Species at Risk Act
Recovery Strategy Series
Adopted under Section 44 of SARA

Recovery Strategy for the Northern Goshawk *laingi* subspecies (*Accipiter gentilis laingi*) in Canada

Northern Goshawk *laingi* subspecies

2018

Government of Canada
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For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

Cover illustration: Ross Vennesland (adult female Northern Goshawk, *Accipiter gentilis laingi*, on Vancouver Island, British Columbia).

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[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

RECOVERY STRATEGY FOR THE NORTHERN GOSHAWK *LAINGI* SUBSPECIES (*Accipiter gentilis laingi*) IN CANADA

2018

Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial government signatories agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of British Columbia has given permission to the Government of Canada to adopt the *Recovery Strategy for the Northern Goshawk, laingi subspecies (Accipiter gentilis laingi) in British Columbia* (Part 2) under Section 44 of the *Species at Risk Act* (SARA). Parks Canada Agency has included a federal addition (Part 1) which completes the SARA requirements for this recovery strategy.

The federal recovery strategy for the Northern Goshawk, *laingi* subspecies in Canada consists of two parts:

Part 1 – Federal Addition to the *Recovery Strategy for the Northern Goshawk laingi subspecies (Accipiter gentilis laingi) in British Columbia*, prepared by the Parks Canada Agency.

Part 2 – *Recovery Strategy for the Northern Goshawk, laingi subspecies (Accipiter gentilis laingi) in British Columbia,* prepared by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team for the British Columbia Ministry of Environment

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Part 1 – Federal Addition to the *Recovery Strategy for the Northern Goshawk laingi subspecies (Accipiter gentilis laingi) in British Columbia*, prepared by the Parks Canada Agency

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the recovery of the Northern Goshawk, *laingi* subspecies and has prepared the federal component of this recovery strategy (Part 1), as per Section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia, First Nations, environmental non-governmental organizations, academic experts, and other stakeholders including representatives of industrial and small-scale forestry operators, as per Section 39(1) of SARA. SARA Section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (Sub-sections 41(1) or (2)). The Province of British Columbia provided the attached *Recovery Strategy for the Northern Goshawk, laingi subspecies (Accipiter gentilis laingi) in British Columbia* (Part 2) as science advice to the jurisdictions responsible for managing the species in British Columbia. It was prepared in cooperation with Environment and Climate Change Canada.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment and Climate Change Canada, the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Northern Goshawk *laingi* subspecies and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and the Parks Canada Agency and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=En&n=6B319869-1%20

In the case of critical habitat identified for terrestrial species, SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

This federal addition to the Province of British Columbia's Recovery Strategy for the Northern Goshawk, *laingi* subspecies (*A. gentilis laingi*) in British Columbia was produced by the Parks Canada Agency, with input from the Northern Goshawk *Accipiter gentilis laingi* Recovery Team and Habitat Recovery Implementation Group (RIG). In particular, Parks Canada would like to acknowledge the crucial science support provided for the critical habitat identification by the following members of the recovery team and/or Habitat RIG: John Deal, David Donald, Frank Doyle, Todd Mahon, Erica McClaren, Louise Waterhouse and Berry Wijdeven. Input was also received from Vanessa Craig, Manon Dubé, Wendy Dunford, Megan Harrison, Paul Johanson, Dave Lindsay, Ian Parnell, Kella Sadler, Warren Warttig and Steven Wilson. Several forestry organizations provided technical input during consultations, including but not limited to British Columbia Timber Sales, Coast Forest Products Association, Interfor, Island Timberlands, TimberWest and Western Forest Products. Critical habitat mapping for breeding areas was conducted by Todd Mahon, Todd Manning, Peter Berst and Paul Chytyck. Appendix A was compiled by Todd Mahon. This federal recovery strategy would not be possible without the many years of effort that the Northern Goshawk *Accipiter gentilis laingi* Recovery Team and Habitat Recovery Implementation Group spent developing the provincial recovery strategy (NGRT 2008; Part 2) that forms the backbone to this federal addition.

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Bird Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

Additions and Modifications to the Adopted Document

The following sections have been included to address specific requirements of the federal *Species at Risk Act* (SARA) that are not addressed in the *Recovery Strategy for the Northern Goshawk, laingi subspecies (Accipiter gentilis laingi) in British Columbia* (NGRT 2008; Part 2 of this document, referred to henceforth as "the provincial recovery strategy") and/or to provide updated or additional information.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery strategy referring to protection of survival/recovery habitat may not directly correspond to federal requirements. Recovery measures dealing with the protection of habitat are adopted; however, whether these measures will result in protection of critical habitat under SARA will be assessed following publication of this final federal recovery strategy.

1. COSEWIC* Species Assessment Information

This updated COSEWIC species assessment (COSEWIC 2013) replaces the COSEWIC species assessment information provided in the provincial recovery strategy.

Assessment Summary – May 2013

Common Name
Northern Goshawk

Scientific Name
Accipiter gentilis laingi

Status:
Threatened

Reason for Designation
Over half of the global range of this subspecies occurs in coastal British Columbia, where it favours mature coniferous forest. This non-migratory bird needs a relatively large home range that contains a good food supply. Despite some recent habitat protection efforts, continuing habitat loss is predicted, in part because of anticipated short rotation times in forest harvest. On Haida Gwaii, populations are very low and face an added risk from declines of prey species due to forest understory losses associated with high levels of browsing from an introduced population of deer.

Occurrence
British Columbia

Status History
Designated Special Concern in April 1995. Status re-examined and designated Threatened in November 2000 and May 2013.

*COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Population and Distribution Objectives

This section replaces the recovery goal section in the provincial recovery strategy.

The provincial recovery strategy defined four conservation regions for the *laingi* subspecies in coastal British Columbia (NGRT 2008): 1) Haida Gwaii, 2) North Coast, 3) Vancouver Island and 4) South Coast. This federal recovery strategy adopts these regions, but as in COSEWIC (2013) and MoFLNRORD (2018) also includes what NGRT (2008) defined as a transition zone between ranges of the *laingi* and *atricapilus* subspecies. This part of the coast is included as a precautionary measure until better information is available on range boundaries because much of this zone has similar forest structure, forest composition and prey assemblages as other parts of the *laingi* range (MoFLNRORD 2018).

In the provincial recovery strategy, the recovery goal was: "*to ensure viable populations ... persist in each conservation region in coastal British Columbia*". The term 'viable' was not defined in the provincial recovery strategy either quantitatively or qualitatively, and as such this goal was difficult to translate into an amount of critical habitat required to support the survival or recovery of the species.

This federal recovery strategy includes quantitative population and distribution objectives for both survival over the short term (defined as 3 generations, or 15 years, COSEWIC 2013), and recovery over the long term (defined as 15 to 65 years). The short term objectives provide a benchmark towards meeting the long term objective. A step wise approach is being used because of the complexity of managing habitat on the coast of British Columbia, due largely to the limited availability of suitable habitat for both breeding and foraging, the slow rate of recruitment of suitable habitat (forests begin to become suitable at a minimum of 65 years; Mahon *et al.* 2015) and a general lack of robust science linked directly to population indices (see Section 4).

In general, the Northern Goshawk will be considered recovered when the main threats (habitat loss and over-browsing by introduced species on Haida Gwaii that has resulted in reduced prey availability; NGRT 2008) have been addressed, when the Canadian portion of the population has achieved a degree of resilience, when suitable habitat for multiple sub-populations is available and protected (representation), and when sufficient suitable habitat is available to allow for perpetuation of the Northern Goshawk population without relying on direct and ongoing intervention (Government of Canada 2016).

Note that Northern Goshawk was assessed as Threatened in part because of a threat of habitat loss that is in part due to relatively short rotation times currently used by the forest harvest industry (COSEWIC 2013). This threat can be addressed by extending rotation times or alternatively by protecting an adequate amount of habitat to meet the population and distribution objectives.

Resilience refers to the ability of a population to recover from a perturbation. Resilience is influenced by population size, level of genetic diversity, as well as

characteristics of the species and its habitat. In order for a species to be resilient the abundance would have to be large enough to have a high probability of persistence. Probability of persistence can be estimated using a population viability analysis (PVA).

There are only a few published reports that have attempted to estimate the viability of Northern Goshawk populations but many were not able to reach a conclusion because of a lack of data or because of high variability in the limited data that were available (Maguire and Call 1993, Broberg 1997, Ingraldi 2001). However, Steventon (2012a, 2012b) successfully conducted a PVA for the *laingi* subspecies on the coast of British Columbia with input and peer review from members of the Province of British Columbia's Northern Goshawk *Accipiter gentilis laingi* Recovery Team. The PVA had a significant degree of uncertainty due to sparse data on population metrics, and did not consider gene flow to the range of the *laingi* subspecies outside of Canada (primarily Alaska), but nonetheless provides a quantitative information source for setting recovery targets.

Steventon (2012a, 2012b) suggested that 346 home ranges[4] would be required in British Columbia for a 90% probability of persistence over 100 years. As one of five primary criteria for assessing the risk of extinction or extirpation of species, COSEWIC assesses species as Threatened if they have a 90% probability of persistence over 100 years or less. This threshold (90% over 100 years) essentially reflects the threshold for what would be required to remove the *laingi* subspecies from its assessment as Threatened. This would satisfy the resilience component for the *survival* of the listed species.

To ensure survival of Northern Goshawk over the short term, a target of 346 home ranges throughout the Canadian range has been chosen for this Threatened species. Distributing this target among the four conservation regions in Canada based on their relative proportions of the Canadian population (as per COSEWIC 2013), sufficient habitat would need to be maintained for 15 home ranges on Haida Gwaii (4.5%), 111 home ranges on the North Coast (31.9%), 125 home ranges on Vancouver Island (36%), and 95 home ranges on the South Coast (27.5%). However, given the isolation of Haida Gwaii and limited exchange of genes with the rest of the Canadian population (Talbot *et al.* 2011, Sonsthagen *et al.* 2012), 15 home ranges is likely too small to prevent inbreeding. Conservation biology theory suggests a minimum of 50 breeding individuals is required to reduce the risk of extinction due to the negative effects of inbreeding depression on demography (Franklin 1980, Soulé 1980, Jamieson and Allendorf 2012). Given an estimated home range occupancy rate of 43% (COSEWIC 2013) and an estimated 1/3 of the population being mature adults not occupying a home range (COSEWIC 2013), 38 home ranges would be required to support 50 breeding adults on Haida Gwaii.

[4] Northern Goshawks are distributed in adult pairs that occupy a home range (sometimes referred to as a territory; COSEWIC 2013). The number of home ranges (rather than the number of birds) is used for the purposes of setting population and distribution objectives.

Therefore, the population and distribution objectives for the Northern Goshawk *laingi* subspecies in Canada over the short term (defined as three generations, or 15 years, COSEWIC 2013) are to:

1. Maintain sufficient suitable habitat to support at least 369 Northern Goshawk *laingi* subspecies home ranges in Canada, and
2. Ensure that sufficient suitable habitat is available amongst the four conservation regions of the Northern Goshawk *laingi* subspecies in Canada to support home ranges as follows: Haida Gwaii – 38 home ranges, North Coast – 111 home ranges, Vancouver Island – 125 home ranges, and South Coast – 95 home ranges.

Recovery of a species is considered by Government of Canada (2016) as a range of options over a continuum from the minimum feasible recovery threshold (defined as a level that exceeds survival, approximates historical representation, improves condition over what was first assessed and does not rely on continued intervention) to the maximum feasible recovery threshold (defined as full recovery; typically the historical condition minus habitat that has been irreversibly changed).

Population sizes were not quantified in early species assessments (*e.g.*, COSEWIC 2000), but in COSEWIC (2013) it was estimated that there was sufficient habitat in the Canadian range to support 723 home ranges (circa 2005 to 2012; Mahon *et al*. 2015). The minimum feasible recovery threshold is therefore considered to be 724 home ranges distributed across all four conservation regions as per the historic capability of each region. This level will exceed that required for short term survival and should provide for resilience, representation and perpetuation without intervention.

Steventon (2012a, 2012b) used data from Smith and Sutherland (2008) and, by simulating what current forests may have looked like historically, estimated that prior to industrial scale forestry there was sufficient habitat for between 740 and 1219 home ranges in Canada (median = 980). As per COSEWIC (2013), approximately 3% of the Northern Goshawk *laingi* subspecies Canadian range has been permanently lost to urban and agricultural development since European settlement. The maximum feasible recovery threshold is therefore estimated to be 951 home ranges.

The population and distribution objective for recovery of the Northern Goshawk in Canada over the long term (15 to 65 years) is thus to:

> Maintain sufficient habitat to support between 724 and 951 Northern Goshawk *laingi* subspecies home ranges in Canada, distributed across all four conservation regions as per the historic habitat capability of each region.

Achievement of the long term objective within 65 years was considered appropriate because newly harvested stands on the southern coast of British Columbia (where forest harvesting has been most extensive) will begin to become suitable for Northern Goshawk nesting at about 65 years (Mahon *et al*. 2015). The historic habitat capability

of each region was estimated by Smith and Sutherland (2008), but requires revision based on updated conservation region boundaries (Table 1).

3. Broad Strategies and General Approaches Recommended to Meet the Population and Distribution Objectives

The majority of the approaches recommended to meet the population and distribution objectives are contained in the recovery planning table of the provincial recovery strategy (Part 2; Table 3. Broad strategies that will be used to address threats and to achieve recovery of habitat and populations for *A. gentilis laingi*). Additional recommended approaches are included here (see Table 1) to meet the federal population and distribution objectives and to lay the groundwork for future recovery planning.

Table 1. Additional Recommended Approaches.

Approach / Strategy	Description of Management and Research Approaches	Outcome / Deliverables	Priority
Discover or manage habitat for additional home ranges to meet population and distribution objectives.	• Option 1 – Discover additional home ranges through the use of surveys for home ranges. • Option 2 – Manage suitable habitat at a landscape level to ensure long term viability of a sufficient number of home ranges.	A sufficient number of home ranges are discovered or managed to meet population and distribution objectives.	Urgent
Develop approaches to mitigate human induced mortality.	• Human induced mortality is a significant issue in at least one region (where landowners are protecting chickens; B. Wijdeven, pers. comm.). • Assist landowners to implement non-lethal measures, where appropriate.	Reduced human induced mortality.	Urgent
Genetic analysis.	• Conduct additional genetic analyses to confirm the range of the *laingi* subspecies.	Revised range boundaries for *laingi* subspecies.	Necessary

Approach / Strategy	Description of Management and Research Approaches	Outcome / Deliverables	Priority
Refine population and distribution objectives.	• The population and distribution objectives require adjustment due to the inclusion of the transition zone in the federal recovery strategy. • The historic capability of each region needs to be determined for the long term objective.	Revised population and distribution objectives that account for inclusion of the transition zone and clarify how many home ranges are required in each region.	Necessary
Refine Steventon (2012 a,b) Population Viability Analysis (PVA).	• Additional work is required to refine the PVA and reduce its level of uncertainty, as well as include the effects of gene flow to areas outside of Canada.	Refinements to both short and long term population and distribution objectives.	Beneficial

4. Critical Habitat

This section replaces the Critical Habitat section in the provincial recovery strategy.

4.1 Identification of Critical Habitat

The *Species at Risk Act* defines critical habitat as "… the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or action plan for the species."

Critical habitat in this recovery strategy is identified for 91 Northern Goshawk breeding home ranges across the four conservation regions: 18 in the Haida Gwaii Conservation Region, 19 in the North Coast Conservation Region, 33 in the Vancouver Island Conservation Region and 21 in the South Coast Conservation Region (Appendix B).

Critical habitat is identified based on Northern Goshawk data available to the Government of Canada from the British Columbia Conservation Data Centre (CDC). Although COSEWIC (2013) provided modelling estimates that suggested the current Canadian population was between 682 and 764 home ranges (mean = 723), only 110 home ranges were available from the British Columbia CDC for potential inclusion in this critical habitat identification (BC CDC 2014).

This critical habitat identification is considered to be a partial identification of critical habitat because:

- Additional surveys (or a different approach to the critical habitat identification) will be required to identify additional suitable and/or occupied habitat to meet the population and distribution objectives (Tables 1 and 3).
- Some critical habitat has not been identified due to insufficient available information. Habitat Suitability Index model output is currently not available for the transition zone (between coastal to interior habitat types; Section 2), and for some lands (mostly private forestry lands and provincial parks) on Vancouver Island (Section 4.1.2);
- Some critical habitat has not been identified due to ongoing cooperation and consultation. The Government of Canada will continue to work cooperatively with applicable organizations to complete the identification of critical habitat; and
- Critical habitat is only identified for home ranges at the scale of the breeding season because habitat requirements for the non-breeding season are not well understood (McClaren *et al.* 2015).

A schedule of studies (Table 3) has been developed to provide the information necessary to complete the identification of critical habitat that will be sufficient to meet the population and distribution objectives.

The identification of critical habitat in this recovery strategy is based on the scale of a breeding home range for the Northern Goshawk. A Northern Goshawk breeding home range (Figure 1) consists of a hierarchical arrangement of components that includes a nest or a cluster of nests that are used by a pair of Northern Goshawks over time (from one to 12 nests on the coast of British Columbia; Mahon *et al.* 2013), Post Fledging Areas (PFAs; see provincial recovery strategy in Part 2) around each nest, a breeding area that includes all PFAs, and a larger foraging area (reviewed by Squires and Kennedy 2006, NGRT 2008, Mahon *et al.* 2013, McClaren *et al.* 2015). The breeding area is the core use area of Northern Goshawks during the breeding season, and is where juveniles spend the majority of their time prior to leaving their natal home range (Kennedy *et al.* 1994, McClaren *et al.* 2005; reviewed by Squires and Reynolds 1997, Squires and Kennedy 2006, McClaren *et al.* 2015). It typically includes multiple nest sites, each having an associated PFA (Kennedy *et al.* 1994, McClaren *et al.* 2005; reviewed by Manning 2012, Mahon *et al.* 2013, McClaren *et al.* 2015). The larger foraging area makes up the majority of the breeding home range and is where the adults hunt (Iverson *et al*. 1996, Bloxton 2002; reviewed by Squires and Reynolds 1997, NGRT 2008, McClaren *et al.* 2015). Foraging areas, and consequently home ranges, vary in size, reflecting differences in the availability of prey, hunting efficiency of individuals, and food requirements (Iverson *et al*. 1996, Bloxton 2002, Mahon *et al.* 2013; reviewed by Squires and Kennedy 2006; NGRT 2008, McClaren *et al.* 2015).

Both breeding areas and foraging areas are considered critical to ensure successful breeding and survival of Northern Goshawks (reviewed by Squires and Reynolds 1997, Daust *et al.* 2010, NGRT 2008, McClaren *et al.* 2015). Therefore, this recovery strategy includes an identification of critical habitat for breeding (based on known nests) and critical habitat for foraging around known nests. These are key concepts in the critical

habitat identification because they delineate the areas within which critical habitat is identified. While breeding and foraging areas are distinct from one another, any given breeding area is overlapped by its associated and larger foraging area. This means that habitat managed for a breeding area can also contribute to habitat requirements for the associated foraging area. The biophysical attributes and amounts of critical habitat required are different for these two home range components, as described below.

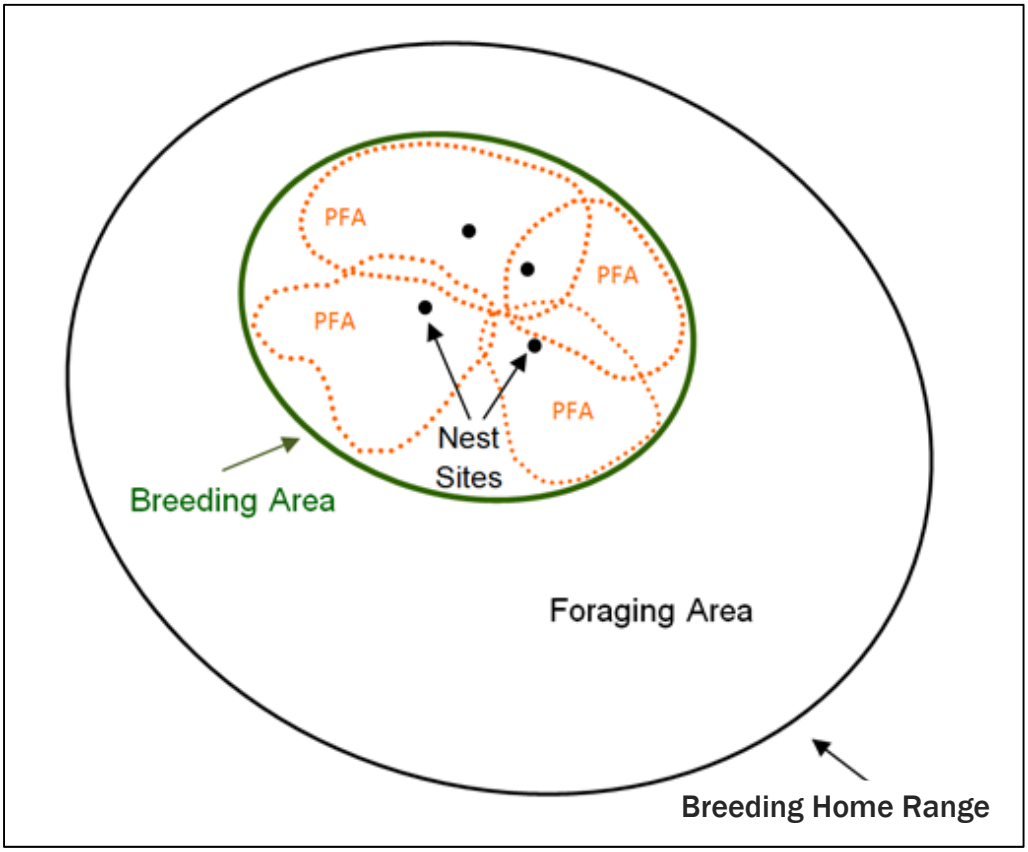

Figure 1. Conceptual illustration of the components of a Northern Goshawk breeding home range (modified from McClaren *et al.* 2015).

Critical habitat is identified in terms of its location, its biophysical attributes, and the amount of it required:

- *Location* describes where critical habitat is found geographically.
- *Biophysical attributes* describe the biological and physical characteristics of the suitable habitat.
- *Amount* describes the quantity and extent of suitable habitat required at each location and/or across the species' distribution.

This recovery strategy outlines and applies a methodology to identify the location, biophysical attributes, and amount of critical habitat required in a breeding home range. The configuration, amount and location of suitable habitat within a home range may change over time. If more suitable habitat is available than required within a given home

range, different areas of critical habitat can be identified and published in an amended recovery strategy and/or action plan. However, at any point in time, the critical habitat must meet the criteria for location, biophysical attributes and amount described herein (where suitable habitat is available).

4.1.1. Location of Critical Habitat

The location of critical habitat is based on the locations of known nests of the Northern Goshawk within coastal British Columbia for which data were available to the Government of Canada as of June 2014. Data on nest locations for 110 Northern Goshawk breeding home ranges were obtained from the British Columbia Conservation Data Centre (CDC). All records of Northern Goshawk nests were included in the identification, irrespective of age of observation or recent occupancy (BC CDC 2014). Breeding home ranges without evidence of recent occupancy were included because Northern Goshawks are difficult to detect and annual monitoring is limited over much of the species range (until recently, intensive annual monitoring only occurred on parts of Vancouver Island[5] and Haida Gwaii[6]), because they exhibit strong site fidelity to a breeding home range (McClaren 2005, Stuart-Smith *et al.* 2012), and because they have been known to re-occupy a particular area even after many years of apparent absence (Kenward 2006, McClaren *et al*. 2015, Province of British Columbia unpubl. data). Consequently, areas where Northern Goshawks have previously been detected are likely to continue to be used by Northern Goshawks, even if they are not detected over several surveys (McClaren 2005). In addition, given the relatively small number of birds known to occur in each conservation region, inclusion of unoccupied nests and/or breeding home ranges is considered necessary, as a precautionary measure, to ensure sufficient nesting locations and breeding home ranges are available to contribute towards providing a reasonable probability of long term persistence (Steventon 2012; see Section 2 *Population and Distribution Objectives*). If through field surveys, critical habitat is confirmed to be unsuitable for Northern Goshawk nesting or foraging, critical habitat can be refined and published in an amended recovery strategy and/or action plan.

4.1.2. Biophysical Attributes of Suitable Habitat

Habitat Suitability Index (HSI) models for Northern Goshawk breeding areas and foraging areas were produced collaboratively by the Habitat Recovery Implementation Group of the Province of British Columbia's Northern Goshawk *Accipiter gentilis laingi* Recovery Team (Mahon *et al*. 2008, 2015). The Mahon *et al*. (2015) models are based on Northern Goshawk habitat usage, and use equations that describe the combination of habitat attributes that are thought to be required by Northern Goshawks. The models are used to analyze standardized British Columbia forest cover data and to score forest stands (on a scale of 0-1) according to how suitable they are predicted to be for Northern Goshawks (with 0.5 to 1 defined as suitable).

[5] For example, Manning and Chytyk (2008).
[6] For example, Doyle (2005).

The biophysical attributes of suitable habitat differ slightly between breeding areas and foraging areas, with breeding habitat being a subset of foraging habitat. In general, mature/old growth forests most often possess the characteristics considered suitable for Northern Goshawks. However, because the models are based on multiple variables, there is some flexibility in the attributes of forests that are rated as suitable. For example, younger forest stands might still qualify as suitable habitat if they have high ratings for all other variables and as long as minimum height and age criteria are met.

The Mahon *et al.* (2015) HSI models are the only information sources that have quantitatively defined the attributes of Northern Goshawk habitat on the coast of British Columbia. They are based on the largest data set of nest locations and Northern Goshawk telemetry data that is available for coastal British Columbia, so represent the most comprehensive descriptions of suitable habitat for breeding and foraging. The Mahon *et al.* (2015) HSI models have not been published and have not been validated (see Section 3.2 *Schedule of Studies)*, but were ground tested for accuracy in each of the four conservation regions (meeting a priori accuracy targets; see Appendix A), were subjected to sensitivity analyses, and have been reviewed by a broad cross section of practitioners in British Columbia (Mahon *et al.* 2008, 2015). The models were iteratively improved as a result of these processes and as more recent data have become available (Mahon *et al.* 2015).

The models are the best tools available to quantify Northern Goshawk habitat currently available. There are no other options available for a multi-parameter quantitative description of suitable habitat. An alternative approach to the use of Mahon *et al.*'s (2015) models would be to use a single parameter, such as tree age or tree height. However, this option would not provide a precise description of suitable habitat (*e.g.*, old trees at high elevation will not be suitable, old trees of certain species will not be suitable, tall trees in some cases will not have the required branching structure to effectively hold nests). The Mahon *et al.* (2015) models take into account the variance in suitability based on the primary factors affecting habitat use for which standard forest cover data are available for mapping. As such, the models provide the most precise description of suitable habitat, based on the largest amount of data on habitat use by Northern Goshawks.

Because the models represent a description of typical habitat use, there will be cases where the models do not fully represent a particular local situation (*e.g.*, highly managed forest lands in a productive landscape). In situations such as these, further planning may allow the models to be tailored to specific landscapes or different scales (*e.g.*, through a home range plan based on a management unit or conservation region, see Section 3.2 *Schedule of Studies*). In cases such as this, the critical habitat identification may be refined for the landscape being considered in an amended recovery strategy and/or action plan.

Spatial mapping output of the Mahon *et al.* (2015) HSI models has been produced using land cover data current to between 2005 and 2012 (Mahon *et al.* 2008, 2015) and is used in this federal recovery strategy to spatially map critical habitat. Although the HSI models met the ground testing accuracy requirements set by the provincial recovery

team (Mahon *et al.* 2015), there remains considerable error associated with the model output (related primarily to the accuracy of underlying forest cover data). Nevertheless, there is no alternative for spatially mapping of critical habitat at this time. Field verification of model outputs can be used to improve the accuracy of mapped critical habitat (Section 3.2 *Schedule of Studies*). In addition, as of 2017 the mapped model output was not available for large areas of Vancouver island (mostly private lands owned by the forest industry and provincial parks), and for the eastern margin of the Canadian range of the *laingi* subspecies, as considered in this federal recovery strategy (Section 2).

Critical habitat is only identified within critical habitat boundaries where the biophysical attributes of critical habitat are present.

See Section 3.2 *Schedule of Studies* for activities to refine the identification of critical habitat, including production of HSI model outputs for the transition zone (from coastal to interior habitat types), provincial parks, protected areas and private lands on Vancouver Island, and field verifications of current model outputs.

Critical habitat for breeding: biophysical attributes

Biophysical attributes of suitable habitat for breeding typically include mature/old forest with large trees suitable for holding large stick nests, a relatively closed canopy (> 50%), an open understory and abundant under-canopy flyways (Iverson *et al.* 1996, Patla 1997, Daw and DeStephano 2001, Finn *et al.* 2002, McGrath *et al.* 2003, Desimone and DeStefano 2005, Doyle 2005, McClaren 2005, Boal *et al.* 2006, Harrower *et al.* 2010, Stuart-Smith *et al.* 2012, Mahon *et al*. 2013; reviewed by Squires and Reynolds 1997, MWLAP 2004, Squires and Kennedy 2006, USFWS 2007, NGRT 2008, Mahon *et al.* 2015).

Using the following equation from the HSI model for breeding habitat (Mahon *et al.* 2015), suitable habitat for breeding must have a HSI rating of 0.5 or more, where:

$$HSI_n = \text{mean}(Age_r, Height_r) * Edge_r * ITG_r * Elev_r * Slope_r * BECvar_r,$$

and where n = nesting and r = rating, from 0-1, based on estimates of how that particular variable affects habitat suitability for Northern Goshawk breeding (see Mahon *et al.* 2015).

The mean tree stand age (Age_r) and height ($Height_r$) are included in the model because Northern Goshawks generally prefer older and taller trees. Estimates of breeding habitat suitability increase linearly from 0 below 40 years and 14 m height up to 1 at 90 years of age and 32 m height. Northern Goshawks also tend to avoid anthropogenic and natural edges ($Edge_r$), so breeding sites farther away from edges are more suitable and receive a higher rating. Inventory Type Group variable (ITG_r) relates certain structural requirements such as canopy to particular forest types. Structural attributes important to Northern Goshawk breeding appear to be most common in hemlock, fir and spruce dominated stands. As such, these forest types typically receive a rating of 1, whereas other forest types have lower ratings. The elevation of an area ($Elev_r$) is included in the

model because data suggest that Northern Goshawks prefer lower elevation sites. Lower elevation areas (400 m on Haida Gwaii, 600 m on the North Coast and 800 m in the southern regions receive a rating of 1; with downgrades to a low of 0.5 at 1,300 m. Slope ($Slope_r$) is included because the vast majority of known nests occur on slopes <60%. Areas with a slope between 0-60% receive a rating of 1; areas with slopes >60% receive a reduced rating. The final variable in the model is the BEC variant ($BECvar_r$), which represents the classification of the area based on the British Columbia Biogeoclimatic Ecosystem Classification System (MacKinnon *et al.* 1992). Each class was assigned a rating, based on estimated habitat suitability for breeding. For example, tundra and alpine parkland classes have the lowest ratings at 0.4. See Appendix A for more details on the variables included in the model.

In addition to the attributes described in the model, an important biophysical attribute of critical habitat for breeding is habitat that is free from loud auditory disturbances during the breeding season from courtship to fledging (15 February – 31 July) (Iverson *et al*. 1996; reviewed by Cooper and Stevens 2000). Activities that create loud noise within or adjacent to an active breeding area can cause disturbances for nesting birds and may have negative consequences for production of young and mortality of young or adults (*e.g.*, Boal and Mannan 1994, Toyne 1997, Bijslma 1999 in Rutz *et al.* 2006, Penteriani and Faivre 2001, Doyle in Stuart-Smith *et al.* 2012; reviewed by McClaren *et al*. 2015). For information on mitigation, see Section 2.3 *Activities Likely to Result in the Destruction of Critical Habitat*.

Where HSI model output was not available, other available data were used to delineate critical habitat for breeding. This included satellite imagery, forest cover information for timber supply area lands, and mapping data on recent and proposed cutblocks (from the Government of British Columbia's Land and Resource Data Warehouse).

Critical habitat for foraging: biophysical attributes

There is strong evidence that Northern Goshawks prefer to forage in forests with typical mature/old characteristics (*e.g*., closed canopy, low stem density, open understory). Eight of nine telemetry studies that were conducted during the breeding season in primarily forested areas of North America found that goshawks foraged in forests with mature/old structural characteristics disproportionately more often than the availability of these forests on the landscape (Austin 1993, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Bloxton 2002, Hargis *et al.* 1994, Iverson *et al.* 1996, Good 1998, Boal *et al.* 2006, Mahon 2009). Forest structure has usually been found to be more important than prey abundance to goshawk foraging, likely because forest structure is a key attribute for prey accessibility. For example, a closed canopy results in a relatively open understory and a low stem density increases sub-canopy flyways; both of which increase access to prey (reviewed by Greenwald *et al*. 2005 and McClaren *et al*. 2015). The biophysical attributes of typical foraging habitat include relatively large trees (a low stem density), open understories and closed canopies; though a variety of other habitat types (*e.g*., alpine areas and shorelines when used by migratory species) are also used (Bloxton 2002, Iverson *et al.* 1996, Boal *et al.* 2006; reviewed by USFWS 2007, NGRT 2008, Stuart-Smith *et al*. 2012, COSWIC 2013, Mahon *et al.* 2015).

Using the following equation from the HSI model for foraging areas (Mahon *et al.* 2015), suitable habitat for foraging must have a HSI rating of 0.5 or more, where

> HSI_f = mean(Age_r, $Height_r$) * ITG_r * $BECvar_r$ or Non-Forest rating, whichever is greater,

and where f = foraging and r = rating. Non-Forest rating is any area that is not classified as a forest type under the British Columbia Biogeoclimatic Ecosystem Classification Program. See above (*Critical habitat for breeding areas: biophysical attributes*) for explanations of the relevant model variables and Appendix A for more details on the variables included in the model.

4.1.3. Amount of Suitable Habitat Required for Critical Habitat

The biophysical attributes above describe biological and physical characteristics of suitable habitat, but not all suitable habitat is necessarily critical habitat.

Critical habitat for breeding: amount of suitable habitat

The amount of suitable breeding habitat required for critical habitat around each nest is 75.5 ha. This is based on an empirical analysis of the use of habitat by fledglings using telemetry for 12 *laingi* nests in British Columbia that found 90% of the nests had a PFA size of up to 75.5 ha (McClaren *et al.* 2005, Mahon *et al.* 2013, McClaren *et al.* 2015). Use of the 90th percentile should ensure that there will be sufficient critical habitat for breeding around each nest for most situations, which is important for species at risk, especially given that breeding areas represent the core use area of a breeding home range (Kennedy *et al.* 1994, Iverson *et al.* 1996, Moser 2009, McClaren *et al.* 2015).

Critical habitat for breeding should provide a buffer for nests from hard edges[7] such as harvested areas (McClaren 2005, Iverson *et al.* 1996, Mahon *et al.* 2013, McClaren *et al.* 2015). Several studies have found that Northern Goshawks relocated their nests in response to timber harvesting near their nest locations (Penteriani and Faivre 2001, Mahon 2009, Stuart-Smith *et al.* 2012). Although not tested compared to controls, a recent analysis of 283 nests on Vancouver Island and Haida Gwaii, Mahon *et al.* (2013) found that 90% of nests were at least 252 m from cut-blocks that were present at the time the nest was first discovered. Additionally, McClaren *et al.* (2005) and McClaren (2005) found that radio-tagged Northern Goshawk fledglings were never confirmed using open areas such as harvested areas (E. McClaren, pers. comm. 2014).

Beyond ensuring sufficient suitable breeding habitat around known nests, additional critical habitat is required in some breeding home ranges to allow for the establishment of new nests. The number of nests within 63 breeding areas of the *laingi* subspecies in coastal British Columbia ranged from one to 12 nests, with a 90th percentile of about six nests (Mahon *et al.* 2013). Therefore, using a precautionary approach, the critical habitat in each breeding area should provide sufficient suitable breeding habitat for

[7] A hard edge is defined as an abrupt change in the forest canopy, typically where mature or old forest is adjacent to non-forested habitat or younger forest, and where the height difference between the two habitat types is at least 15 m (*e.g.*, clearcut edge, lake shore, alpine area).

supporting PFAs for at least six nests. Given that the median distance between nests is 275 m and the 90th percentile of intra-nest distances is 840 m (Parks Canada, unpubl. data, n=294 intra-nest distances from 111 breeding home ranges), each supplementary PFA area, where necessary, should be centered at a location not less than 275 m and not more than 840 m from a known nest or other supplementary PFA locations.

Based on the above, critical habitat for breeding requires:

- 75.5 ha of suitable breeding habitat around each known nest. The critical habitat must encompass the nest tree, and the critical habitat must be located within 840 m of each nest. In addition, there must be at least 252 m of contiguous suitable breeding habitat around each nest. Any suitable habitat within 840 m of more than one nest can count towards the critical habitat necessary for each of those nests. If there is currently insufficient suitable habitat around a known nest to meet the 75.5 ha target, critical habitat will include all currently available suitable habitat within the 840m radius of the nest and the area should be managed to achieve the 75.5 ha through appropriate management actions outlined in an amended recovery strategy or action plan.
- For breeding home ranges with fewer than six known nests, additional critical habitat for breeding (75.5 ha per location, as above) will be required in order to allow for the establishment of new nests. The additional critical habitat for breeding areas should be centered at locations not less than 275 m and not more than 840 m from known nests or supplementary nest locations, so that a total of six known or supplementary nest locations are contained within the critical habitat for breeding areas for each breeding home range. Where insufficient suitable habitat exists, the area should be managed to achieve this over time through appropriate management actions outlined in an amended recovery strategy, home range plan or action plan.

Critical habitat for foraging: amount of suitable habitat required

Critical habitat for foraging, defined biophysically using the HSI model on the coast of British Columbia (Mahon *et al*. 2015), typically has mature/old forest characteristics. As outlined earlier, there is strong evidence that Northern Goshawks disproportionately select foraging habitat with mature/old forest characteristics over other habitats such as young forests and open areas. Given this result, it is not surprising that five of seven studies have shown a positive relationship between home range occupancy and the amount of forest with mature/old characteristics within home ranges (Crocker-Bedford 1990, Crocker-Bedford 1995, Ward *et al.* 1992, Patla 2005, Finn *et al.* 2002, McClaren and Pendergast 2003, Mahon 2009). In British Columbia, a recent analysis suggested that Northern Goshawks have selected home ranges for the amount of critical habitat for foraging within them on both Haida Gwaii and Vancouver Island (Vennesland 2018). Data was not available for other conservation regions.

Critical habitat for foraging has declined on the coast of British Columbia, though there is some evidence that this decline has slowed in recent years. COSEWIC (2013) documented a widespread 20% to 31% (depending on the region) decline in critical habitat for foraging since industrial scale forestry began. Czembor (2012) used recent

satellite land cover data (Spot imagery from 2004 to 2007 and Landsat imagery from 1999 to 2011) and HSI modelled habitat (Mahon *et al*. 2015), and documented a decline in suitable foraging habitat of approximately 1% per year on the South Coast and Vancouver Island. On the North Coast, critical habitat for foraging had increased slightly (<0.2%) and no data were available for Haida Gwaii. More recently, the Province of British Columbia (unpubl. data) found only a very slight (<1%) overall decline across all conservation regions from 2000 to 2015, balanced by slight increases on the North Coast and South Coast and a slightly stronger decline (2.6%) on Vancouver Island. The difference between the results of Czembor (2012) and Province of British Columbia (unpubl. data) may be due to declining rates of harvest or better accounting for recruitment that offsets declines from harvesting in the unpublished data from the Province of British Columbia.

As with breeding areas, there is limited unequivocal information about the size of the home range (or foraging area) and how much suitable foraging habitat is required within the home range (reviewed by NGRT 2008, Stuart-Smith *et al.* 2012, McClaren *et al*. 2015). For example, home ranges vary in size, in part according to ecological conditions such as weather and prey availability as well as between males and females (Kennedy *et al.* 1994, Iverson *et al.* 1996, Bloxton 2002). Both the size and quality of breeding home ranges likely vary across the four conservation regions (Doyle 2005, Doyle 2006, NGRT 2008, Deal and Mogensen 2013, Mahon *et al.* 2013, Manning and Chytyk 2018). Most studies have recommended that 40-60% of the full landscape area within home ranges be composed of suitable foraging habitat, including specifically for the coast of British Columbia (McClaren *et al*. 2015). However, these recommendations (in British Columbia and elsewhere) have typically not been based on clear empirical information (e.g., Reynolds et al. 1992).

To determine the amount of suitable habitat required for critical habitat for foraging within the breeding home range, two steps were followed: 1) mean breeding home range size was determined, and 2) the amount of suitable habitat required to be critical habitat within this foraging area was determined. To ensure a regionally appropriate critical habitat identification, these values were determined separately for each conservation region (and in some cases, the regions were further subdivided to reflect variation where data were available; see maps B-1 to B-6, Appendix B). The results are summarized in Table 2.

First, regional estimates of mean breeding home range size (based on the spacing of breeding home ranges on the landscape) were used to determine the size of foraging areas used by Northern Goshawks during the breeding season (McClaren *et al.* 2015, Manning and Chytyk 2018). Previous studies determined that breeding home range spacing for the *laingi* subspecies was highest on Haida Gwaii (Doyle 2006, NGRT 2008), where McClaren *et al.* (2015) estimated home range spacing at 10.4 km. McClaren *et al* (2015) also estimated home range spacing for Vancouver Island at 6.9 km. A more recent study by Manning and Chytyk (2018) looked at home range spacing in all regions except for Haida Gwaii using updated data (Province of British Columbia, unpubl. data) and estimated home range spacing for the North Coast near Bella Coola where home ranges appear to be tightly packed (4.8 km), remaining areas of the North

Coast (6.6 km), the Coastal Dry Ecosystem Zone that encompasses a large area of Vancouver Island and smaller areas of the North Coast and South Coast regions (6.1 km), and remaining areas of Vancouver Island (6.9 km) and the South Coast (6.6 km). Spacing estimates reflect the presumed diameter of home ranges, which was used to calculate the estimated area of home ranges (Table 2). The region or sub-region of a home range was defined by where the home range centroid was located.

Sub-regional spacing estimates were considered in determining the amount of suitable habitat required in home ranges because detailed survey data in both the Bella Coola region of the North Coast and in the Coastal Dry Ecosystem Zone of the south (defined as the Coastal Douglas-fir biogeoclimatic zone and the Coastal Western Hemlock xm1 and xm2 subzone variants; MacKinnon *et al.* 1992) suggested that home ranges were more tightly spaced in these areas, likely due to different ecological conditions that increase prey abundance/availability (Manning and Chytyk 2018). Conversely, on Haida Gwaii, the negative effects of introduced deer on prey availability is presumed to have resulted in a wider spacing of home ranges as goshawks must fly further to find sufficient prey for successful breeding (Doyle 2005; reviewed by NGRT 2008).

These estimates of mean breeding home range sizes likely under-estimate the true size of home ranges because of several biases (Manning and Chytyk 2018), most prominently because estimates of home range spacing have been produced considering all known home ranges whether or not they were known to be occupied. However, the estimates of home range size likely over-estimate the annual required amount of suitable habitat because Northern Goshawks tend to use a relatively small area of their breeding home range each year (*e.g.*, 32% as per Kennedy *et al.* 1994; see also Bloxton 2002, Moser 2009). Balancing these biases in the data, the mean of the observed breeding home range sizes should provide a reasonable and precautionary conservation target.

Second, the amount of suitable habitat required within the foraging area of each breeding home range was determined based on the amount of suitable foraging habitat (as predicted by the Mahon *et al.* 2015 foraging HSI model) that was present in breeding home ranges that had evidence of occupation in at least one year over the period 2000 to 2017 (Province of British Columbia, unpubl. data). Given the general lack of strong empirical results for the required amount of suitable habitat in a home range, this recovery strategy uses a ‘no net loss’ strategy to cease further habitat loss while studies are undertaken to provide better science on goshawk requirements. To this end, the amount of critical habitat for foraging required in each home range is based on the 50^{th} percentile (median) of the proportions of suitable habitat across breeding home ranges with evidence of occupation. The median was chosen rather than the mean because these data are typically not symmetrically distributed and the median thus provides a better representation of the general tendency of the midpoint of the data. The same six conservation regions or sub-regions were used for this analysis as with the home range spacing analysis. Median values for each region or sub-region were computed as the average median proportion from 2000 to 2015 of suitable habitat in the full landscape of home ranges (Province of British Columbia, unpubl. data).

The median amount of suitable habitat in breeding home ranges with evidence of occupation was 65.5% for Haida Gwaii, 49.5% for the North Coast, 50.1% for the Bella Coola area of the North Coast, 44.6% for Vancouver Island, 47.4% for the South Coast and 50.0% for the Coastal Dry Ecosystem Zone (Province of British Columbia, unpubl. data).

The total amount of suitable habitat needed for critical habitat for foraging in breeding home ranges is summarized in Table 2. In the South Coast region for example, the target for critical habitat for foraging is 1622 ha of suitable habitat within a 6.6 km diameter circle of the nest centroid (the centroid of all known nests and supplementary nest locations) for the breeding home range.

Table 2. The maximum diameter requirement (based on breeding home range size estimates) for critical habitat for foraging, and the percentage and total amount of suitable habitat that is required for each breeding home range, for each of the six conservation regions and sub-regions considered for critical habitat for foraging.

Conservation Region or Sub-region[1]	Breeding home range diameter estimate (km)	Suitable habitat required (%)[4]	Amount suitable habitat required for critical habitat for foraging (ha)
Haida Gwaii	10.4 [2]	65.5	5,564
North Coast	6.6 [3]	49.5	1,693
North Coast – Bella Coola	4.8 [3]	50.1	907
Vancouver Island	6.9 [2,3]	44.6	1,668
South Coast	6.6 [3]	47.4	1,622
Coastal Dry Ecosystem Zone	6.1 [3]	50.0	1,461

[1] See maps B-1 to B-6 (Appendix B) for regional and sub-regional boundaries (Manning and Chytyk 2018).
[2] McClaren *et al.* (2015)
[3] Manning and Chytyk (2018)
[4] Median proportion of home ranges comprised of suitable foraging habitat (based on mean of estimates from 2000 to 2015; Province of British Columbia, unpubl. data).

Because foraging within any given home range occurs throughout the breeding home range, critical habitat for breeding will also contribute to the required amount of critical habitat for foraging (critical habitat for breeding always overlaps with critical habitat for foraging).

If the amount of suitable habitat available within the breeding home range radius estimate is currently less than the amount of suitable habitat required (Table 2) and critical habitat includes all currently available suitable habitat within the polygon, the regionally appropriate threshold should be achieved over time through appropriate management actions outlined in an amended recovery strategy, home range plan or action plan. Of the 91 home ranges for which critical habitat has been identified, the

amount of suitable habitat required for foraging critical habitat is currently below the estimated targets for 79 home ranges (see Table B-1 in Appendix B). The remaining 12 home ranges had an amount of suitable habitat at or above the estimated targets. In cases where the amount of suitable habitat available in a home range was above the required foraging critical habitat target in Table 2, the breeding home range radius was reduced until the amount of suitable habitat for foraging critical habitat was reached. This method was used based on the prediction that habitat utility will decline with distance from the breeding area, as per the theory of Central Place Foraging (Orians and Pearson 1979; for example, Bloxton 2002).

4.1.4. Maps of Critical Habitat

The areas containing critical habitat for breeding and critical habitat for foraging for the Northern Goshawk are presented in Appendix B, Figures B-2 to B-6. Within the areas identified as containing critical habitat for Northern Goshawk, critical habitat is identified only where the biophysical attributes are found (Section 3.1.2). Detailed methods and decision-making processes relating to the critical habitat identification are archived in a supporting document.

Home ranges with small amounts of critical habitat may not be obvious on the maps included in this appendix, so it is recommended that those with interests on the land base acquire more detailed mapping resources (e.g., GIS spatial layers). For access to detailed mapping resources and supporting documents outlining the methods used for critical habitat in this strategy, please see the contact information listed for Northern Goshawk *laingi* subspecies on the Species at Risk Public Registry: http://www.registrelep-sararegistry.gc.ca/.

4.2 Schedule of Studies to Identify Critical Habitat

A list of studies and activities recommended to achieve a complete identification of critical habitat for Northern Goshawk is provided in Table 3. Further studies and activities are required to 1) identify additional critical habitat that is required for the survival and recovery of the species, and 2) possibly refine critical habitat identification to maximize its implementation effectiveness (*e.g.*, verify whether critical habitat identification is most effective at a breeding home range, a management unit, or a regional scale).

Table 3. Studies and activities required for a full identification of critical habitat for Northern Goshawk to meet the population and distribution objectives for the species in this federal recovery strategy.

Description of activity	Outcome/rationale	Timeline
To meet the population and distribution objectives, identify additional critical habitat in 1) currently known home ranges that have an insufficient amount of critical habitat (Table B-1, Appendix B), and 2) additional home ranges found through surveys or habitat mapped at a landscape scale (see also Table 1).	• A sufficient amount of critical habitat is identified to meet the population and distribution objectives.	Ongoing
Some critical habitat has not been identified due to ongoing cooperation and consultation. The Government of Canada will continue to work cooperatively with applicable organizations to increase the amount of critical habitat identified.	• Increased amount of critical habitat identified. • Progress made towards achieving population and distribution objectives.	Ongoing, pending progress respecting consultations
Produce HSI model output for lands where currently not available (*e.g.*, transition zone from coastal to interior habitat types, provincial parks and private lands on Vancouver Island, see Section 4.1)	• To increase the number of breeding home ranges for which HSI data are available, allowing more critical habitat to be identified.	2019-2022
Conduct research to determine the required availability of breeding and foraging habitat at home range and/or landscape scale.	• Results will provide a better understanding of the breeding and foraging habitat thresholds required to sustain the overall Northern Goshawk population on the coast of British Columbia, and can be applied to re-assess the approach to identify critical habitat. • Additional empirical evidence, including occupancy and reproductive success where possible, will help to assess current thresholds and approaches to identifying foraging habitat. • Determine the extent to which areas with HSI ratings <0.5 can occur within a	2019-2024

Description of activity	Outcome/rationale	Timeline
	breeding or foraging area without having an effect on long-term occupancy.	
Continue to research critical habitat knowledge gaps (*e.g.*, patterns of home range use in breeding and non-breeding seasons, prey abundance, availability and diversity).	• Information on winter habitat associations may influence the habitat included in critical habitat. • Knowledge of relationships between prey abundance, availability and diversity and foraging habitat characteristics will allow the refinement of specific foraging habitat targets for different habitat types. • Additional data to allow validation of HSI and other models. • Assessment of potential alternatives to current habitat models. • Assessment of the benefit of spacing and/or thinning for enhancing habitat suitability. • Assessment of and approaches to deal with introduced deer on Haida Gwaii. • Knowledge of the relationship between rotation times of harvested forest and Northern Goshawk occupancy can be used to better manage critical habitat.	2019-2024
Validation of the HSI model outputs at stand-level scale.	• Improve accuracy/precision of critical habitat boundaries.	2019-2029

4.3 Activities Likely to Result in the Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Examples of activities likely to destroy critical habitat are provided below (Tables 4 and 5). However, destructive activities are not limited to those listed. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one point in time or from cumulative effects over time.

Destruction of Northern Goshawk critical habitat includes, but is not limited to, the alteration or removal of forest suitable for breeding or foraging. In addition, loud noises occurring between the beginning of courtship (approximately mid-February) until fledging (approximately beginning of August) can disturb Northern Goshawks and potentially reduce the quality of the habitat in which they reside. Disturbance stimuli can

cause the abandonment of nests, which can result in the mortality of eggs or young in the nest (Craig 2002, Environment Canada 2014).

Table 4. Examples of activities within or near to critical habitat for breeding and foraging that are likely to result in the destruction of critical habitat at all times of the year.

Activity categories	Examples of potential effects on habitat	Examples of potential effects on Northern Goshawk
• Forest harvesting, such as clear cutting, that removes critical habitat. • Industrial or urban/residential development that removes or alters critical habitat (*e.g.*, oil and gas, mines, construction of buildings or other infrastructure, hydro dams, roads and other linear developments, etc.)	• Reduces quality and or quantity of critical habitat for breeding and critical habitat for foraging • Negatively affects prey populations	• Insufficient critical habitat remains to maintain a breeding pair of Northern Goshawks • Reduced availability of prey • Increased rate of predation of adults with increased edge habitats • Increased rate of breeding abandonment from human disturbance • Greater competition with edge or open habitat-adapted species

Table 5. Examples of activities likely to destroy critical habitat for breeding during the breeding season, and proposed setback distances that will make the activity unlikely to destroy critical habitat. Proposed setbacks were determined using the results of previous studies and considerations of the potential of a stimulus to cause a disturbance (*i.e.*, potentially intense stimuli deserve more precautious setbacks; Environment Canada 2014). Mitigations should be in effect from courtship to the end of the nestling phase (15 February – 31 July; Iverson 1996, reviewed by Cooper and Stevens 2000).

Disturbance stimuli	Buffer distance from active nest (m)
Hauling with truck[1]	100
Road construction[2]	500
Tree Felling[3]	500
Aircraft[4] - repeated overflights or any overflights of heavy lift aircraft	1,000[6]
Blasting[5]	1,000

[1] McLaughlin (2002), Grubb *et al.* (2012), Deal (2013), E. McClaren pers. comm.
[2] Vernier and Brunnell (2002), Stuart-Smith *et al.* (2012), E. McClaren pers. comm.
[3] Boal and Mannan 1994, Penteriani and Faivre 2001, McLaughlin (2002), Stuart-Smith *et al.* (2012), E. McClaren pers. comm.
[4] Stuart-Smith *et al.* (2012), E. McClaren pers. comm.
[5] McLaughlin (2002), Stuart-Smith *et al.* (2012), E. McClaren pers. comm.
[6] Aircraft buffer distance applied horizontally and vertically.

It should be noted that loud disturbance stimuli such as described here may only temporarily destroy critical habitat for breeding. The effects of noise disturbance may be very short (*e.g.*, an adult temporary leaves the nest), occur for one season (*e.g.*, the adults abandon the nest for the season but return the next year) or longer if the nest is abandoned for one or more years. But it is likely that if the physical habitat attributes remain suitable, the site should continue to be viable once the disturbance stimuli have ceased.

4.4 Summary of Current Provincial Measures to Manage Activities within Northern Goshawk Habitat

Substantial work has already been completed or is underway to manage activities within habitat for Northern Goshawk in British Columbia For example, 1.6 million ha of suitable breeding and foraging habitat occurs in provincial forestry reserves and parks (MoFLNRO and MoE 2013). In addition, provincial 'fine filter' regulations constrain forest harvesting activities on the managed land base within 28 known breeding areas using Wildlife Habitat Areas, or WHAs, under the Forest and Range Practices Act, FRPA, or Reserves under the Land Act. These WHAs and Reserves total to 4,300 ha of core breeding habitat (i.e., suitable breeding and post-fledging habitats) and over 14,000 ha of suitable foraging habitat (MoFLNRO and MoE 2013).

Specific activities in some breeding and foraging habitat on provincial Crown land are constrained within:

- Parks and protected areas (*e.g.*, British Columbia *Park Act);*
- Ungulate Winter Ranges through the FRPA;
- Old Growth Management Areas through the British Columbia *Land Act;*
- Conservancies, Biodiversity, Mining and Tourism Areas and Strategic Level Reserve Design polygons within the Ecosystem-based Management planning area on the North and Central Coast (*e.g.*, Horn *et al.* 2009); and
- Strategic Land Use Agreements (SLUAs) with protection under Land Use Objectives Orders under the British Columbia *Land Act* (*e.g.*, on Haida Gwaii).

In addition to the habitats under the designations described above, timber harvesting in British Columbia is regulated through an "allowable annual cut" that is based on modelling of timber supply. Over the long term, it is projected that a steady state of forest age-classes (both structure and distribution) will be achieved so that the amount of old and mature age classes will become relatively constant over the long term (MoFLNRO and MoE 2013).

5. Measuring Progress

Performance measure for short term Population and Distribution Objective 1:

- Within 15 years of final posting of the strategy, there is sufficient suitable habitat in Canada to meet critical habitat targets for at least 369 breeding home ranges[8].

Performance measure for short term Population and Distribution Objective 2:

- Within 15 years of final posting of the strategy, there is sufficient suitable habitat to meet critical habitat targets across all four conservation regions (suitable habitat for at least 38 breeding home ranges[8] on Haida Gwaii, 111 on the North Coast, 125 on Vancouver Island, and 95 on the South Coast).

Performance measures for long term Population and Distribution Objective:

- Within 65 years of final posting of the strategy, there is sufficient suitable habitat in Canada to meet critical habitat targets for between 724 and 951 breeding home ranges[8].
- Within 65 years of final posting of the strategy, sufficient suitable habitat for between 724 and 951 breeding home ranges[8] in Canada is distributed across conservation regions as per the historic capability of each region (to be determined, see Table 1).

6. Socio-Economic Considerations

The section in the provincial recovery strategy entitled Socioeconomic Considerations is not considered part of the federal *SARA* recovery strategy for this species.

A socio-economic analysis is not required in a recovery strategy under Section 41(1) of SARA. A formal evaluation of the socio-economic costs and benefits of implementing the action plan(s) will be included in one or more action plan(s) as required by *SARA* (Section 49(e)).

7. Action Plan

This section modifies information in the provincial recovery strategy.

One or more actions plans for Northern Goshawk will be completed and posted on the Species at Risk Public Registry five years following the final posting of this federal recovery strategy.

It is expected that home range plans will be developed to outline how breeding home ranges will be managed to maintain or attain a sufficient amount of critical habitat over

[8] Breeding home ranges are based on British Columbia Conservation Centre records and do not require recent evidence of occupancy because of the difficulty in detecting Northern Goshawks, a lack of widespread annual monitoring, and because they have been known to re-occupy a particular area even after many years of apparent absence (see details in Section 3.1.1).

time. Home range plans may be stand-alone documents or components of other planning documents, including action plans. The main purpose of a home range plan would be to outline how activities within the breeding home range will be managed over space and time to ensure a sufficient amount of critical habitat is protected from destruction. As such, each home range plan should outline the measures and steps that will be taken to manage the interaction between human disturbance, natural disturbance, and the need to maintain or establish sufficient breeding or foraging habitat to satisfy the requirements described in this recovery strategy.

8. Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[9]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[10] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of the Northern Goshawk, *laingi* subspecies through addressing knowledge gaps associated with population size, intra- and interspecific competition, amount and distribution of critical habitat, and winter habitat / diet associations; and reduction / mitigation of threats and maintenance of sufficient habitat on the landscape (long term).

The SEA concluded that this recovery strategy would have several positive effects and not cause any important negative effects. Other wildlife with similar habitat requirements and experiencing similar threats would stand to benefit from this recovery strategy. Further project-specific environmental assessments of actions identified as a result of research conducted in this recovery strategy, may be required.

[9] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[10] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

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Appendix A: Northern Goshawk Habitat Suitability Index Models

Mahon *et al.* (2008, 2015) created Habitat Suitability Index (HSI) models for Northern Goshawk to aid in the identification of suitable habitat for Northern Goshawk. The model applications and output were described in Smith and Sutherland (2008). Habitat was rated by the models as highly suitable (HSI > 0.75), moderately suitable (HSI = 0.75-0.5), of low suitability (HSI < 0.5, or not suitable (HSI = 0).

This section provides an overview of the suitability models as per Mahon *et al.* (2015). The models are used to describe the biophysical attributes of critical habitat that is identified in this federal recovery strategy.

For critical habitat for breeding areas, model parameters included:

1. Stand age and height, where suitability increased linearly from lowest suitability (HSI = 0) below 40 years old and 14 m tall to highest suitability (HSI = 1) above 90 years old and/or 32 m tall. These estimates were based on habitat data collected around known nest areas on Haida Gwaii, the North Coast, and Vancouver Island. The model used an average of the ratings of these two variables because stand age and height are typically highly correlated.
2. Edge habitat, where the presence of a ‘hard’ edge within 200 m of the nest area makes the habitat less suitable. A ‘hard’ forest edge was considered to occur where mature forest was adjacent to non-forested habitat or younger forest, and where the height difference between the two habitat types was > 15 m. The impact of the edge habitat varied with distance from the nest area (< 100 m or 100-200 m), and the type of edge habitat: anthropogenic (primarily forest harvesting) or natural (*e.g.,* along lakes or marshes). The impact of edge habitat was considered more severe when it was closer to the nest area, and occurred through anthropogenic influence.
3. Forest composition, where stands dominated by Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), Subalpine Fir (*Abies lasiocarpa*), Amabilis Fir (*Abies amabilis*), or mixed forest were considered most suitable; stands dominated by Western Redcedar (*Thuja plicata*), deciduous forest, or Lodgepole Pine (*Pinus contorta*), or with Lodgepole Pine or Yellow Cedar (*Chamaecyparis nootkatensis*) as a secondary species were considered moderately suitable; and pure stands of Western Redcedar, or stands dominated by Yellow Cedar were rated low suitability.
4. Elevation, where habitat at all elevations was considered potential breeding habitat if other suitable conditions existed. Overall habitat suitability declined slowly in a linear fashion from HSI = 1 below 400 m on Haida Gwaii, 600 m on the North Coast, and 800 m on the South Coast and Vancouver Island to a minimum of HSI = 0.5 at 1,300 m.
5. Slope, where habitat at all elevations was considered potential breeding habitat if other suitable conditions existed. Slopes < 30^{o} were considered most suitable (HSI = 1), with a non-linear decrease in suitability to HSI = 0.5 at 90^{o}.

6. Biogeoclimatic Ecosystem Classification (BEC) zone variant, where most BEC zone variants were considered to provide potential breeding habitat if other suitable conditions existed. The most suitable habitat was in the Coastal Douglas-Fir (CDF) and Coastal Western Hemlock (CWH) zones. Slightly lower ranked, but still of high suitability were the remaining CWH zone variants and the Mountain Hemlock (MH) zone. Engelmann Spruce – Subalpine Fir (ESSF) was of moderate suitability, and alpine tundra, alpine parkland, and ESSF parkland were all of low suitability.

The parameters were used in a habitat model that used a limiting factor, non-compensatory structure, where deficiencies in one parameter could not be compensated for by another parameter (Mahon *et al.* 2015).

For critical habitat for foraging areas, model parameters included:

1. Stand age and height, where the lowest score for foraging habitats was HSI = 0.3, acknowledging that younger forests can provide some suitability for foraging (*e.g.*, Bloxton 2002). Suitability increased linearly from lowest suitability (HSI = 0.3) below 40 years old and 14 m tall to highest suitability (HSI = 1) above 90 years old and/or 32 m tall. The model used an average of the ratings of these two variables because stand age and height are typically highly correlated.
2. Forest composition, where all forest types have potential value as foraging habitat (lowest HSI = 0.6) if stand age and height were suitable. Stands where spruce is the dominant or secondary species, where Douglas-fir or Amabilis Fir is dominant (except where Yellow Cedar or Lodgepole Pine are secondary species) were considered most suitable. Stands dominated by Western Redcedar (> 80%) or Lodgepole Pine, or stands where Yellow Cedar was the dominant or secondary species were considered of moderate suitability.
3. BEC variant, where most BEC variants were considered to have the potential to provide foraging habitat (Lowest HSI = 0.4) if other suitable conditions existed. The most suitable habitat was in the CDF and for some variants in CWH. The remaining CWH variants, MH and some variants of ESSF were ranked as moderate suitability, and alpine tundra was ranked as low suitability.
4. Non-productive and non-forested habitats, where habitats such as wetlands and bogs, non-productive brush, and alpine potentially provide foraging habitat for Northern Goshawks. All vegetated polygons with a non-productive or non-forested descriptor (*e.g.,* alpine, alpine forest, swamp, non-productive brush, clearing, meadow, open range, non-productive burn, or non-commercial brush) were assigned a low suitability rating (HSI = 0.3). Non-vegetated polygons with a non-productive or non-forested descriptor (*e.g.,* rock, gravel, sand, clay bank, lake, gravel bar, river, or human development) were assigned a nil suitability rating (HSI = 0).

The foraging habitat model, like the nesting (breeding) habitat model, used a limiting factor, non-compensatory structure, where deficiencies in one parameter could not be compensated for by another parameter (Mahon *et al.* 2015).

The performance of the nesting (breeding) and foraging models was assessed in each conservation region using formal accuracy assessment procedures determined prior to field work. The accuracy assessment compared model predictions to field ratings assessed by Northern Goshawk experts at each location. Accuracy scoring used two methods (for different ways the model outputs might be used) and was conducted at three scales (site, stand and regional scales), to account for potential spatial accuracy issues and to advise on management activities that may be conducted at those scales. Using the primary scoring method (based on the difference between the model and field ratings) and the stand-level scale, the nesting model averaged 82% accuracy and overestimated suitability by 0.01 – 0.09 HSI units (depending on conservation region). The foraging model averaged 85% accuracy and underestimated suitability by 0.04-0.06 HSI units. Accuracy scores and patterns of bias were consistent across regions, suggesting that the models performed fairly robustly across the coast. Model errors appeared to be largely driven by errors in forest cover data, which has two significant implications: 1) errors in the underlying data limit potential model revisions to improve performance, and 2) use of the model outputs should be consistent with generally accepted practices and limitations associated with using forest cover data for other forest and habitat management activities. Although the accuracy of the models exceeds the a priori target of 80% initial set by the provincial recovery team, precautionary use of model outputs is recommended, including verification of model predictions via ground truthing or aerial imagery.

Appendix B: Amount and Location of Critical Habitat

Included in this appendix are maps showing the layout of all conservation regions and sub-regions (Figure B-1) and the location of critical habitat for Northern Goshawk, *laingi* subspecies in each region or sub-region (Figures B-2 to B-6), and a table (Table B-1) that lists the home ranges within which critical habitat is identified for Northern Goshawk, the conservation region or sub-region in which the home range occurs, and the amount of area within which critical habitat is found for breeding and foraging.

Home ranges with small amounts of critical habitat may not be obvious on the maps included in this appendix, so it is recommended that those with interests on the land base acquire more detailed mapping resources (*e.g.*, GIS spatial layers).

For access to detailed mapping resources and supporting documents outlining the methods used for critical habitat in this strategy, please see the contact information listed for Northern Goshawk, *laingi* subspecies on the Species at Risk Public Registry: http://www.registrelep-sararegistry.gc.ca/.

Figure B-1. The Northern Goshawk *laingi* subspecies conservation regions and sub-regions within which home ranges occur and where critical habitat is identified on the coast of British Columbia

Figure B-2. Critical habitat for Northern Goshawk *laingi* subspecies in the Haida Gwaii Conservation Region.

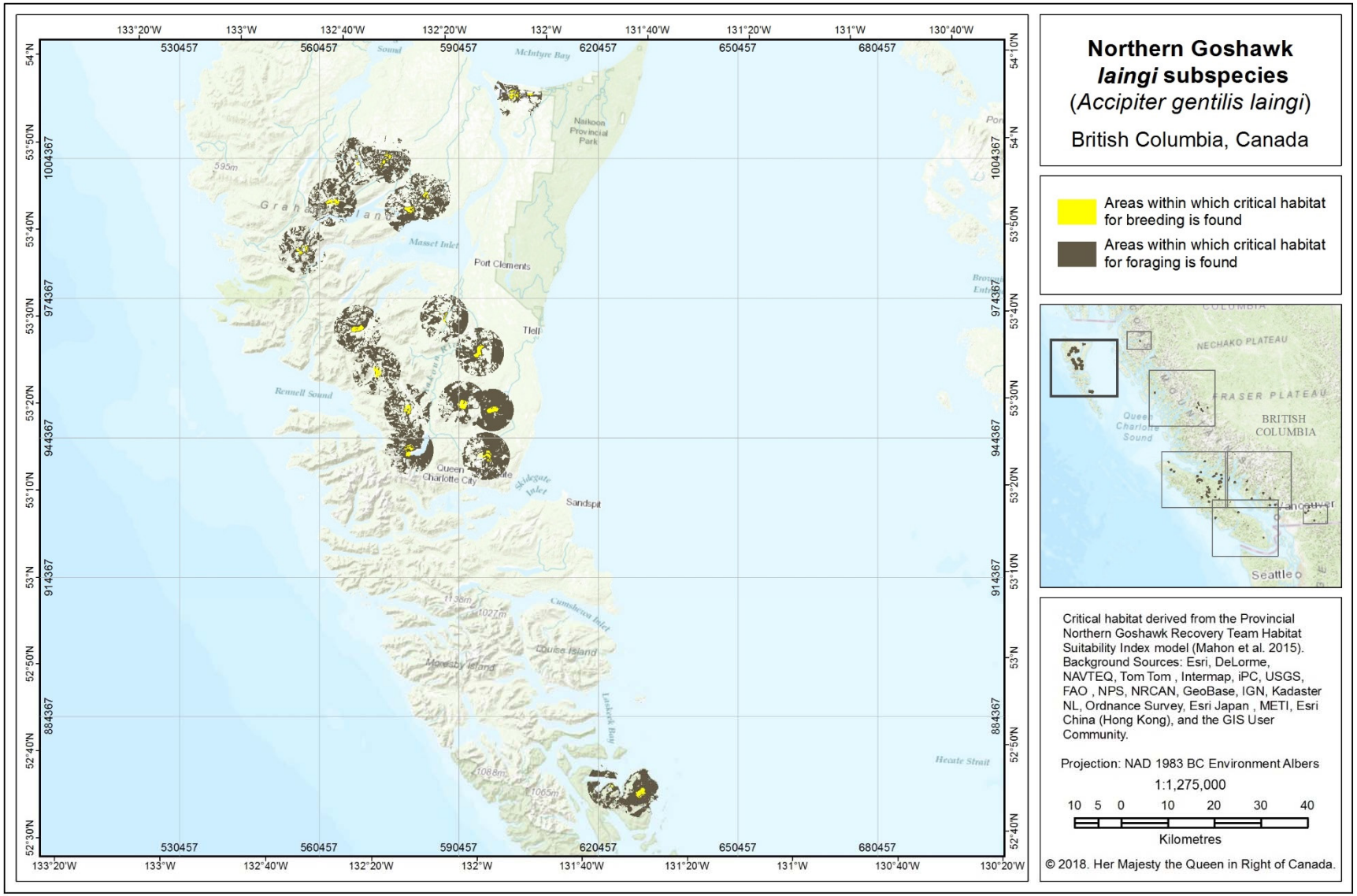

Figure B-3. Critical habitat for Northern Goshawk *laingi* subspecies in the northern reaches of the North Coast Conservation Region and the North Coast–Bella Coola sub-region.

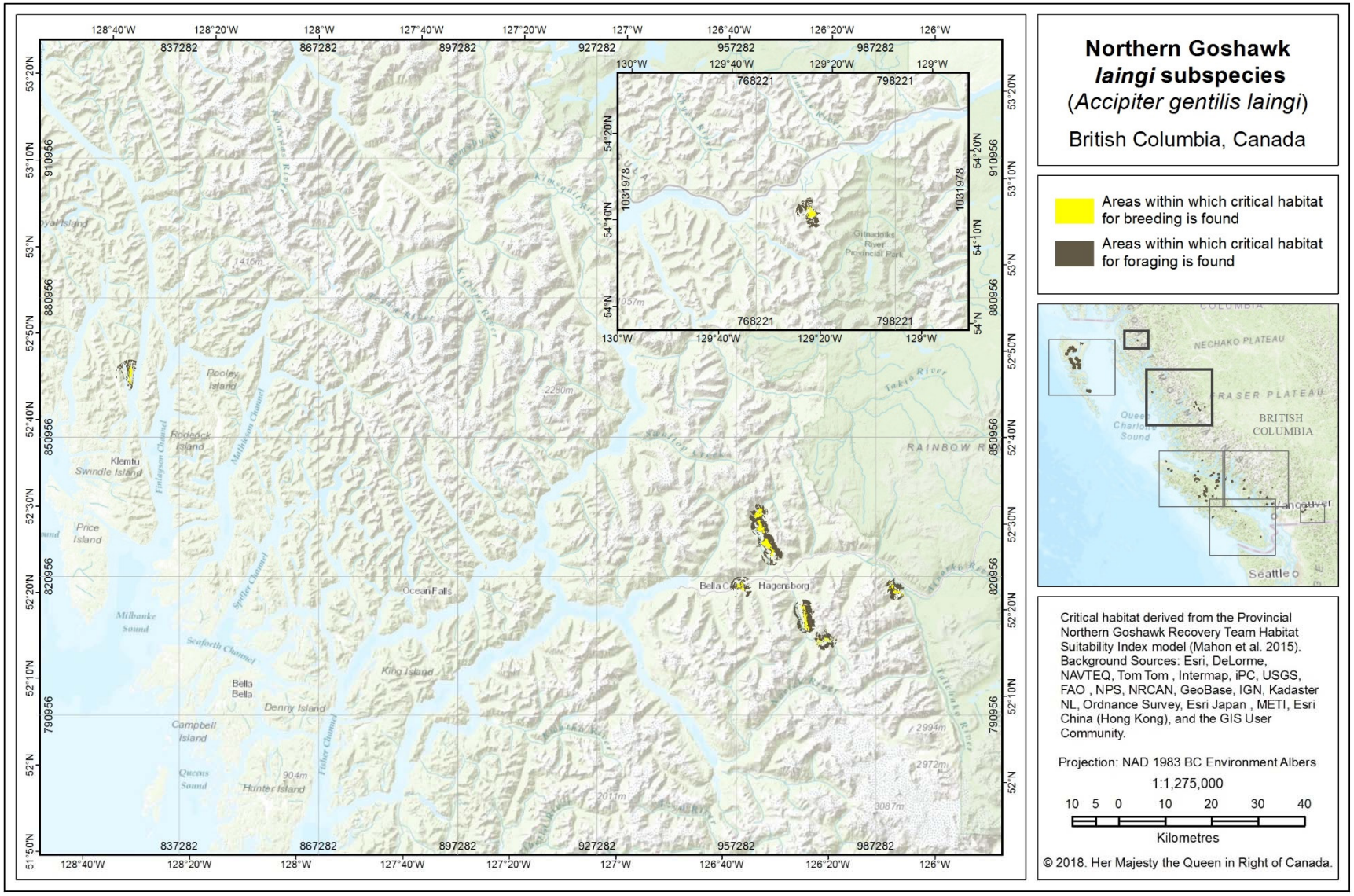

Figure B-4. Critical habitat for Northern Goshawk, *laingi* subspecies in the North Coast and Vancouver Island Conservation Regions and the Coastal Dry Ecosystem sub-region.

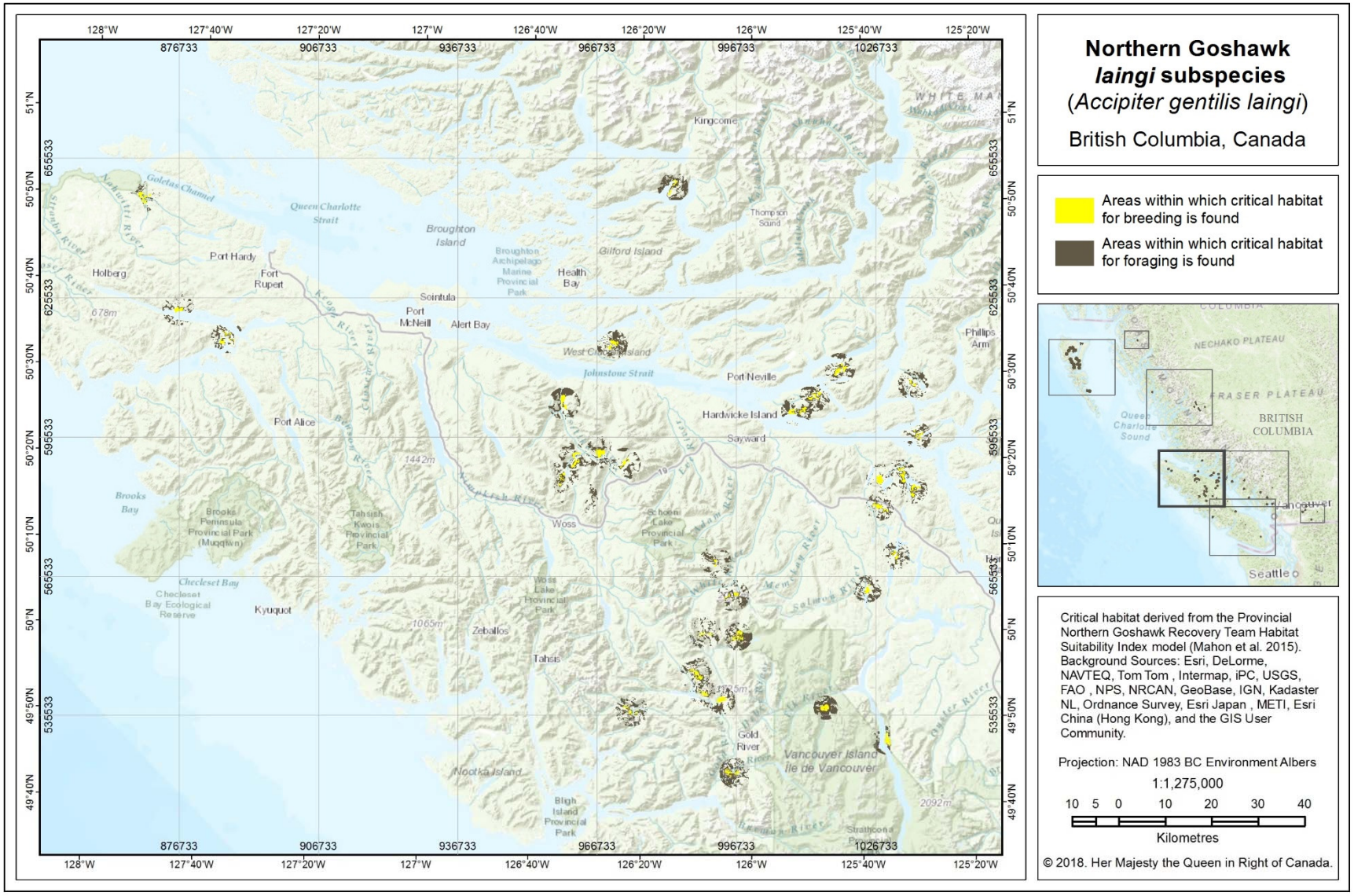

Figure B-5. Critical habitat for Northern Goshawk, *laingi* subspecies in the South Coast and Vancouver Island Conservation Regions and the Coastal Dry Ecosystem Zone sub-region.

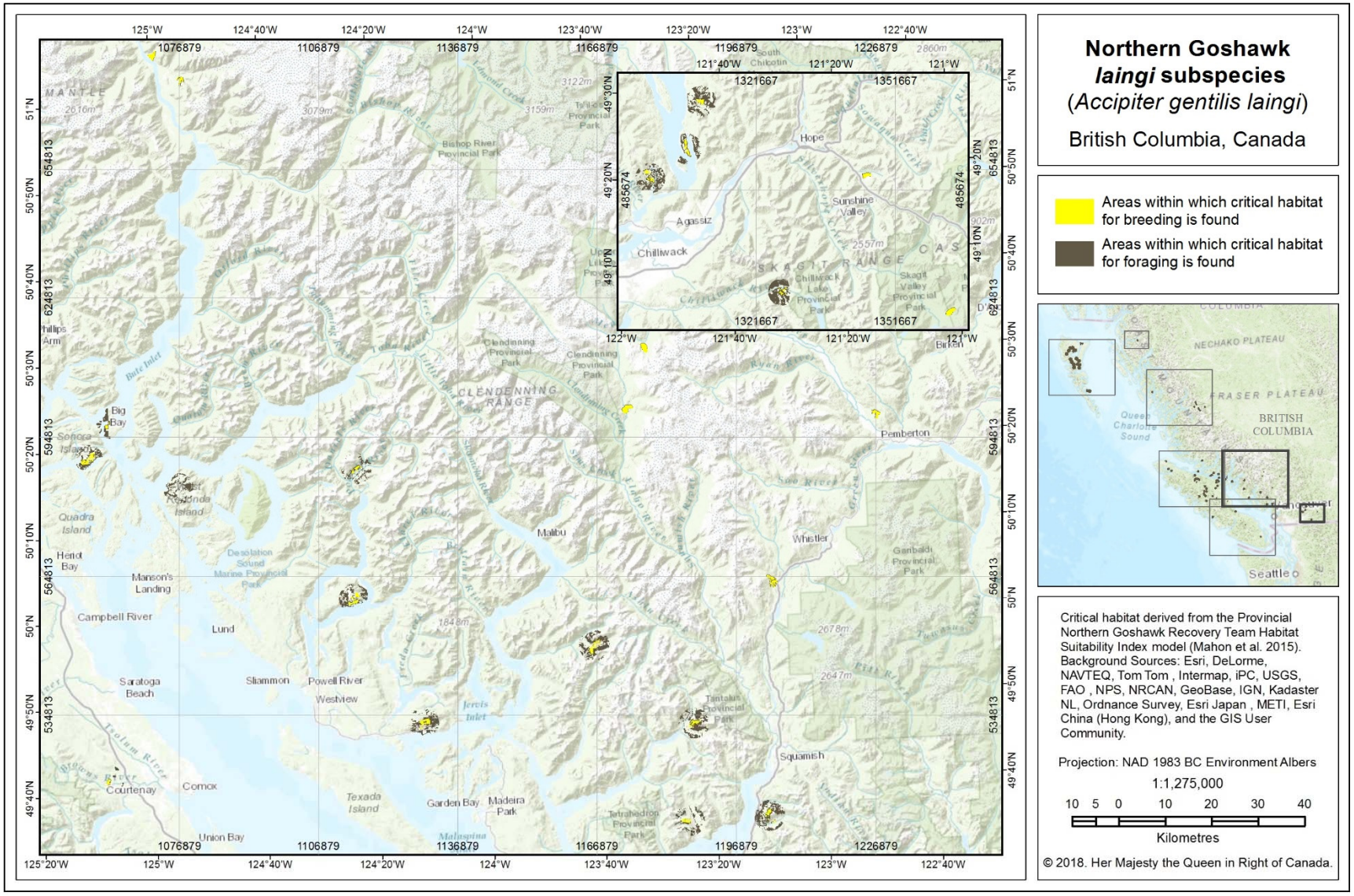

Figure B-6. Critical habitat for Northern Goshawk, *laingi* subspecies on the southern reaches of the Vancouver Island and South Coast Conservation Regions and the Coastal Dry Ecosystem Zone sub-region.

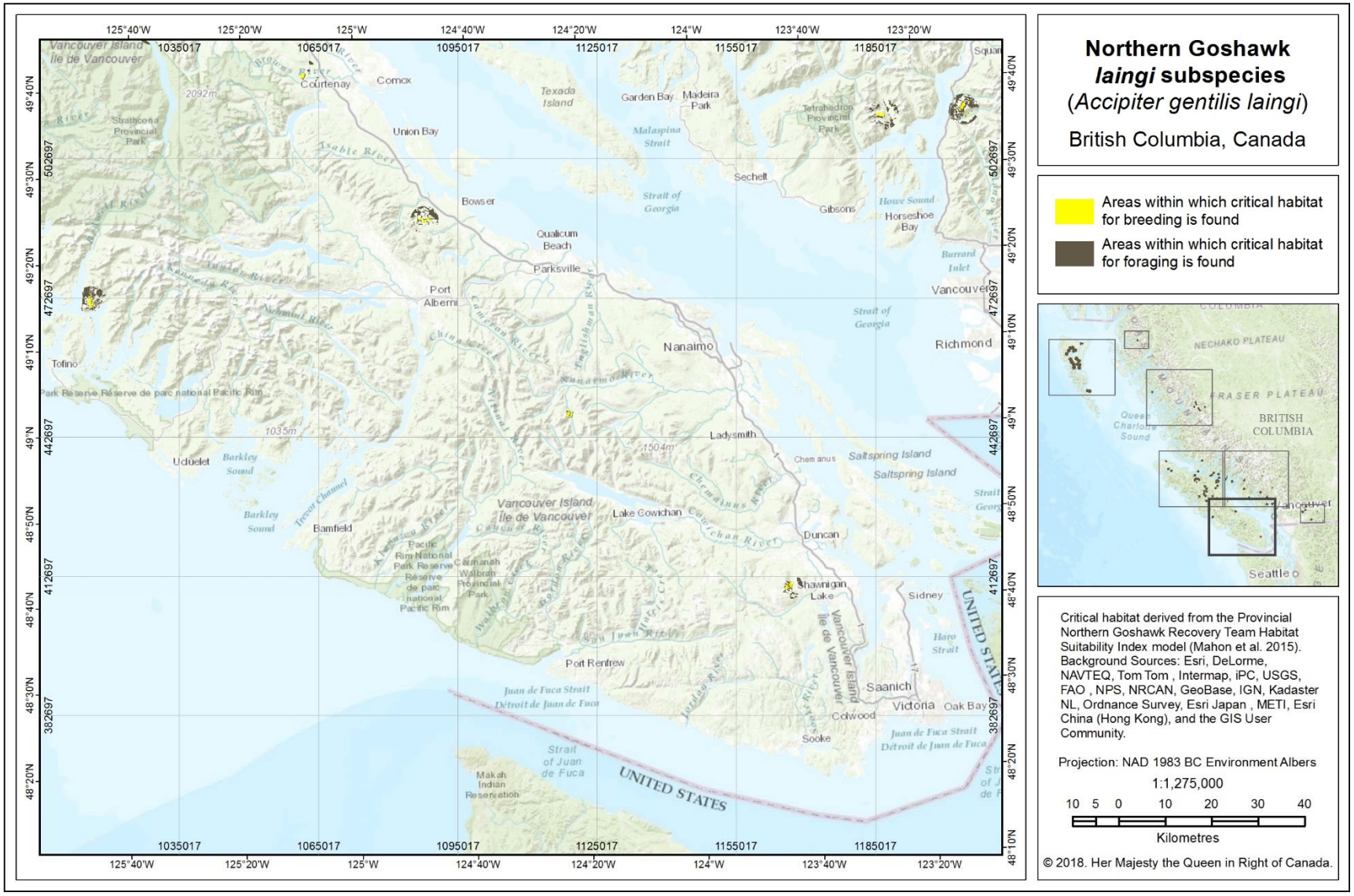

Table B-1. Location and amount of area within which critical habitat for breeding and foraging is found in each home range (n=110 home ranges).

Home Range	Conservation Region or Sub-region	Figure No.	Nest Centroid[1] X Coordinate	Nest Centroid[1] Y Coordinate	Amount of area within which critical habitat for breeding is found (ha)	Amount of area within which critical habitat for foraging is found (ha)
Ain*	Haida Gwaii	Figure B-2	579719.8969	993378.4499	174	3942
Black Bear	Haida Gwaii	Figure B-2	594981.7197	962828.0109	246	4770
Bonanza	Haida Gwaii	Figure B-2	572769.3218	958805.9823	200	3855
Crease	Haida Gwaii	Figure B-2	563268.7205	994962.4386	201	4333
Datlamen	Haida Gwaii	Figure B-2	568791.1792	967757.4813	240	4118
Delkatla*	Haida Gwaii	Figure B-2	603100.3057	1018036.7313	218	1799
Demon	Haida Gwaii	Figure B-2	579574.5056	950723.1420	168	3752
Florence Creek	Haida Gwaii	Figure B-2	587318.8681	970138.7639	58	3892
Ian	Haida Gwaii	Figure B-2	556785.6519	984715.2892	129	3120
Ian 990	Haida Gwaii	Figure B-2	574972.7504	1004244.6332	137	4166
Lignite Creek	Haida Gwaii	Figure B-2	568743.3114	1003845.7744	34	3692
Sandy Creek	Haida Gwaii	Figure B-2	623284.7293	869704.1455	30	3226
Skowkona	Haida Gwaii	Figure B-2	596290.3259	940449.6442	192	5564
Survey	Haida Gwaii	Figure B-2	597709.4306	950365.7403	223	5563
Three Mile	Haida Gwaii	Figure B-2	591203.7414	951475.4417	242	4397
Upper Hancock	Haida Gwaii	Figure B-2	583478.4479	996422.8382	88	4531
Windy Bay	Haida Gwaii	Figure B-2	629501.0558	867975.5473	250	4408
Yakoun Lake	Haida Gwaii	Figure B-2	579828.6504	941730.3671	202	4991
Alder Creek	North Coast	Figure B-3 (Inset)	780010.3879	1027138.0996	229	1282
Brooks Bay*	North Coast	Figure B-4	1034804.3224	606943.6762	69	1129
Forward Harbour	North Coast	Figure B-4	1019053.3336	610362.5647	220	1251
Hardwicke Island 1	North Coast	Figure B-4	1009660.1727	601173.4269	239	1214
Hardwicke Island 2	North Coast	Figure B-4	1013691.8286	604384.1789	168	1316

Home Range	Conservation Region or Sub-region	Figure No.	Nest Centroid[1] X Coordinate	Nest Centroid[1] Y Coordinate	Amount of area within which critical habitat for breeding is found (ha)	Amount of area within which critical habitat for foraging is found (ha)
Kwatzi Bay	North Coast	Figure B-4	983029.2161	649360.3208	115	1482
Princess Royal Is.	North Coast	Figure B-3	826765.3134	864309.0561	160	742
West Cracroft	North Coast	Figure B-4	969937.9639	615444.6177	173	1537
Nusatsum East	North Coast-Bella Coola	Figure B-3	971881.2708	813567.6396	159	907
Nusatsum North	North Coast-Bella Coola	Figure B-3	972346.6560	810585.9015	182	907
Nusatsum South UK & Nusatsum South	North Coast-Bella Coola	Figure B-3	976538.8181	807313.4263	109	824
Saloompt Central	North Coast-Bella Coola	Figure B-3	962467.5543	831660.8268	225	907
Saloompt Central 2	North Coast-Bella Coola	Figure B-3	962026.0616	834446.4349	224	907
Saloompt fireblock	North Coast-Bella Coola	Figure B-3	964962.8623	825598.2900	91	907
Saloompt South UK	North Coast-Bella Coola	Figure B-3	963651.3121	828087.4956	245	907
Snootli Creek	North Coast-Bella Coola	Figure B-3	958391.9576	818639.7902	134	730
Talchako*	North Coast-Bella Coola	Figure B-3	991507.5056	818124.8921	152	899
Anderson Lake*	Vancouver Island		1103524.7071	407389.5990	0	0
Cervus Creek	Vancouver Island	Figure B-4	1015970.4105	537155.9172	191	1668
China Creek*	Vancouver Island	Figure B-6	1102099.3472	458981.3824	0	1
Claude Elliot*	Vancouver Island	Figure B-4	959229.1349	586901.6852	88	966
Clayoquot Sound	Vancouver Island	Figure B-6	1016040.1622	471704.8101	163	1193
Colony Lakes*	Vancouver Island	Figure B-4	887100.5553	617041.7518	157	852
Consort Creek	Vancouver Island	Figure B-4	996040.6297	561333.9118	133	1083
Conuma River	Vancouver Island	Figure B-4	974105.6303	536592.1861	125	1239
Derby	Vancouver Island	Figure B-4	959597.1157	602765.5632	189	1586
Elbow Creek	Vancouver Island	Figure B-4	997128.4559	552448.1705	251	1668
Garbage Creek*	Vancouver Island		1140076.2676	398006.0272	0	0
Gerald Creek	Vancouver Island	Figure B-4	992174.8933	568626.9231	58	917

Home Range	Conservation Region or Sub-region	Figure No.	Nest Centroid[1] X Coordinate	Nest Centroid[1] Y Coordinate	Amount of area within which critical habitat for breeding is found (ha)	Amount of area within which critical habitat for foraging is found (ha)
Loon Lake*	Vancouver Island		938457.2223	581169.7360	0	0
Lukwa*	Vancouver Island	Figure B-4	963400.5490	582515.8690	0	142
Mt. Edinburgh*	Vancouver Island		1115739.1474	403760.6305	0	0
Nadira 700*	Vancouver Island		1101651.9915	442404.9643	0	0
Nahmint*	Vancouver Island		1074261.1158	459163.0774	0	0
Norton Point	Vancouver Island	Figure B-4	876578.1574	622966.7631	141	720
Oktwanch	Vancouver Island	Figure B-4	987969.1223	544435.6589	237	1206
Shushartie Bay	Vancouver Island	Figure B-4	869217.8035	647221.2375	211	540
Tlatlos	Vancouver Island	Figure B-4	972586.5138	589770.3571	101	896
Tsitika	Vancouver Island	Figure B-4	967344.7598	592241.6515	236	1012
Tsitika West	Vancouver Island	Figure B-4	961876.3810	591137.0466	217	1213
Twaddle Lake	Vancouver Island	Figure B-4	989901.0254	553172.9849	77	909
Ucona River	Vancouver Island	Figure B-4	996337.5994	523154.4043	196	1668
Bear Creek	South Coast	Figure B-5 (Inset)	1309685.7723	504829.2255	106	1517
Brew Creek*	South Coast	Figure B-5	1204820.4341	564067.8197	244	244
Chehalis Woodlot*	South Coast	Figure B-5 (Inset)	1298797.1887	488336.9429	157	1557
Chilliwack River (Nesaqauatch)*	South Coast	Figure B-5 (Inset)	1327127.8577	463834.8952	94	1622
Furry Creek	South Coast	Figure B-5 & B-6	1204044.1164	513293.4597	134	1602
Goat Island	South Coast	Figure B-5	1114527.4825	559967.3462	233	1216
Harrison Lake	South Coast	Figure B-5 (Inset)	1306629.5217	494669.7475	173	1052
Homathco 2*	South Coast	Figure B-5	1076932.7714	672057.1100	113	113
Homathco 3*	South Coast	Figure B-5	1070806.5054	676802.2438	158	158
Lillooett River*	South Coast	Figure B-5	1227647.6666	599915.2614	160	160
McNab Creek	South Coast	Figure B-5 & B-6	1186799.4532	512130.1729	116	876

Home Range	Conservation Region or Sub-region	Figure No.	Nest Centroid[1] X Coordinate	Nest Centroid[1] Y Coordinate	Amount of area within which critical habitat for breeding is found (ha)	Amount of area within which critical habitat for foraging is found (ha)
PD 203	South Coast	Figure B-5	1114996.7024	588024.7513	96	754
Red Tusk Creek	South Coast	Figure B-5	1187752.6331	533140.7597	155	1417
Saltery Bay ST048	South Coast	Figure B-5	1129506.8923	533172.5606	216	1292
Skyline Trail*	South Coast	Figure B-5 (Inset)	1363724.9570	459869.8328	202	202
Stewart Island*	South Coast	Figure B-5	1062241.3557	597705.6799	51	377
Upper Elaho 1*	South Coast	Figure B-5	1173620.8009	601067.6571	237	237
Upper Elaho 2*	South Coast	Figure B-5	1176749.2162	614111.1476	197	197
Vancouver River	South Coast	Figure B-5	1166242.5239	549840.4224	206	1544
West Hope Slide*	South Coast	Figure B-5 (Inset)	1344855.8261	488676.3399	131	131
West Rhodonda*	South Coast	Figure B-5	1076790.2281	583756.9857	0	977
Cook Creek*	Coastal Dry Ecosystem Zone	Figure B-6	1087884.5642	489409.7636	120	953
Corrigan Creek*	Coastal Dry Ecosystem Zone		1095816.9584	448222.0686	0	0
Dorr Lake*	Coastal Dry Ecosystem Zone	Figure B-5	1057443.2592	590124.7865	262	998
Dove Creek*	Coastal Dry Ecosystem Zone	Figure B-5 & B-6	1061902.4989	520820.0879	72	126
East Thurlow	Coastal Dry Ecosystem Zone	Figure B-4	1035696.5886	595745.9221	108	860
Frost Lake*	Coastal Dry Ecosystem Zone		960057.0204	572123.4096	0	0
Gold Park	Coastal Dry Ecosystem Zone	Figure B-4	993499.4977	538730.9011	181	1092
Great Central Lake B*	Coastal Dry Ecosystem Zone		1063639.4443	479021.1315	0	0
Green River*	Coastal Dry Ecosystem Zone	Figure B-6	1118958.3650	447840.5510	97	97
Hoomak Lake*	Coastal Dry Ecosystem Zone		962712.0718	575944.2790	0	0
John Road*	Coastal Dry Ecosystem Zone		964493.2468	566616.3805	0	0
Kaipit Road*	Coastal Dry Ecosystem Zone		945297.0429	579613.7835	0	0
Kelvin Creek*	Coastal Dry Ecosystem Zone	Figure B-6	1166322.2959	410595.2664	129	535
Klaklakama*	Coastal Dry Ecosystem Zone		966117.0030	572162.1581	0	0

Home Range	Conservation Region or Sub-region	Figure No.	Nest Centroid[1] X Coordinate	Nest Centroid[1] Y Coordinate	Amount of area within which critical habitat for breeding is found (ha)	Amount of area within which critical habitat for foraging is found (ha)
Lower Stella	Coastal Dry Ecosystem Zone	Figure B-4	1032259.3585	587667.0608	205	849
Lukwa South (CT060)*	Coastal Dry Ecosystem Zone	Figure B-4	960320.7264	578835.7102	0	8
Lupin Falls*	Coastal Dry Ecosystem Zone	Figure B-4	1029044.7493	530181.9554	181	658
Mclaughlin*	Coastal Dry Ecosystem Zone		1100126.6612	461569.4505	0	0
Muchalat Lake	Coastal Dry Ecosystem Zone	Figure B-4	989772.4974	540176.7431	109	696
Museum*	Coastal Dry Ecosystem Zone		1096154.8869	453041.9702	0	0
Paterson Lake	Coastal Dry Ecosystem Zone	Figure B-4	1024965.4565	562773.3080	118	1279
Pye Lake	Coastal Dry Ecosystem Zone	Figure B-4	1027736.9567	586671.3140	198	478
Roberts Lake	Coastal Dry Ecosystem Zone	Figure B-4	1027583.8842	580547.1916	191	885
Rona Loop*	Coastal Dry Ecosystem Zone		956858.4213	576098.5124	0	0
Surprise Lake	Coastal Dry Ecosystem Zone	Figure B-4	1031117.7888	569998.6294	114	878
Thomas Creek*	Coastal Dry Ecosystem Zone		1092216.8359	452181.4872	0	0
Toad Road*	Coastal Dry Ecosystem Zone		950164.9709	579225.5568	0	0
Upper Stella	Coastal Dry Ecosystem Zone	Figure B-4	1034864.6394	584283.7026	188	930
Vernon Ridge*	Coastal Dry Ecosystem Zone		968732.6489	561105.8301	0	0

[1] Nest centroid is the centroid of all known nest and supplementary nest locations for a breeding home range.
*Some critical habitat has not been identified due to insufficient available information or ongoing cooperation and consultation (see schedule of studies in Table 3).

Part 2 – *Recovery Strategy for the Northern Goshawk, laingi subspecies (Accipiter gentilis laingi) in British Columbia,* prepared by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team for the British Columbia Ministry of Environment

Recovery Strategy for the Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*) in British Columbia

Prepared by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

April 2008

About the British Columbia Recovery Strategy Series

This series presents the recovery strategies that are prepared as advice to the Province of British Columbia on the general strategic approach required to recover species at risk. The Province prepares recovery strategies to meet its commitments to recover species at risk under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada – British Columbia Agreement on Species at Risk*.

What is recovery?

Species at risk recovery is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

A recovery strategy represents the best available scientific knowledge on what is required to achieve recovery of a species or ecosystem. A recovery strategy outlines what is and what is not known about a species or ecosystem; it also identifies threats to the species or ecosystem, and what should be done to mitigate those threats. Recovery strategies set recovery goals and objectives, and recommend approaches to recover the species or ecosystem.

Recovery strategies are usually prepared by a recovery team with members from agencies responsible for the management of the species or ecosystem, experts from other agencies, universities, conservation groups, aboriginal groups, and stakeholder groups as appropriate.

What's next?

In most cases, one or more action plan(s) will be developed to define and guide implementation of the recovery strategy. Action plans include more detailed information about what needs to be done to meet the objectives of the recovery strategy. However, the recovery strategy provides valuable information on threats to the species and their recovery needs that may be used by individuals, communities, land users, and conservationists interested in species at risk recovery.

For more information

To learn more about species at risk recovery in British Columbia, please visit the Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

Recovery Strategy for the Northern Goshawk, *laingi* subspecies (*Accipiter gentilis laingi*) in British Columbia

Prepared by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team

April 2008

Recommended citation

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Cover illustration/photograph

Mike Stini. Adult female Northern Goshawk (*Accipiter gentilis laingi*) on Vancouver Island, British Columbia.

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

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Disclaimer

This recovery strategy has been prepared by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team, as advice to the responsible jurisdictions and organizations that may be involved in recovering the species. The British Columbia Ministry of Environment has received this advice as part of fulfilling its commitments under the *Accord for the Protection of Species at Risk in Canada*, and the *Canada – British Columbia Agreement on Species at Risk*.

This document identifies the recovery strategies that are deemed necessary, based on the best available scientific and traditional information, to recover Northern Goshawk, *laingi* subspecies, populations in British Columbia. Recovery actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. These goals, objectives, and recovery approaches may be modified in the future to accommodate new objectives and findings.

The responsible jurisdictions and all members of the recovery team have had an opportunity to review this document. However, this document does not necessarily represent the official positions of the agencies or the personal views of all individuals on the recovery team.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this strategy. The Ministry of Environment encourages all British Columbians to participate in the recovery of the Northern Goshawk, *laingi* subspecies.

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RESPONSIBLE JURISDICTIONS

The recovery strategy for Northern Goshawk, *laingi* subspecies was developed by the Northern Goshawk *Accipiter gentilis laingi* Recovery Team on behalf of the Province of British Columbia.

Northern Goshawk *laingi* subspecies populations occur throughout coastal forests of British Columbia, including some provincial and national parks. The British Columbia Ministry of Environment is responsible for producing a recovery strategy for this species under the *Accord for the Protection of Species at Risk in Canada.* Parks Canada Agency and Environment Canada's Canadian Wildlife Service participated in the development of this recovery strategy. In addition, Northern Goshawk *laingi* subspecies occurs in southeast Alaska and Washington and so their populations are considered trans-boundary to the United States. The U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game also participated in the preparation of this recovery strategy.

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EXECUTIVE SUMMARY

The Northern Goshawk is a raven-sized predatory bird with short, rounded wings and a long tail. Immature birds differ from adults in their plumage colouration for the first 2 years, after which all individuals ≥3 years are indistinguishable. Two subspecies of Northern Goshawk reside in Canada: *Accipiter gentilis laingi* and *A. gentilis atricapillus*. They were formerly referred to as Queen Charlotte Goshawk and Northern Goshawk, respectively. Originally, separation of the two subspecies was based on size and plumage colour, with *A. gentilis laingi* being smaller and having darker colouration than *A. gentilis atricapillus*. More recently, preliminary results from genetic analyses suggest coastal populations may be genetically distinct from interior populations and this difference may be greatest for populations inhabiting Haida Gwaii (Queen Charlotte Islands), British Columbia (B.C.) — the location of the original *A. gentilis laingi* type specimen. The focus of this recovery strategy is on the Northern Goshawk *laingi* subspecies, although the recovery team has also included relevant literature from studies on *A. gentilis atricapillus* and European Goshawks (*A. gentilis gentilis*).

Accipiter gentilis laingi is listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because of its estimated small breeding population size (<1,000 mature individuals) and perceived threats to its habitat, primarily from forest harvesting. Population estimates and trends are uncertain for this subspecies because it breeds at low densities and can be difficult to detect. *Accipiter gentilis laingi*'s selection of relatively large amounts of mature and old forests for nesting and foraging has caused conservation biologists to raise concerns. This has challenged resource managers to balance coastal forest management for timber resources and the maintenance of healthy *A. gentilis laingi* populations.

Accipiter gentilis laingi occurs within the Northwest coast of North America. In the United States, *A. gentilis laingi* occurs within coastal areas of Alaska and Washington and possibly Oregon and California. Within Canada, 100% of the range of *A. gentilis laingi* occurs within B.C., where it inhabits Haida Gwaii/Queen Charlotte Islands; Vancouver Island and coastal islands between Vancouver Island and mainland B.C.; and portions of the coastal mainland, west of the Coast Mountains. The recovery team has mapped the range of *A. gentilis laingi* to follow the Coastal Western Hemlock biogeoclimatic zone maritime variants. The precise range boundaries are unclear and there is likely some overlap between *A. gentilis laingi* and *A. gentilis atricapillus* where coastal forests transition to interior forests. To mitigate threats and implement recovery actions, the recovery team has divided *A. gentilis laingi*'s range into six conservation regions: (1) southeast Alaska (SEAK); (2) Haida Gwaii (HG); (3) North Coast, B.C. (NC); (4) South Coast, B.C. (SC); (5) Vancouver Island (VI); and (6) Western Washington (WA). The recovery team did not include California and Oregon in conservation regions because the occurrence of *A. gentilis laingi* within these areas is less certain. This document is a Canadian recovery strategy, so only those conservation regions within Canada (HG, NC, SC, and VI) will be addressed in this strategy, although the development of this strategy was based on relevant data collected within the United States and Canada. Until more information is available through habitat suitability and supply modelling, it is thought that approximately 54% of this subspecies current range (based on total landmass) is within Canada. Within B.C., about 47% is within the NC Conservation Region, 27% within the VI Conservation Region, 17% within the SC Conservation Region, and 9% within the HG Conservation Region.

No data exist on the historic or current changes in the distribution of *A. gentilis laingi*. There is no evidence to suggest major range contractions have occurred; however, small portions of its range (ca. 5%) have been permanently lost as a result of clearing forest lands for urbanization and agriculture, primarily within the VI, SC, and WA Conservation Regions. Harvesting of mature and old forests throughout this subspecies' range, reduced rotation periods between harvests, and changes in distributions and composition of prey species (e.g., introduced species) have likely influenced the distribution patterns of *A. gentilis laingi* over the past century.

Current and historic estimates of population abundance for *A. gentilis laingi* are imprecise. Estimates of population trends are uncertain for this subspecies because nest areas are difficult to monitor (low detection rates, high annual variability in occupancy, large distance between alternative nests) and survivorship data are lacking. Therefore, most estimates of abundance are inferred from relationships between breeding success and habitat characteristics, rather than from population parameter estimates and population modelling. Using estimates for the number of nest areas, the density of adjacent breeding pairs, and known annual occupancy rates, the recovery team estimated the number of breeding pairs within each conservation region as: 261–336 for SEAK, 48 for WA, 10–18 for HG, 71–75 for NC, 106–116 for SC, and 165 for VI. From these estimates, 661–758 breeding pairs are present range-wide: 352–374 in Canada and 309–384 in the United States. The recovery team and Recovery Implementation Groups (RIGs) will refine estimates of population abundance in B.C. using advanced techniques for modelling habitat and population levels as outlined in the critical habitat section. This work will contribute toward critical habitat delineation, which will be presented in an action plan.

The most imminent threats to populations of *A. gentilis laingi* within B.C. are related to the loss and fragmentation of nesting and foraging habitat, and subsequent reductions in prey diversity and availability. As well, 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 the HG Conservation Region, introduced species threaten *A. gentilis laingi* but are also a source of prey. Consequently, the overall effect of introduced species within this conservation region is unclear. Currently, the level of each threat within conservation regions is not well understood and more work will be necessary to evaluate these perceived threats.

Notwithstanding these threats, the recovery team considers the recovery of *A. gentilis laingi* to be biologically and technically feasible throughout its B.C. range. The recovery team based this assessment on the estimated size of the current breeding population, evidence of successful breeding throughout the species' B.C. range, and the ability to mitigate perceived threats and to recruit suitable habitat where necessary. The recovery team anticipates that there will be trade-offs between maintaining a sufficient amount of habitat for survival and recovery of populations of *A. gentilis laingi* and continuing to manage forests at current allowable annual cut levels and rotation periods within coastal B.C.

The long-term goal of this recovery strategy is to ensure that viable populations of *A. gentilis laingi* persist in each conservation region in coastal B.C. The recovery objectives are to (1) manage and, where necessary, conserve and recover habitat that meets the needs of *A. gentilis laingi* through its annual cycle; and (2) conserve and, where necessary, recover a well-distributed

and viable population of *A. gentilis laingi* within coastal B.C. These objectives are broad at this time because the recovery team lacks basic information on the amount of suitable habitat available historically, relative to current supply and predicted future supplies (under different management scenarios), as well as population responses to habitat supply over time. Therefore, the recovery team has outlined a number of activities in the critical habitat section that will help close these information gaps, refine population and habitat objectives, and delineate critical habitat for *A. gentilis laingi*.

Current recovery actions already underway include habitat suitability models that are being developed and verified by the Habitat Recovery Implementation Group (RIG) to determine habitat supply and distribution within the four Canadian conservation regions. Once habitat suitability is mapped, the RIG will use a territory model to predict how many pairs could potentially be supported within each conservation region. Habitat and territory models can be overlaid with a population model to estimate viable population size for each conservation region. The recovery team will use this information to set measurable population and distribution objectives, and to delineate habitat for the survival and recovery of populations within each conservation region.

Critical habitat will be defined within an action plan which will be completed within 2 years after approval of this recovery strategy. Ongoing and new inventory and monitoring programs enable the recovery team to evaluate breeding populations. Stewardship and outreach will be important components to the success of implementing this recovery strategy and subsequent action plan recommendations.

Terms in boldface type appear in the glossary at the end of this document. As well, unpublished reports cited within this document are available, where possible, at the Ministry of Forests website: <http://www.for.gov.bc.ca/hfd/library/index.htm>. Data statistics are reported as means ± standard errors, unless otherwise specified.

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Status Rankings

Species assessment information from COSEWIC

Common Name: Northern Goshawk, *laingi* subspecies
Scientific Name: *Accipiter gentilis laingi*
Status: Threatened
Reason for Designation: This small, **sedentary**[1] goshawk population has been negatively impacted by degradation of forested habitat.
Last Examination and Change: November 2000 up-listed from Special Concern to Threatened
Canadian Occurrence: British Columbia
Status History: Designated Special Concern in April 1995. Status re-examined and designated Threatened in November 2000. Last assessment based on an updated status report.

B.C. Conservation Data Centre

The Northern Goshawk, *laingi* subspecies, is ranked a globally (T2) and provincially imperilled subspecies (S2B; Natureserve 2007; B.C. Conservation Data Centre 2005).

United States

The status of *A. gentilis laingi* in southeast Alaska has had an extensive litigation history in U.S. courts beginning in 1994 and this debate is ongoing (Squires and Kennedy 2006; S. Brockman, pers. comm.). Currently, the Alaska Department of Fish and Game consider *A. gentilis laingi* as a species of Special Concern and the U.S. Fish and Wildlife Service (USFWS) consider *A. gentilis laingi* to be a Sensitive species in southeast Alaska (http://wildlife.alaska.gov/index.cfm?adfg=concern.goshawk). The Washington Department of Fish and Wildlife (WDF&W) only recognizes *A. gentilis atricapillus* to occur in Washington (Desimone and Hays 2004), although several researchers believe *A. gentilis laingi* reside in the coastal forests of western Washington (S. Finn, pers. comm.; S. Desimone, pers. comm.). The WDF&W consider Northern Goshawks[2] in Washington to be a State Candidate species because of concerns about its population status (Desimone and Hays 2004).

Description of the Species

Identification characteristics

Northern Goshawks are raven-sized (55–61 cm in length; Squires and Reynolds 1997) raptors with short, rounded wings and long tails; males are smaller than females. Although individuals

[1] **Terms in boldface type** appear in the glossary at the end of this document.
[2] "Northern Goshawk" within this document refers generically to both subspecies (*A. gentilis laingi* and *A. gentilis atricapillus*), unless the subspecies is specified.

may become sexually mature within their first year (Squires and Reynolds 1997), plumage characteristics differ between birds <3 years old (immatures) and ≥3 years old (adults). Adults have a conspicuous white eye-stripe that separates their black crown from their blue-grey back. Their chests are white with dense grey barring that appears light grey from a distance; their tails have bands of alternating grey and black. Adult eye-colour varies from orange to dark red, and generally becomes darker with age. Immatures have a faint white eye-stripe and are overall brown with chests that are buff-coloured with dark brown vertical streaks. Immature Northern Goshawks start with a blue-grey eye colour that turns yellow in their first year. These descriptions are based on those outlined by Squires and Reynolds (1997), National Geographic Society (1999), and Sibley (2000). Intermediate plumages between immature and adults are described by Bond and Stabler (1941) and Squires and Reynolds (1997). Goshawks can be aged from plumage characteristics until they are 3 years old; individuals ≥3 years have similar feather colouration and patterns (Bond and Stabler 1941).

Northern Goshawks may also be distinguished from most other raptors by their flight pattern of flap-flap-flap-glide and direct powerful flight within forests (Dunne *et al.* 1988), although other *Accipiter* species (*A. cooperii*, *A. striatus*) have similar flight patterns.

Taxonomic position

Two **subspecies** of Northern Goshawks are recognized in British Columbia based on morphological distinctions: *Accipiter gentilis atricapillus* and *A. gentilis laingi* (AOU 1957, 1983; Palmer 1988; COSEWIC 2000). The subspecies *A. gentilis laingi* was described from a type-specimen collected on Haida Gwaii/Queen Charlotte Islands (hereafter Haida Gwaii) by Taverner (1940) and was therefore formerly referred to as the Queen Charlotte Goshawk. Originally, *A. gentilis laingi* was considered a unique subspecies because adults and immatures had darker plumage than *A. gentilis atricapillus* (Taverner 1940). Later, *A. gentilis laingi* was also recognized to be smaller (Johnson 1989; Whaley and White 1994; Flatten and McClaren, in prep.). *Accipiter gentilis laingi* likely hybridizes with *A. gentilis atricapillus* along the range boundary between these two subspecies.

The ecological significance of the darker plumage and smaller size of *A. gentilis laingi* may be an adaptation to inhabiting the darker, denser coastal forests. Within coastal **habitats**, darker plumage may increase camouflage and enhance thermoregulation, and a smaller size may improve manoeuvrability. Compared with the interior subspecies of Northern Goshawk, *A. gentilis laingi* appears to consume more and smaller avian prey, and their smaller size may aid in the capture of such prey (Whaley and White 1994; Watson *et al.* 1998; Ethier 1999; Lewis *et al.* 2006).

Early genetic analyses of Northern Goshawks throughout North America detected little genetic variation throughout their range (Gavin and May 1996). However, early genetic techniques are now considered to be inappropriate for delineating subspecific differences (Andersen *et al.* 2003). Additionally, no genetic samples from Haida Gwaii or Vancouver Island were included in early analyses. More advanced genetic techniques are currently being conducted by the U.S. Geological Survey in Anchorage, Alaska (Sonsthagen *et al.* 2004; Talbot *et al.* 2005; S. Talbot, pers. comm.) and by UC Davis, California (Bayard de Volo *et al.* 2005; R.T. Reynolds, pers.

comm.). These analyses include samples of blood, eggshells, and feathers collected by researchers from areas within the range of *A. gentilis laingi* (Vancouver Island, Haida Gwaii, southeast Alaska, and the mainland coast of B.C.) and areas along the range boundary (interior Alaska and interior B.C.). Recent 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). Preliminary results from mtDNA suggest that populations in Haida Gwaii have two unique haplotypes and may have been isolated for >9,000 years (Talbot 2006).

To understand the genetic relationship among coastal populations, S. Talbot is conducting more detailed genetic analyses. To date, microsatellite DNA analyses suggest that Vancouver Island and coastal mainland B.C. populations are interbreeding. However, Vancouver Island and coastal mainland B.C. populations appear not to be interbreeding with interior B.C. populations. Although the recovery team requires more genetic samples from coastal mainland B.C., especially along the range boundary, it recognizes that an intergradation zone is likely along the range boundary of the subspecies where genetic delineations will be less clear.

Although the recovery team is not yet able to interpret the significance of Talbot's (2006) genetic analyses with respect to the status and distribution of *A. gentilis laingi*, it will consider these results to inform recovery actions within different conservation regions.

Distribution

Global distribution

Accipiter gentilis laingi occurs within the Pacific Northwest coast of the United States and Canada (Figure 1). In the United States, *A. gentilis 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 southeast Alaska, the core range for *A. gentilis laingi* occurs from Dixon Entrance, through the coastal mainland and islands of the Alexander Archipelago, north to Icy Strait and Lynn Canal (Iverson *et al.* 1996); a small portion of the range may also occur north of Yakutat Bay. The recovery team produced a map that reflects the best available information on the potential range of *A. gentilis laingi* using a combination of morphometric data, radio-telemetry data, and base mapping that reflected coastal habitat and prey types for this subspecies (Figure 1). Within this range map the recovery team identified a zone where coastal habitat types transition to interior habitat types, which reflects an area where differences between *A. gentilis laingi* and *A. gentilis atricapillus* are likely less clear. *Accipiter gentilis laingi* may occur within coastal Oregon and California but, until better information becomes available, these areas are not considered to be part of the range of *A. gentilis laingi*. Habitat base mapping data were extracted from ecoregional mapping from the Shining Mountains Project database[3] and biogeoclimatic ecosystem classification mapping for British Columbia (MacKinnon *et al.* 1992). The recovery team used base thematic mapper satellite imagery from B.C. and coverage produced by the WDF&W[4] to map the extent of urbanization and agriculture to reflect potential permanent range loss for *A. gentilis laingi*. Although there is currently no evidence of breeding

[3] <http://srmwww.gov.bc.ca/ecology/bei/shiningmtns.html>
[4] <http://wdfw.wa.gov/wlm/gap/landcov.htm>

by *A. gentilis laingi* within the urban/agricultural zone on the range map (see Rutz *et al.* 2006), the recovery team acknowledges that scattered pairs may breed within the area it is considering to be historic.

To mitigate threats and implement recovery actions, the recovery team identified six conservation regions within the global range of *A. gentilis laingi*: (1) southeast Alaska (SEAK); (2) Haida Gwaii (HG); (3) North Coast, B.C. (NC); (4) South Coast, B.C. (SC); (5) Vancouver Island (VI); and (6) Western Washington (WA) (Figure 1). The recovery team chose these conservation regions because they reflect differences in habitat types, prey species composition, and land use pressures, and therefore have unique threats (see Table 2).

Because this is a Canadian recovery strategy, only those conservations regions within Canada (HG, NC, SC, and VI) will be addressed in this strategy. However, this strategy was developed based on data collected within the United States and Canada.

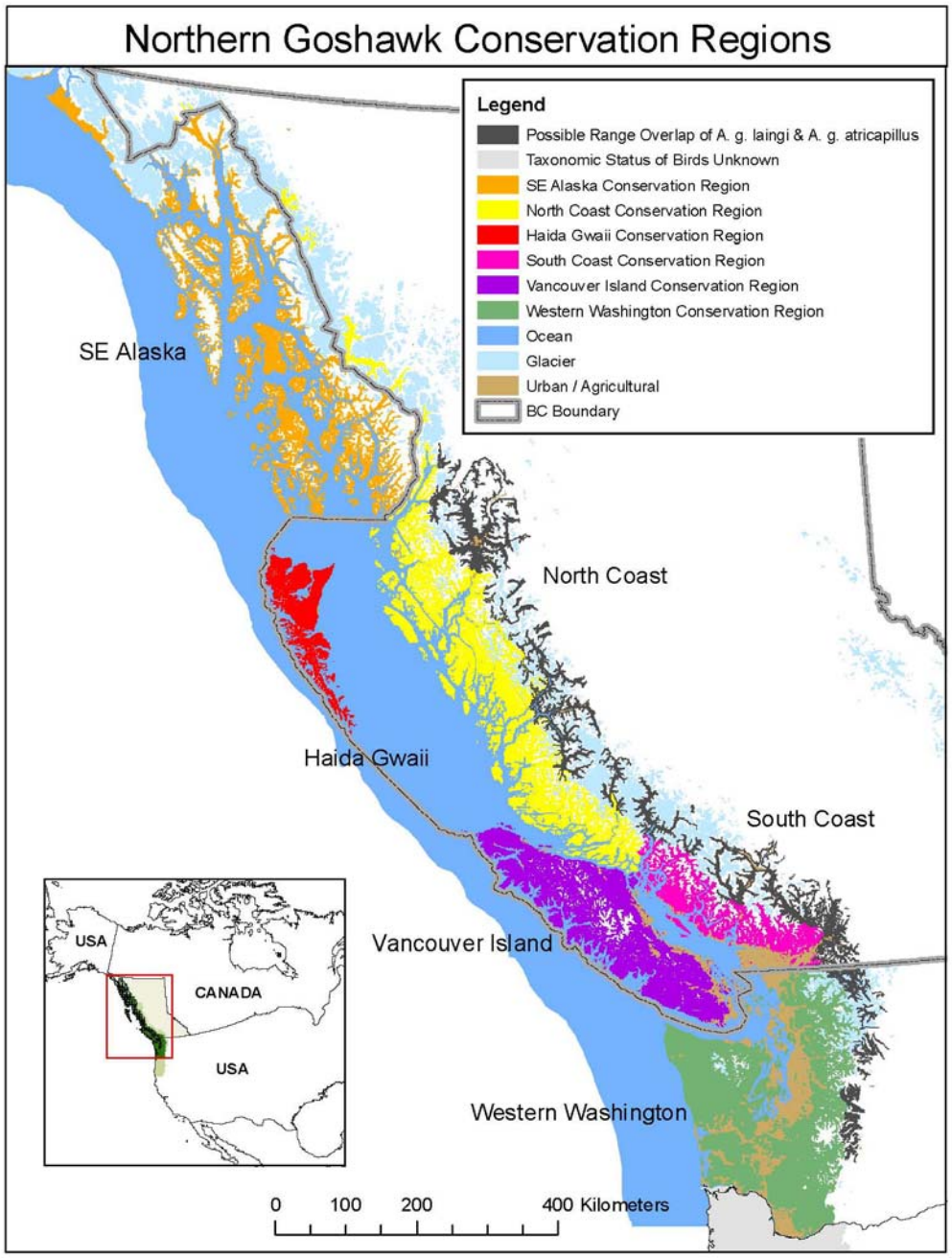

Figure 1. Range map for Northern Goshawk, *Accipiter gentilis laingi*. The British Columbia portion of the range of *A. gentilis laingi* reflects the distribution of wet Coastal Western Hemlock (CWH) biogeoclimatic subzones/variants and the Coastal Douglas-fir (CDF) biogeoclimatic zone. The recovery team has identified a zone (the drier variants of CWH on the coastal mainland) where *A. gentilis laingi* and *A. gentilis atricapillus* likely overlap. The recovery team used urbanization and agriculture as the best way to approximate the portions of the range of *A. gentilis laingi* that have been permanently lost, although the recovery team recognizes scattered pairs may be breeding within these areas. Four conservation regions (Haida Gwaii, North Coast, South Coast, and Vancouver Island) occur within Canadian jurisdiction (British Columbia) and two occur within U.S. jurisdiction (Western Washington and SE Alaska). The taxonomic status of individuals within coastal Oregon and California remains unknown. This recovery strategy will only address the Canadian portion of the range of *A. gentilis laingi*.

Canadian distribution

Within Canada, 100% of the range of *A. gentilis laingi* occurs within B.C. (Figure 1). Within B.C., this subspecies inhabits Haida Gwaii, Vancouver Island, the coastal islands, and the coastal mainland west of the Coast Mountains (AOU 1983; Campbell *et al.* 1990b; COSEWIC 2000; McClaren 2003). Within B.C., the range of *A. gentilis laingi* is divided among four conservation regions such that approximately 47% of current range (all of which may not be suitable habitat) is within the NC Conservation Region, 17% within the SC Conservation Region, 27% within the VI Conservation Region, and 9% within the HG conservation region. Until further information is available, the recovery team assumes the Canadian range of this subspecies follows the distribution of the Coastal Western Hemlock (CWH) and Coastal Douglas-fir (CDF) **biogeoclimatic subzones/variants** (Green and Klinka 1994). Within the NC and SC Conservation Regions, glaciated regions of the Coast Mountain Range likely form a divide between *A. gentilis laingi* and *A. gentilis atricapillus* populations. However, in less glaciated areas, drier CWH subzones link coastal forests to interior forests. The recovery team considers these drier CWH subzones/variants (CWHds1, CWHds2, CWHms1, CWHms2, CWHws1, CWHws2) to be transitional between subspecies. This transitional area accounts for 18% of the total B.C. range. A lack of substantial populations of Snowshoe Hare (*Lepus americanus*) within the CWH biogeoclimatic zone (Nagorsen 2005) suggests these forests may be less suitable for *A. gentilis atricapillus*. Using spatial data layers discussed in the "Global distribution" section, the recovery team calculated that about 3% of the B.C. range of *A. gentilis laingi* has been lost to urbanization and agriculture.

Proportion of distribution in Canada

Range boundaries for *A. gentilis laingi* are imprecise; therefore the exact percentage of the global population distribution within Canada is unknown. Using the *A. gentilis laingi* range map (Figure 1), it is estimated that approximately 50–60% of the total land mass occurs within Canada and 100% of Canada's distribution of this subspecies is within B.C.

Distribution trend

Historic and current changes in the distribution of *A. gentilis laingi* are unknown. Although small amounts (ca. 5%) of the range of this subspecies has been permanently lost from clearing forest lands for urbanization and agriculture along the southeast coast of Vancouver Island, lower mainland B.C. and Seattle, WA, there is little evidence to suggest this habitat loss has resulted in major range contractions. Nevertheless, the distribution patterns of Northern Goshawks in North America have likely been influenced over the past century by harvesting of mature and old forests, reduced rotation periods between harvests (second and third pass relative to first pass), and changes in distributions and composition of prey species (e.g., introduced species) (DeStefano 1998; Andersen *et al.* 2003; Kennedy 2003).

Population Abundance

Global abundance

Current and historic estimates of population abundance for *A. gentilis laingi* are imprecise because it is very difficult to estimate their survival and recruitment. Therefore, estimates of population abundance have been inferred from the number of pairs that a given amount of suitable habitat could support, breeding densities, as well as habitat suitability and supply modelling. Habitat suitability modelling has not been completed for VI, WA, and SEAK conservation regions, and therefore population estimates for these conservation regions are less certain than those for HG, SC, and NC conservation regions. The recovery team estimated the range of breeding pairs within each conservation region using the estimated number of **territories,** breeding densities, and measured annual occupancy rates (Table 1; see "Population trends" section). It is important to integrate occupancy rates and estimated number of pairs because not all **nest area**s are occupied annually by breeding pairs and research suggests that individuals, especially adult females, may use more than one nest area to breed over successive years (Iverson *et al.* 1996; McClaren 2003). This methodology assumes that breeding pairs are territorial and do not pack into available suitable habitat. Estimates of population abundance in B.C. will be refined with advanced techniques used to model habitat and populations (see "critical habitat" section).

COSEWIC's designation of Threatened for *A. gentilis 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). There is strong evidence to suggest that breeding densities of *A. gentilis laingi* are lower than those of *A. gentilis atricapillus* (Reynolds *et al.* 1994; Titus *et al.* 1994; Woodbridge and Detrich 1994; Doyle 2003a; McClaren 2003). Non-breeding individuals may play an important role in buffering populations of *A. gentilis laingi* from decline (Newton 1991; Iverson *et al.* 1996; Hunt 1998). In Finland, Lindén and Wikman (1983) estimated 35–52% of a population of European Goshawks (*A. gentilis gentilis*) to be non-breeders. Non-breeding floaters within populations play an important role to fill vacancies in nest areas when breeding individuals die; during periods of high prey availability, more individuals are available to occupy nest areas and produce young (Doyle and Smith 1994).

Until further genetic work suggests otherwise, the recovery team will assume that coastal populations of *A. gentilis laingi* are panmictic, except for individuals from Haida Gwaii, which may be genetically isolated from adjacent populations (Talbot *et al.* 2005; Talbot 2006).

Percentage of global abundance in Canada

Estimates of population abundance for *A. gentilis laingi* are imprecise. Based on the best available population estimates provided in Table 1 and the following population trends section, approximately 50% of the global population of *A. gentilis laingi* resides within Canada.

Population trends

Estimates of population trends are uncertain for *A. gentilis laingi* because nest areas are difficult to monitor (low detection rates, high annual variability in occupancy, large distance between alternative nests) and survivorship data are lacking from several conservation regions (Doyle 2003a; McClaren 2003; McClaren *et al.* 2003).

Table 1. Estimated number of breeding pairs of *A. gentilis laingi* within each conservation region.

Country	Conservation region	Estimated # of potential territories	Territory occupancy rates	Territory spacing $\bar{x} \pm$ se (range)	Estimated # of breeding pairs
Canada	Haida Gwaii	24–43[a]	43%[b]	10.8 ± 0.6 km[c]	10–18
Canada	North Coast, B.C.	130–136	unknown, applied VI's 55%[d]	unknown, used HG's estimate of 10.8 km	71–75
Canada	South Coast, B.C.	193–210	unknown, applied VI's 55%	unknown, used VI's estimate of 6.9 km	106 - 116
Canada	Vancouver Island	300[e]	55%	6.9 ± 0.7 km[f]	165
TOTAL	**CANADA**				**352–374**
USA	Southeast Alaska	580–747[g]	45%[h]	10.5 (7–15.2)[i]	261–336
USA	Washington	120[j]	40%[k]	unknown	48
TOTAL	**UNITED STATES**				**309–384**
TOTAL	**RANGE WIDE**				**661–758**

Note: The number of potential territories modelled for HG, NC, and SC conservation regions was based on a medium habitat threshold of >40% moderate and high foraging habitat suitability within territories (Mahon *et al.* 2007; Smith *et al.* 2007).

[a] Holt (2004); [b] Doyle (2005); [c] Doyle (2003a); [d] McClaren (2003) [e] COSEWIC (2000); [f] McClaren (2003); [g] USFWS (2007); [h] Flatten *et al.* (2001); [i] Iverson *et al.* (1996); [j] S. Finn, pers. comm., 2005; T. Bloxton, pers. comm., 2005 [k] Finn *et al.* (2002).

Habitat Needs of the Northern Goshawk

Home ranges of breeding Northern Goshawks are described as a hierarchical arrangement of biological components including the nest area (nest trees), **post-fledging (family) area** (PFA), and **foraging area** (Reynolds *et al.* 1992; Kennedy *et al.* 1994; McClaren *et al.* 2005; Figure 2). Threats to these habitat components should be mitigated simultaneously, because all components

are necessary to ensure successful breeding and survival, and to facilitate dispersal of juvenile Northern Goshawks. See the "Critical habitat" section for action plan.

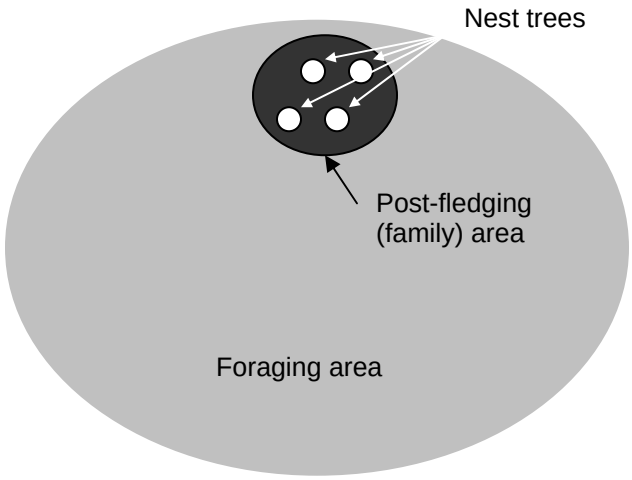

Figure 2. Graphical representation of the hierarchical components within home ranges of Northern Goshawks (revised from Reynolds *et al.* 1992). The location of nest trees and post-fledging areas are not necessarily centred within foraging areas.

Nesting habitat

Nest areas function to provide multiple nest trees, roost trees, and prey plucking posts, and they act as centres for courtship behaviours and fledgling movements during the post-fledging period (Reynolds *et al.* 1992). PFAs surround and include active nest trees and may correspond to the **core-use areas** of adult females and the area young birds use before they become independent of adults and leave their natal areas (Kennedy *et al.* 1994). The spacing pattern of alternative nest trees within home ranges, coupled with information from radio-telemetry of fledglings from 12 nests on Vancouver Island, suggests the size of the PFA for *A. gentilis laingi* is about 100–200 ha (McClaren *et al*. 2005). Because the biological role of post-fledging areas and nest areas appear to be functionally similar (McClaren *et al.* 2005), these areas will be considered as one in this document.

In general, *A. gentilis laingi* select nesting habitat based on stand structure rather than on stand age and species composition per se. Universal characteristics of nest stands of Northern Goshawks throughout North America include mature and old forests, closed canopies (≥50%), and relatively large diameter trees (Iverson *et al.* 1996; Squires and Reynolds 1997; Daw *et al.* 1998; Ethier 1999; Andersen *et al.* 2003; Kennedy 2003; Greenwald *et al.* 2005). Goshawks select nest trees with structural attributes that will support their relatively large stick nests (ca. 1-m diameter; E. McClaren, unpublished data) and these often include trees with deformities and sometimes snags. Within VI and SC conservation regions, forests may reach these characteristics on productive growing sites at >50–60 years whereas within NC and HG conservation regions, forests do not obtain these characteristics until >80–100 years (McClaren 2003; Doyle 2006). At

a larger scale, *A. gentilis laingi* typically nest >200 m from **hard edges** and in stands that are >100 ha (Ethier 1999; McClaren and Pendergast 2003). *Accipiter gentilis laingi* nest at elevations between 0 and 900 m, on moderate slopes (<50%) and typically within the mid- to lower mesoslope position (McClaren 2003; Doyle 2005). Suitable biogeoclimatic zones for breeding throughout the range of *A. gentilis laingi* include the Coastal Western Hemlock and Coastal Douglas-fir biogeoclimatic zones (McClaren 2003). Maritime variants of the Coastal Western Hemlock zone constitute the core part of the range of *A. gentilis laingi,* whereas submaritime variants form the transitional zone where both subspecies likely occur.

Foraging habitat

Foraging areas make up the majority of Northern Goshawk breeding home ranges; within these areas, adults and dispersing immatures hunt. Foraging areas may include nest trees and PFAs. As well, individuals within a pair may have entirely different foraging areas from each other (Boal *et al.* 2003) and they may change their foraging areas among 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 *A. gentilis laingi* 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. However, Bloxton (2002) reported that *A. gentilis laingi* on the Olympic Peninsula, Washington, concentrated foraging activities within 5 km of active nests and within only 15% of their entire breeding home range. On the Olympic Peninsula, average breeding season home range size for males and females (breeders and non-breeders combined) was 3710 ± 688 ha (n = 14; range: 844–8676 ha; Bloxton 2002). In southeast Alaska, median breeding home ranges for *A. gentilis laingi* were 4,300 ha (n = 16) for females and 4,600 ha (n = 20) for males (S. Lewis, unpublished data). It is important to consider foraging habitat for both members of a pair because Boal *et al.* (2003) reported that breeding home ranges of 10 pairs of *A. gentilis atricapillus* in Minnesota overlapped ≤50% within pairs. Home ranges of *A. gentilis laingi* appear to be larger than for *A. gentilis atricapillus* likely because prey densities are lower throughout coastal forests (Crocker-Bedford 1994; Titus *et al.* 1994; USFWS 1997; Boal *et al.* 2003).

In general, it is more difficult to discern unique patterns of habitat selection by Northern Goshawks at larger 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. However, most studies suggest somewhere between 40 and 60% of suitable foraging habitat within home ranges of Northern Goshawks will support a pair over time (Reynolds *et al.* 1992; Patla 1997; Finn *et al.* 2002; Doyle 2005). Northern Goshawks are morphologically and behaviourally adapted for using the flight space between forest canopies and understorey vegetation (see the “Hunting behaviour and prey availability” section). Therefore, foraging habitats are similar to nesting habitats and are characterized by closed

canopies, relatively large diameter trees, and open understoreys (Beier and Drennan 1997; Bloxton 2002; Drennan and Beier 2003; Boal *et al.* 2005) — attributes that provide for flight space and access to prey. Radio-telemetry data suggest that Northern Goshawks also forage in areas where they do not nest, including forest edges, riparian areas, estuaries, and elevations >900 m (Iverson *et al.* 1996; Bloxton 2002; McClaren 2003; Squires and Kennedy 2006).

Winter habitat

Foraging habitat attributes for *A. gentilis laingi* in the winter are poorly understood. In southeast Alaska, *A. gentilis laingi* expanded its breeding home ranges during winter to a median size of 14,700 ha (n = 18) for females and 13,400 (n = 14) for males (S. Lewis, unpublished data). Radio- and satellite-telemetry work on Vancouver Island and in southeast Alaska suggests foraging habitat characteristics for *A. gentilis laingi* in winter are similar to the breeding season, although some individuals may use subalpine forests to follow altitudinal gradients in prey, and use shoreline habitats (Iverson *et al.* 1996; McClaren 2003). It is unknown whether winter habitat for juvenile Northern Goshawks differs from adults.

Dispersal habitat

Habitat characteristics that facilitate successful dispersal for *A. gentilis laingi* are unknown. The recovery team assumes these characteristics are similar to foraging habitat characteristics because some studies suggest immature *A. gentilis atricapillus* are more vulnerable to depredation and starvation in areas with low canopy closure and low prey abundance and availability (Wiens *et al.* 2006). The spatial configuration between dispersal habitat of Northern Goshawks and where individuals first breed is unknown, but it is reasonable to assume that large distances between suitable breeding areas will reduce successful dispersal.

Roosting habitat

Little information is available for the habitat characteristics of roost sites for *A. gentilis laingi*. A recent study on *A. gentilis atricapillus* in California reported roost trees to be in stands that had similar canopy closure and tree diameter to nests but had higher tree densities than nest stands (Rickman *et al.* 2005). Roost trees were also smaller in diameter and lower in height than nest trees (Rickman *et al.* 2005).

Habitat trends

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 *A. gentilis laingi* (COSEWIC 2000; Doyle 2003a; Holt 2004; Smith *et al.* 2007). It is unclear whether the overall balance of suitable habitat for *A. gentilis laingi* will be stable, positive, or negative in future years as second-growth forests mature and become suitable habitat for this subspecies. However, many of these forests are also becoming commercially viable for harvesting. Current and predicted future amounts of suitable habitat throughout the Canadian range of *A. gentilis laingi*, relative to historic amounts, will be calculated and reported in an action plan (see the critical habitat section). Within southeast Alaska, approximately 15% of productive old-growth forests on national forest and private lands were harvested as of 1995 and second-growth forests are not

yet structurally suitable for nesting (Iverson *et al.* 1996). Coastal forests in Washington have had similar harvesting pressures as VI and SC conservation regions (Finn *et al.* 2002).

Biological Limiting Factors

Reproduction

Population trends and population estimates for goshawks are unclear and, as in many other species this is because the biological limiting factors are likely a combination of several biological traits including relatively low reproductive rates, low first year survival, late breeding age and relatively few reproductive years.

Most individuals initiate breeding at >2 years but some females breed at 1–2 years of age (Squires and Reynolds 1997; McClaren 2003). As the age of birds ≥3 years cannot be reliably determined (Bond and Stabler 1941), the exact age of most breeding birds captured is unknown. In a long-term study of known-age marked birds in Arizona, the average age that *A. gentilis atricapillus* were observed first breeding was 4.2 ± 0.3 years and 3.9 ± 0.3 years for females and males, respectively (Wiens *et al.* 2006). Northern Goshawks are **socially monogamous**, territorial, **non-colonial**, **synchronously breeding** raptors (Kennedy 2003). During the winter and into the courtship period, females must reach a critical body mass required for egg laying (Marcström and Kenward 1981; Newton *et al.* 1983). Therefore, prey availability in late winter and early spring influences the onset of breeding each year (Keane 1999). Females obtain nearly all food from mates during the pre-laying, incubation, and brooding periods (Duncan and Kirk 1994; Iverson *et al.* 1996). Cool, wet weather in the spring may cause egg-chilling and nestling mortality directly or it may indirectly cause nest failure by limiting foraging opportunities of males (Kostrzewa and Kostrzewa 1990; Penteriani 1997; Bloxton 2002). Average clutch size for *A. gentilis laingi* is unknown. The clutches of *A. gentilis atricapillus* in North America average 2.7 eggs with a range from 1 to 5 eggs (Squires and Reynolds 1997). Females lay only one clutch per breeding season (Squires and Reynolds 1997). Lifetime reproductive success for *A. gentilis laingi* is unknown but high turnover rates of adult females within nest areas on Vancouver Island (78.9%, n = 57) suggest it could be low (McClaren 2003). A long-term study on European Goshawks reported adult females to breed for a median of 2 years of their lifespan and produce a median of two nestlings over this time (Krüger 2005). Likewise, in Arizona, females and males spent an average of 2.18 ± 0.11 years and 1.96 ± 0.11 years, respectively, as breeders (Wiens and Reynolds 2005).

Mean nest productivity for *A. gentilis laingi* was 1.6 ± 0.1 fledglings per **active nest** (n = 141) for Vancouver Island from 1994 to 2002 (McClaren 2003), 1.5 ± 0.2 fledglings per active nest (n = 15) for Haida Gwaii from 1995 to 2004 (Chytyk and Dhanwant 1997; Doyle 2005), and 2.1 fledglings per active nest (n = 87) from 1991 to 1998 in southeast Alaska (Titus *et al.* 1999). Fledgling Northern Goshawks are fed by their parents for 35–55 days (McClaren *et al.* 2005) within nursery areas near nests called **post-fledging (family) areas** (**PFA**s) (Reynolds *et al.* 1992). The total time from egg laying until young initiate dispersal is between 100 and 127 days (Titus *et al.* 1994; Kennedy and Ward 2003; McClaren *et al.* 2005; Wiens *et al.* 2006).

Annual **occupancy rates** of nest areas for *A. gentilis laingi* are variable (HG: 43%, *n* = 35, Doyle 2005; WA: 40%, *n* = 50, Finn *et al.* 2002; SEAK: 45%, *n* = 283, Flatten *et al.* 2001; VI: 55%, *n* = 163, McClaren 2003), and generally, individual nest areas are occupied by breeding pairs once every 2–3 years. The actual occupancy rates are very difficult to determine because none of these estimates are adjusted for detection probability (MacKenzie *et al.* 2006), so the reported values likely represent minimum estimates. However, long-term monitoring of the same nest areas within each of these study areas has increased the probability of detecting birds earlier in the breeding season and has reduced the chance of detecting only successful breeders.

Breeding pairs space themselves regularly throughout suitable habitat, likely because of territoriality (McGowan 1975; Reynolds and Joy 1998; McClaren 2003; Reich *et al.* 2004; Doyle 2005). Breeding densities likely reflect prey availability and abundance (Newton 1979). Densities of *A. gentilis laingi* are low relative to those of *A. gentilis atricapillus* (Doyle and Smith 1994; Iverson *et al.* 1996; Doyle 2003b; McClaren 2003; Reich *et al.* 2004). Kennedy (1997) estimated the mean distance between adjacent breeding pairs for *A. gentilis atricapillus* to be from 3.0 to 5.6 km in North America whereas this distance is 6.9 ± 0.7 km (*n* = 16) between pairs of *A. gentilis laingi* on Vancouver Island (McClaren 2003) and is 11.3 ± 2.2 km (SD; *n* = 6) on Haida Gwaii (Doyle and McLennan 2003). These estimates need to be interpreted cautiously because they assume a census of the survey area and do not account for effective area surveyed (Roberson *et al.* 2005) or some other estimate of detection probability (MacKenzie *et al.* 2006).

Survivorship

Lifespan for *A. gentilis laingi* is unknown but the maximum lifespan reported for wild *A. gentilis atricapillus* is >15 years (R.T. Reynolds, pers. comm.). Mark-recapture analyses using radio-telemetry data from SEAK suggest mean annual survivorship of *A. gentilis laingi* adults (genders combined) to be 0.72 (*n* = 39; 95% CI: 0.56–0.88; Iverson *et al.* 1996), and 0.59 ± 0.10 (*n* = 31) for adult males only (K. Titus, unpublished data). Mean annual survival estimates reported for *A. gentilis atricapillus* (see review in Squires and Kennedy 2006) varies from 0.75 ± 0.02 in Arizona (Reynolds *et al.* 2004) and 0.86 ± 0.09 in New Mexico (Kennedy 1997) compared with 0.81 for *A. gentilis gentilis* (Kenward *et al.* 1999). Comparisons among subspecies are difficult because different studies employ different methods with different assumptions to calculate survivorship estimates. Although survival estimates after the first year do not exist for juvenile Northern Goshawks, mean survival for up to three months post-fledging for *A. gentilis atricapillus* hatched in Arizona was 0.71 (*n* = 89; 95% CI: 0.60–0.93; Wiens *et al.* 2006). In New Mexico and Utah, survival estimates ranged from 0.93 ± 0.06 (5.5 months post-fledging) to 0.56 ± 0.12 (3 months post-fledging; see review in Squires and Kennedy 2006). These studies suggest that food availability has the largest influence on fledgling survival during this time (Ward and Kennedy 1996; Dewey and Kennedy 2001; Wiens *et al.* 2006). Squires and Reynolds (1997) predict that survival of Northern Goshawks, like most raptors, is probably lowest during the first year of life. Sensitivity analyses of demographic parameters within population models for *A. gentilis laingi* suggest persistence of this subspecies would be sensitive to fluctuations in both adult and juvenile survivorship and to the proportion of females successfully nesting each year (Broberg 1997; USFWS 1997). Wiens *et al.* (2006) also suggested that populations of *A. gentilis atricapillus* are sensitive to juvenile survivorship because dispersing juveniles serve as an important mechanism for gene flow among populations.

Mortality

Populations of *A. gentilis laingi* experience the same general causes of mortality as other medium-sized raptors, including: starvation; depredation of adults, young, and eggs; **ectoparasites** and infectious diseases; prolonged periods of poor weather; competitive interactions; collisions; felling of active nest trees; and **persecution** (Marcström and Kenward 1981; Kostrzewa and Kostrzewa 1991; Patla 1997; Penteriani 1997; USFWS 1997; McClaren 2003). Individually, none of these factors are currently considered to threaten the subspecies. Pesticides and other contaminants, which were historically important causes of mortality, are no longer considered significant (Snyder *et al.* 1973; Havera and Duzan 1986; USFWS 1997; Cooper and Stevens 2000). Potentially new sources of mortality for *A. gentilis laingi* include epidemic disease from West Nile Virus (WNV) and other emerging diseases (see "Disease" under the "Threats" section). The degree to which each of the above mortality factors regulates *A. gentilis laingi* populations is unknown and probably varies by conservation region.

Recruitment and dispersal

Information on **recruitment** and **natal dispersal** in populations of Northern Goshawks is limited (USFWS 1997; Cooper and Stevens 2000; COSEWIC 2000; Squires and Kennedy 2006). No marked fledglings from VI (n = 59) or SEAK (n = 86) have joined their natal breeding populations (McClaren 2003; C. Flatten, unpublished data). Data from an 11-year study in Arizona suggest recruitment rates in *A. gentilis atricapillus* are very low (11%: 69 of 614 marked individuals; Wiens 2004).

Radio-tagged juvenile *A. gentilis laingi* were reported 11–162 km from natal sites on VI (n = 2; McClaren *et al.* 2005) and in SEAK (n = 14; Titus *et al.* 1994) during their first year. Distances between natal sites and breeding sites are unknown for this subspecies, although the median distance for *A. gentilis atricapillus* was 15 km (0.1–58.1 km) in Arizona (Reynolds *et al.* 2000; Wiens *et al.* 2006) and recoveries of dead birds up to 442 km from natal areas (Reynolds *et al.* 2000) suggest Northern Goshawks are capable of long-distance natal dispersal. However, water bodies between several populations of *A. gentilis laingi* may limit successful long-distance dispersal (e.g., nearest distance between HG and SEAK and between HG and NC Conservation Regions is 60 and 90 km, respectively).

Breeding dispersal of adult females appears to be more common in populations of *A. gentilis laingi* than in other subspecies and may result from poor-quality nesting areas or mates, the death or departure of a mate, low breeding densities, low annual productivity, or annual variation in food availability. For example, in SEAK, approximately 45% of radio-tagged adult females (n = 19) exhibited breeding dispersal compared with 5% for adult female *A. gentilis atricapillus* breeding in Northern Arizona (Reynolds and Joy 2006). Iverson *et al.* (1996) suggested that above-average site fidelity of males and higher breeding dispersal rates of female *A. gentilis laingi* in SEAK, compared to *A. gentilis atricapillus*, may reflect nest site scarcity for males and food stress for females. In general, both males and females exhibit site fidelity to nest areas, although pairs frequently use different nest trees within nest areas in consecutive breeding years. As long as sufficient nesting and foraging habitat exists within and near nest areas, *A. gentilis*

laingi pairs will continue to use nest areas over long periods (>10 years) (McClaren 2003; Doyle 2005).

Populations of *A. gentilis laingi* are characterized as non-migratory (Iverson *et al.* 1996; Bloxton 2002; McClaren 2003), although in some years adults may move from **breeding home ranges** to completely different **winter home ranges;** in other years adults will include their breeding home range within their winter home range (Iverson *et al.* 1996; McClaren 2003).

Hunting behaviour and prey availability

Northern Goshawk populations are described as being food-limited; prey availability and abundance are closely associated with landscape alterations, climate, and annual weather patterns (Squires and Reynolds 1997; McClaren *et al.* 2002; Keane *et al.* 2006; Reynolds *et al.* 2006). As well, food supply can indirectly be linked to competition for nest sites, siblicide rates, and depredation of adults or eggs (Estes *et al.* 1999; Dewey and Kennedy 2001).

Northern Goshawks possess morphological and behavioural adaptations for hunting within forested habitats (Squires and Reynolds 1997). Unlike Buteo hawks (e.g., Red-tailed Hawks, *Buteo jamaicensis*), Northern 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), manoeuvring between trees below the forest canopy. Northern Goshawks are generalist predators of medium-sized birds and mammals (Squires and Reynolds 1997). Pronounced differences in body size between the sexes (males are smaller than females) may help mates to partition food resources and reduce competition. Prey caching may also assist individuals in meeting their energetic requirements during times of low prey availability or low hunting success (Schnell 1958; Lewis *et al.* 2006).

Populations of *A. gentilis laingi* inhabit islands and dense coastal forests with a low abundance and diversity of prey available compared with the drier, interior forest habitats occupied by *A. gentilis atricapillus* (Roberts 1997; Ethier 1999; Doyle 2003b; Lewis *et al.* 2006). Mammalian prey items comprise a lower proportion of the prey of *A. gentilis laingi* than *A. gentilis atricapillus* (Watson *et al.* 1998; Ethier 1999; Bloxton 2002; Andersen *et al.* 2003; Lewis *et al.* 2006). Nevertheless, Red Squirrels (*Tamiasciurus hudsonicus*) dominate breeding season diets of *A. gentilis laingi* (Roberts 1997; Ethier 1999; Doyle 2003b; Lewis *et al.* 2006). Introductions of prey species and land use activities may have altered prey composition and availability throughout the range of this subspecies. Such changes may not have been uniform across conservation regions (see prey diversity and availability under the threats section). Little information is available on the winter diet of *A. gentilis laingi*.

Competition

The degree to which *A. gentilis laingi* populations are limited by **intra-specific and inter-specific competition** for nest sites and for food is unknown.

Ecological Role

Accipiter gentilis laingi 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. However, it is known that *A. gentilis atricapillus* and *A. gentilis gentilis* 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). Furthermore, *A. gentilis laingi* functions 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 forest raptor, *A. gentilis laingi* likely influences the spacing and distribution of other forest raptors (Krüger 2002). Northern Goshawks are often considered to be an indicator of mature forest ecosystem health because they require the structural complexity of these forests to breed and forage.

Importance to People

Northern Goshawks are prized by birdwatchers and wildlife photographers because they are a rare sight and an impressive forest predator. They are also an important indicator of old and mature forest biodiversity, which is valued by many Canadians. *A. gentilis laingi* were a part of the St'aawaas Xaaydagaay (Haida Cumshewa ruling family name) culture and were referred to as the "Blue Hawk," likely a result of its blue-grey plumage (Barb Wilson, pers. comm. 2004). Northern Goshawks are sought by falconers for their aggressive nature and impressive flight and hunting skills (Squires and Reynolds 1997).

Known and Perceived Threats

The threats and rankings in Table 2 are based on the best available scientific information and, where data were unavailable, are based on expert opinion and data-derived estimates. Some threats within this table are interrelated but have been separated to focus recovery actions. Rankings within this table will need to be re-evaluated over time and additional threats may need to be added.

Table 2. Identification and ranking (0 = no threat; 1 = low; 2 = moderate; 3 = high) of threats posed to *A. gentilis laingi* within each B.C. conservation region.

Threat	Conservation region rankings			
	HG	**NC**	**SC**	**VI**
Habitat loss-nesting	2	1.5	2	2.5
Habitat loss-foraging	3	1.5	2	3
Habitat fragmentation	3	1.5	2	3
Prey diversity*	3	1	1	2
Prey availability	3	1.5	2	2.5
Genetic isolation*	3	0.5	0.5	0.5
Introduced species	2	0	0	0
Depredation of adults, eggs, and young	1	1	1	1
Competition for nest sites	1	1	1	1

Climate change*	1	1	1	1
Human disturbance	1	1	1	1
Disease*	1	1	1	1
Persecution	1	0	0.5	0.5

*The recovery team considers that it will have limited success at mitigating these threats.

Nesting and foraging habitat loss and fragmentation

Two major threats to populations of *A. gentilis laingi* are the conversion of mature and old-growth forest to young **seral stages** (i.e., **habitat loss**) and **habitat fragmentation**. Land use activities that create small, isolated patches of suitable habitat surrounded by young, dense, even-aged stands with few large diameter trees and reduced tree, shrub, and herb diversity may be detrimental to *A. gentilis laingi* and its prey populations (Iverson *et al.* 1996; Cooper and Stevens 2000; Krüger and Lindström 2001; Kennedy 2003). The consequences of the reduction in habitat quantity and quality discussed above include (1) reduced availability of nest sites; (2) reduced ability for immatures to disperse; (3) increased risk of depredation of adults, eggs, and young; (4) reduced gene flow among local populations; (5) reduced prey abundance and availability; (6) increased inter-specific competitive interactions with edge-adapted and open habitat species for prey and nest sites; (7) decreased survival and productivity; (8) decreased carrying capacity of landscapes for breeding pairs; (9) increased disturbance from humans; and (10) loss of suitable microclimate conditions at nest sites (Iverson *et al.* 1996; Squires and Reynolds 1997; COSEWIC 2000; Cooper and Stevens 2000; Kennedy 2003). The USFWS (1997) hypothesized that populations of *A. gentilis laingi* may be more energetically stressed than *A. gentilis atricapillus* because of lower prey densities throughout their range, and therefore, they may be more sensitive to reductions in habitat quality.

The primary cause of habitat loss and fragmentation for populations of *A. gentilis laingi* within productive coastal forests is large-scale forest harvesting. As well, harvest rotation periods (which in productive forests may be 50–80 years) coincide with forests developing suitable characteristics for *A. gentilis laingi*. Extensive forest harvesting in eastern North America and parts of Europe dramatically reduced populations of Northern and European Goshawks in the late 1800s (Petty 1989; Widén 1997; Kennedy 1997, 2003). In comparison, large-scale harvesting is much more recent in coastal B.C., and most harvesting before 1940 was small-scale and occurred near human settlements (Mackie 2000; Pearse 2001). Industrialized forestry was adopted between 1940 and 1980 within coastal B.C. and the allowable annual cut (AAC) steadily increased during this time, causing accessible, low elevation old-growth forests to be converted to younger forests through clearcutting (Marchak *et al.* 1999; Pearse 2001). Within the VI and SC conservation regions, second-growth forests are being recruited as habitat for *A. gentilis laingi*, especially within the drier and very productive biogeoclimatic variants (CDF, CWHxm1, CWHxm2), as these forests reach structural characteristics suitable for nesting and foraging (McClaren 2003; Marquis *et al.* 2005). Forests within the NC and HG conservation regions have a more recent harvest history and slower growing conditions, which will likely lengthen the time that second-growth forests will require to become suitable habitat for *A. gentilis laingi* (Doyle 2006).

Ultimately, the rate and extent at which habitat for *A. gentilis laingi* is removed relative to its recruitment, and the levels of protection of currently suitable habitat, will determine the severity

of this threat to populations. The level of threat is not merely a calculation of the balance between habitat loss and recruitment because Northern Goshawks have high fidelity to their breeding areas and so habitat loss within home ranges may have long-lasting effects on breeding pairs. The introduction of the Forest Practices Code of B.C. in 1995 shifted forest practices on Crown forest lands within coastal B.C. from progressive large-scale clearcutting to smaller (<40 ha) cutblocks with variable amounts of wildlife tree retention patches (B.C. Ministry of Forests 1995). As well, the increased use of helicopters as a harvest system for previously inaccessible stands has expanded the accessible timber harvesting landbase. Private forest lands within B.C. have not had to meet the same biodiversity objectives as Crown forest lands. Harvest pressures on private forest lands will pose the greatest threat to *A. gentilis laingi* within the VI conservation region, where 67% of the province's private forest lands exist and comprise approximately 3% of the managed forest landbase.[5] As well, a lower diversity of mammalian prey on Vancouver Island and Haida Gwaii may mean that threats to foraging habitat are greater within these conservation regions.

To a lesser extent, urban development, windthrow (sometimes increased through harvest activities; Kramer *et al.* 2001; Penteriani *et al.* 2002), conversion of forests to agricultural lands, and forest insects and disease may also reduce the habitat quality for *A. gentilis laingi* (Squires and Reynolds 1997; Burleigh and Hodge 2004).

See Appendix 1 for an outline of existing approaches and measures available to protect *A. gentilis laingi* habitat in B.C.

Prey diversity and availability

The theory of island biogeography (MacArthur and Wilson 1967) suggests that species diversity will be lower on smaller than larger islands, and diversity will also be reduced as distances between mainland source populations and islands increases. It is therefore expected that VI and HG conservation regions should have a lower diversity of prey species for *A. gentilis laingi* than NC and SC conservation regions on mainland B.C. This is generally true as VI and HG conservation regions have lower avian and mammalian prey diversity than mainland conservation regions, and HG conservation region has even fewer species than VI conservation region (Campbell *et al.* 1990a, 1990b, 1990c, 1990d; Nagorsen 2002). This reduction in prey diversity may be a further threat to *A. gentilis laingi* populations on the islands, as any reduction in the annual abundance of any one prey may impact the ability of *A. gentilis laingi* to obtain enough food to meet their annual energetic requirements.

Genetic isolation

Genetic work by Talbot (2006) suggests that Vancouver Island and coastal mainland B.C. populations are interbreeding. However, Vancouver Island and coastal mainland B.C. populations appear not to be interbreeding with interior B.C. populations. Therefore, these populations have a small level of threat from genetic isolation. *Accipiter gentilis laingi* from Haida Gwaii have a very high risk of genetic isolation because genetic analyses suggest there is

[5] <www.pmflc.ca>

very little gene flow among these individuals and other populations of *A. gentilis laingi* (Talbot 2006).

Introduced species

It is unlikely that **introduced species** within the VI, SC, and NC conservation regions have posed a threat to *A. gentilis laingi* populations. Instead, this subspecies may use some introduced species such as Eastern Cottontail Rabbits (*Sylvilagus floridanus*; Nagorsen 2002) as prey. However, within the HG conservation region, introduced species may substantially threaten *A. gentilis laingi*. Relevant introduced species include Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*), Red Squirrels, Raccoons (*Procyon lotor*), and rats (*Rattus* spp.). Black-tailed Deer, first introduced to Haida Gwaii in 1878 and then again in 1911 (Englestoft and Bland 2002), are likely having the greatest impact on prey populations of *A. gentilis laingi* because most of their prey occur within the ground-shrub zone (Reynolds and Meslow 1984) which the deer have over-browsed. With the exception of Black Bears (*Ursus americanus*), there are no predators to help regulate deer populations, resulting in an extremely high density of deer on Haida Gwaii (~30 deer/km^2; Martin and Baltzinger 2002) compared with other conservation regions. Allombert *et al.* (2005a) showed that songbird abundance was 55–70% lower on islands with a >50-year history of deer browsing compared with islands without deer. Therefore, *A. gentilis laingi* may be indirectly impacted by deer overgrazing understorey vegetation, which may reduce nest site availability and food supply for songbirds, which in turn may reduce populations of songbirds (Allombert *et al.* 2005b). Blue Grouse (*Dendragapus obscurus)*, also a prey item of *A. gentilis laingi* (Ethier 1999; Lewis *et al.* 2006), may be particularly affected by understorey vegetation removal by deer (Doyle 2004). Red Squirrels are the main prey of *A. gentilis laingi* throughout their range (Roberts 1997; Ethier 1999; Lewis *et al.* 2006), however they were not present on Haida Gwaii until 1947 when they were introduced to increase the endemic populations of Pine Marten (*Martes americana nesophila*). Red Squirrels are now the main summer prey of *A. gentilis laingi* on the islands (Doyle 2003b). It is unclear, however, how the introduction of Red Squirrels has influenced *A. gentilis laingi* populations, as the squirrels may negatively affect other goshawk prey through nest predation. Raccoons, a predator of *A. gentilis laingi* and their prey (Zwickel 1992; Laskeek Bay Conservation Society 1996; Hewitt *et al.* 2001), were introduced to Haida Gwaii in the 1940s to provide another source of fur for trappers. Furthermore, Black Rats (*Rattus rattus*) and Norway Rats (*Rattus norvegicus*) are two other persistent nest predators that may threaten prey populations of *A. gentilis laingi*. Black Rats were first verified on Haida Gwaii in 1919 (Laskeek Bay Conservation Society 1996) and Norway Rats were first observed in 1988, although they were probably introduced during the Second World War (Englestoft and Bland 2002). These possible food-web relationships on Haida Gwaii need to be tested by empirical data gathering and modelling (cf. Gurevitch and Padilla 2004; Clavero and Garcia-Berthou 2005) to better understand the threats they pose to *A. gentilis laingi* populations within the HG Conservation Region.

Depredation and competition

The conversion of forests to younger seral stages and increased fragmentation of forests may favour edge and open habitat species such as Red-tailed Hawks (*Buteo jamaicensis*), Barred Owls (*Strix varia*), and Great Horned Owls (*Bubo virginianus*) over interior forest species such

as *A. gentilis laingi*. Kenward (1996) hypothesized European Goshawk populations may be more adaptable to forest fragmentation than North American populations because of raptor guild differences. Red-tailed Hawks and several large owl species use Northern Goshawk nests for breeding and they often initiate breeding before Northern Goshawks and so there may be indirect competition for nest sites among these species (Campbell *et al.* 1990b; Doyle 2000). La Sorte *et al.* (2004) compared habitat characteristics around nests of Red-tailed Hawks and *A. gentilis atricapillus* in Arizona and found that their breeding habitats overlapped. However, Red-tailed Hawks selected more open forest nest sites adjacent to clearings whereas Northern Goshawks typically nested in denser forests, farther in from edges. Therefore, if nest sites of *A. gentilis laingi* occur in small (i.e., 12 ha), isolated fragments of forests, they may become more suitable for Red-tailed Hawks and this has been observed on Vancouver Island (Lindsay *et al.* 2004; E.L. McClaren, pers. observation, 1999. *Accipiter gentilis laingi* may compete for food with Red-tailed Hawks and large owls, although these potential competitors do not eat as many birds and they typically hunt in different habitat types (Bosakowski and Smith 1992). In Arizona, 48% of the diet of Red-tailed Hawks consisted of species that also occurred in the diets of *A. gentilis atricapillus* (Gatto *et al.* 2005). As well, Red-tailed Hawks, Great Horned Owls, and Bald Eagles (*Haliaeetus leucocephalus*) have been observed to kill adult, fledgling, and nestling Northern Goshawks (Rohner and Doyle 1992; Squires and Ruggiero 1995; Wiens 2004). It is difficult to predict the influence that habitat fragmentation and loss will have on predator/competitor communities, and the level of threat posed to *A. gentilis laingi* will vary by conservation region.

Climate change

The threats caused by climate change within coastal forests are unknown and are difficult to mitigate through this recovery strategy. Climate change may affect Northern Goshawk populations positively or negatively. Negative impacts may include altered microclimate conditions within coastal forests, changes in vegetation and species composition of forests (Hamann *et al.* 2006), altered prey abundance and availability, increased likelihood of forest fires, and diseases such as West Nile Virus and forest pest outbreaks (Hansen and Biringer 2003). Because weather and prey availability influence the reproduction and survival of Northern Goshawks (Doyle 2000; Dewey and Kennedy 2001; Bloxton 2002; Salafsky 2004; Wiens *et al.* 2006), climate change may impart a higher degree of annual **environmental stochasticity** on demographic rates, which may ultimately result in these relatively isolated populations of *A. gentilis laingi* becoming more susceptible to extirpation (Caughley and Gunn 1996). Alternatively, *A. gentilis laingi* may benefit from climate change if changes result in larger expanses of forest types that provide the structural attributes necessary for nesting and foraging, and support a greater abundance and diversity of prey species.

Human disturbance

Anecdotal evidence suggests that *A. gentilis laingi* are sensitive to disturbance at nest and roost sites (COSEWIC 2000), although some individuals are more tolerant than others (McLaughlin 2002; E.L. McClaren, pers. observation, 1998). The effect of human disturbance near nest and roost sites of *A. gentilis laingi* depends on the timing, intensity and proximity of the disturbance (Toyne 1997; COSEWIC 2000). The level of this threat may increase along with more road networks through forests, enabling greater levels of human access into remote areas.

Disease

West Nile Virus has not yet been documented within B.C.; however, it is as far west as Alberta in Canada and Washington and Oregon in the United States (H. Schwantje, pers. comm., 2005). West Nile Virus occurs in several bird species (including raptors; Nemeth *et al.* 2006) and the threat it poses to populations of *A. gentilis laingi* is unknown and difficult to predict (Komar *et al.* 2003; Marra *et al.* 2004). More information can be gained regarding the prevalence of infection from West Nile Virus to wild *A. gentilis laingi* by collecting tissue samples via feathers from captured individuals (H. Schwantje, pers. comm., 2005).

Human persecution

Although historic bounty hunting programs may have reduced populations of *A. gentilis laingi* near urban and agricultural centres in coastal areas, human persecution toward *A. gentilis laingi* is currently considered to be low and not a major threat (Table 2). There is a small chance that this threat is underestimated because of the recovery team's lack of knowledge of illegal persecution, especially of immature birds pursuing domestic fowl and racing pigeons (E.L. McClaren, pers. observation, 1999. B. Wijdeven, pers. observation, 2004; M. Buelow, pers. comm., 2005).

Actions Already Completed or Underway

Habitat Recovery Implementation Group (RIG)

The habitat RIG was formed in 2005. One of the first tasks of the RIG was to oversee development of a habitat model for *A. gentilis laingi* within each conservation region in B.C. Between 2005 and 2007, the habitat RIG developed models for nesting, foraging, and territories for HG, NC, and SC conservation regions (Marquis *et al.* 2005; Smith *et al.* 2007). As well, species experts in B.C. outlined habitat characteristics of *A. gentilis laingi* (Mahon *et al.* 2007). In 2007/2008, the Habitat RIG plans to complete habitat models for each conservation region, depending on funding and data availability. Between 2007 and 2009, the habitat RIG also plans to ground verify habitat model predictions for each conservation region to determine the accuracy and precision levels of models. To improve model predictions, habitat RIG members will revise habitat models based on the results of ground verification, where necessary. Refined habitat models will then be used to help the habitat RIG and recovery team to identify and delineate critical habitat in the action plan.

Inventory and monitoring

Structured inventory work for *A. gentilis laingi* occurred for 9 years on Vancouver Island (McClaren 2003) and is ongoing in Haida Gwaii (Doyle 2005). Monitoring programs are being carried out by forest licensees within some areas of Vancouver Island and throughout Haida Gwaii as part of an adaptive management strategy (Manning *et al.* 2003). The recovery team has initiated inventory work for *A. gentilis laingi* on the coastal mainland of B.C. in 2007.

Stewardship

The recovery team has initiated a program in Haida Gwaii to work with poultry farmers to report trapped *A. gentilis laingi*, to facilitate the collection of DNA samples and to assist the recovery team to assess the severity of this threat and to mitigate it, where necessary. As well, the recovery team is working to develop "science-based guidelines for working in and around *A. gentilis laingi* nesting and foraging habitats."

Knowledge Gaps

The recovery team has identified knowledge gaps that are directly related to recovery planning and the success of recovery activities. Although the recovery team has a good knowledge base in several areas for *A. gentilis laingi*, there are many unknowns around what limits the population size of this subspecies. As well, the recovery team has better information on the habitat requirements of *A. gentilis laingi* at small scales relative to large scales. Data deficiencies were prioritized within each topic listed below based on perceived risks to our ability to recover *A. gentilis laingi* populations.

Habitat availability and requirements

1. Amount, distribution, and characteristics of critical habitat.
2. Relationship between habitat components and the reproduction and survival of *A. gentilis laingi*, and how forest harvesting affects these. This includes the degree of surrounding landscape contiguity that maintains successful breeding over time (e.g., the spatial relationship between foraging areas and PFAs).
3. Winter habitat associations.
4. Relationships between prey assemblages and foraging habitat characteristics.
5. Dispersal habitat characteristics.
6. Relationship between characteristics of breeding habitat and competition for nest sites.
7. Amount of suitable breeding and foraging habitat throughout the range of *A. gentilis laingi*, and the number of breeding pairs this habitat could support historically (pre-industrialized logging), currently and under future harvest scenarios.

Diet and prey availability

1. Breeding season diet in NC and SC conservation regions.
2. Winter diet in all conservation regions.
3. Change in prey abundance as a result of introduced species in HG conservation region.
4. Effects of annual fluctuations in weather patterns (e.g., El Niño and La Niña, on prey).

Population abundance and demographic parameters

1. Determine population abundance and trend estimates (i.e., population viability analyses and parameter sensitivity analyses):
   a. annual occupancy rates of nest areas in NC and SC conservation regions;
   b. monitoring of occupancy rates of known nest areas over time;
   c. breeding density within NC and SC conservation regions;
   d. average life span and number of reproductive years;
   e. survival estimates (adult and juvenile);
   f. immigration, emigration, dispersal, and recruitment rates; and
   g. dispersal distances.

2. How competition for nests sites, siblicide, depredation of adults, young, and eggs, and climate regulate populations.

Population genetics and distribution

1. Genetic flow among conservation regions and refinement of the range boundaries for *A. gentilis laingi*.

Miscellaneous threats

1. Degree of risk posed by diseases/viruses such as West Nile Virus.
2. Degree of risk from climate change and the associated changes in habitat and prey assemblage that may follow.
3. Level of threat posed by human persecution and disturbance near nest sites.

RECOVERY

Recovery Feasibility

Based on its answers to criteria outlined in Environment Canada's draft policy on the feasibility of recovery (Environment Canada 2005), the recovery team determined that *A. gentilis laingi* was biologically and technically feasible to recover in B.C.:

1. **Are individuals capable of reproduction currently available to improve the population growth rate or population abundance? Yes.**
   - An estimated 352–374 breeding pairs are present within B.C. (see Table 1) and some pairs are present in all conservation regions.
   - Average offspring gender ratios of 50:50 within the VI conservation region (McClaren and Pendergast 2003) suggest an equal number of males and females entering the population (assuming survival and recruitment rates are approximately equal).
   - There is evidence of successful breeding within each conservation region.
   - Evidence of younger (<2 years) individuals reproducing suggests that the breeding population is not skewed towards only older individuals.

2. **Is sufficient habitat available to support the species or could it be made available through habitat management or restoration? Yes.**
    - Individuals breed in mature second- and old-growth forests and so it is possible to recruit habitat after harvest.
    - Permanent habitat loss (agriculture/urbanization) is minor (ca. 3%) throughout the Canadian range of *A. gentilis laingi*.

3. **Can significant threats to the species or its habitat be avoided or mitigated through recovery actions? Yes.**
    - Significant threats listed in Table 2 and their mitigation actions include:
        - Habitat loss can be mitigated through reduced harvest levels, lengthened rotation periods, reforestation, and stand treatment activities to improve the structure of younger stands (e.g., spacing, pruning, and fertilization).
        - Habitat fragmentation can be mitigated through landscape-level planning, reduced harvest levels, lengthened rotation periods, and reforestation.
        - Introduced species within the HG conservation region that may result in increased depredation of adults, eggs, and young, and reduced prey availability can be mitigated through population control measures. Eradication of introduced species may not be technically feasible or economically viable.
        - Genetic isolation within the HG conservation region may be mitigated through translocation of individuals from surrounding conservation regions (although this may not be desirable if they are genetically distinct from adjacent populations) or re-introduction from captive breeding programs.

4. **Do the necessary recovery techniques exist and are they demonstrated to be effective? Yes.**
    - Both *A. gentilis gentilis* and *A. gentilis atricapillus* exhibit the ability to rebound and re-establish themselves (naturally or via re-introduction) when populations have been reduced and excluded from portions of their range due to persecution and habitat destruction (Speiser and Bosakowski 1984; Petty 1989; Lensink 1997; Kennedy 1997, 2003), providing threats to populations were mitigated.

Recovery Goal

The long-term goal of this recovery strategy is to ensure viable populations of Northern Goshawk *A. gentilis laingi* persist in each conservation region in coastal British Columbia.

Recovery Objectives

This recovery strategy has the following objectives:

Objective 1:
To manage and, where necessary, conserve and recover habitat that meets the needs of Northern Goshawk *A. gentilis laingi* through its annual cycle.

Objective 2:
To conserve and, where necessary, recover a well-distributed and viable population of Northern Goshawk *A. gentilis laingi* within coastal B.C.

These objectives are broad at this time because the recovery team lacks basic information on the amount of suitable habitat available historically, relative to current supply and predicted future supplies (under different management scenarios), as well as population responses to habitat supply over time. Therefore, the recovery team has outlined a number of activities and associated timelines, which will help close these information gaps at which time the recovery objectives can be refined and updated.

Approaches Recommended to Meet Recovery Objectives

Recovery planning table

Table 3. Broad strategies that will be used to address threats and to achieve recovery of habitat and populations for *A. gentilis laingi*

Objective 1: To manage and, where necessary, conserve and recover habitat that meets the needs of the Northern Goshawk *A. gentilis laingi* through its annual cycle						
Threat(s) addressed	**Broad strategy**	**Priority**	**Recommended approaches to meet recovery objectives**	**Action**	**Conservation region**	**Timeline (initiation-completion)**
Habitat loss and fragmentation – nesting	Habitat protection	High	Protect known nest trees and PFAs	Pursue available tools for protection on public and private lands. See Appendix 1.	All	1999–2012
Habitat loss and fragmentation – nesting and foraging	Science-based guidelines for habitat management; stewardship	High	Manage nesting and foraging habitat that is required but cannot be included in Wildlife Habitat Areas (WHAs) for required forest attributes & human disturbance impacts	Develop science-based guidelines (incl. stand structure, seral stage distribution, human disturbance, access planning) for nesting and foraging habitat	All	2008
Habitat loss and fragmentation – foraging	Habitat management; stewardship	High	Develop land use designations for *A. gentilis laingi* foraging areas	Develop and implement general wildlife measures to ensure sufficient *A. gentilis laingi* foraging habitat outside WHAs is conserved	All	2008–2017

Objective 1: To manage and, where necessary, conserve and recover habitat that meets the needs of the Northern Goshawk *A. gentilis laingi* through its annual cycle						
Threat(s) addressed	**Broad strategy**	**Priority**	**Recommended approaches to meet recovery objectives**	**Action**	**Conservation region**	**Timeline (initiation-completion)**
Habitat loss and fragmentation – nesting and foraging	Research; habitat management guidelines	High	Identify habitat requirements for population goals	Use landscape modelling to identify the quality, abundance, and distribution of nesting and foraging habitat. This will assist the recovery team to determine where there are habitat deficits and where critical habitat needs to be delineated.	All	2005–2009
Habitat loss and fragmentation – nesting and foraging; prey diversity and availability	Research; habitat management guidelines	High	Recover sufficient habitat to support population goals	Research, develop and implement silvicultural techniques to promote stand attributes for the recovery, maintenance, and diversity of prey populations	All	1999–ongoing
Habitat loss and fragmentation – foraging; introduced species; prey diversity and availability	Research; habitat management guidelines; stewardship; outreach	High	Manage introduced species to minimize habitat impact	Develop and implement management plans for introduced species (e.g., deer) that are affecting foraging habitat and prey of *A. gentilis laingi*	HG	2008–ongoing

Objective 1: To manage and, where necessary, conserve and recover habitat that meets the needs of the Northern Goshawk *A. gentilis laingi* through its annual cycle						
Threat(s) addressed	**Broad strategy**	**Priority**	**Recommended approaches to meet recovery objectives**	**Action**	**Conservation region**	**Timeline (initiation-completion)**
Habitat loss and fragmentation – nesting and foraging; prey diversity and availability; introduced species; human disturbance	Stewardship; outreach	Medium	Engage public and private landowners, and resource managers in conserving habitat for *A. gentilis laingi*	Develop and implement outreach and education strategies for these groups	All	1995–ongoing
Habitat loss and fragmentation	Monitoring; adaptive management	High	Assess the effectiveness of habitat management actions to protect habitat of *A. gentilis laingi*	Conduct effectiveness monitoring as required	All	1995–ongoing
Research; habitat management guidelines	Research; habitat management guidelines	Low	Consider habitat management requirements over decadal time scales	Predict change in habitat attributes and distribution related to climate cycles and climate change scenarios, using climate modelling exercises	All	2012–2017

Objective 2: To conserve and, where necessary, recover a well-distributed and viable population of Northern Goshawk *A. gentilis laingi* within coastal B.C.						
Threat(s) addressed	**Broad strategy**	**Priority**	**Recommended approaches to meet recovery objectives**	**Action**	**Conservation region**	**Timeline (initiation-completion)**
Genetic isolation	Research; Population management guidelines	High	Define population and distribution objectives for each conservation region	• Use **spatially explicit population modelling** for each conservation region • Continue to collect and analyze genetic samples	All	2007–2009
Habitat loss and fragmentation-nesting and foraging; genetic isolation	Implement habitat management guidelines to manage populations; inventory; monitoring	High	Manage populations by conservation region to meet defined population and distribution objectives	• Use habitat conservation and management strategies defined under objective 1 to conserve and recover populations • Conduct inventory and monitoring as required	All	1999–ongoing 1995–ongoing
Introduced species; prey diversity and availability	Introduced species guidelines	High	Manage introduced species to minimize population impacts	• Develop and implement management plan for introduced species interactions affecting *A. gentilis laingi* indirectly (prey diversity and availability) and directly (predation)	HG	2008-ongoing
Prey diversity and availability	Monitoring; research	Medium	Assess and monitor prey abundance and diversity	• Determine primary prey species for *A. gentilis laingi* • Monitor prey populations and assess	NC, SC All	2008–2009 1994–ongoing

Objective 2: To conserve and, where necessary, recover a well-distributed and viable population of Northern Goshawk *A. gentilis laingi* within coastal B.C.						
Threat(s) addressed	**Broad strategy**	**Priority**	**Recommended approaches to meet recovery objectives**	**Action**	**Conservation region**	**Timeline (initiation-completion)**
				impacts of forest harvest techniques on prey		
Persecution	Stewardship; outreach; research	Low	Assess threat to *A. gentilis laingi* from persecution and reduce if required	• Evaluate degree of risk to *A. gentilis laingi* posed by persecution • Address persecution issues through outreach and education strategies, if required	All	2006–2012
Disease	Monitoring; research	Low	Monitor for presence of West Nile Virus and other potential diseases	• Design and implement monitoring program for WNV (model potential impacts)	All	2015–2017
Competition, depredation	Monitoring; research	Low	Monitor populations of edge-adapted predators and competitors	• Design and implement a monitoring program for edge-adapted competitors and predators (e.g., Red-tailed Hawks, Great Horned Owls, Barred Owls)	All	2010–2012

Performance Measures

Key performance measures are identified below.

- Are known nest trees and PFA's protected by 2012?
- Have population and distribution objectives been defined for each conservation region by 2009?
- Have habitat requirements for population goals been identified by 2009?
- Have science-based guidelines been developed by 2008?
- Has prey abundance and diversity been assessed and monitoring been initiated by 2009?
- Have threats from prosecution been assessed and reduced, if required, by 2012?
- Has monitoring of populations of edge-adapted predators and competitors been initiated by 2012?

Critical Habitat

Identification of the species' critical habitat

Critical habitat is defined in the *Species at Risk Act* as habitat that is necessary for the survival (current) or recovery (future recruitment) of a listed species (Environment Canada 2006). Within this recovery strategy, the recovery team describes the biophysical attributes of habitat components for *A. gentilis laingi* (see "Habitat needs" section).

Critical habitat cannot be defined at this time. The recovery team feels that it has insufficient information regarding both the amount and location of suitable habitat within each conservation region to be able to confidently determine which areas are necessary to meet the recovery goal. As well, without population modelling, the team cannot set meaningful population objectives for each conservation region.

Recommended schedule of studies to identify critical habitat

The recovery team lacks information to develop numerically bound and measurable population and habitat targets for *A. gentilis laingi*. Most of the following activities will be carried out by the habitat RIG and the results incorporated into an action plan, with strategic direction and periodic review from the recovery team.

Steps required to establish habitat and population targets for *A. gentilis laingi* are outlined in Table 4.

Table 4. Steps necessary to establish measurable and science-based habitat and population objectives and to delineate critical habitat for *A. gentilis laingi* within each conservation region in B.C.

Activity	Timeline[a]	Status
Develop habitat suitability (nesting and foraging) and **territory models** for *A. gentilis laingi* within each conservation region	2007–2008	In progress
Develop standards for ground **verification** of habitat suitability models	2006–2007	Complete

Verify habitat suitability models within each conservation region and refine models accordingly	2006–2009	In progress
Use habitat suitability models to assess quantity, quality, and distribution of nesting and foraging habitat within each conservation region	2008–2009	In progress
Develop a population model for each conservation region in B.C. and overlay this with the habitat suitability model so that it is spatially explicit	2008–2009	Not yet initiated
Determine viable population targets for each conservation region	2009	Not yet initiated
Determine habitat targets and distribution for each conservation region	2008–2009	Not yet initiated
Delineate survival and recovery habitat (action plan) for populations by conservation region	2008–2010	Not yet initiated

[a] ability to meet anticipated deadlines will depend on funding availability.

Existing and Recommended Approaches to Habitat Protection

See Appendix 1 for existing approaches and measures available to protect habitat for *A. gentilis laingi.*

Effects on Other Species

Several species that select habitat characteristics similar to *A. gentilis laingi* will benefit from implementation of this recovery strategy. Specifically, recovery processes involving Marbled Murrelets, Spotted Owls, and Coastal Douglas-fir (CDFmm1) ecosystems will likely benefit from this recovery strategy. Although *A. gentilis laingi* prey upon Marbled Murrelets and Spotted Owls, they could potentially regulate populations of other predators of these species and they provide nest platforms for Spotted Owls (Forsman and Giese 1997). As well, prey species of *A. gentilis laingi* such as grouse, woodpeckers, small forest owls, and Red Squirrels will benefit from habitat management aimed at improving foraging habitat of this subspecies. To the best of our knowledge, no SARA-listed species will be negatively impacted through implementation of this recovery strategy.

Socioeconomic Considerations

A detailed socioeconomic cost–benefit analysis (SEA) is not required in a recovery strategy but will accompany the recovery action plan(s). The recovery team deemed it prudent, however, to note the scale of potential socioeconomic impacts of recovery.

Because of the extensive spatial requirements for nesting, post-fledging, and foraging, recovery of *A. gentilis laingi* may have a substantial impact on coastal B.C.'s forested landbase (see Figure 1). Activities affected include mainly forest harvesting, but may also include non-timber forest harvesting for mining, power generation, recreation, agriculture, and housing. Recovery may also impact both First Nations economic and traditional use practices. Promoting

stewardship activities and creating incentive packages, especially on private lands, may be required to address action plan needs.

While there are economic costs associated with recovery of *A. gentilis laingi*, the benefits associated with ecosystem maintenance and habitat protection are more difficult to quantify economically. The citizens of B.C. have consistently expressed strong support for protection of species at risk. This support is reflected in the government's stated goal to lead the world in sustainable environmental management (Speech from the Throne, Opening of the Sixth Session, Thirty-Seventh Parliament of the Province of British Columbia, February 8, 2005). Furthermore, substantial social, political, and economic benefits are likely involved in recovery of the species including compliance with the federal *Species at Risk Act* (SARA) and avoidance or reduction of costs related to captive breeding programs.

Anticipated Conflicts

Northern Goshawks have been at the centre of debate surrounding forest harvesting practices throughout North America (Crocker-Bedford 1990, 1998; Kennedy 1997; Daw *et al.* 1998; Andersen *et al.* 2003; Kennedy 2003; McGrath *et al.* 2003) and Europe (Widén 1997) for over a decade. Several petitions have been launched by environmental organizations and concerned citizens to list *A. gentilis laingi* under the U.S. *Endangered Species Act* (see U.S. litigation review in Squires and Kennedy 2006). As soon as forests become structurally mature and suitable for *A. gentilis laingi*, they also become economically viable for timber harvesting. The recovery team anticipates that there may be conflict associated with maintaining a sufficient amount of habitat for the survival and recovery of populations of *A. gentilis laingi* and with continuing to manage forests at current allowable annual harvest levels and rotation periods within coastal B.C.

Threats to *A. gentilis laingi* from introduced species in Haida Gwaii may be challenging to overcome. Forest fragmentation has the potential to increase depredation of adults, eggs, and young, and increase competition for nest sites for *A. gentilis laingi*, which may be difficult to mitigate. As well, the recovery team is unsure how it will be able to reduce threats posed by emerging diseases (e.g., West Nile Virus) and climate change within our action plan. Importantly, the recovery team anticipates challenges associated with obtaining sufficient funding to fill the knowledge gaps that have been identified (see "Knowledge Gaps" section).

Recommended Approach for Recovery Implementation

This recovery strategy for *A. gentilis laingi* was developed for the four conservation regions in B.C. (see "Global distribution" section). Although these conservation regions may not encompass discrete populations, each region has its own suite of threats and management issues. Therefore, recovery activities must occur at multiple scales including conservation regions, watersheds within conservation regions, and potential home ranges. Reynolds *et al.* (1992) have implemented this approach in southeastern Arizona where forested landscapes are managed for foraging and nesting habitats as well as for prey species. Because of the high site fidelity exhibited by this species, conservation measures within B.C.'s conservation regions have historically focused on sites known to contain breeding pairs. However, managing *A. gentilis*

laingi on a nest-by-nest basis is an ineffective management approach at a population scale because individuals have large breeding and winter home ranges and they build multiple nests within breeding areas throughout their lifetime. Additionally, *A. gentilis laingi* are difficult to detect and locating all nests within a breeding home range is virtually impossible because nests will fall out of trees over time and new nests will be constructed. The recovery team recommends addressing the management of *A. gentilis laingi* at a landscape or watershed level to ensure that suitable breeding, foraging, and wintering habitats exist throughout the landscape. Ultimately, a multi-scale approach will be necessary to ensure the recovery of *A. gentilis laingi*. A multi-scale approach will require that sufficient levels of foraging habitat be maintained within close proximity to suitable nesting habitat, and that habitat among pairs is sufficient in amount and distribution to facilitate successful dispersal and mate-pairing to maintain healthy populations.

Statement on Action Plans

The Habitat RIG plans to complete an action plan within 2 years after final posting on the B.C. government website of the recovery strategy (as outlined in Table 4).

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GLOSSARY

Active nest: a nest where there is sufficient evidence that a breeding attempt has occurred within a given year. Sufficient evidence includes eggshell fragments at the base of a nest tree, an incubating adult or nestlings on a nest, or evidence that nestlings were present within a nest such as sufficient excrement below the nest tree.

Biogeoclimatic subzone: a climatic or zonal classification system that uses vegetation, soils, and topography to infer the regional climate of a geographic area. Biogeoclimatic subzones are delineated where different plant associations occur; this is the basic unit of this climatic classification system (<http://www.for.gov.bc.ca/hre/becweb/system/how/climatic.html>).

Biogeoclimatic variant: areas that are slightly drier, wetter, snowier, warmer, or colder than that considered typical for the subzone. These climatic differences result in corresponding differences in vegetation, soil, and ecosystem productivity, although the changes in the vegetation are not sufficient to define a new plant association. The differences in vegetation are evident as a distinct climax plant subassociation (<http://www.for.gov.bc.ca/hre/becweb/system/how/climatic.html>).

Breeding dispersal: the movement of adult birds from one breeding site to another between years (Greenwood 1980). For Northern Goshawks, this may include movement between alternative nest sites within a single nest area or between different nest areas.

Breeding home range: the area used by adult birds from courtship until young vacate natal areas (February through early September for *A. gentilis laingi*).

Core-use area: areas of an organism's larger home range where activities (such as breeding) are concentrated.

Critical habitat: the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.

Ectoparasites: parasites that live on a host's outer surface.

Environmental stochasticity: fluctuating environmental conditions such as rainfall, snow levels, temperatures, etc.

Foraging area: the areas where adult and dispersing immature Northern Goshawks hunt. Foraging areas may or may not include nest trees and post-fledging areas and they make up the majority of an individual's home range (Reynolds *et al.* 1992).

Habitat: the resources and conditions present in an area that produce occupancy — including survival and reproduction — by an organism (Hall *et al.* 1997).

Habitat fragmentation: the isolation of parcels of habitat such that suitable habitat patches are separated from other suitable habitat patches by unsuitable habitat.

Habitat loss: a reduction in the amount of area that serves as habitat for a particular species.

Hard edges: the edge between two adjacent forest stands that differ in age and structural characteristics. For example, the edge between one stand that is <20 years and another stand that is >45 years. These types of edges are often created through human disturbances on the landscape rather than through natural processes.

Intra-specific competition: interactions between individuals of the same species for limited resources.

Inter-specific competition: interactions between individuals of different species for limited resources.

Introduced species (also known as an exotic species)**:** is an *organism* that is not indigenous to a given place or area and instead has been accidentally or deliberately transported to this new location by *human* activity.

Natal dispersal: the process whereby individuals move from their natal area to where they first reproduce.

Nest areas: the component of a Northern Goshawk's home range that is occupied by one breeding pair during each breeding season and contains multiple alternative nest trees. Nest area size varies and depends on the topography and availability of suitable breeding habitat.

Non-colonial: individuals that nest singularly rather than in groups (colonies).

Occupancy rates: a nest area of *A. gentilis laingi* is considered to be occupied if at least one adult or fledgling is detected. This metric is calculated using the number of nest areas with active nests divided by the total number of nest areas assessed for occupancy.

Panmictic: a population where all individuals are potential breeding partners (i.e., there are no group structures or mating restrictions in the population).

Partial foraging habitat: a segment or part of a breeding pair's foraging habitat.

Persecution: persistent harassment or mistreatment by humans.

Post-fledging (family) area: the area around nest trees that fledglings use to retrieve food and learn to fly before they become independent of adults and leave their natal areas (Reynolds *et al.* 1992; Kennedy *et al.* 1994).

Residence: defined in the *Species at Risk Act* as a dwelling-place, such as a den, nest, or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding, or hibernating.

Recruitment: the process whereby immature individuals enter into the breeding population.

Sedentary: non-migratory.

Seral stage: stages of forests as they age and progress through a number of successional structural forms.

Socially monogamous: when individuals pair with the same mate for at least one breeding season.

Spatially explicit population model: a model that links vital rates (survival, productivity, lifespan, dispersal) for species to landscape-level habitat characteristics.

Subspecies: a taxonomic subdivision of a species that includes a group of organisms whose behaviour and/or genetically encoded morphological and physiological characteristics differ from those of other members of their species. Members of different subspecies of the same species are potentially capable of breeding with each other and of producing fertile offspring but there are often geographic, behavioural, or other such "barriers" that minimize interbreeding.

Synchronous breeder: individuals of a species that initiate breeding at approximately the same time within the breeding season.

Territory model: a model that uses information from nesting and foraging habitat suitability models to predict where sufficient nesting and foraging habitat is present to support a breeding pair of *A. gentilis laingi* (i.e., territory). This model also uses information about the spacing patterns between adjacent pairs of *A. gentilis laingi* to predict how many breeding pairs could be supported within a given landscape.

Verification: the process of collecting data during site visits to check whether predictions from habitat suitability models, and variables used as inputs for models, are valid.

Winter home range: the area used by birds during the non-breeding season (September through February for *A. gentilis laingi*).

APPENDIX 1. Existing approaches and measures available to protect habitat for *A. gentilis laingi*

Within Table A1, the recovery team has outlined current legislation in Canada, and the mechanisms within the legislation, that may provide habitat protection for *A. gentilis laingi* either through targeted or incidental habitat protection. As well, the recovery team has estimated the scale of habitat protection that may be enabled through each legislation/mechanism. Once critical habitat has been delineated for *A. gentilis laingi*, the recovery team will have a clearer understanding of how useful these tools will be for protecting their critical habitat.

Table A1. Legislation and mechanisms available to protect *A. gentilis laingi* and their habitats.

Legislation	Mechanism(s)	Responsible agency	Scale of habitat protection for *A. gentilis laingi*	Implementation date and status
Wildlife Act <http://www.qp.gov.bc.ca/statreg/stat/W/96488_01.htm> • Section 34	Protection	MOE — provincial[a]	Individual, eggs, active nests	1996
Wildlife Amendment Act[b] <http://www.legis.gov.bc.ca/37th5th/1st_read/gov51-1.htm> • Section 5	**Residences**	MOE – provincial	Individual, eggs, nests	2006 – ongoing development
Forest and Range Practices Act (FRPA) <http://www.for.gov.bc.ca/tasb/legsregs/frpa/frpa/frpatoc.htm> • *FRPA S. 3*	Forest Stewardship Plans	MOFR – provincial[c]	Nest trees, post-fledging area, foraging habitat	Dec. 31, 2006 – ongoing development
• *FRPA S.5(b)(i)(ii)*	Objectives set by government and other FRPA objectives	MOFR – provincial MOE – provincial MAL – provincial[d]	Nest trees, post-fledging area, foraging habitat	Dec. 31, 2006 – ongoing development
• *FRPA S. 180, S. 181 and S. 182*	Grandparented ungulate winter ranges, wildlife habitat areas, general wildlife measures	MOE – provincial	Nest trees, post-fledging area, foraging habitat	Carry-over from Forest Practices Code (FPC)

Legislation	Mechanism(s)	Responsible agency	Scale of habitat protection for *A. gentilis laingi*	Implementation date and status
Forest Planning and Practices Regulation (FPPR) <http://www.for.gov.bc.ca/tasb/legsregs/frpa/frparegs/forplanprac/fppr.htm> • *FPPR S. 7(1)(a)(b)*	Objectives set by government for wildlife • Amount, distribution and attributes for species in S. 7(2) Notices	MOE – provincial	Nest trees, post-fledging area	Notice provided by Forest District – December 31, 2005
• *FPPR S. 8*	Objectives set by government for water, fish, wildlife, and biodiversity within riparian areas • Riparian Reserve Zone • Riparian Management Zone	MOFR – provincial	**Partial foraging habitat**[f]	Carry-over from FPC
• *FPPR S. 9*	Objectives set by government for wildlife and biodiversity – landscape level • Harvest patterns should mimic natural disturbance regimes • Cutblock size	MOFR – provincial	Partial-foraging habitat	Carry-over from FPC
• *FPPR S. 9.1*	Objectives set by government for wildlife and biodiversity – stand level • Wildlife tree patches	MOFR-provincial	Partial-foraging habitat	Carry-over from FPC

Legislation	Mechanism(s)	Responsible agency	Scale of habitat protection for *A. gentilis laingi*	Implementation date and status
Government Actions Regulation (GAR) <http://www.for.gov.bc.ca/tasb/legsregs/frpa/frparegs/govact/gar.htm> • *GAR S. 9*	• General wildlife measures	MOE – provincial	Nest trees, post-fledging area, partial-foraging habitat	Carry-over from FPC
• *GAR S. 10*	• Wildlife habitat area for *A. gentilis laingi* • Wildlife habitat area for other category of species at risk	MOE – provincial	Nest trees, post-fledging area, partial-foraging habitat Nest trees, partial-foraging habitat	Carry-over from FPC
• *GAR S. 11*	Wildlife habitat feature	MOE – provincial	Nest trees	Being developed – 2006
• *GAR S. 12*	Ungulate winter ranges	MOE – provincial	Nest trees, post-fledging area, partial-foraging habitat	Carry-over from FPC
Land Use Objectives Regulation • *Land Amendment Act* <http://www.legis.gov.bc.ca/37th4th/3rd_read/gov46-3.htm> • *S. 93.8 Old-growth Order* <http://srmwww.gov.bc.ca/rmd/oldgrowth/index.htm>	• Land use plans • Land and resource management plans • Order establishing provincial non-spatial old-growth objectives	MAL – provincial	Nest trees, post-fledging area, foraging habitat Nest trees, post-fledging area, partial-foraging habitat	February 1, 2006 June 30, 2004
Park Act <http://www.qp.gov.bc.ca/statreg/stat/P/96344_01.htm>	Management plans	MOE – provincial	Nest trees, post-fledging area, foraging habitat	August 1, 1990

Legislation	Mechanism(s)	Responsible agency	Scale of habitat protection for *A. gentilis laingi*	Implementation date and status
Ecological Reserve Act <http://www.qp.gov.bc.ca/statreg/stat/E/96103_01.htm>	Management plans	MOE – provincial	Nest trees, post-fledging area, foraging habitat	1996
Species at Risk Act (SARA) <http://lois.justice.gc.ca/en/S-15.3/index.html> • SARA S. 32 • SARA S. 33 • SARA S. 57–58	• Individual harm • Residence • Action plan o Safety nets for non-federal lands	Parks Canada, Fisheries and Oceans Canada, Environment Canada (Canadian Wildlife Service) - Federal	Individuals, eggs Nest Nest trees, post-fledging area, partial-foraging habitat	• June 2004 • Being developed by MOE and federal government • After identified by recovery team and published in Canada Gazette
Canada National Parks Act <http://laws.justice.gc.ca/en/n-14.01/251405.html>	National Parks and Heritage sites	Parks Canada – federal	Individuals, eggs, nest trees, post-fledging area, foraging habitat	October 20, 2000
Private Managed Forest Land Act <http://www.legis.gov.bc.ca/37th4th/3rd_read/gov88-3.htm>	Critical wildlife habitat	Private managed forest landholders	Nest trees, post-fledging area	August 2004
Canadian Environmental Assessment Act (CEAA) <http://lois.justice.gc.ca/en/C-15.2/225560.html>	Environmental assessments of projects and listed activities (Inclusion List Regulations)	Canadian Environmental Assessment Agency and other responsible authorities under CEAA	Individual, eggs, nest trees, post-fledging area partial-foraging habitat	January 19, 1995

Note: Several other mechanisms may assist in protecting habitat for *A. gentilis laingi* that do not include legislation. These can be extremely important and include forest certification programs (<http://www.for.gov.bc.ca/het/certification>), professional responsibilities to manage for species at risk (<http://www.abcfp.ca/regulating_the_profession/documents/guideline-species-at-risk.pdf>*)* under the B.C. *College of Applied Biology Act* (<http://www.for.gov.bc.ca/tasb/legsregs/biology/caba.htm>) and the B.C. *Professional Forester's Act* (<http://www.qp.gov.bc.ca/statreg/stat/F/03019_01.htm>), as well as shared stewardship and best management practices.

[a] British Columbia Ministry of Environment; [b] The *Wildlife Amendment Act* will eventually be amalgamated with the *Wildlife Act;* [c] British Columbia Ministry of Forests; [d] British Columbia Ministry of Agriculture and Lands; [e] Partial foraging habitat indicates that only portions of breeding pair's foraging areas will be protected. The amount and distribution are variable and determined by the party who applies the mechanism.