (Cooper and Stevens 2000; Penteriani 2002; Drennan and Beier 2003; Boal *et al.* 2005; McGrath *et al.* 2003). These forests are characterized by structural attributes that provide nest platforms, understory flight space to access prey and nests and protection from predators. Goshawk home ranges are described as a hierarchical arrangement of biological components including the nest trees, post-fledging areas (PFA), and foraging areas (Reynolds et al. 1992: post-fledging family area; Kennedy et al. 1994; McClaren et al. 2005). Within home ranges, there may be considerable overlap among foraging areas of adjacent goshawk pairs. The nest area is the smallest component of a home range and it functions as the centre of breeding activities throughout the reproductive season – mid-February to the early September. The nest area usually includes multiple nest sites. Goshawks exhibit very strong fidelity to nest areas once established, often using them intermittently for periods of years or decades (McClaren 2003, Doyle 2005).

Across relatively homogenous forests, goshawk nest areas are generally evenly distributed (Reich *et al.* 2004; Reynolds *et al.* 2005) with the distance between nest areas being primarily driven by prey and habitat availability within landscapes (Doyle and Smith 1994, 2001; Reich *et al.* 2004). Nest area spacing ranges from approximately 7 km on Vancouver Island (McClaren 2003) to approximately 11 km on Haida Gwaii (Doyle 2005), corresponding to territory sizes ranging from 3800 ha – 9200 ha, respectively. Although their home ranges may expand in the winter and individuals may spend periods of time away from nest areas, goshawks seem to be year-round residents throughout coastal B.C. (McClaren 2003).

Unlike Buteo hawks (e.g., Red-tailed Hawks, *Buteo jamaicensis*), goshawks generally do not soar in open habitats while hunting; they use a stop-and-go, short-stay perched-hunting pattern (Kenward 1982; Kennedy 2003), maneuvering between trees below the forest canopy. Their main prey during the breeding season includes red squirrels, forest passerines (typically thrushes and jays), woodpeckers, and grouse (Roberts 1997; Ethier 1999; Mahon and Doyle 2003).

There are three scales of planning for goshawks, with a focus on the landscape scale:

Sub-regional scale:	population scale management
Landscape scale:	pair specific management to protect foraging habitat within home ranges
Stand scale:	nest areas / post-fledging areas

Goshawks occur throughout forested landscapes in varying densities throughout coastal B.C. Therefore to manage local populations, their habitat needs to be managed at a scale that is larger than a home range but smaller than an entire region. Landscape units across the region are typically large enough to provide an appropriate spatial scale for goshawk territorial management, and also provide for useful administrative boundaries. Other than on Haida Gwaii, and possibly Vancouver Island, where there is likely limited immigration due to island biogeography, there is no basis to identify distinct meta/sub-populations.

8.1.2 Conservation Status and Legal Designations

8.1.2.1 Conservation status

COSEWIC's designation of Threatened for *A. g. laingi* was based on an estimate of <1,000 mature individuals within Canada combined with imminent threats posed from degradation of forested habitat (COSEWIC assessment criterion D1; COSEWIC 2000).

Goshawk habitat management in B.C. is primarily a fine filter approach implemented using guidelines outlined in the Identified Wildlife Management Strategy (McClaren 2004), to protect both nests, and the surrounding post-fledging areas using Wildlife Habitat Areas (WHAs). Portions of goshawk foraging habitat may be protected incidentally by other fine filter mechanisms (e.g., overlap with Ungulate Winter Ranges or other Category of Risk species WHAs) or from coarse filter mechanisms such as old-growth management areas, riparian reserve zones, stand level retention, Parks and Protected Areas/Conservancies and Higher Level Plan Objectives.

8.1.2.2 Existing and proposed management designations

Wildlife Habitat Areas:

- There is one approved WHA for goshawks in the North Coast and no other WHAs established throughout the rest of coastal mainland B.C.
- There are 15, 9, and 3 known nest areas for goshawks within the South Coast, Mid Coast and North Coast sub-regions, respectively.

8.1.3 Threats to northern goshawks

- The most imminent threats to coastal goshawk populations within B.C. are related to the loss and fragmentation of nesting and foraging habitat, and subsequent reductions in prey diversity and availability. Relative to the abundance of mature and old-growth forests that existed before industrialized forest harvesting, there has been a reduction in the amount of habitat for goshawks in coastal B.C. (COSEWIC 2000; Doyle 2003a; Holt 2004; Smith and Sutherland 2008).
- It is unclear whether the overall balance of suitable habitat for goshawks will be stable, positive, or negative in future years as second-growth forests mature. However, many second-growth forests are becoming commercially viable for harvesting and will therefore potentially not be available as goshawk nesting habitat.
- Increased forest fragmentation leads to more open habitats and a subsequent increase in edge-dwelling species. This may result in greater depredation of adults, young, and eggs, and competition for nests sites.
- Within Haida Gwaii, introduced species threaten goshawks but are also a source of prey. Consequently, the overall effect of introduced species within this conservation region is unclear.
- Goshawks in Haida Gwaii have a very high risk of genetic isolation because genetic analyses suggest there is very little gene flow among these individuals and other coastal goshawk populations (Talbot 2006).
- Currently, the level of each threat to goshawk populations throughout coastal B.C. is not well understood and more work will be necessary to evaluate these perceived threats. Furthermore, population monitoring in most areas of coastal B.C. has been inadequate to determine population trends.

8.1.4 Northern goshawks as a focal species

- Goshawks are an ideal focal species because they are a top avian predator within mature and old forests. As such, they likely play a complex ecological role and humans may never completely understand the mechanisms and associations of this role.

- It is known that goshawks can regulate prey populations, especially in areas where they select a few key prey species (Doyle and Smith 1994; Tornberg and Colpaert 2001; Kennedy 2003).
- Goshawks function as a primary nest builder for other birds such as large forest owls (including Spotted Owls; Forsman and Giese 1997), Common Ravens (*Corvus corax;*, E.L. McClaren, pers. observation 1998), and Great Blue Herons (*Ardea herodias;* F. Doyle, pers. observation 2000).
- As a large, territorial forest raptor, goshawks likely influence the spacing and distribution of other forest raptors (Krüger 2002).
- Goshawks are often considered to be an indicator of mature forest ecosystem health because they depend on the presence of prey species that are themselves dependent on the structural complexity of these forests.

8.2 Habitat Quality

Habitat models for goshawks were developed from forest cover attribute, digital elevation and Biogeoclimatic Ecosystem Classification (BEC; Mackinnon *et al.* 1992) data. The overall goal of domain experts was to select habitat attributes that reflected differences in habitat quality, measured by survival and reproduction. Unfortunately, there are information gaps surrounding exact relationships between habitat attributes and goshawk population parameters. Consequently, nesting habitat quality is used as a surrogate of reproductive habitat quality and foraging habitat quality is used as a surrogate of survival habitat quality (Squires and Kennedy 2006, Mahon *et al.* 2008). Therefore, domain experts identified potentially relevant habitat variables from the published literature, regional studies and their expert opinions that were important to goshawk nesting and foraging (Mahon *et al.* 2008). The selection of parameters was limited by what was available to use in GIS databases and which habitat parameters could be projected forward in time sequences for habitat supply scenario runs.

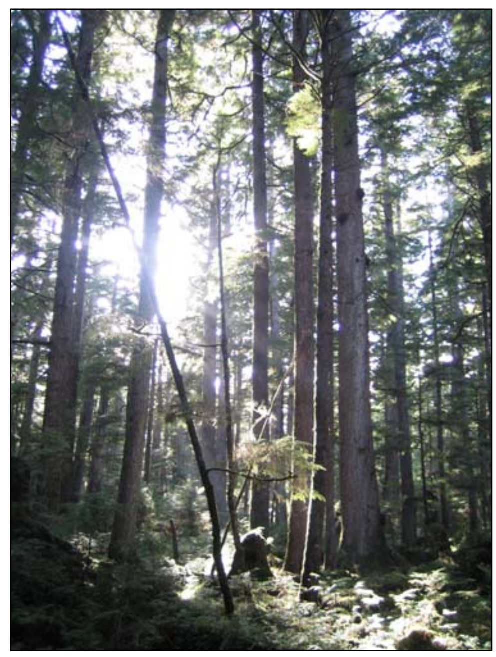


Photo: E. McClaren

8.2.1 Features that apply to all goshawk habitat

Goshawk nest areas, post-fledgling areas and foraging habitats are characterized by closed canopies, relatively large diameter trees, and open understories (Bloxton 2002, Drennan and Beier 2003, Boal *et al.* 2005, Squires and Kennedy 2006, Mahon *et al.* 2008) — attributes that provide for nest platforms, protection from predators, sub-canopy flyways and access to prey. Radio-telemetry data suggest that goshawks also forage in areas where they do not nest, including forest edges, riparian areas, estuaries, and high elevations (>900 m) with more open canopies (McClaren 2003, Squires and Kennedy 2006, U.S. Fish and Wildlife Service 2007). Therefore, nest area habitat characteristics are more specific than foraging habitat characteristics.

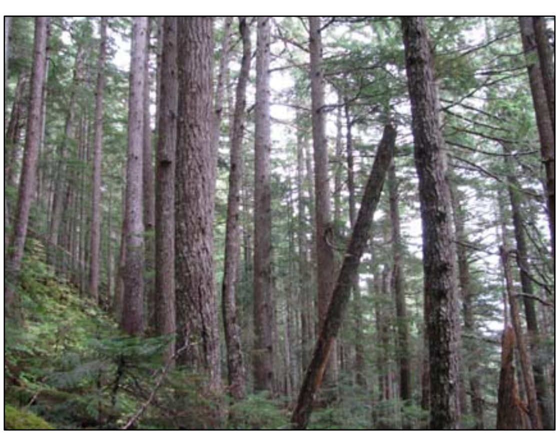
8.2.1.1 Stand Characteristics

The structural maturity of a stand, and trees within a stand, form the fundamental basis for nesting and foraging suitability for goshawks (Squires and Reynolds 1997). Individual trees must have large enough branches to support relatively large (ca. 1 m diameter; E. McClaren, unpublished data) stick nests. Suitable stands will have progressed through the self-thinning stage and be tall enough to provide open flyways below the main canopy layer (Penteriani 2002). As well, in the coastal rainforests dominant tree canopies need to be sufficiently closed (>50%) to provide for open understories and protection from predation and weather (Bloxton 2002, Mahon *et al.* 2008). Typically the desired structural conditions in this region occur in tall (>28 m) mature and old growth stands, although favourable structure may occur in highly productive Douglas fir (*Pseudotsuga menziesii*) stands as young as 50 – 80 years on Vancouver Island and the South Coast of B.C. (Mahon *et al.* 2008). Stands with high compositions of Douglas fir, Western hemlock (*Tsuga heterophylla*) or Sitka spruce (*Picea sitchensis*) are most suitable for goshawk nesting and foraging because they typically provide high canopy closure, sufficient nest platforms and cones for red squirrels (*Tamiasciurus hudsonicus*); a key prey item of goshawks (Roberts 1997; Ethier 1999; Doyle 2003b; Lewis *et al.* 2006). Yellow-cedar (*Chamaecyparis nootkatensis*) and Western redcedar (*Thuja plicata*) dominated stands are less suitable for goshawks because they generally have low canopy closure, dense understories and lateral limbs that droop and do not provide adequate nest platforms (Mahon *et al.* 2008). Abundant coarse woody debris and snags are important for goshawk prey (for cover and forage) as well as for perches and plucking posts for goshawks while hunting. Therefore, stands with a combination of suitable structural characteristics and abundant coarse woody debris and snags are extremely valuable to goshawks.

8.2.1.2 Landscape Characteristics

At a larger scale, goshawks typically nest >200 m from hard edges[6] and in stands that are >100 ha (Ethier 1999; McClaren and Pendergast 2003). Goshawks select nest trees at low to mid-elevations (<900 m: Vancouver Island and South Coast B.C.: <600 m, North Coast B.C., <400 m: Haida Gwaii, Mahon *et al.* 2008) on moderate slopes (<60%) and typically within the mid- to lower mesoslope position (McClaren 2003; Doyle 2005). Suitable biogeoclimatic zones for breeding throughout the range of goshawks include the Coastal Western Hemlock and Coastal Douglas-fir biogeoclimatic zones (McClaren 2003). Maritime subzones of the Coastal Western Hemlock zone constitute the core part of the range of *A. g. laingi,* whereas submaritime subzones form the transitional zone where both *A. g. laingi* and *A. g. atricapillus* likely overlap (Northern Goshawk *A. g. laingi* Recovery Team 2008).

8.2.2 Features of nest areas and post-fledging areas


High value nesting habitat Photo: T. Mahon

Nest areas function to provide multiple nest trees, roost trees, and prey plucking posts, and they act as centers for courtship behaviour and fledgling movements during the post-fledging period (Reynolds *et al.* 1992). Goshawks may build several nests (>7) within their nest areas and these may be re-used, or a new nest built annually. The spacing pattern of alternative nest trees within home ranges, coupled with information from radio-telemetry data on fledglings from 12 nests on Vancouver Island, suggests the functional size of the PFA for *A. g. laingi* is between 100 ha and 200 ha (McClaren *et al*. 2005). The biological role of post-fledging areas and nest areas appears to be functionally similar (McClaren *et al.* 2005),

6 Hard edges occur where mature forest meets non-forested or early seral habitats and the difference in height is >15 m.

and so these areas have been considered as one spatial scale in this document.

8.2.3 Features of foraging areas

Foraging areas make up the majority of goshawk breeding home range; and this area may include the nest trees, and PFAs. This foraging area will be used by both the adults and dispersing immature birds. However, within this area individuals within a pair may have entirely different foraging areas (Boal *et al.* 2003), and they may change the area they hunt between seasons and years (Titus *et al.* 1994; McClaren 2003). Foraging areas vary in size among localities and among individuals according to experience, hunting efficiency, food requirements (brood size), and the availability of food within home ranges (Kennedy *et al.* 1994).

Few studies have estimated the size of foraging areas for goshawks because limited information is available on foraging activities. Most often, the size of the foraging area is based on the estimated home range size, with the assumption that individuals forage widely throughout their home range. In southeast Alaska, median breeding home ranges for goshawks were 4,300 ha (n = 16) for females and 4,600 ha (n = 20) for males (S. Lewis, unpublished data). Home ranges of *A. g. laingi* appear to be larger than for *A. g. atricapillus* likely because prey densities are lower throughout coastal forests (Crocker-Bedford 1994; Titus *et al.* 1994; USFWS 1997; Boal *et al.* 2003).

In the absence of extensive radio-telemetry data, breeding home range sizes for goshawks in coastal B.C. were estimated from distances between nest area centroids (geographic center of nests within a nest area). Because of the territorial nature of goshawks, adjacent pairs will space themselves fairly evenly throughout contiguous landscapes (Reich *et al.* 2004; Reynolds *et al.* 2005) area spacing ranges from approximately 7 km on Vancouver Island (McClaren 2003) to approximately 11 km on Haida Gwaii (Doyle 2005), corresponding to home range sizes between 3800 ha – 9200 ha, respectively.

8.2.4 Influence of roads

Roads can have positive or negative impacts on goshawks depending on the type of road (highway, mainline forest road, secondary forest road, abandoned road) and the landscape context of the road (forested on both sides, within recent cutblocks). Goshawks use roads as flight corridors and for hunting, especially secondary forest roads and abandoned roads where there is suitable foraging habitat on one or both sides of the road corridor. High traffic roads are probably used infrequently by goshawks and, if they are used, may result in collisions between goshawks and vehicles.

8.3 Habitat Distribution and Connectivity

8.3.1 Habitat distribution

In general, it is more difficult to discern unique patterns of habitat selection by goshawks at larger spatial scales and as the landscape context around nests becomes more varied (Iverson *et al.* 1996; Ethier 1999; Daw and DeStefano 2001; Finn *et al.* 2002; McClaren and Pendergast 2003; McGrath *et al.* 2003). Within B.C., there is a lack of information on the amount and juxtaposition of foraging habitat required by a breeding pair to support successful reproduction and survival.

The territorial nature of goshawks makes it unlikely for pairs to “pack” into areas with concentrations of suitable habitat that are smaller than the size of a single territory (Reich *et al.* 2004; Reynolds *et al.* 2005). Nest area spacing corresponds to prey abundance and availability over time and in years of high prey abundance, more territories may be occupied than in years of reduced prey abundance (Doyle 2005), however, the overall spacing pattern remains similar.

During the breeding season, goshawks are restricted energetically where they can forage, because they must return to nests to deliver food to young. Therefore, it is more important for high quality foraging habitat to be closer to active nest areas than farther away. Bloxton (2002) reported that goshawks on the Olympic Peninsula, Washington, concentrated foraging activities within 5 km of active nests and within only 15% of their entire breeding home range.

Within watersheds, territories are primarily bounded by major geographic barriers (e.g., large lakes, mountains) not by forest condition. Therefore, within several u-shaped watersheds along coastal BC, goshawk territories would be expected to be distributed along the length of valleys which provide both suitable nesting and foraging habitat, rather than from low to high elevations (Mitchell *et al.* 2008).

8.3.2 Connectivity

Connectivity among suitable habitat patches is more important for nesting habitat than for foraging habitat, especially among alternative nest stands and PFAs. Adult goshawks are highly mobile and are able to travel large distance between foraging habitat patches, although this may be disadvantageous from an energetic perspective and connectivity may be important to goshawk prey. Goshawks may be more vulnerable to predation while traversing unsuitable habitat patches (i.e., non-forested areas) and so they may avoid traversing vast expanses of water and clearcuts. For example, genetic isolation of goshawks in Haida Gwaii is likely the result of the expansive distance (90 km) of water between these islands and the adjacent mainland.

Young goshawk on nest, Haida Gwaii Photo: B. Widjeven

8.4 Habitat Quantity

Population objective: To maintain sufficient habitat to maintain viable breeding territories and, therefore, populations.

Studies throughout North America and Europe show that goshawks are found in a variety of landscape conditions and that availability of prey is the driver behind habitat suitability (Squires and Reynolds 1997, Kenward 2006). In the coastal rainforest of B.C., goshawk prey abundance (red squirrels, forest thrushes, woodpeckers and forest grouse) and availability is associated with mature-old growth stands (Ethier 1997, Bloxton 2002, Doyle 2006b). Correlative evidence suggests the amount of mature and old forests within home ranges improves territory occupancy within the temperate coastal rainforests (Finn *et al.* 2002, McClaren and Pendergast 2003, Doyle 2005), More specifically, Finn *et al.* (2002) and Doyle (2005) noted that landscapes associated with occupied nest areas had > 40% of the landscape (various scales) in late seral forests. In the management recommendations for goshawks in southwestern Arizona, Reynolds *et al.* (1992) suggests that 60% of the foraging area should be maintained in mid-aged to old forest and at least 40% should be in mature and old. Overall, most studies hypothesize between 40 - 60% of suitable foraging habitat within goshawk home ranges will support pairs over time (Reynolds *et al.* 1992; Patla 1997; Finn *et al.* 2002; Doyle 2005).

Based on available information on habitat thresholds from the scientific literature referenced above and from regionally collected data on goshawk populations, the Northern Goshawk *A. g. laingi* Recovery Team and Habitat RIG have identified three thresholds of foraging habitat abundance within goshawk home ranges and associated probabilities of continued occupancy:

20 - 40%	low probability of occupancy
40 - 60%	medium probability of occupancy
> 60%	high probability of occupancy

Nest areas/PFAs provide the core of breeding home ranges and the integrity of these areas should be a focus for fine-filter habitat management (i.e., old-growth retention areas). Because goshawks demonstrate high fidelity to nest area/PFAs over long time periods, it makes sense to manage these areas as reserves. However, foraging areas within home ranges should be managed through a combined fine and coarse filter approach. Coarse filter management for foraging habitats should consider a more dynamic approach to habitat protection, with changing landscapes, as long as seral stage targets are achieved near nesting habitats through time.

8.5 Research and inventory gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

8.5.1 Research questions

All future research questions need to be cognisant of the potential that climate change is continually changing the environment in which the birds live, such that the relationship between habitat-prey-nesting may not remain static.

The following information gaps are identified as priorities for research:

- The relationship between nesting and foraging habitat attributes and population parameters such as productivity and survival.
- Habitat thresholds at the territory level e.g., thresholds of % foraging habitat in different landscape types that are required to maintain long-term occupancy and successful reproduction by goshawk pairs.
- Spatial configuration of nesting and foraging habitat necessary to support successful territories. Further information is needed about the spacing pattern of territories on the north and south coast of B.C.
- Winter habitat use/prey selection by goshawks. This information is necessary to create annual habitat management plans for this species.

8.5.2 Inventory gaps

- Very little goshawk inventory work has occurred throughout coastal BC. Two years of standardized inventory work occurred out of Bella Coola in 2007-2008 which resulted in the discovery of seven nest areas. Although more inventories would be ideal to examine some research questions (i.e., territory spacing patterns) above, it is impractical to complete a census of the entire BC coast for goshawk nest areas/PFAs. Therefore, domain experts recommend a move away from requiring known goshawk nest areas to create reserves and use the best methods available to identify and protect areas with high nesting and foraging habitat suitability.

8.6 References and Recommended Readings

A. Edie and Associates. 2004. *Morice Land & Resource Management Plan. Environmental risk assessment*. unpubl. rep. for Min. Sustainable Resource Management, Skeena Region, Smithers, BC.

American Ornithologists' Union (AOU). 1957. *Check-list of North American birds. 5th ed*. American Ornithologists' Union. Baltimore, MD.

American Ornithologists' Union. 1983. *Checklist of North American birds. 6th ed.* Allen Press, Lawrence, KS.

Ardron, J.A., Possingham, H.P., and Klein, C.J. (eds) 2008. *MARXAN Good Practices Handbook. External review version; 17 May, 2008*. Pacific Marine Analysis and Research Association, Vancouver, B.C. 155 pages. www.pacmara.org.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia. Occasional Paper No. 17. B.C Provincial Museum Victoria, BC.

Bloxton, T. D., Jr. 2002. *Prey abundance, space use, demography, and foraging habitat of Northern Goshawks in Western Washington.* M. Sc. Thesis, University of Washington, Seattle, WA.

Boal, C. W., Andersen, D. E. and P. L. Kennedy. 2005. *Foraging and nesting habitat of breeding male Northern Goshawks in the Laurentian Mixed Forest Province, Minnesota*. Journal of Wildlife Management 69:1516-1527.

British Columbia Conservation Data Centre. 2005. *BC* Species and Ecosystems Explorer. BC Ministry of Environment Victoria, BC. Available: http://srmapps.gov.bc.ca/apps/eswp/ (accessed [November 20, 2005]).

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper, G. W. Kaiser, and M. C. E. McNall. 1990. T*he Birds of British Columbia. Volume II: Nonpasserines*. Royal British Columbia Museum, Victoria, BC.

Cooper, J. M. and V. Stevens. 2000. *A review of the ecology, management and conservation of the Northern Goshawk in British Columbia*. Ministry Environment Lands and Parks, Victoria, BC. Wildlife Bulletin B-101.

Committee on the Status of Endangered Wildlife in Canada. 2000. *COSEWIC assessment and update status report on the Northern Goshawk Laingi subspecies Accipiter gentilis laingi in Canada.* Ottawa, ON. vi + 36 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Crocker-Bedford, D.C. 1994. *Conservation of the Queen Charlotte goshawk in Southeast Alaska*. Report to Alaska Region of the U.S. Forest Service. 40 pp.

Daw, S. K. and S. DeStefano. 2001. *Forest characteristics of northern goshawk nest stands and post-fledging areas in Oregon*. J. Wildl. Manage. 65:59-65.

Doyle, F. 2003a. *Identification of Goshawks' Biological Requirements on Haida Gwaii*. Ministry of Water, Land and Air Protection. Smithers, BC.

Doyle, F. 2003b. *Managing for Goshawks in TFL39 on Haida Gwaii/ Queen Charlotte Islands: Goshawk and Marbled Murrelet Habitat Suitability*. Weyerhauser Limited. Nanaimo, BC.

Doyle, F. I. 2005. *Breeding success of the goshawk (A. g. laingi) on Haida Gwaii/Queen Charlotte Islands 2005: is the population continuing to decline*? Unpublished report. Wildlife Dynamics Consulting, Telkwa, BC.

Doyle, F. 2006a. *Managing for Goshawks on the North Coast*. Unpublished Report. Ministry of Water, Land and Air Protection. Smithers, BC.

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

Doyle, F. I., 2006c. *Maintenance of habitat suitability for Northern Goshawks (Accipiter gentilis laingi) and Marbled Murrelets using heli-select harvesting on Haida Gwaii: 2-3 years post-harvest*. Unpublished Report. Wildlife Dynamics Consulting, Telkwa, B.C.

Doyle, F. I. and J. M. N. Smith. 1994. *Population responses of Northern Goshawks to the 10-yr cycle in numbers of Snowshoe hares*. Studies in Avian Biology 16:122-129.

Doyle, F. I. and D. McLennan, 2003. *Goshawk territory distribution, nest and foraging area requirements and a habitat assessment of predicted nest areas, both in TFL 39 and in the adjacent landscape, on the Queen Charlotte Islands/Haida Gwaii*. Unpublished report. Wildlife Dynamics Consulting, Telkwa, BC.

Drennan, J. E. and P. Beier. 2003. *Forest structure and prey abundance in winter habitat of Northern Goshawks*. Journal of Wildlife Management 67:177-185.

Environment Canada. 2005. *Draft policy on feasibility of recovery*. Environment Canada Species at Risk Recovery Program, Ottawa, ON.

Environment Canada. 2006. *Draft policy on the identification and protection of critical habitat under SARA, version 2.5*. Environment Canada Species at Risk Recovery Program, Ottawa, ON.

Ethier, T. J. 1999. *Breeding habitat of Northern Goshawks (Accipiter gentilis laingi) on Vancouver Island: a hierarchical approach*. M. Sc. Thesis, University of Victoria, BC.

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

Finn, S. P., Marzluff, J. M. and D. E. Varland. 2002. *Effects of landscape and local habitat attributes on Northern Goshawk site occupancy in western Washington*. Forest Science 48:427-436.

Flatten, C. J. and E. L. McClaren. In prep. *Size and color variation of Northern Goshawks from southeast Alaska and Vancouver Island*.

Forest and Range Practices Act. 2004. BC Ministry of Forests and Range, Victoria, BC. Available: http://www.for.gov.bc.ca/tasb/legsregs/frpa/frpa/frpatoc.htm (accessed [August 2, 2006]).

Forsman, E. D. and A. R. Giese. 1997. *Nests of Northern Spotted Owls on the Olympic Peninsula, Washington*. Wilson Bulletin 109:28-41.

Greenwald, D.N., D.C. Crocker-Bedford, L. Broberg, K.F. Suckling and T. Tibbitts. 2005. *A review of northern goshawk habitat selection in the home range and implications for forest management in the western United States*. Wildlife Society Bulletin 33(1): 120-129.

Holt, R. F. 2004. *Environmental conditions report for the Haida Gwaii/Queen Charlotte Islands Land Use Plan*. Unpublished report. Veridian Ecological Consulting Ltd., Nelson, BC.

Iverson, G. C., G. D. Hayward, K. Titus, E. DeGayner, R. E. Lowell, D. C. Crocker-Bedford, P. F. Schempf, and J. Lindell. 1996. *Conservation assessment for the Northern Goshawk in southeast Alaska*. U.S.D.A. Forest Service Publication PNW-GTR-387.

Jewett, S.A., Taylor, W. A., Shaw, W. T. and J. W. Aldrich. 1953. *Birds of Washington State*. University of Washington Press, Seattle, WA. 767 pp.

Johnson, D. R. 1989. *Body size of Northern Goshawks on coastal islands of British Columbia*. Wilson Bulletin 101:637-639.

Keane, J. J. 1999. *Ecology of the Northern Goshawk in the Sierra Nevada, California*. Ph.D. Dissertation, University of California, Davis, CA, USA.

Kennedy, P. L. 2003. *Northern Goshawk (Accipiter gentilis atricapillus): a technical conservation assessment*. USDA, Forest Service, Rocky Mountain Region, Species Conservation Project. 131 pp.

Kennedy, P.L., Ward, J. M., Rinker, G. A. and J.A. Gessamen. 1994. *Post-fledging areas in Northern Goshawk home ranges*. Studies in Avian Biology 16:75-82.

Kennedy, P. L. and J. M. Ward. 2003. *Effects of experimental food supplementation on movements of juvenile Northern Goshawk (Accipiter gentilis atricapillus)*. Oecologia 134:284-291.

Kenward, R. E. 1982. *Goshawk hunting behaviour, and range size as a function of food and habitat availability*. Journal of Animal Ecology 51:69-80.

Kenward, R. E. 2006. *The Goshawk*. T & D Poyser. London.

Krüger, O. 2002. *Interactions between Common Buzzard Buteo buteo and goshawk Accipiter gentilis: trade-offs revealed by a field experiment*. Oikos 96:441-452.

Lewis, S. B., Titus, K. and M. R. Fuller. 2006. *Northern Goshawk diet during the nesting season in Southeast Alaska*. Journal of Wildlife Management 70:1151-1160.

MacKinnon, A., D. Meidinger, and K. Klinka. 1992. *Use of the bigeoclimatic ecosystem classification system in British Columbia*. For. Chron. 68:100–120.

Mahon, T., Doyle, F.I. and Morgan, D. 2003. *Northern Goshawk (Accipiter gentilis ??) habitat in the North Coast Forest District*. Foraging area and nest area habitat suitability models. Unpublished report. Wildfor Consultants Limited, Telkwa, BC.

Mahon, T., E. McClaren, and F. Doyle. 2008. *Parameterization of the Northern Goshawk (Accipter gentilis laingi) Habitat Model for Coastal BC. Nesting and Foraging Habitat Suitability Models and Territory Analysis Model*. DRAFT. Unpublished report prepared for the Northern Goshawk *Accipiter gentilis laingi* Recovery Team and Habitat Recovery Implementation Group, Nanaimo, BC. Note: this report has not been released publicly by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team/Habitat Recovery Implementation Group.

McClaren, E. L. 2003. Northern Goshawk (*Accipiter gentilis laingi*) population inventory summary for Vancouver Island 1994-2002. Unpublished report. Ministry of Water, Land and Air Protection, Nanaimo, BC.

McClaren, E. 2004. “Queen Charlotte Goshawk” British Columbia Ministry of Water, Land and Air Protection. 2004. Accounts and Measures for Managing Identified Wildlife. Version 2004. Biodiversity Branch, Identified Wildlife Management Strategy, Victoria, B.C.

McClaren, E. L., Kennedy, P. L. and D. D. Doyle. 2005. *Northern Goshawk (Accipiter gentilis laingi) post-fledging areas on Vancouver Island, British Columbia*. Journal of Raptor Research 39:253-263.

McClaren, E. L. and C. L. Pendergast. 2003. *Relationship between forest age class distribution around Northern Goshawk nests and occupancy and nest productivity patterns at three spatial scales*. Unpublished report. Ministry of Water, Land and Air Protection, Nanaimo, BC.

McGrath, M. T., S. DeStefano, R. A. Riggs, L. L. Irwin, and G. J. Roloff. 2003. *Spatially explicit influences on Northern Goshawk nesting habitat in the interior Pacific Northwest*. Wildlife Monographs 154:1-63.

Mitchell, A., Michelfelder, V., and R. van der Marel. 2008. *Proposed wildlife habitat areas for the Northern Goshawk (Accipiter gentilis laingi) on the central coast of British Columbia.* Unpublished Report. Ministry of Environment, Hagensborg, B.C.

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

Palmer, R. S. 1988. Northern Goshawks. Pgs 355-378 in R. S. Palmer, ed. *Handbook of North American Birds. Volume 4. Diurnal Raptors*. Yale Univ. Press, New Haven, CT.

Patla, S. M. 1997. *Nesting ecology and habitat of the Northern Goshawk in undisturbed and timber harvest areas of the Targhee National Forest, Greater Yellowstone Ecosystem*. M.Sc. Thesis, Idaho State University, Boise, ID.

Penteriani, V. 2002. *Goshawk nesting habitat in Europe and North America: A review*. Ornis Fennica 79(4):149-163.

Reich, R. M., Joy, S. M., and R. T. Reynolds. 2004. *Predicting the location of Northern Goshawk nests: modeling the spatial dependency between nest locations and forest structure*. Ecological Modeling 176:109-133.

Reynolds, R. T., R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce Jr., G. Goodwind, R. Smith and E.L. Fisher. 1992. *Management recommendations for the Northern Goshawk in the southwestern United States*. USDA Forest Service, Ft. Collins, CO. Gen. Tech. Rep. RM-217.

Reynolds, R. T. and S. M. Joy. 1998. *Distribution, territory occupancy, dispersal, and demography of northern goshawks on the Kaibab Plateau, AZ*. Arizona Game and Fish. Heritage Project No. I94045

Reynolds, R. T. J. D. Weins, S. M. Joy, and S. R. Salford. 2005. *Sampling considerations for demographic and habitat studies of Northern Goshawks*. Journal of Raptor Research 39:274-285.

Roberts, Anne-Marie. 1997. *Food habits of Northern Goshawks in the Queen Charlotte Islands and in the Kispiox Forest District 1996*. Unpublished Report. Ministry of Environment, Lands and Parks. Smithers, BC.

Squires, J. R. and P. L. Kennedy. 2006. *Northern Goshawk ecology: an assessment of current knowledge and information needs for conservation and management*. Studies in Avian Biology 31:8-62.

Squires, J. R. and R. T. Reynolds. 1997. *Northern Goshawk (Accipiter gentilis).* In Birds of North America, No. 298. (A. Poole and F. Gill, eds.). Academy of Natural Sciences , Philadelphia, PA and American Ornithologists' Union, Washington, DC.

Smith, J. and G. Sutherland. 2008. *Northern Goshawk Habitat and Territory Models. Modelling Methodology and Implementation & Scenario Results for Coastal British Columbia. Final Draft*. Cortex Consultants Ltd., Victoria, BC. Unpubl. report for BC Ministry of Environment, Nanaimo, BC.

Talbot, S.L. 2006. *Genetic characteristics of goshawks in northwest North America: testing subspecies and Pleistocene refugium hypotheses*. Abstract, 4th N. Am. Ornithological Conference, Veracruz, Mexico.

Taverner, P. A. 1940. *Variation in the American Goshawk*. Condor 42:157-160.

Titus, K., Flatten, C. J., and R. E. Lowell. 1994. *Northern Goshawk ecology and habitat relationships on the Tongass National Forest (goshawk nest sites, food habits, morphology, home range and habitat data)*. Unpublished report. First Annual Progress Report USDA Forest Service, Alaska Department of Fish and Game, Juneau, AK. Contract 43-0109-3-0272.

Tornberg, R. and A. Colpaert. 2001. *Survival, ranging, habitat choice and diet of the Northern Goshawk Accipiter gentilis during winter in Northern Finland*. Ibis 143:41-50.

Ward, L.Z. D.K. Ward and T.J. Tibbits. 1992. *Canopy density at goshawk nesting territories on the North Kaibab Ranger District, Kaibab National Forest. Final report, non-game and endangered wildlife program.* Arizona Game and Fish Department, Phoenix, USA.

Whaley, W. H. and C. M. White. 1994. *Trends in geographic variation of Cooper's Hawk and Northern Goshawk in North America: a multivariate analysis*. Western Foundation of Vertebrate Zoology 5: 161- 209.

U. S. Fish and Wildlife Service. 2007. *Queen Charlotte Goshawk status review*. U. S. Fish and Wildlife Service Alaska Region, Juneau Fish and Wildlife Field Office. Juneau, Alaska. 169 pp.

9.0 Coastal Tailed Frog (*Ascaphus truei*)

Domain experts:

Pierre Friele, Cordilleran Geoscience

Volker Michelfelder, Ministry of Environment

Glenn Sutherland, Cortex Consultants

Photo: A. Brandt

9.1 Species Overview

9.1.1 Introduction

Tailed frogs are a unique and ancient line of frogs (Green et al 1980) endemic to the western Cordillera of North America. They differ from other frogs in that they are physically and behaviourally adapted to life in flowing water (i.e., lotic habitat), specifically cool, turbulent upland streams. Physical adaptations include internal fertilization (using a cloacal 'tail'), morphological adaptations to streamline their bodies and allow them to burrow into open spaces amid cobbles and boulders in the stream bed, and a sucker on the tadpoles to allow them to adhere to the stream substrate. Delayed laying of eggs until after the spring freshet is an example of a behavioural adaption. Another can be observed when adults are held temporarily in a bucket - if the bucket is tapped, the adults will retract their limbs; this is clearly a response developed to avoid having limbs pinched off by bedload movement during floods.

Taxonomy

There are two species of tailed frog in B.C.: the Coastal tailed frog (*Ascaphus truei*) and the Rocky Mountain tailed frog (*Ascaphus montanus*) (Ritland et al 2000; Neilson et al 2001). They occur in contrasting climatic regimes: maritime versus continental, and have developed slightly different physical and behavioural traits in response (Metter 1967; Karraker et al 2006).

The Rocky Mountain tailed frog occurs in two disjunct populations in southeastern B.C.; its range extends south into Idaho and Montana. This species is adapted to the continental climate and drier habitat conditions of the Interior. Most notably, it is highly sedentary within its breeding streams and on land (Daugherty and Sheldon 1982a).

The Coastal tailed frog is endemic to western British Columbia and the United States (Washington, Oregon and California). In B.C., its range is centered on the humid maritime Coast and Mountains ecoprovince. It varies in frequency of occurrence and abundance throughout Coastal Western Hemlock (CWH) forests and vertically associated biogeoclimatic zones (Mountain Hemlock (MH) and Engelmann Spruce Subalpine Fir (ESSF)) into the Coastal Mountain Heather Alpine (CMA). Its eastern range follows the western edge of the Interior Plateau, and is defined by cold stream conditions (Dupuis and Friele 2003). In the west, the Coastal tailed frog is present in all but the Hecate Lowlands. It is absent from on Vancouver Island and Haida Gwaii, but does occur on some coastal islands, such as King and Gribble. The northern extent of their range is Portland Canal, at the northern end of the coastal planning area (Dupuis and Friele 2003).

Life History

At the north end of their range in B.C. tailed frogs take up to four years to metamorphose into frogs, and a further 1-2 years to become sexually mature. It is estimated they may live up to 15+ years in total (Daugherty and Sheldon 1982b). Tailed frogs life history is both lotic and terrestrial.

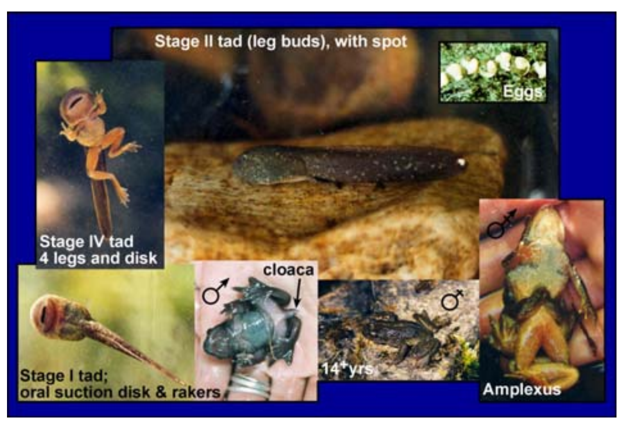
Lotic life stage:

A. truei occur in upland streams with cascade and step-pool bedforms typified by coarse, stable substrate and turbulent streamflow. These 2nd and 3rd order perennial streams represent typical breeding habitat, and are defined as “core” habitat. Although tadpoles may be found along mainstem, floodplain-forming streams, their numbers there are generally low; their presence explained by downstream drift. Since tadpoles take up to four years to metamorphose they are highly vulnerable to events that affect the physical conditions of the stream habitat, such as changes to water temperature, sedimentation levels, and the hydrologic regime (e.g., peak and low flows). Tadpole abundance is strongly correlated to substrate composition and the amount of coarse and fine organic materials in the stream. A key factor in tadpole survival is the presence of interstitial spaces in the stream bed that they can use to forage, for thermal and predatory refuge, and to escape seasonal floods. Habitat quality is greatly reduced when these interstitial spaces become clogged by sedimentation.

There are likely many predators of tailed frog tadpoles. Cutthroat trout (*Salmo clark*), brook trout (*Salvelinus fontinalis*), and Giant salamanders (*Dicamptodo* sp.) are significant predators, known to affect tailed frog tadpole feeding habits, two, three and six fold respectively (Feminella and Hawkins 1994). Fish species are predators where their habitat overlaps along the downstream end of a tailed frog population’s distribution. The Pacific Giant salamander is the only giant salamander in B.C., and it is restricted in distribution to the Chilliwack area south of Fraser River. American dippers (*Cinclus americanus*) are predators throughout the tailed frog’s range.

Terrestrial life stage:

As juveniles and adults, tailed frogs forage terrestrially when conditions are adequately cool and wet. Since they breathe through their skin they need to keep moist. For this reason their movement may be restricted during drought conditions or in open environments where there is less cover from the sun and wind. Since the Coast is wetter than the Interior, with higher ambient humidity and higher drainage density, *A. truei* may disperse more readily between upland streams than *A. montanus*. It could be argued that loss of canopy cover is less restrictive to terrestrial dispersal of coastal tailed frog (Wahbe et al 2004), but this overlooks the benefit that old growth retention has on the hydrologic and sedimentation regime of upland streams.



Tailed frog life stages Diagram: P. Friele

Definition of a Population

Friele and Dupuis (2007) define a population as all of the occurrences within a major watershed unit (<100 km^2 in area). By this definition, a population is formed of those individuals residing in several hillslope tributaries (or upland streams) that are linked by a mainstem stream with a specific catchment of less than about 100 km^2. Individuals within the population move along the riparian network and across the slope between upland streams (Wahbe et al 2004). Gene flow between populations occurs along mainstems and over low divides. Large rivers (e.g., Skeena), lakes (e.g., Chilco), and the sea form downstream barriers while alpine cirque topography forms headwater barriers.

Tailed frogs habitat can be considered at various spatial scales:

- at the landscape (macro) scale they are responsive to climate (temperature and precipitation) and geology (bedrock geology and physiography).
- at the watershed (meso) scale, the abundance of frogs is linked to topography (elevation and aspect), channel size, vegetation (forest age, presence of riparian buffers), watershed features such as basin ruggedness and configuration, stream gradient, and type and extent of development (road density, area of forest removal);
- at the reach/stand (micro) scale, factors include substrate composition, substrate embeddedness, and disturbance frequency, channel stability, and flow permanence (perennial/intermittent/ephemeral).

9.1.2 Conservation Status and Legal Designations

9.1.2.1 Conservation Status

A. truei is considered a species of special concern provincially (blue-listed; B.C. Conservation Data Centre 2008) and federally (Schedule 1 of the Species at Risk Act [SARA] Registry; Environment Canada 2009). *A. montanus* has a much smaller and more restricted range, and is considered endangered in B.C. (red-listed; B.C. Conservation Data Centre 2008) and in Canada (Schedule 1 of SARA Registry; Environment Canada 2009).

Tailed frogs are protected from being killed, collected or harmed under the provincial *Wildlife Act*. Critical (breeding) habitats of tailed frogs are protected on federal lands under the Species at Risk Act (SARA). Under the Identified Wildlife Management Strategy of the Forest Practices Code, the tailed frog is considered a species of management concern and Wildlife Habitat Areas (WHAs) can be established to protect its critical breeding habitats in provincial crown lands. The B.C. Conservation Framework identifies coastal tailed frogs as a priority 1 species under the goal of "preventing species and ecosystems from becoming at risk" (Goal 2).

9.1.2.2 Existing and proposed management designations

Coastal Orders

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

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

Wildlife Habitat Areas

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

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

9.1.3 Threats to Tailed Frogs

Coastal tailed frogs are vulnerable to land use practices that alter stream thermal and hydrologic regimes, cause increased sedimentation or more severe debris flow impacts, fill channels with slash, or cause channel drying. It is for this reason that Coastal tailed frogs remain listed as identified wildlife. Forestry and run-of-river hydro are specific land-uses that pose threats to tailed frog over wide areas of their range. The species has some resilience to change and is thought to be able to re-colonize areas following localized extirpation, but little is known about their capacity for recovery.

- Studies have demonstrated a marked difference in tadpole abundance between streams in logged and unlogged watersheds (Corn and Bury 1989; Dupuis and Friele 2003; Frid et al 2003). Riparian buffers appear to prevent direct physical damage and sedimentation of channel beds (Steventon et al 1996; Dupuis and Steventon 1999).
- Roads increase the risk of sedimentation (Beschta 1978; Reid and Dunne 1984), particularly where traffic levels are high. Logging roads are also strongly implicated in post logging landslide activity (Rollerson et al. 1998). It is well documented that fine (sand and pebble) stream substrate is negatively correlated with tailed frog abundance. Development activities that introduce fine sediment into streams damages tailed frog habitat by filling interstitial spaces between coarse substrate that act as foraging and refuge areas. Step pool streams are said to be sediment supply-limited, meaning available fine sediment (sand and pebbles) is transported rapidly through the system, leaving coarse, armoured streambed. Thus, one-time introductions of sediment probably have low impact on tailed frog; whereas, chronic sediment inputs from roads, gully sidewall failures and bank erosion, all typical logging impacts, negatively affect tailed frog. It is not possible to generalise about the longevity of such impacts. Certainly watershed restoration activities (road deactivation, bioremediation of slides) benefit tailed frog.
- *A. truei* are vulnerable to harvesting activities that remove the moderating effect of the forest canopy against sun and wind. The result can be a drier and harsher terrestrial environment for amphibians, which restricts their movement (Johnston and Frid 2002). In maritime settings, because of the humid climatic conditions, canopy removal, in itself (without considering road-related impacts), may not be as harmful to tailed frog (Wahbe et al 2004) during all but the driest part of the growing season. Canopy removal may be more of an issue on the South Coast, especially on the leeward side of the Cascade Range (Merritt Forest District) because there the drier climate becomes a limiting factor.
- The level of hydrologic green-up is a concern. Removal of a significant amount of forest cover from a watershed may affect the hydrologic regime, including the magnitude of flood peaks and low flows. Changes in peak flow could increase scour and sediment transport and decrease channel stability, while decrease in low flow could lead to stream impermanence. Both phenomena would be detrimental to tailed frog tadpoles.
- The effects of applied chemicals (e.g., fertilizers and herbicides) may be important where used, but the magnitude of effects on *A. truei* are poorly understood.

9.1.4 Tailed Frog as a Focal Species

Coastal tailed frogs were selected as a focal species because:

- They have specialized habitat requirements, being adapted to perennially flowing upland streams with stable bedforms, low sedimentation rates and cool water temperatures. Since they are highly philopatric, long-lived and have relatively stable populations, their relative abundance can be an indicator of habitat quality in upland streams (Welsh and Olivier 1998).
- Upland streams lacking fish are not protected under the *Forest and Range Practices Act* and management for other focal species will not adequately protect these headwater stream habitats. The objectives for upland streams in the Coast Orders do not provide for their

direct protection (i.e., through buffering of riparian areas), only protection of hydrologic regime via controls on clearcut equivalent area.

- Tailed frogs are the largest and most common vertebrates in most coastal headwater streams. As a dominant grazer, they are an umbrella species and protecting their habitat will serve to protect other inhabitants of upland streams. Given that upland streams are upstream segments in the stream continuum (Naimann et al 2000; Gomi et al 2002), protection of tailed frog streams will indirectly benefit fish streams downslope.
- For the purpose of old seral retention, *A. truei* has life history characteristics that are directly responsive to forestry practices. Development-related factors that affect habitat quality include proportion of watershed in hydrologic green-up; stream management (e.g., whether to cross-stream yard, fall-away, yard-away or buffer); and road related issues (e.g., road density and usage, number and quality of stream crossings); and gully management, including windthrow.
- Most research points to *A. truei* being highly associated with old forest (Bury 1983; Welsh 1990; Bury et al 1991; Aubry and Hall 1991; Welsh and Lind 1991; Dupuis and Steventon 1999; Stoddard and Hayes 2005; Kroll et al. 2008) although there are studies that show otherwise (Gilbert and Allwine 1991; Richardson and Neill 1998). This variation is typical of case studies because in a mulitivariate system different factors become significant in different settings (Dupuis and Friele 2006). For example, in a maritime setting with robust channel conditions (plutonic bedrock/moderate ruggedness), canopy removal may trigger a phytoplankton bloom and a temporary increase in *A. truei* numbers due to increased food availability (Richarson and Neill 1998). In contrast, where logging causes a decline in channel condition, then tailed frog populations suffer. This latter case is probably most common. On balance then, and especially when developing regional management priorities, it is prudent to assume tailed frogs are old growth dependent.

9.2 Habitat Quality

Co-location of old growth reserves should be directed to habitats that are likely to have the highest abundance of tailed frogs. There are fixed and variable factors contributing to the quality of tailed frog habitat.

9.2.1 Fixed habitat factors

Researchers have characterized the main fixed factors associated with occupancy and abundance of tailed frogs (Dupuis and Friele 2003; Frid et al. 2003; Dupuis and Friele 2006). Three key factors are basin area, basin ruggedness and bedrock geology. Abundance is also affected by location in the valley, with valley-mouth settings supporting streams with a warmer, stable flow regime, while backend valley settings often have a cool to cold, dynamic channel regime (high elevation, flashy floods, active colluviation).

9.2.1.1 Basin size

Basin size is a proximate variable for stream size, which is a primary determinant of tailed frog distribution and abundance. Extensive inventory in British Columbia has established a range of basin sizes that contain suitable tailed frog streams.

- Basin areas >50 km^2 are typically large floodplain-forming river channels. These are not tailed frog breeding streams, although low occurrence rates may reflect dispersal.
- Basin areas between 10-50 km^2 are typically mainstem channels linking upland streams. Again, these are not breeding reaches. On these channels there is a high probability of

occurrence resulting from active dispersal and downstream drift, but abundance may not be very high.

- Basin areas between 0.3 - 10 km^2 support perennial upland streams. These are typical breeding reaches supporting high occurrence and abundance rates.
- Basin areas <0.3 km^2 support ephemeral streams and do not provide breeding habitat. These channels may be used for dispersal.

9.2.1.2 Basin ruggedness

Ruggedness, or basin slope, is a proximate variable for disturbance regime, with increasing ruggedness correlated with increasing flashiness and sediment production. Occurrence and abundance are optimised in streams with moderate ruggedness (31 – 70%), but in areas of competent bedrock streams in steep basins (70 - 120%) also typically provide suitable habitat. In areas of week rock (certain volcanics and sedimentary rock) increasing steepness results in increased bank instability and sediment production, thereby decreasing habitat quality.

9.2.1.3 Bedrock geology

Bedrock geology controls sediment calibre and yield. Weak bedrock (certain volcanics and sedimentary rocks), characteristic of the Insular Mountains and Leeward Ranges, produce abundant fine sediment; while plutonic rock, characteristic of the spine of the Coast Mountains, yields low volumes of coarse sediment. Tailed frogs thrive in the latter. Plutonic rocks underlie the tailed frog range in the study area. Since the Coast Plutonic Complex underlies most of the study area, it is not a useful variable in this particular exercise. Also, bedrock geology mapping is regional (1/250,000 scale) and site specific detail (fracture zones, fracture density, weathered bedrock, etc) is lacking. As such, the available bedrock mapping is not a strong predictor for occurrence and abundance.

9.2.1.4 Aspect

Stream aspect can play a significant role in habitat suitability, but this varies across the Coast Mountains from windward to leeward.

- In *the leeward* part of the range, north aspects are colder and may support alpine glaciers in headwaters. Thus streams on north aspects may be cold-limiting. In these settings south aspects would be favoured.
- On the *windward* part of the range, maritime conditions moderate extremes in temperature. Thus, cold stream conditions are not a limiting factor. However, storms track in from the south, and south facing basins can receive intense precipitation, resulting in flashy runoff. North-facing basins, on the other hand, may be in a subtle rainshadow, sheltered, less flashy, and more productive.
- In the central part of the range, between these extremes, aspect may not be significant. As a result of this varied response, aspect is difficult to apply in a habitat suitability model.

9.2.1.5 Valley Position

Although not always true, it is typical that as one advances up a valley, not only does the valley floor elevation rise, but so does the elevation of the divides. At the mouth of a valley, the divides are often forested, but moving back they climb, and at the headwater there may be alpine-cirque topography. Thus, from warmer, stable creeks, the cline leads to colder water temperatures and higher disturbance rates (rockfall, snow avalanches, debris flows) as one proceeds into headwaters.

A model algorithm 'back-end rule', was used in the derivation of the Coast Information Team tailed frog distribution model. It was meant to describe increasing coldness of headwater streams using a simple ratio based on the proportion of a contributing watershed that is located above timberline. Because other variables (geology, aspect, topography and climate) affect channel condition, this variable is not considered a reliable predictor for tailed frog occurrence and abundance at a regional scale.

9.2.1.6 Range

The Coastal tailed frog is limited to the Coast Ranges as far north as Portland Canal, and does not occur in the low relief landscapes of the Hecate Lowlands or on the Interior Plateau. Some coastal islands have tailed frogs (Princess Royal, King and Gibbs) and some do not. Colonization of certain islands was likely based on chance dispersal.

9.2.2 Variable habitat factors

Localized variables include water temperature, canopy closure, substrate embeddedness, channel disturbance (Dupuis and Friele 2003) and riparian buffer width along and above breeding reaches (Stoddard and Hayes 2005). These variables are potentially affected by land management practices.

9.2.2.1 Features of aquatic habitats

Watershed-level management is very important with respect to tailed frogs. What goes on upstream affects downstream habitats (Naimann et al 2000) and the hydrologic system needs to be considered in its entirety.

The key features of good aquatic habitat quality are:

- cool-moderate (6-18^{o}C) stream temperatures,
- single thread (versus braided) channel, with cobble/boulder substrate and well developed step-pool form,
- low sediment transport rates, as indicated by low percentages of fine (sand and pebble) sediment and low cobble embeddedness,
- stable flow regime, not too flashy as would be indicated by large difference between low flow and peak flow channel width,

Tailed frog egg string Photo: P. Friele

- low frequency (less than 1 in 5 years) of debris flows.
- water chemistry may have an effect but is not well researched.

9.2.2.2 Features of riparian habitats

Features of good riparian habitat quality are:

- late to old seral vegetation to provide a humid microclimate and mesic to humic soil moisture regime in riparian habitat, and
- forested ecosystems forming networks connecting upland streams together, with mainstems and over passable divides.

Tailed frog habitat Photo: P. Friele

The quality of *A. truei* habitat can be maintained, to a large extent, by good riparian management (Dupuis and Steventon 1999). Retaining adequate forested buffers prevents yarding damage to the stream, such as slash loading, bank gouging, bank failure and associated channel disturbance. The size of the forested buffer depends on the landform, though, based on work on the coast of Oregon, Stoddard and Hayes (2005) suggest that juvenile and adult densities are positively correlated with riparian buffers of at least 50m in width along, and above, breeding reaches. Creeks with unstable side walls and loose material will need a wider buffer to prevent blowdown and associated impacts to streams. The side walls of deep gullies are potentially-unstable to unstable and are often excluded from cutblocks.

Localized seepages are available wet spots that act as refuges in times of dryness. These should be identified in old forest networks, especially if they coincide with a drainage divide. This feature is most critical in drier climates.

9.3 Habitat Distribution, Spatial Configuration and Connectivity

9.3.1 Habitat distribution

Because *A. truei* is widespread, co-location should be distributed across landscape units within the known range of the animal as shown on maps provided in Dupuis and Friele (2003), Frid et al (2003) and Friele and Dupuis (2007). Dispersed reserves harbouring tailed frog streams will provide a network of tailed frog refuges within the managed landscape. These will act as founding populations for *A. truei* to re-populate habitats impacted through natural or human disturbance.

9.3.2 Spatial configuration

A multi-scaled approach is needed for *A. truei:*

Within populations:

On the Coast there are three wildlife habitat area (WHA) models that have been implemented to protect tailed frog streams: 1) buffering of short (less than 500m long) stream segments along known occurrences; 2) buffering entire lengths of upland stream and invoking management measures in the contributing watershed; and 3) protecting the entire contributing watershed of a selected upland stream. The first is not satisfactory, while the latter may be too conservative. The second model is preferred. This approach relies on good communication between the ministry responsible for environmental stewardship and the proponent conducting logging.

A basic assumption is that a disproportional amount of ecological benefit (say 80%) is gained through provision of adequate streamside buffers, and that the remaining ecological benefit (20%) is gained through watershed level measures. An adequate riparian buffer is large enough to moderate stream temperature and riparian microclimate conditions, and be resilient to extensive windthrow.

When designing reserves for *A. truei,* it is also good to consider a channel's long-profile. An irregular long-profile is better than a simple concave profile as benches will act as deposition zones, preventing disturbances from propagating the full length of the channel system.

Protecting entire watersheds provides a higher level of conservation for specific *A. truei* populations. These basins need to be strategically selected for their habitat value as well as their links to other high value basins (see below).

9.3.3 Connectivity

It is important to provide within-basin dispersal as well as to provide opportunities for migration between watersheds.

- Within-basin dispersal is critical because *A. truei* needs to be able to move from one part of a stream network to another. Dispersal occurs upstream (frogs) and downstream (tadpoles), and within moist landscapes frogs disperse across the hillslope between streams (Wahbe et al 2004). Good hydroriparian management is a good start for creating connectivity along riparian areas. In addition, moist microsites that are at a distance from streams can be protected to facilitate dispersal across the hillslope.
- Dispersal over drainage divides provides linkages between populations. These are passes linking ephemeral headwater streams that the frogs can navigate through. It is thought that retaining old growth reserves in suitable passes will enhance dispersal between populations. Passes with cliffs, neve or glaciers will act as barriers. Suitable passes could be identified manually, or by GIS query.
- At lower elevations, connectivity is addressed through hydroriparian objectives and management of salmon habitat.

9.4 Habitat Quantity

Precautionary objective: To capture the full range of habitat variability across each landscape unit

The factors associated with good habitat quality for *A. truei* are well-understood, but less is known about habitat quantity and thresholds of change. We are more likely in a situation of being precautionary, and setting up trials for data-gathering as opposed to applying prescriptive management solutions.

A. truei is a widely distributed species. It occurs in more places than is shown by the existing inventories but it is hard to determine the actual extent of its range without further inventory. Population trends are unknown, as no monitoring has been done. Precautionary management is recommended.

Wahbe et al (2004) recommend preserving groups of interconnected streams to improve conservation success. This approach has been advocated in WHA design (Dupuis and Friele 2003; Michelfelder and Dunsworth 2007). At a wider scale, several suitable basins per landscape unit might provide adequate distribution of conservation areas. This would be the minimum, although somewhat arbitrary, number required to ensure regional persistence.

For the coastal planning area, the focus should be on capturing the full range of habitat variability across landscape units. This would need to be done based on ‘expert judgment’ rather than modelling.

9.5 Research and inventory gaps

The information in this section is to guide priorities for future adaptive management projects as well as other research and inventory projects.

9.5.1 Research questions

- Habitat association studies (Dupuis and Friele 2003; Frid et al 2003) show significant drop in occurrence rates (20 - 60%) in logged versus unlogged streams, and in remaining occupied streams, a significant drop (40%) in abundance. Major unknowns are:
  - How quickly do subpopulations with reduced abundance bounce back?
  - How quickly are local extirpations re-colonised?
  - How does local extirpation affect population viability and meta-population dynamics?
  - What are minimum landscape level thresholds for population collapse?
- What is the optimal spatial configuration of conservation areas for *A. truei* e.g., ribbons vs. basins.
- Is changing climate additively increasing the risk of loss of subpopulations in managed watersheds?
- *A. truei* do not extend into lowland environments such as the Hecate Lowland. There is a need to better define the limiting conditions in lowland streams (water chemistry, flashiness, seasonality). For example, the tannic waters in lowland coastal streams may be more acid.

9.5.2 Inventory gaps

There are numerous gaps in the existing inventory. Although extensive (i.e., wide ranging) sampling has been conducted throughout the coast, the density of samples is low. Continued inventory and monitoring is required to adequately assess population trends.

Rather than routine reconnaissance surveys of tailed frog presence, undertake intensive surveys that are designed to inform responses to land uses (e.g., how timber harvesting impacts the ability of tailed frogs to move across the landscape; how tailed frogs respond to microclimate changes as a result of forest cover removal) and climate change. Examples include:

- stratified random sampling of geomorphically different landscapes.
- paired basin studies of cohort-specific survival rates under different conditions of temperature and channel stability.

A priority project is a radio-telemetry study of movement and/or inter- and intra-population genetics.

More inventory and demographics work is needed with regard to presence and distribution on coastal islands and eastern range limits.

Inventory of temperature sensitive streams. There are different types of temperature-sensitive stream: streams that might become too warm with land use or climate change; those that are too cold but might become suitable; and those that are too cold.

9.6 References and Recommended Readings

Aubry, K.B. and PA. Hall. 1991. *Terrestrial amphibian communities in the southern Washington Cascade Range*. In: Ruggiero, Leonard; Aubry, Keith; Carey, Andrew; Huff, Mark; tech cords. Wildlife and Vegetation in Unmanaged Douglas-fir Forests. USFS Pacific Northwest Research Station (Oregon) general technical report PNW-GTR-285: 326-338.

Beschta, M. 1978. *Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range*. Water Resources Research 14(6):1011-1016.

B.C. Conservation Data Centre. 2008. B.C. Species and Ecosystems Explorer. Min. of Enviro. Victoria, B.C.. Available: http://a100.gov.bc.ca/pub/eswp/ (accessed [February 2, 2009].

Bury, R.B. 1983, *Differences in amphibian populations in logged and oldgrowth redwood forest*. Northwest Science 57: 167-178

Corn, P.S. and R.B. Bury. 1989. *Logging in western Oregon: responses of headwater habitats and stream amphibians*. Forest Ecology and Management 29: 39-57.

Daugherty, C.H. and A.L. Sheldon. 1982a. *Age-specific movement patterns of the tailed frog Ascaphus truei*. Herpetologica 38: 468-474.

Daugherty, C.H. and A.L. Sheldon. 1982b. *Age-determination, growth, and life history of a Montana population of the tailed frog (Ascaphus truei).* Herpetologica 38:461–468.

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

Dupuis, L.A. and P. Friele. 2006. *The distribution of the Rocky Mountain tailed frog (Ascaphus montanus) in relation to the fluvial system: implications for management and conservation*. Ecological Research 21: 489 – 502.

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

Environment Canada. 2009. Species At Risk Public Registry. http://www.sararegistry.gc.ca [accessed February 2, 2009].

Feminella, J.W. and C.P. Hawkins. 1994. *Tailed frog tadpoles differentially alter their feeding behavior in response to non-visual cues from four predators*. J. N. AM. Benthol. Soc. 13(2): 310-320.

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

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. Xxx B.C.

Kroll, A.J., Risenhoover, K., McBride T., Beach, E., Kernohan, B., Light J. and J. Bach. 2008. *Factors influencing stream occupancy and detection probability parameters of stream-associated amphibians in commercial forests of Oregon and Washington, USA***.** Forest Ecology and Management 255(11): 3726-3735.

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

Maxcy, K. 2004. *Indicators and Methods for Effectiveness Monitoring of Tailed Frog Wildlife Habitat Areas*. Ministry of Water, Land and Air Protection, Victoria, B.C.

Metter, D.E.. 1967. *Variation in the ribbed frog Ascaphus truei Stejneger*. Copeia 1967:634–649.

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.

Nielson, M., K. Lohman and J. Sullivan. 2001. *Phylogeography of the tailed frog (Ascaphus truei): implications for the biogeography of the Pacific Research Northwest*. Evolution 55:147–160.

Ritland, K., L.A. Dupuis, F.L. Bunnell, W.L.Y. Hung, and J.E. Carlson. 2000. *Phylogeography of the tailed frog (Ascaphus truei) in British Columbia*. Canadian Journal of Zoology 78:1749–1758.

Rollerson, T.P., B. Thomson, and T. Millard. 1998. *Post-logging terrain stability in Clayoquot Soud and Barkley Sound.* In Proceedings of the 12th Annual Vancouver Geotechnical Society Symposium on Site Characterization, 28 – 29 May 1998, Vancouver B.C. Bitech Publishers. Vancouver, B.C.

Steventon, D., L.A Dupuis, and P. Friele. 1996. *Riparian Management and the Tailed Frog in Northern Coastal Forests.* Ministry of Forests Extension Note #15. Forest Sciences, Prince Rupert Forest Region. Smithers, B.C.

Stoddard, M. and M. Hayes. 2005. The influence of forest management on headwater stream amphibians at multiple spatial scales. Ecological Applications 15(3): 811-823.

Sutherland, G., M.P. Hayes, T. Quinn, L.A. Dupuis, T.R. Wahbe, D.E. Runde, and J.S. Richardson. 2001. *Predictive Habitat Models for the Occurrence and Abundance of Olympic Tailed Frog Ascaphus truei Stejneger 1899 and the Rocky Mountain Tailed Frog, Ascaphus Mmontanus (Mittleman and Myers) 1949: A Pilot Meta-Analysis*. Washington State Department of Natural Resource. Olympia, Washington.

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

Welsh, H.H. Jr. 1990. *Relictual Amhibians and Old-Growth Forests*. Cons. Biol. 4(3): 309-312.

Welsh, H.H., Jr. and A.J. Lind. 1991. *The structure of the herpetofaunal assemblage of the Douglas-fir forests of Northwestern California and Southwestern Oregon*. In: Carey AB, Ruggiero LF, editors. Wildlife-habitat relationships: sampling procedures for Pacific Northwest vertebrates. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. General Technical Report 275. p 394–413.

Welsh, H.H., Jr. and L.M. Ollivier. 1998. *Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods*. Ecological Applications 8:1118–1132.

Yao, A. 2007. *Routine Evaluation (2007) of Coastal Tailed Frog Wildlife Habitat Areas of the Skeena Region, B.C.* Ministry of Forests and Range, Smithers, B.C.

Appendix 1. List of Peer Reviewers

The following people reviewed chapters for each focal species and provided peer review comments. These comments and responses will be summarized in a separate document.

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

Appendix 2. Description of UB.C. Marine Foraging Study

Project Title: Do Marine Considerations Influence Marbled Murrelet Terrestrial Reserve Selection?

Stephanie Hazlitt and Peter Arcese
Centre of Applied Conservation Research, Forest Sciences, University of British Columbia

---

Project Background

Marbled murrelets (*Brachyramphus marmoratus*) are small seabirds that live along the northern Pacific Coast of North America. Marbled murrelets spend approximately 90% of their time in marine waters; however murrelets come onto land during the spring and summer breeding season, where they typically nest on mossy covered branches of old-growth trees. The Canadian population of marbled murrelets was assessed as Threatened in 1990 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), based on declines in nesting coastal old growth forest habitat, resulting in there listed status under the federal *Species at Risk Act* (threatened, schedule 1, 2003). In addition to declines in terrestrial nesting habitat, recent studies suggest that the quality of near-shore marine habitat, particularly the availability of forage fish, can affect the breeding success of marbled murrelets and is likely an important factor for regulating marbled murrelet populations and for population recovery (e.g. Norris et al., 2007, Becker et al., 2007, Peery et al., 2004).

The Province of British Columbia is currently planning and implementing terrestrial habitat protection and management measures for marbled murrelets along the BC coast, using tools and provisions such as old-growth reserve areas through ecosystem-based management (EBM) planning and the Identified Wildlife Management Strategy under the *Forest and Range Practices Act*. While recent research suggests that the proximity of old growth nest sites to productive marine areas may affect the potential quality of old growth nesting habitat (see above paragraph), empirical data for marbled murrelet marine foraging use or marine 'hot spots' are often lacking. As a result, conservation initiatives for marbled murrelets have often focused solely on the selection of high quality terrestrial habitat. However, numerous recent research projects have demonstrated some common predictors of marbled murrelet near-shore foraging habitat (e.g. Yen et al., 2004, Burger et al., 2008, Ronconi, 2008, Barrett, 2008, Kuletz, 2005, Miller et al., 2002), which could be used to explore the likely impact of considering marine foraging habitats on optimal terrestrial reserve design for marbled murrelets.

Project Objectives

The goal of this project is to provide a decision support framework that includes marine habitat considerations when identifying marbled murrelet terrestrial reserves in BC. The project objectives are to:

(i) Demonstrate 'best' solutions for the spatial design of marbled murrelet nesting habitat reserves with and without the inclusion of marine foraging habitat information, and contrast and compare with the reserves;

(ii) Examine the impacts of varying levels of marbled murrelet marine foraging data quality and complexity on marbled murrelet terrestrial reserve design;

(iii) Understand the trade-offs of including marine foraging considerations and data quality/quantity when determining the 'best' terrestrial reserve design for marbled murrelets.

Project Methods

This project is a collaborative effort between the EBM working group and the Centre of Applied Conservation Research, UBC. This project will support the EI02c Focal Species and DS04 Co-location projects, which are informing the development of a decision support tool to strategically design old growth reserves in a manner that optimizes retention of habitat supply (e.g. old growth habitat, habitats for multiple focal species) while minimizing impact to timber supply. Marbled murrelet is one of the seven focal species identified for old growth planning and assessment by the EBM working group. In addition to terrestrial habitat targets for marbled murrelet, EI02c domain experts have recommended the inclusion of shoreline marine regions (foraging areas) in the planning exercise. This project will facilitate the collating of the necessary marine data and explore the consequences to marbled murrelet terrestrial habitat targets when adding key marine areas into the optimization process.

The project will focus on the south central coast region of BC and will utilize existing data and information (e.g. primary literature, Marbled Murrelet Recovery Team habitat algorithm) to design an optimal terrestrial habitat reserve for marbled murrelets; to develop multiple marbled murrelet marine foraging maps (e.g. hypotheses); and to include marine foraging hypotheses in subsequent terrestrial reserve analyses. The resulting proposed solutions will be analyzed using spatial statistics for synergies (e.g. overlap), key differences and any trade-offs when including marine considerations. Reserve design solutions will be derived using the optimization algorithm MARXAN v1.8.2 (Ball and Possingham, 2000, Possingham et al., 2000), using standard systematic conservation planning methods.

Literature Cited in Appendix 1

BALL, I. & POSSINGHAM, H. (2000) MARXAN (V1.8.2): *Marine Reserve Design Using Spatially Explicit Annealing, a Manual*. Australia, The University of Queensland and The Australian Government Antarctic Division.

BARRETT, J. (2008) T*he influence of oceanographic and terrestrial attributes on marbled murrelet (Brachyramphus marmoratus) marine habitat selection during the breeding season*. MREM Research Project, Simon Fraser University, Canada.

BECKER, B. H., PEERY, M. Z. & BEISSINGER, S. R. (2007) *Ocean climate and prey availability affect the trophic level and reproductive success of the marbled murrelet, an endangered seabird*. Marine Ecology-Progress Series 329**,** 267-279.

BURGER, A. E., HITCHCOCK, C. L., STEWART, E. A. & DAVOREN, G. K. (2008) *Co-existence and spatial distributions of marbled murrelets (Brachyramphus marmoratus) and other Alcids off Southwest Vancouver Island, British Columbia*. Auk 125**,** 192-204.

CARWARDINE, J., ROCHESTER, W. A., RICHARDSON, K. S., WILLIAMS, K. J., PRESSEY, R. L. & POSSINGHAM, H. P. (2007) *Conservation planning with irreplaceability: does the method matter?* Biodiversity and Conservation 16**,** 245-258.

CHAN, K. M. A., SHAW, M. R., CAMERON, D. R., UNDERWOOD, E. C. & DAILY, G. C. (2006) *Conservation planning for ecosystem services.* Plos Biology 4**,** 2138-2152.

GRAND, J., CUMMINGS, M. P., REBELO, T. G., RICKETTS, T. H. & NEEL, M. C. (2007) *Biased data reduce efficiency and effectiveness of conservation reserve networks*. Ecology Letters 10**,** 364-374.

KULETZ, K. J. (2005) *Foraging behavior and productivity of a non-colonial seabird, the marbled murrelet (Brachyramphus marmoratus), relative to prey and habitat*. PhD Thesis, University of Victoria, Canada.

MILLER, S. L., MEYER, C. B. & RALPH, C. J. (2002) *Land and seascape patterns associated with marbled murrelet abundance offshore*. Waterbirds 25**,** 100-108.

NORRIS, D. R., ARCESE, P., PREIKSHOT, D., BERTRAM, D. F. & KYSER, T. K. (2007) *Diet reconstruction and historic population dynamics in a threatened seabird*. Journal of Applied Ecology 44**,** 875-884.

PEERY, M. Z., BEISSINGER, S. R., NEWMAN, S. H., BURKETT, E. B. & WILLIAMS, T. D. (2004) *Applying the declining population paradigm: Diagnosing causes of poor reproduction in the marbled murrelet*. Conservation Biology 18**,** 1088-1098.

POSSINGHAM, H., BALL, I. & ANDELMAN, S. (2000) *Mathematical methods for identifying representative reserve networks.* In Furson, S. and Burgman, M. (Eds.) Quantitative methods for conservation biology. Springer-Verlag, New York.

RONCONI, R. A. (2008) P*atterns and processes of marine habitat selection: foraging ecology, competition and coexistence among coastal seabirds.* PhD Thesis, University of Victoria, Canada.

YEN, P. P. W., HUETTMANN, F. & COOKE, F. (2004) *A large-scale model for the at-sea distribution and abundance of Marbled Murrelets (Brachyramphus marmoratus) during the breeding season in coastal British Columbia, Canada*. Ecological Modelling 171**,** 395-413.