DRAFT

Species at Risk Act
Recovery Strategy Series

Amended Recovery Strategy for the Spotted Owl *caurina* subspecies (*Strix occidentalis caurina*) in Canada

Spotted Owl *caurina* subspecies

2021

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

Official version

The official version of the recovery documents is the one published in PDF. All hyperlinks were valid as of date of publication.

Non-official version

The non-official version of the recovery documents is published in HTML format and all hyperlinks were valid as of date of publication.

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[1] www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

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 Species at Risk Public Registry.

The Minister of Environment and Climate Change is the competent minister under SARA for the Spotted Owl *caurina* subspecies and has prepared this amended recovery strategy, as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the province of British Columbia [any others to be included – federal government departments, Indigenous organizations – **will fill in as cooperation and consultation proceeds, prior to publication**], as per section 39(1) of SARA.

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 or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Spotted Owl *caurina* 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 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.

In the case of critical habitat identified for terrestrial species including migratory birds 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.

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2

[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 Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

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

Many people are to be acknowledged for their involvement in the federal recovery planning process for the Spotted Owl *caurina* subspecies. Development of this recovery strategy was coordinated by Megan Harrison (Environment and Climate Change Canada, Canadian Wildlife Service - Pacific Region (ECCC-CWS-PAC). Greg Rickbeil, Danielle Yu, and Leon McCarthy (ECCC-CWS-PAC) provided geospatial modelling and mapping support. This amended recovery document borrows significantly from the original Recovery Strategy for the Northern Spotted Owl (*Strix occidentalis caurina)* in British Columbia (Chutter et al. 2004), which was adopted as part of the Federal Recovery Strategy for the species in 2006. All those involved in the development of that original document are gratefully acknowledged. In addition, thanks are owed to Jared Hobbs and Glenn Sutherland (independent experts); Joe Buchanan (Washington Department of Fish and Wildlife); and Ian Blackburn, Nicola Bickerton, Joel Gillis, and Louise Waterhouse (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development), who provided expert input into this updated document. Helpful review comments were also provided by Emma Pascoe and Marie-Eve Paquet (ECCC-CWS – National Capital Region), Noella Trimble (ECCC-Enforcement), Joanna Hirner and Kirk Safford (B.C. Ministry of Environment and Climate Change Strategy - B.C. Parks), David Leung (B.C. Ministry of Indigenous Relations and Reconciliation), Alanah Nasadyk (B.C. Ministry of Environment and Climate Change Strategy), Todd Kohler (Department of National Defense), and Kristen Mancuso (Syilx / Okanagan Nation Alliance). **Additional individuals and/or groups who provide input into this document prior to publication will be added here.**

Executive Summary

This document builds on the original Recovery Strategy for the Northern Spotted Owl (*Strix occidentalis caurina)* in British Columbia (Chutter et al. 2004), which was adopted as part of the Federal Recovery Strategy for the species in 2006. However, the original document contained more comprehensive information on the species' life history and early recovery measures, so should be consulted for background. Additional detailed planning/strategy documents published since the original recovery strategy (e.g., Sutherland et al. 2007; Fenger et al. 2007) should also be consulted.

The Spotted Owl *caurina* subspecies (henceforth, "Spotted Owl") is a medium-sized owl with dark brown plumage patterned by small pale spots over most of the body. The species was first assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Endangered in 1986. Its status was re–assessed and re-confirmed in 1999, 2000, and 2008. Reasons for the species' designation as Endangered are linked with itscatastrophic population decline, severely depressed population size, ongoing habitat loss and fragmentation, and competition from the closely-related Barred Owl (*Strix varia*).

Spotted Owl once occurred throughout mixed-coniferous old-growth forests in southwestern B.C., and may have numbered as many as 500 pairs prior to the results of significant human activity. Its historical range spans three ecological sub-regions that differ in their mean annual precipitation and corresponding habitat characteristics: the wet 'Maritime', moist 'Sub-maritime', and dry 'Continental'. Both the population and the distribution of Spotted Owl have declined precipitously from historical estimates, with only three individuals detected within one small part of the province (<10,000-ha area in the Sub-maritime sub-region) during surveys in 2020.

Throughout its range, the Spotted Owl is strongly associated with mixed-coniferous forests that are characterized by: an uneven-aged cohort of trees; a multi-layered, relatively closed canopy; numerous large trees with broken tops, deformed limbs, and large cavities; and numerous large snags and accumulations of logs and downed woody debris. The full set of features and attributes needed to support all life functions (nesting, roosting, foraging, and safe movement/dispersal) are best represented within in old-growth forests. Mature forests more often contain only a subset of these attributes, which may for example support foraging and safe movement/dispersal, but not other life functions such as nesting.

The primary threats to Spotted Owl in B.C. include: problematic native species (i.e., competition from Barred Owls), logging and wood harvesting, roads and railroads (including logging roads), and fire and fire suppression.

The population and distribution objective is to recover Spotted Owl in Canada by restoring a stable population of at least 250 mature individuals distributed within a connected network of habitat representative of all three sub-regions within the species' historical Canadian range, and linked to the larger population in the U.S.A.

Recognizing that the population and distribution objective will take >50 years to achieve, the following short-term statements toward meeting the population and distribution objective have been established:

1. Immediately cease human-caused threats that would cause loss of the habitat needed for recovery (i.e., the critical habitat).

2. Re-introduce at least 50[4] captive-bred Spotted Owls back into the wild within 10 years (by 2031), with at least 10 released individuals surviving to become adult residents.
3. Complete annual Barred Owl surveillance at sites occupied by Spotted Owl and/or where reintroductions are planned within 10 years, and within habitat falling in between adjacent occupied/reintroduction sites, and remove all Barred Owls that are detected.

Broad strategies and general approaches toward addressing the primary threats to the survival and recovery of the species, as well as key knowledge gaps, are presented in section 6. Successful implementation of these broad strategies and approaches will be required for the population and distribution objective to be met.

Critical habitat has been identified to the extent possible, based on the best available information for Spotted Owl. It is recognized that the acoustic critical habitat identified is insufficient to achieve the population and distribution objectives for the species. A schedule of studies (Section 7.2) has been developed to provide the information necessary to complete the identification acoustic critical habitat that will be sufficient to meet population and distribution objectives.

Three performance indicators were developed to measure progress towards meeting the population and distribution objective. One or more action plans for Spotted Owl will be posted on the Species at Risk Public Registry within five years of the final posting of the recovery strategy.

[4] This number is derived from current projections by the provincial government (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development [MFLNRORD] 2021) but is subject to adjustment following the pilot phase of the reintroduction (2021-2025), based on the actual annual reproductive output of captive pairs and the survival outcomes of released individuals.

Recovery Feasibility Summary

Based on the following three criteria that Environment and Climate Change Canada uses to establish recovery feasibility, it is considered to be biologically and technically feasible to recover the Spotted Owl in Canada, although there are some significant uncertainties associated with this determination. In keeping with the Species at Risk Policy on Recovery and Survival (Environment and Climate Change Canada 2021), where there is a range of uncertainty associated with the full extent of improvements that are biologically and technically feasible, the determination defaults to the upper bound of what is considered to be within the scope of biological and technical feasibility.

1. **Survival characteristics:** Can survival characteristics be addressed to the extent that the species is no longer at significantly greater risk of extinction or extirpation as a result of human activity?

YES: Spotted Owl is currently assessed as Endangered on the basis of four key survival characteristics: (i) resilience (D1 COSEWIC quantitative criteria) - its population is estimated to be small (well below the 250-individual threshold for Endangered status) and is in decline; (ii) redundancy and connectivity (linked with COSEWIC B2ab indicators) – its habitat and associated distribution is in decline and fragmented (iii) stability (linked with COSEWIC A2ac, C1+2a, and E indicators) - there is an ongoing decline in the number of mature individuals and area/quality of habitat, and a quantitative analysis showing high probability of extirpation, and (iv) continuing impacts caused by ongoing human-caused threats.

- Resilience: Prior to impacts of human activity (i.e., in its natural condition), Spotted Owl had a small population likely not exceeding 1000 individuals. This small population size would have meant the species was somewhat precarious even in its natural condition (e.g., would still be assessed as Threatened under the COSEWIC D1 quantitative criteria, which apply to a species with <1000 mature individuals). However, the results of human activity have put the species at a significantly greater risk of extirpation, such that it is now assessed as Endangered on the D1 indicator (i.e., population below 250-individuals). For recovery to be considered feasible, it must be biologically and technically feasible to improve the resilience of Spotted Owl such that it exceeds the 250-individual D1 threshold associated with Endangered status, and thus returns to a status of Threatened (on the basis of D1 criteria).

  In 2020, only one nesting pair and one single owl were detected during surveys of 10 previously-occupied sites (J. Gillis, pers. comm. 2020). Spotted Owl is known to suppress its calling in the presence of the closely-related competitor, the Barred Owl (*Strix varia*; Kelly et. al 2003; Crozier et al. 2006; Van Lanen et al. 2011; Yackulic et al. 2019) and Barred Owls have been detected at all 10 of the recently-surveyed sites that were historically occupied by Spotted Owl, so it is possible that some owls are present at surveyed sites but are going undetected by standard call-playback survey methods. Comprehensive, range-wide surveys have also not been undertaken in recent years, so some owls may still exist in unsurveyed areas. However, even accounting for some undetected individuals, the wild population is clearly extremely small, and incapable of recovering on its own, so this key survival characteristic cannot be addressed without the population first being restored through reintroduction of owls from a captive breeding program (Fenger et al. 2007). A Spotted Owl captive breeding and

reintroduction program has been in operation in B.C. since 2007. It has had slow initial success rates and has not released any captive-bred owls to date. However, the captive population now stands at 31, and releases are being planned in the near term (J. McCulligh pers. comm. 2021; B.C. MFLNRORD 2021). Assuming that the captive breeding and reintroduction program meets its minimum targets[5] of releasing ~4 individuals/year from 2023 to 2024, ~9 individuals/year from 2025-2030, and ultimately ~14 individuals/year thereafter, and that released individuals have a minimum survival rate of 20%, the provincial government projects that it is within the scope of biological and technical feasibility to restore ≥250 mature individuals to the landscape within 50 years (B.C. MFLNRORD 2021).

- Redundancy, connectivity, and stability: Prior to impacts of human activity (i.e., in its natural condition), Spotted Owl had a relatively restricted distribution, concentrated in southwestern B.C. Although the precise bounds of its historical range (including extent of occurrence and area of occupancy) are unknown, it would have included three ecologically distinct sub-regions, i.e., the wet 'Maritime', moist 'Sub-maritime', and dry 'Continental' sub-regions, with connectivity in suitable habitat within and across these sub-regions (and continuous with the subspecies' historical range in the U.S.A.) to support a stable and genetically diverse population. With connectivity in habitat, and stability in population and distribution characteristics, it is unlikely that any of the COSEWIC quantitative criteria associated with redundancy, fragmentation, and/or stability would have been met for the species in its natural condition. For recovery to be considered feasible, it must be biologically and technically feasible to stabilize the declines in population and distribution characteristics, and to ensure there is a connected network of habitat that will support at least 250 mature individuals. Based on the configuration of existing and regenerating Spotted Owl habitat (see Critical Habitat section), it is considered to be within the scope of biological and technical feasibility to achieve a connected network of suitable habitat sufficient to support ≥250 mature individuals within 50 years. In its recovered condition, Spotted Owl should not meet the quantitative criteria for assessment as Endangered or Threatened based on A,B,C, or E COSEWIC indicators.

- Protection from human-caused threats: There are ongoing human-caused threats that must be addressed (ceased, mitigated, or avoided) in order for the preceding key survival characteristics to be addressed, and for recovery to be feasible. The most significant ongoing human-caused threats include: problematic native species (i.e., competition from the closely-related Barred Owl), and habitat impacts caused by logging and wood harvesting, roads and railroads (including logging roads), and fire and fire suppression. It is biologically and technically feasible to cease or mitigate the human-caused threats of logging, road-building, and fire / increased fuel loads resulting from fire suppression. However, addressing the human-caused spread of Barred Owls into habitat that Spotted Owl would have occupied historically poses a greater biological and technical challenge. Barred Owls are now considered to be one of the highest-level threats to Spotted Owl both in B.C. and range-wide in North America (section 4 of this document; USFWS 2011). Barred Owl control programs (translocation and lethal removal) have been initiated within both the U.S.A. and B.C. (Diller et al. 2016, Gillis 2016a&b, Wiens et al. 2020) as an important component of Spotted Owl

[5] This number is derived from current projections by the provincial government (B.C. MFLNRORD 2021) but is subject to adjustment following the pilot phase of the reintroduction (2021-2025), based on the actual annual reproductive output of captive pairs and the survival outcomes of released individuals.

conservation efforts. Post-treatment monitoring in some regions of the U.S.A. has shown increases in local Spotted Owl site occupancy, survivorship and productivity within four years of (lethal) Barred Owl removal, but results have been slower in other regions, including Washington and B.C. (Diller et al. 2016; Gillis 2016a&b, Wiens et al. 2020). The slower responses in Washington and B.C. have been attributed to the more established Barred Owl populations in these areas and the lower numbers of Spotted Owls available to recolonize empty territories (Yackulic et al. 2019). However, the planned re-introduction of Spotted Owls in B.C. could help address the low colonizer number issue. While there is uncertainty, it is still considered to be within the scope of biological and technical feasibility that impacts of Barred Owl can be managed successfully, to the extent that the preceding survival characteristics can be addressed.

2. **Independence**: Is the species currently able to persist in Canada independent of deliberate human interventions, and/or will it eventually be able to achieve and maintain independence in the state where condition (1) is met, such that it is **not reliant on significant, direct, ongoing human intervention**?

YES. Spotted Owl is currently nearing extirpation in Canada and requires significant, direct human interventions in the short-to-medium term (i.e., within the next 20 years), in order for condition '1' of recovery feasibility to be met. Barred Owl control is the primary intervention that may need to continue for a longer period (i.e., beyond 20 years); however, habitat improvement/recovery is expected to improve Spotted Owl persistence in combination with Barred Owl control and may help reduce the necessary level of investment in Barred Owl removals in the future (Yackulic et al. 2019). Although there is a high level of uncertainty, it is considered to be within the scope of biological and technical feasibility that a point will be reached in the longer term (up to 50 years), where the Spotted Owl population has recovered such that it can remain stable in the absence of ongoing human interventions.

3. **Improvement:** Can the species' condition be improved over when it was assessed as at risk?

YES. It is biologically and technically feasible to meaningfully improve the condition of Spotted Owl in Canada through addressing one or more key survival characteristics as they pertain to results of human activity, such that the species' risk of extinction or extirpation is reduced. Population stability and resilience may be improved, and population/habitat connectivity and redundancy restored, through a) applying protection to a connected network of habitat, so that the habitat needed to support all life functions for a population of >250 mature individuals is available on the landscape when the recovering/recovered population needs it; b) continuing the captive breeding and reintroduction program, so that protected habitat is repopulated, and c) continuing Barred Owl control efforts, so that Spotted Owls can survive and reproduce successfully within protected habitats.

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1. COSEWIC* Species Assessment Information

Date of Assessment: April 2008

Common Name (population): Spotted Owl *caurina* subspecies

Scientific Name: *Strix occidentalis caurina*

COSEWIC Status: Endangered

Reason for Designation: This owl requires old-growth forests for its survival and has suffered a catastrophic population decline over the past 50 years as habitat is lost and fragmented. With the severely depressed population, an additional threat is the recent arrival of the closely related Barred Owl as a breeding bird in B.C.; this species competes with and hybridizes with the present species. Its historical population of about 500 adult owls in Canada has been reduced to 19, and only 10 of these are in breeding pairs. All adults are old and near the end of their breeding age and there is no recruitment of young owls into the population. If current trends are not reversed, extirpation will likely occur within the next decade.

Canadian Occurrence: British Columbia

COSEWIC Status History: Designated Endangered in April 1986. Status re–examined and confirmed in April 1999, May 2000, and April 2008.

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

The above summary reflects population status information as of the 2008 COSEWIC assessment. Since 2008 there has been new information about historical and current population levels (summarized in section 3.2 – species population and distribution).

2. Species Status Information

The legal designation for Spotted Owl on SARA Schedule 1 is Endangered (2003). Approximately 8% of the global (historical) range of the Spotted Owl is located in Canada (COSEWIC 2008). The species' status ranks, globally and in the different parts of its range, are summarized in Table 1.

Table 1. List and description of various conservation status ranks for the Spotted Owl (*caurina* subspecies) (NatureServe 2021).

Global (G) Rank	National (N) Rank	Sub-national (S) Rank	COSEWIC Status
Rounded global rank (of G3G4T3) = T3 (vulnerable)	Canada (N1 – critically imperiled) United States (N3 - vulnerable)	British Columbia (S1) California (S2) Oregon (S1S2) Washington (S1)	EN (Endangered)

S1: Critically Imperiled; S2: Imperiled; S3: Vulnerable; S4: Apparently Secure; S5: Secure; SNR: Unranked; SNA: Not Applicable; B: Breeding.

3. Species Information

3.1 Species Description

The Spotted Owl is a medium-sized owl averaging 45 cm in length and 90 cm in wingspan. Plumage is dark overall with brown feathers patterned by small pale spots over most of the body. The tail has white horizontal bars and there are no “ear” tufts. Eyes are large, dark brown and are set within lighter brown facial disks (Forsman 1981; Gutiérrez et al. 1995). Age classes can be identified by differences in plumage characteristics. Juveniles <5 months old are identified by visible down feathers. Sub-adults (1-2 years old) and adults (>2 years) may be differentiated based on tail feathers; sub-adults have pointed tail feathers with white tips whereas adult tail feathers are rounded and usually mottled in colour (Forsman 1981). Males and females have similar plumage but females are ~15% larger (Blakesley et al. 1990; Gutiérrez et al. 1995).

3.2 Species Population and Distribution

3.2.1 Population

The global population of the Spotted Owl was estimated at roughly 6000 breeding pairs in the late 1980s (Thompson et al. 1990), with the bulk of the population (>90%) occurring in the U.S.A. (COSEWIC 2008). Local population declines were observed at demographic study areas within Washington, Oregon, and California between 1985 and 2013, with an overall annual rate of decline of 3.8% (Dugger et al. 2015). Although no formal global population estimates have been published in recent decades, an approximate current population estimate can be deduced using the annual rates of decline observed in long-term study areas; assuming a 6000-pair starting population and a 3.8-% annual decline from 1985-2021, the global population would now be <1500 pairs. Declines have been most pronounced within sites in Washington, Oregon and B.C., and less pronounced in California (Blackburn and Godwin 2003; Dugger et al. 2015).

Before European settlement, the Canadian Spotted Owl population likely did not exceed 500 breeding pairs, or ~10% of the global population (Blackburn et al. 2002). In 1991, it was estimated at fewer than 100 potential breeding pairs (Dunbar et al.1991; Dunbar and Blackburn 1994) and by 2002 it had declined further to fewer than 33 (Blackburn and Godwin 2003). A survey of 10 previously-occupied sites in 2020 found one pair and one single owl at two sites (J. Gillis pers. comm. 2020). This represents an ~99% decline from historical levels in Canada, with Canada now supporting <0.01% of the global (combined Canada and U.S.A.) population.

However, in addition to the three known birds remaining in the wild (in 2020), there are 31 individuals housed in a captive breeding facility (J. McCulligh, pers. comm. 2021). The combined wild and captive population has been relatively static since 2004, with the wild population continuing to decline (partly as a result of individuals periodically being taken into the captive breeding program) and the captive population beginning to grow (Figure 1).

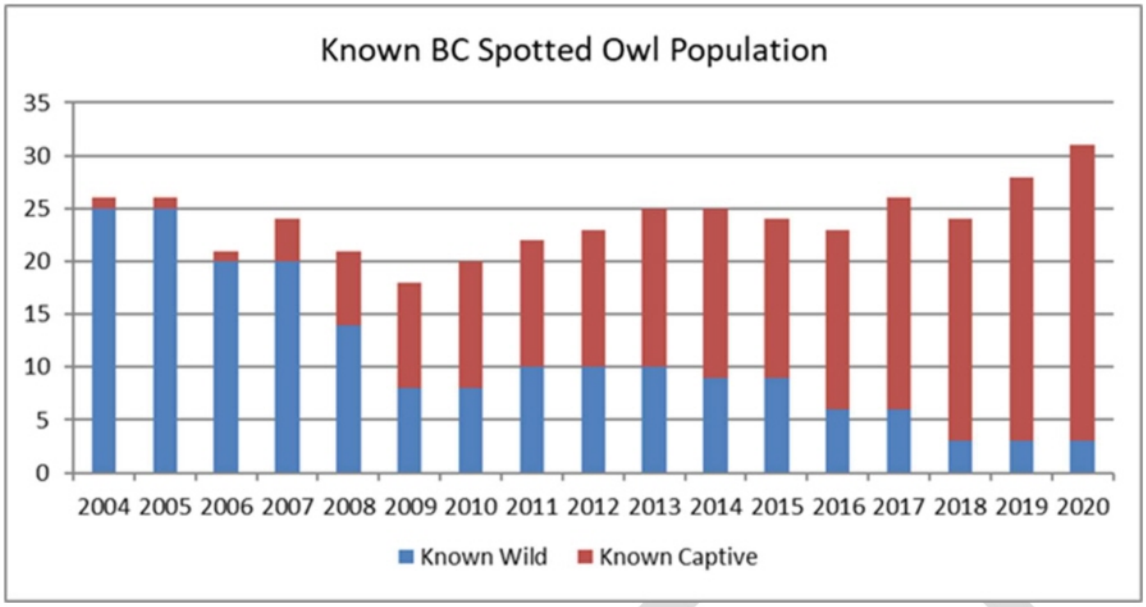

Figure 1. Known Spotted Owl population in Canada from 2004 to 2020 (Government of B.C. 2020).

3.2.2 Distribution

The Spotted Owl *caurina* subspecies is one of three subspecies of Spotted Owls found within North America (Figure 2). The *caurina* subspecies is distributed from the southwest mainland of B.C. through western Washington, western Oregon and the west coast of California, south to San Francisco Bay.

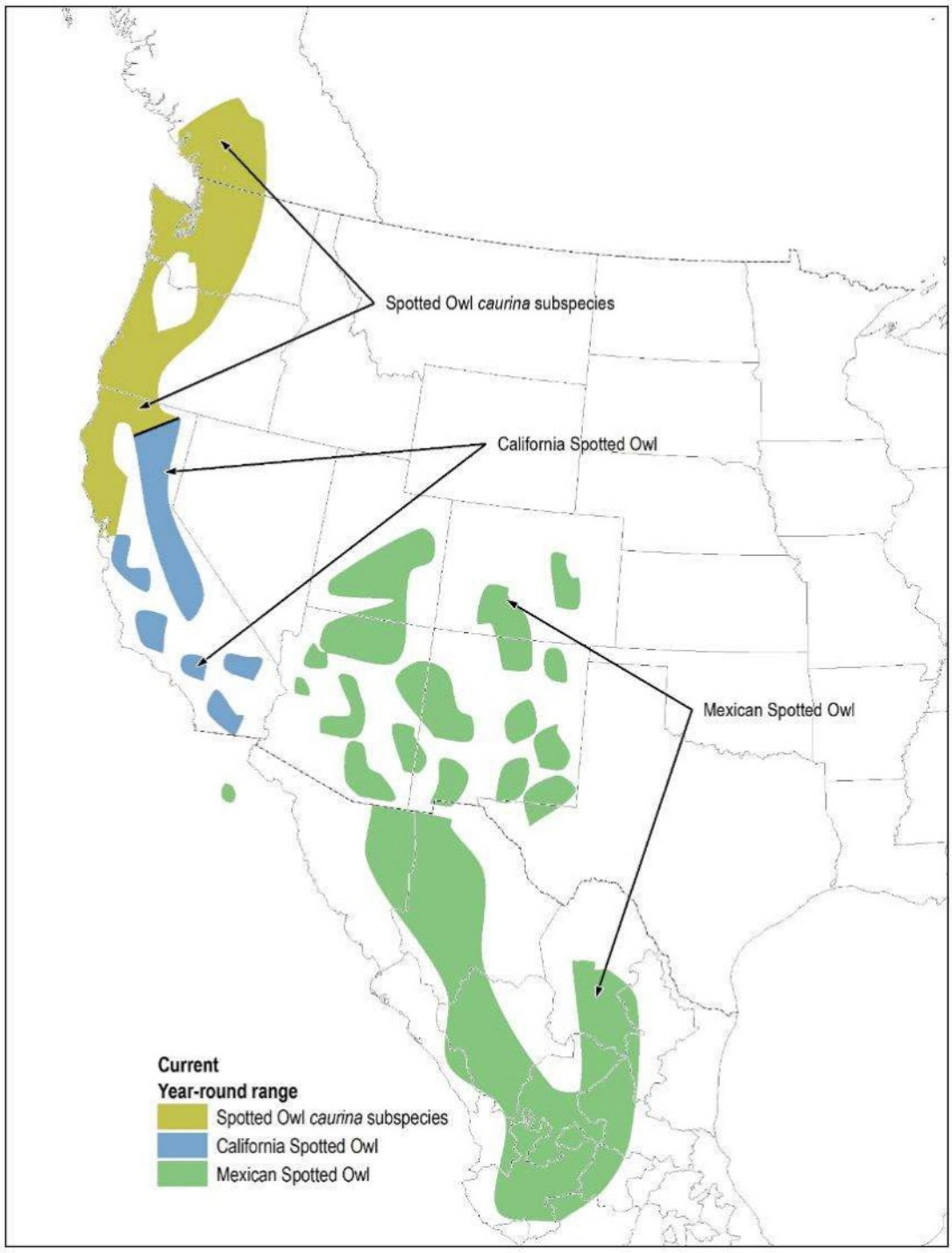

Figure 2. Approximate historical year-round range of Spotted Owls (three subspecies) in North America. (BirdLife International 2018). The *caurina* subspecies is often also referred to as the Northern Spotted Owl.

Historically, the Spotted Owl's range in B.C. extended from the U.S.A. border north ~200 km to Carpenter Lake, and ~160 km from Howe Sound in the west to the Cascade Range in the east (Figure 3; Chutter et al. 2004). Within this range, there are three ecological sub-regions that

differ in their mean annual precipitation and corresponding habitat characteristics: the wet 'Maritime', moist 'Sub-maritime', and dry 'Continental'. Permanent range contraction occurred within the Lower Mainland and Lower Fraser Valley where once suitable habitat has been irreversibly lost to human development (Chutter et al. 2004; Figure 3); however, habitat remains within the rest of the historical range and could one day be re-occupied. The remaining known wildlife individuals can be found within the Sub-maritime sub-region.

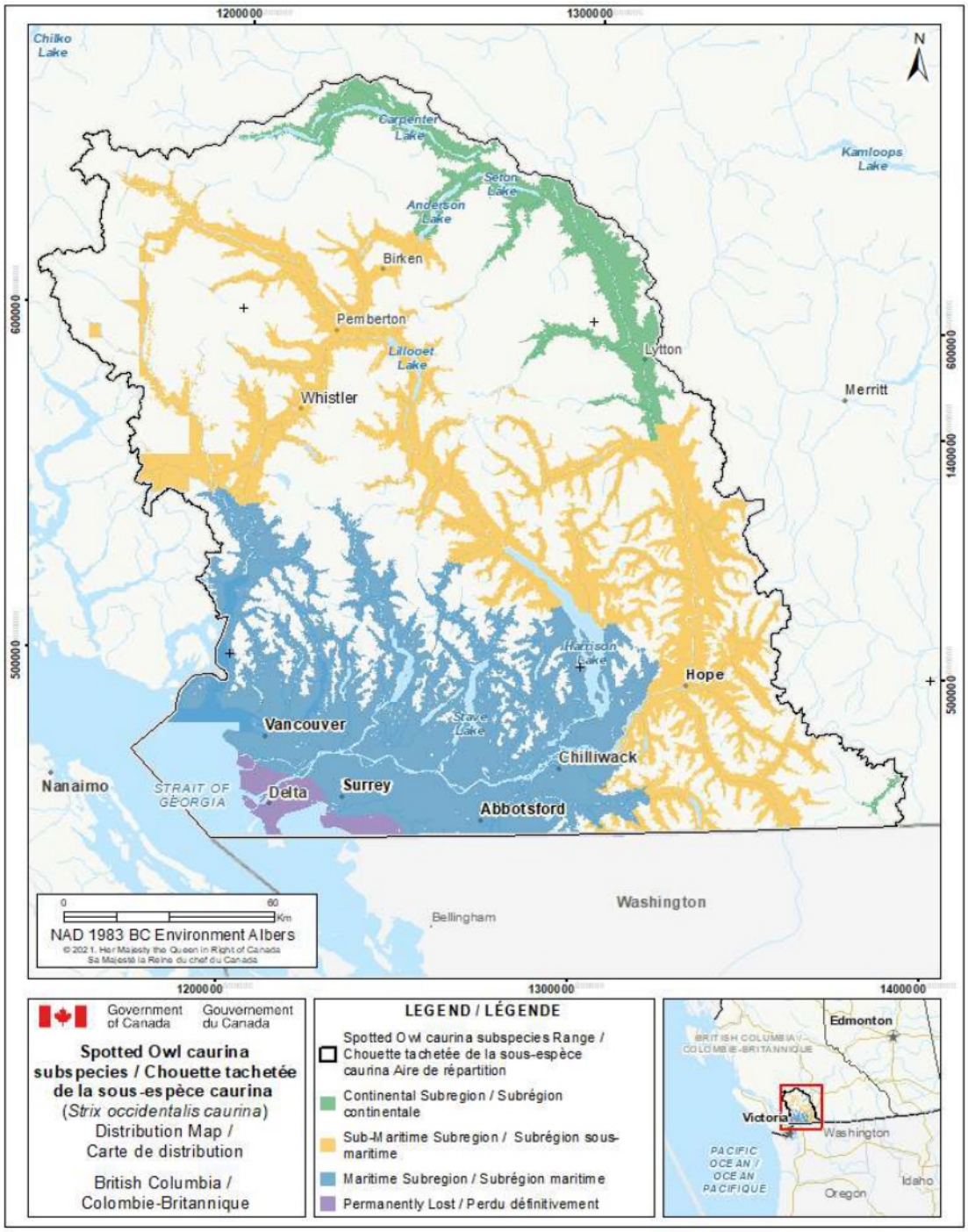

Figure 3. Approximate historical distribution of Spotted Owl *caurina* subspecies in British Columbia.

3.3 Needs of the Spotted Owl

Historically, Spotted Owls occurred primarily within the Coastal Western Hemlock (CWH) and Interior Douglas Fir (IDF) biogeoclimatic zones in B.C. (Meidinger and Pojar 1991; SOMIT 1997; Sutherland et al. 2007). Their historical range would also have included parts of the Coastal Douglas Fir zone, though that habitat has been permanently lost to human development (Chutter et al. 2004; Sutherland et al. 2007; Figure 3). The species is associated with mixed-coniferous forests characterized by: an uneven-aged cohort of trees; a multi-layered, relatively closed canopy; numerous large trees with broken tops, deformed limbs, and large cavities; and, numerous large snags and accumulations of logs and downed woody debris (Thomas et al. 1990; USDI 1992). In moist parts of the range (west of the Cascade Range), these habitat characteristics are found exclusively within old-growth forests. In drier parts of their range (east of the Cascades), Spotted Owls have also been observed in younger stands where structural complexity typically associated with old-growth was created by fire, wind events, or disease factors such as root rot or mistletoe infections (Dunbar and Blackburn 1994).

Habitat configuration

Landscape-level configuration

In order for a stable Spotted Owl population to exist within a landscape, habitat must be configured such that it can support all critical life functions (breeding, roosting, foraging, and safe movement/dispersal) for the entire population. This requires patches capable of supporting the year-round needs of breeding pairs and resident individuals, as well an overall configuration of both the year-round habitat patches and seasonally-used dispersal habitat that maximizes survival/success of dispersing individuals. Juvenile Spotted Owls disperse from their natal site in the late summer / early fall of their first year, and then may disperse several more times and persist in the background as “floaters” for up to 5 years before settling and beginning to breed (Forsman et al. 2002). Breeding-age owls also occasionally disperse to new locations, particularly when their original location has been disturbed (Forsman et al. 2002; Jenkins et al. 2019).

Population modelling results for the species suggest that larger year-round habitat clusters are most likely to achieve stable long-term (100-year) occupancy due to the ability for individuals to disperse within their natal/original cluster versus having to exit their cluster and disperse across a less hospitable matrix (Lamberson et al. 1994; Marcot et al. 2013). Marcot et al. (2013) also found that clusters were more likely to achieve stable long-term occupancy when they were spaced more closely together (<15 km). Being a highly-mobile species, Spotted Owls are capable of dispersing long distances (maximum: 177 km; mean: 23.8 km ± 19.2 km standard deviation; Hollenbeck et al. 2018) and across a range of habitat types; large non-forested valleys, high-elevation subalpine forest, alpine tundra and large water bodies are the only features suspected to act as complete barriers to dispersal (Forsman et al. 2002; Chutter et al. 2004). However, Spotted Owls must feed and escape predation in order to survive dispersal, and in moving through areas that lack foraging resources and escape/safe roosting features, dispersing individuals are expected to incur an increased energetic/survival cost (Lamberson et al. 1994; Buchanan 2004; Sutherland et al. 2007; Marcot et al. 2013; Conlisk et al. 2020). In their population modelling, Marcot et al. (2013) found that as more of the landscape becomes suitable (i.e., overall habitat more contiguous), all cluster size/spacing configuration options become sufficient to achieve low dispersal mortality and high long-term stability. There have

been few empirical studies of dispersal habitat use and demographic associations; however, a study in western Oregon, Miller (1997) showed that juveniles that used more clearcut areas during dispersal had higher mortality rates than those using more intact forest habitat. Similarly, in an analysis of over 1530 successful juvenile dispersal events in the U.S.A., Hollenbeck et al. (2018) found that dispersal pathways tended to coincide with the distribution of forested areas along mountain ranges. Overall population stability is therefore most likely when a landscape includes not just large, closely-configured, year-round habitat patches, but also habitat falling in between year-round patches that provides foraging and safe roosting opportunities for dispersing birds.

Home range-level configuration

Within suitable landscapes, areas that adult/resident Spotted Owls occupy year-round are represented by their home ranges. Home ranges can be occupied by unpaired resident birds, or by a breeding pair. A certain amount of habitat must be present in these areas in order to support nesting, roosting, and foraging life history functions (as described below). Further, this habitat must not be dispersed across too large an area, so that it can be accessed without excess energy expenditure and/or exposure to predation (Carey et al. 1992; Courtney et al. 2004; Sutherland et al. 2007). The mean area of habitat required to support a resident Spotted Owl home range varies from the wetter to the drier sub-regions: Maritime – 3010 ha, Sub-maritime – 2224 ha, Continental – 1907 ha (Chutter et al. 2004; Sutherland et al. 2007). In locations with 100% contiguous habitat, these numbers also represent minimum home range sizes. Home ranges become larger as habitat is more fragmented/dispersed (Carey et al. 1992). The maximum areas across which the abovementioned habitat amounts can be dispersed and thus an energetically-viable home range can be sustained within Canada are estimated at 11,047, 7258, and 6305 ha in the Maritime, Sub-maritime, and Continental sub-regions, respectively (Sutherland et al. 2007).

Patch-level configuration

Owing to a combination of both natural and anthropogenic disturbances, remnant Spotted Owl habitat in Canada exists in a range of patch sizes, from large contiguous expanses to patches <1 ha in size. In addition to patch dispersion, a patch's size also impacts whether it can provide functional habitat for a Spotted Owl. Ten hectares has been estimated by experts within Canada as the minimum habitat patch size within which preferred prey can persist and thus Spotted Owls can successfully forage (reviewed in Sutherland et al. 2007). In addition to absolute size, the irregularity of a patch may also impact its utility for Spotted Owls. Research from Pacific Northwest forests have found that microclimate (including humidity and solar exposure) can be impacted up to ~100 m from an edge (Kremsater and Bunnell 1999) and that these impacts may be particularly pronounced for species of fungi and lichens, which are often adapted to the cooler, moisture, darker conditions associated with interior forest (Crockatt 2012; Gauslaa et al. 2018). Spotted Owls in Canada feed disproportionately (>40% of diet) on Northern Flying Squirrels (*Glaucomys sabrinus*; Horoupian et al. 2004), which in turn feed preferentially on fungi and lichens associated with coniferous forested habitats (Carey 1991; Carey et al. 1992; Waters and Zabel 1995). In small or highly-irregular forest patches with high edge-to-interior ratios, the conditions necessary to sustain foraging resources for Northern Flying Squirrels may not exist. Competitors (of Spotted Owls) that are better adapted to foraging within diverse habitats may also over-exploit preferred prey species in openings and along edges, further reducing prey availability for Spotted Owls in small or irregular patches (Wilson and Forsman 2013; Weins et al. 2014).

Habitat attributes

Nesting

Spotted Owls do not build their own nests, but depend on naturally-occurring or previously-constructed (by other raptor species) nest sites (Chutter et al. 2004, Waterhouse et al. 2012; Wilks et al. 2018). Nest sites include broken treetops, tree cavities, abandoned raptor nests, mistletoe brooms, and debris accumulations captured in branches (Forsman et al. 1984, Dawson et al. 1986, Waterhouse et al. 2012; Wilk et al. 2018). In captivity, nesting has occurred in artificial cavities (McCulligh 2019, see also Gutierrez et al. 1995). In general, cavities are more often used in moist climates and platforms are more frequently used in drier climates, particularly where cavities in trees >50 cm in diameter are not available (Chutter et al. 2004). In a survey of known nest trees in B.C., Waterhouse et al. (2012) found that nest cavities were exclusively in trees >98 cm in diameter. A variety of different tree species are used for nesting within the species' range although large Douglas-fir may be selected more frequently in the drier regions (Waterhouse et al. 2012; Wilk et al. 2018). In the wetter regions, Western Hemlock and Western Redcedar have been used in equal proportion to Douglas-fir (Forsman and Giese 1997； Wilk et al. 2018). Nest site fidelity[6] is high and re-use of nest structures is common (Forsman et al. 1984).

Breeding Spotted Owls may experience stress, reduced reproductive output, and disrupted nesting behaviours when exposed to acute noise within their nesting areas (Wasser et al. 1997, Hayward et al. 2011, USFWS 2020), therefore, in order to successfully carry out breeding functions they also require nesting areas to be free of significant acoustic disturbance. Acoustic disturbance significant enough to impact nesting functions can result from activities that result in an overall sound level above 90 db (e.g., operation of large machinery, use of chainsaws, blasting, operation of large engines and engine brakes, operation of motorized recreational vehicles) or that increase the sound level above ambient conditions by over 20 db (USFWS 2020).

Roosting and escape

Spotted Owls require roosting sites that provide good protective cover, from both predators and inclement weather. The multi-storied nature and high percentage closure of old-growth canopies enables thermoregulation and escape from inclement weather, as well as providing protection from predators (Blackburn et al. 2009). Spotted Owl is easily subjected to heat stress and reduces its exposure by moving between roosting habitats in different parts of the canopy (Barrows 1981). The closed canopies of old-growth habitats also provide refuge from rain and snow (North et al. 2000). Great Horned Owls (*Bubo virginianus*) are the primary predator of Spotted Owl (Gutierrez et al. 1995), and favour edge habitats and openings where they have greater access to prey (Artuso et al. 2013). Susceptibility to Great Horned Owl predation may thus be minimized in areas with intact, contiguous old-growth/mature forest (Johnson 1993).

Foraging

Spotted Owls require habitat with characteristics that promote abundant and accessible prey, which is primarily comprised of arboreal and semi-arboreal small mammals (Chutter et al. 2004; Wiens et al. 2014). Studies in western Washington and British Columbia showed that Northern Flying Squirrels, Bushy-tailed Woodrats (*Neotoma cinerea*), and Deer Mice (*Peromyscus* sp.)

[6] Tendency to return to the same nesting location and/or re-use the same nest structure in subsequent years.

were the most common prey for Spotted Owls in the northern extent of the Spotted Owl's range (Forsman et al. 2001; Horoupian et al. 2004; Wiens et al. 2014). The abundant large coarse woody debris (CWD), standing snags, and diverse shrub layers present within old-growth forests support prey populations by providing moist microclimates, protective cover for movement, nest/burrow sites, and food in the form of fungi, plants and invertebrates (Carey 1991; Carey et al. 1997; Carey et al. 1999; Wilson and Forsman 2013). The open mid-storey structure of old-growth habitats also enables Spotted Owls to have more efficient access to those prey through providing longer sightlines and unimpeded flight paths (Chutter et al. 2004; D'Anjou et al. 2015).

Safe movement / dispersal

Like resident Spotted Owls, dispersing individuals require available prey and safe roosts/escape features, therefore, old-growth and mature forests (i.e., the same forests that support nesting/roosting and foraging) are understood to provide ideal conditions (reviewed in Buchanan 2004). Safe movement/dispersal is thus best-supported by nesting/foraging quality habitat falling either within year-round patches (enabling within-patch dispersal) or in between patches. Where contiguous nesting/foraging quality habitat does not exist between year-round habitat patches, survival rates during dispersal may also be improved through the provision of forested habitat in other seral stages. Research is required to determine the additional habitat types and quantities that can contribute towards successful dispersal (Buchanan 2004).

Distribution of competitors

In addition to habitat amount, quality and configuration, the distribution and abundance of the Spotted Owl's primary competitor, the Barred Owl, has been shown to strongly influence Spotted Owl occupancy across the landscape (Dugger et al. 2011; Dugger et al. 2016; Yackulic et al. 2019; Jenkins et al. 2019). Barred Owls reduce Spotted Owl occupancy of otherwise suitable habitat through both competition for prey (exploitative competition) and territorial displacement (Dugger et al. 2011; Wiens et al. 2014). See the Threats section for more details.

Classification of habitat for Spotted Owl

The Vegetation Resource Inventory (VRI) geospatial database provides detailed information about the characteristics of forests in B.C. The VRI attributes used to classify forests as potentially suitable for Spotted Owl in B.C. (not accounting for configuration considerations) are summarized in Table 2. 'Nesting' quality habitat is characterized by old, tall, low-elevation stands, and 'foraging' quality habitat is characterized by mature, moderately tall stands that may extend further upslope. Both 'nesting' and 'foraging' quality habitats are considered to have characteristics that also support roosting and safe movement / dispersal. Nesting quality habitat is used disproportionately relative to its availability on the landscape, whereas foraging quality habitat is used in proportion with its availability on the landscape (Forsman et al. 1984; Carey et al. 1990; Carey et al. 1992).

The provincial government is also continuing to develop and refine habitat classification approaches as part of its Stewardship Baseline Objectives Tool (Government of B.C. 2020).

Table 2. Summary of attributes used to classify forests as potentially suitable for Spotted Owl in B.C. using the Vegetation Resource Inventory (VRI) geospatial database (from Sutherland et al. 2007). Note that this does not account for habitat configuration, competitor distribution, or the locations where captive-bred Spotted Owls will be released, which ultimately determine the likelihood that habitat will support recovery of the Spotted Owl.

Function / Class	**Attribute**	**VRI polygon-level selection thresholds**					
		Maritime sub-region *(CWHdm, CWHvm1&2, CWHxm1)**		**Sub-maritime sub-region** *(CWHds1, CWHms1, IDFww)*		**Continental sub-region** *(IDFdc, IDFdk1,2&3, IDFww1, IDFxc, IDFxh1&2, PPxh2)*	
		Structure present**	**Structure absent****	**Structure present**	**Structure absent**	**Structure present**	**Structure absent**
Nesting, roosting and safe movement	Stand age	≥ 140 years	≥ 200 years	≥ 110 years	≥ 200 years	≥ 110 years	≥ 200 years
	Stand height	≥ 28.5 m		≥ 23 m		≥ 23 m	
	Elevation	≤ 900 m		≤ 1000 m		≤ 1200 m***	
Foraging, roosting and safe movement	Stand age	≥ 120 years	≥ 140 years	≥ 100 years	≥ 120 years	≥ 80 years	≥ 100 years
	Stand height	≥ 19.5 m		≥ 19.5 m		≥ 19.5 m	
	Elevation	No limit, other than BEC		No limit, other than BEC		No limit, other than BEC	

*****Biogeoclimatic Ecosystem Classification (BEC) zones and variants within which selection occurred. Note: re-mapping of BEC variants in the Continental sub-region since 2004 has resulted in some additions/deletions to the selected variants from the Sutherland et al. (2007) version. For descriptions and definitions see: https://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/index.html

**This distinction is relevant to future projections only, in determining whether a stand that was previously harvested will have the structural characteristics of nesting and foraging class habitat within the 50-year recovery timeframe. Stands that were of natural disturbance origin or that were harvested prior to the advent of clear cut harvesting are assumed to have remnant old forest structure present, and so are expected to have all the attributes required to support Spotted Owl nesting and/or foraging at a younger age. In comparison, stands harvested since the advent of clearcut harvesting will not have old forest structure remaining, so will take longer to re-acquire these characteristics.

***Increased from 1100 m (Sutherland et al. 2007) to 1200 m to accommodate nests found more recently >1100 m in the Continental sub-region.

4. Threats

The Spotted Owl threat assessment is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational). Limiting factors are not considered during this assessment process. For purposes of threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in the Description of Threats section.

Table 3. Threat calculator assessment.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
1	Residential & commercial development	Low	Small	Extreme	High
1.1	Housing & urban areas	Low	Small	Extreme	High
1.2	Commercial & industrial areas	Low	Small	Extreme	High
1.3	Tourism & recreation areas	Low	Small	Extreme	High
2	Agriculture & aquaculture	Negligible	Negligible	Extreme	High
2.1	Annual & perennial non-timber crops	Negligible	Negligible	Extreme	High
2.2	Wood & pulp plantations	Negligible	Negligible	Extreme	High
2.3	Livestock farming & ranching	Negligible	Negligible	Slight	High
3	Energy production & mining	Low	Small	Extreme	High
3.1	Oil & gas drilling	Negligible	Negligible	Moderate	High
3.2	Mining & quarrying	Low	Small	Extreme	High
3.3	Renewable energy	Negligible	Negligible	Extreme	High
4	Transportation & service corridors	Medium	Restricted	Extreme	High
4.1	Roads & railroads	Medium	Restricted	Extreme	High
4.2	Utility & service lines	Low	Small	Extreme	High
4.4	Flight paths	Negligible	Negligible	Negligible	High
5	Biological resource use	High	Large	Extreme	High
5.1	Hunting & collecting terrestrial animals	Negligible	Negligible	Negligible	High
5.2	Gathering terrestrial plants	Negligible	Negligible	Negligible	High
5.3	Logging & wood harvesting	High	Large	Extreme	High
6	Human intrusions & disturbance	Low	Restricted	Slight	High
6.1	Recreational activities	Low	Restricted	Slight	High
6.2	War, civil unrest & military exercises	Negligible	Negligible	Negligible	High

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
7	Natural system modifications	Medium	Restricted	Extreme	High
7.1	Fire & fire suppression	Medium	Restricted	Extreme	High
7.2	Dams & water management/use	Negligible	Small	Negligible	High
8	Invasive & other problematic species & genes	Very High	Pervasive	Extreme	High
8.1	Invasive non-native/alien species/diseases	Negligible	Negligible	Negligible	High
8.2	Problematic native species/diseases	Very High	Pervasive	Extreme	High
8.3	Introduced genetic material	Negligible	Negligible	Negligible	High
8.4	Problematic species/diseases of unknown origin	Unknown	Unknown	Unknown	Unknown
8.5	Viral/prion-induced diseases	Unknown	Unknown	Unknown	Unknown
8.6	Diseases of unknown cause	Unknown	Unknown	Unknown	Unknown
9	Pollution	Negligible	Negligible	Negligible	High
9.1	Domestic & urban waste water	Negligible	Negligible	Negligible	High
9.2	Industrial & military effluents	Negligible	Negligible	Negligible	High
9.3	Agricultural & forestry effluents	Negligible	Negligible	Negligible	High
9.5	Air-borne pollutants	Negligible	Negligible	Slight	High
9.6	Excess energy	Negligible	Negligible	Negligible	High
10	Geological events	Negligible	Negligible	Moderate	High
10.3	Avalanches/landslides	Negligible	Negligible	Moderate	High
11	Climate change & severe weather	Unknown	Unknown	Unknown	Unknown
11.1	Habitat shifting & alteration	Unknown	Unknown	Unknown	Unknown
11.2	Droughts	Unknown	Unknown	Unknown	Unknown
11.3	Temperature extremes	Unknown	Unknown	Unknown	Unknown
11.4	Storms & flooding	Unknown	Unknown	Unknown	Unknown

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.1 Description of Threats

Based on IUCN threat evaluation criteria, the overall range-wide threat impact for Spotted Owl in Canada is 'very high'. There is one 'very high' impact threat, one threat that is 'high' impact, two threats that are 'medium' impact, seven threats that are 'low' impact, and numerous threats that were evaluated as having 'negligible' or 'unknown' impacts, within the 10-year IUCN assessment timeframe (Table 3).

Very High Impact Threats

IUCN 8.2 – Problematic native species

The Barred Owl is native to eastern Canada but has expanded its range westward and southward. This is hypothesized as being a consequence of human introduction of trees across the previously tree-less prairie regions of central North America, e.g., through European settlers excluding fires historically set by First Nations, suppressing fires and planting trees (Livesy 2009b). In the 1960s Barred Owls began to overlap the range of the Spotted Owl in British Columbia (Campbell et al. 1990; Dunbar et al. 1991). Barred Owls were detected at all 10 of the previously-occupied Spotted Owl survey sites visited in 2019 (J. Gillis pers. comm. 2019). They have also been detected extensively along general owl survey routes throughout the Spotted Owl's historical range. Barred Owls thrive in a variety of forest types and seral stages and have adapted to more varied food sources than Spotted Owl (Livezey et al. 2009a&b; Wiens et al. 2014; Diller et al. 2016; Dugger et al. 2016). Barred Owls threaten Spotted Owl primarily through competition for habitat and prey (Dugger et al. 2011). Hybridization and predation have also been observed on rare occasions (Leskiw and Gutiérrez 1998; Kelly and Forsman 2004); however, these are not considered serious threats (USFWS 2011).

In recognition of the severity of this threat, Barred Owl control programs have been initiated within the range of both the American and Canadian Spotted Owl populations (Diller et al. 2016; Dugger et al. 2016; Gillis 2016a; Wiens et al. 2020). American programs have employed lethal removal and the B.C. program has employed a combination of translocation and lethal removal. Results from Barred Owl removal studies have varied with more immediate success at the southern edge of the range and uncertain/slower results at the northern edge of the range. In California, the annual Spotted Owl population growth rate four years after (lethal) removals was 1.029 (increasing) on removal sites versus 0.870 (declining) on control sites (Diller et al. 2016), and in Oregon and Washington, increases in Spotted Owl occupancy and fecundity and decreases in local extinction rates were observed 4.5 years following Barred Owl removals (Wiens et al. 2020). However, responses were slower in the more northern sites in Oregon and in Washington (Wiens et al. 2020) and in B.C. (lethal and non-lethal) removal efforts have not yet been sufficient to offset Barred Owl recolonization rates (Gillis 2016a&b; Gillis and Waterhouse 2020).

Diller et al. (2016) suggested that Spotted Owl populations further north may experience slower recovery following Barred Owl removal because Barred Owl populations are more well-established (so require more intensive and sustained removal efforts to overcome recolonization by floaters/dispersers) and Spotted Owl populations are too small to recover quickly (fewer floaters/dispersers waiting to take up available territories). The supplementation of the B.C. Spotted Owl population through re-introduction may counter this effect. However, even if Barred Owl control is effective, it is unknown whether this threat can be mitigated or avoided to the

extent that Spotted Owl can recover without ongoing human intervention (Bodine and Capaldi 2017). Research and adaptive management will be required to determine if and how the Barred Owl threat can be effectively addressed over the long term and thus whether a recovered Spotted Owl population can be sustained in the absence of ongoing Barred Owl control.

High Impact Threats

IUCN 5.3 – Logging and wood harvesting

Logging has had severe impacts on Spotted Owl, including direct loss of old forest habitat (loss of nesting, roosting, and foraging habitat attributes) and fragmentation (COSEWIC 2008, Chutter et al. 2004). The primary impact of forestry-related habitat fragmentation appears to relate to foraging energetics (reviewed in Courtney et al. 2004). As foraging patches become more dispersed following forest harvest, they may no longer be accessible within an individual's energetic budget, and so the individual may starve or be forced to disperse to a new location (Sovern et al. 2014; Jenkins et al. 2019). Further, as residual patches become smaller and more irregular, they may no longer be able to support adequate numbers of the Spotted Owls' preferred prey species (see section 3.3 – Needs of the Spotted Owl). Additional impacts of logging can include noise disturbance associated with logging operations, when operations take place within 400 m of nesting areas (Wasser et al. 1997, Hayward et al. 2011, USFWS 2020). The conversion of the landscape from old-growth coniferous forest to other habitat types may also increase the exposure of Spotted Owls to their primary predator, the Great Horned Owl (Johnson 1993). Competitive pressure may also be greater within harvested landscapes as Barred Owls are better able to adapt to the more varied seral stages and food sources present in harvested landscapes than are Spotted Owls (Hamer et al. 2007; Wiens et al. 2014; Yackulic et al. 2019).

Improved forestry practices on Crown Land under the *Forest and Range Practices Act* as well as Spotted Owl-specific habitat protection initiatives under the Spotted Owl Management Plans (1 and 2) have partially reduced forestry impacts on Spotted Owl and other old forest-dependent species by requiring or promoting the retention of veteran trees, snags, and riparian areas; reducing cut block size; increasing retention area size; and providing some measure of habitat protection for tracts of old forest through the designation of Wildlife Habitat Areas (WHAs), Old Growth Management Areas (OGMAs) and Ungulate Winter Ranges (UWRs) (Government of B.C. 2009). However, a large amount of nesting and foraging class habitat within the Spotted Owl's range still falls within the unprotected portions of the Timber Harvesting Land Base, and harvesting continues to both remove and isolate habitat.

Medium Impact Threats

IUCN 4.1 – Roads and railroads

Spotted Owl nesting habitat falls within low-land forests where there has been increasing concentration of roads for logging and other purposes. Major railway corridors also fall in these areas. Road-building and expansion results in direct and often permanent habitat loss through eliminating old forest habitat within the immediate road surface and managed right-of-way. Roads and railways also expose individuals to risk of collisions (Forsman et al. 2002), and noise disturbance from road and rail traffic can increase individual stress levels and reduce reproductive output when it occurs near nesting areas (Wasser et al. 1997, Hayward et al. 2011) as well as potentially altering nesting behaviours (USFWS 2020). Great Horned Owls may also

be more prevalent along linear corridors such as roads and railways, putting Spotted Owls at greater risk of predation when these features transect their habitat (Johnson 1993). Road-building will continue to accompany resource extraction/development activities (e.g., forest harvesting). New rail lines are not being planned within the Spotted Owl range.

IUCN 7.1 – Fire and fire suppression

Within the drier Sub-maritime and Continental sub-regions, vigorous fire protection by the B.C. Forest Service between the 1960s and 1990s extended fire return intervals well beyond their historical range, creating an accumulation of woody fuels, which can lead to more intense, stand-replacing wildfires (Wong et al. 2003, ESTR Secretariat 2014). Within the American portion of the range, Davis et al. (2016) estimated that 191,900 ha of nesting and roosting habitat on federal lands had been lost to wildfires between 1994 and 2013, four times the amount of habitat that was harvested. A similar analysis in the Canadian portion of the species' range by the Canadian Wildlife Service using annual fire disturbance mapping from 1985 to 2015 (Hermosilla et al. 2015a&b, 2017), indicated that 47,915 ha of forests within the areas classed as suitable for Spotted Owl has been detectably[7] impacted by fire across that 30-year period, primarily within the drier Sub-maritime and Continental sub-regions, with annual burn areas as large as 4156 ha. Fire impacts are expected to increase in the Spotted Owl range under climate change (reviewed in Spies et al. 2018). Within the wetter regions (i.e., Maritime sub-region in Canada), overall area impacted by fire is expected to remain relatively low owing to the naturally very low fire incidence there, even when multiplied according to climate projections (Littell et al. 2010). However, in the drier sub-regions, where existing fire intervals are shorter and fire extents larger, the increase will translate into more significant habitat impacts (reviewed in Spies et al. 2018). Applying an assumption that future annual burn rates under climate change are likely to approximate the upper end of the annual burn rates observed in the previous 30 years (i.e., up to 4156 ha per year), it is estimated that as much as 207,800 ha of Spotted Owl habitat within Canada will be impacted by fire within the 50-year recovery timeframe. This projection was supported during the 2021 fire season when as much as 7700 ha of Spotted Owl habitat may have been impacted by fire (based on B.C. Fire Perimeters mapping). Although not all of these fires will be stand-destroying and result in long-term habitat loss, projections of increasing incidence and area of catastrophic fire under climate change do indicate that fire will be a significant driver of habitat loss in the future (reviewed in Spies et al. 2018; Price and Daust 2016). Wildfire risk reduction efforts could counter this risk; however, such efforts also have the potential to impact Spotted Owl habitat directly (through loss of potential nesting trees and the features required to support prey populations) when crews target downed wood (CWD) and snags for removal. Addressing the risk of fire and climate change-mediated increases in fire impacts to Spotted Owl will require a number of strategies, including increasing the overall area conserved in support of Spotted Owl recovery to account for projected fire impacts, ensuring a high level of connectivity as well as alternate connections to provide refugia and enable recolonization/recovery following disturbance, and employing carefully-managed wildfire risk reductions efforts (e.g., avoiding irreplaceable old forest elements such as snags and CWD) in more fire-prone regions that have surplus fuel loads as a consequence of historical fire suppression.

Low Impact Threats

IUCN 1.1 – Housing and urban areas & IUCN 1.2 – Commercial and industrial areas

[7] Fire impacts were significant enough to result in changes to the forest canopy that could be detected within satellite imagery.

Historically (prior to the 1930s), urbanization (and associated commercial and industrial development) resulted in broad-scale loss of mixed-coniferous forests throughout the Lower Mainland (Boyle et al. 1990) as well as portions of the Lower Fraser Valley where agricultural development did not predate the urbanization. However, most old forest habitat within range of these population centers has now been converted to urban areas (Chutter et al. 2004; Sutherland et al. 2007), so this is not expected to represent a significant, broad-scale threat in the next decade.

IUCN 1.3 – Tourism and recreation areas

Several large ski resorts exist within the Maritime sub-region in areas with habitat for Spotted Owl. Expansion of resort infrastructure within existing ski areas could lead to additional, localized, habitat loss. Planning is also underway for one new ski resort in the Sub-maritime sub-region, although proposed development is largely within the footprint of an existing mine, so additional habitat impacts may be minimal. Use of provincial parks and other accessible Crown lands within all three sub-regions has also increased dramatically in the last decade (B.C. Parks 2018; J. Hirner, pers. comm. 2020), creating pressure to expand trails and park infrastructure into potential Spotted Owl habitat. However, this threat applies to a relatively small percentage of the species' range, so the overall impact is low.

IUCN 3.2 – Mining and quarrying

Mining and mineral exploration activities are uncommon in the Spotted Owl range; however, because they are exempt from the prohibitions on forest harvest under the General Wildlife Measures in WHAs (Government of B.C. 2019), such activities have the potential to cause habitat loss even in areas under timber harvest constraints. Any Spotted Owls nesting or foraging within the vicinity of mining or quarrying operations could also be disturbed by operational noise. However, this threat applies to a relatively small percentage of the species' range, so the overall impact is low.

IUCN 4.2 – Utility and service lines

As with roads, habitat clearing associated with utility and service line construction (which includes pipelines) will result in some direct habitat loss and the linear edge habitats created could impact prey populations and increase predator exposure. Any Spotted Owls nesting or foraging within the vicinity of utility or service lines during construction or maintenance could also be disturbed by machine noise. However, this threat applies to a relatively small percentage of the species' range (only one major utility line project is currently being planned/constructed in the species' range), so the overall impact is low.

IUCN 6.1 – Recreational activities

Backcountry recreation use has increased dramatically within Southern B.C. Visitor numbers at B.C. Parks in southern regions increased by 60% between 2007 and 2017 (B.C. Parks 2018). Recreational use of other accessible Crown lands has also increased dramatically in the last decade (J. Hirner, pers. comm. 2020). As more backcountry users visit parks and recreation areas where Spotted Owls nest, the potential for human disturbance increases. Motorized recreation, in particular, could disturb Spotted Owls nesting in the vicinity of recreational trails/areas. However, this threat applies to a relatively small percentage of the species' range, so the overall impact is low.

Negligible and Unknown Impact Threats

Eleven individual threats or complete IUCN threat categories were classified as having a negligible impact on Spotted Owl based on limited spatial overlap with the species' range and habitat and/or no anticipated impacts within the 10-year IUCN-CMP assessment timeframe.

A further five threats were classified as having unknown impacts within the 10-year assessment timeframe; most related to climate change. Climate change impacts could be significant, particularly within the 50-year recovery timeframe, but there remains considerable uncertainty around the direction and magnitude of climate change-mediated shifts in weather, natural disturbance, and forest health within the Spotted Owl range, as well as the likely response of Spotted Owls to those changes (reviewed in Courtney et al. 2004; Spies et al. 2018).

A comprehensive review of climate modelling research has been undertaken for the Northwest Forest Plan (in the U.S.A.), which is focused on management of old-growth forests for Spotted Owl recovery (Spies et al. 2018). Most models assessed within that review project that the region will experience warmer, drier summers and potentially warmer and wetter winters. Conditions are projected to exceed the 20th-century range of variability by the 2050s. These predictions are supported by modelling that also covers the Canadian portion of the Spotted Owl's range (Wang et al. 2016). A comprehensive analysis of Spotted Owl survival and recruitment in relation to predictors including climate (Dugger et al. 2015) found an association between climate variables and both juvenile recruitment and adult annual survival. Recruitment was lowest when conditions during the previous winter were cold and wet, and highest when the previous winter was cold and dry. Observed survival rates were higher when winters were relatively warmer and drier. Given predicted temperature and precipitation patterns under climate change, it is difficult to predict how Spotted Owl population parameters may be impacted.

When it comes to habitat impacts of climate change, lower elevation, moist vegetation zones (e.g., those within much of the Maritime sub-region in Canada) are expected to experience decreased growth and productivity, especially where tree species are already water limited during the growing season (reviewed in Spies et al. 2018). Within drier forests (e.g., those within the Continental sub-region and some portions of the Sub-maritime) most models predict an increased role of fire, including more area burned and larger patches of high-severity fire (reviewed in Spies et al. 2018; Price and Daust 2016), which will increase the rate of fire-related habitat loss, relative to past decades (e.g., see IUCN-CMP 7.1, above). A preliminary assessment of anticipated climate change vulnerability for a number of species in B.C. was conducted in 2016 (Price and Daust 2016). Although Spotted Owl was not amongst the species assessed, other old forest-associated species with similar ranges were assessed as having moderate-high climate change vulnerability, primarily owing to increased climate change-mediated natural disturbance within their old forest habitats.

While it is difficult to predict the full magnitude of climate change-mediated impacts on Spotted Owls and their habitat, it is possible to anticipate and implement strategies for reducing/mitigating those impacts whilst contributing to national and global solutions towards climate change mitigation. Old-growth forests have the potential to buffer local warming, and thus function as local refugia for species reliant on cooler conditions (Spies et al. 2018; Dinerstein et al. 2019). In addition, many old forests have reached an advanced age without being impacted by stand-destroying disturbance because they exist within areas that are naturally less prone to catastrophic disturbances such as fires (e.g., moist riparian zones,

cooler/more shaded aspects; Krawchuk et al. 2020; USGS 2021). As such, on a local level, existing old forest patches are more likely to continue to experience less disturbance (than the surrounding matrix) under climate change and function as microrefugia, enabling species to persist and recolonize even as average disturbance rates increase. On a broader scale, landscapes dominated by old forests are also predicted to exhibit relatively low climate sensitivity (compared to landscapes dominated by younger forest) and act as macrorefugia (Thom et al. 2019). Within B.C., there is significant spatial overlap between the low-elevation old-forest-dominated habitat throughout the Spotted Owl range and landscapes with high predicted climate change resilience and macrorefugia potential (Beckers and Carroll 2020). In their 2016 climate change vulnerability assessment Price and Daust recommended maintaining "sufficient old forest habitat to buffer changes in temperature and moisture and allow for dispersal" and "to maintain sufficient habitat as disturbance rate increases" as strategies to mitigate the effects of climate change for other old forest-associated species. They also recommended maintaining "landscape connectivity noting that natural landscapes provide the best opportunities for dispersal". Ensuring protection of highly-connected networks of old-forest Spotted Owl habitat, which could function as refugia in an increasingly disturbance-prone landscape, will be an essential component of mitigating climate change-mediated disturbance and maintaining climate change resilience for Spotted Owls and other forest-dependent species (Gayton 2008; Spies et al. 2018; Thom et al. 2019; Krawchuk et al. 2020; USGS 2021).

5. Population and Distribution Objectives

Population and Distribution Objective:

To recover Spotted Owl in Canada by restoring a stable population of at least 250 mature individuals distributed within a connected network of habitat representative of all three sub-regions within the species' historical Canadian range, and linked to the larger population in the U.S.A.

Rationale:

Historically, the Spotted Owl's restricted range and small population size (<1000 individuals) would have made it naturally precarious (i.e., naturally falling within COSEWIC's Threatened status); however, the population was believed to be large enough to be stable, with connectivity/representation across its range. In contrast, the species is now assessed as Endangered on the basis of compromised stability, redundancy, connectivity, and resilience.

There has been permanent loss of habitat within the Lower Mainland and Lower Fraser Valley (now a major human population center), which both reduces the overall area available to the species in Canada and restricts the potential for continued gene flow between Canada and the U.S.A. (Chutter et al. 2004). However, portions of habitat within the remainder of the range, across all three historically-occupied sub-regions, are either still intact or can be regenerated (through being left to mature naturally over time) to improve size, quality, connectivity, and historical representation, and other limitations to recovery are believed to be manageable over the long term, given current/anticipated tools (Chutter et al. 2004; Government of B.C. 2020; B.C. MFLNRORD 2021). Assuming that planned actions are undertaken to i) protect and restore sufficient Spotted Owl habitat; ii) control Barred Owls to reduce interspecific competition; iii) breed Spotted Owls in captivity, and iv) release captive-born Spotted Owls to supplement wild populations and achieve successful breeding of reintroduced owls in the wild, the provincial

government projects that it is within the scope of biological and technical feasibility to achieve the COSEWIC threshold for Threatened status (i.e., ≥250 mature individuals) within 50 years (B.C. MFLNRORD 2021). The amount, configuration and attributes of habitat that is necessary to achieve this population target in context of distribution objectives (connectivity and representation) are described in section 7 of this document. Recovery of Spotted Owls will require significant targeted interventions in the form of population augmentation and competitor control in the short- to medium-term (10-30 years), therefore, short-term statements toward meeting the objective are set out below, to facilitate recovery implementation.

Short-term Statements Toward Meeting the Population and Distribution Objective:

1. Immediately cease human-caused threats that would cause loss of the habitat needed for recovery (i.e., the critical habitat).
2. Re-introduce at least 50[8] captive-bred Spotted Owls back into the wild within 10 years (by 2031), with at least 10 released individuals surviving to become adult residents.
3. Complete annual Barred Owl surveillance at sites occupied by Spotted Owl and/or where reintroductions are planned within 10 years, and within habitat falling in between adjacent occupied/reintroduction sites, and remove all Barred Owls that are detected.

6. Broad Strategies and General Approaches to Meet Objectives

6.1 Actions Already Completed or Currently Underway

Habitat protection, enhancement and stewardship

Management planning

In 1997, a Spotted Owl Management Plan (SOMP) was developed with a goal of stabilizing (and possibly improving) the population over the long-term, without significant impacts on timber supply and forestry employment (SOMIT 1997). SOMP established 21 Special Resource Management Zones (SRMZs) that included pre-existing protected areas as well as Crown forest land. Within the SRMZs that fell outside protected areas, 67% of the habitat was to remain suitable for Spotted Owl, while the remaining 33% was eligible for harvest using certain prescriptions.

In 2009, an updated version of SOMP ('SOMP2') was released, which involved transferring SRMZs into Long Term Owl Habitat Areas (LTOHAs; managed for Spotted Owl conservation) and Managed Future Habitat Areas (MFHAs; managed for forest harvest with consideration for long-term Spotted Owl habitat development) and creating updated harvesting guidelines/designations (Blackburn et al. 2009; Government of B.C. 2009). The requirement to limit significant impacts on timber supply and forestry employment remained. In 2012, the LTOHA and MFHA areas under SOMP2 became legally-designated Wildlife Habitat Areas

[8] This number is derived from current projections by the provincial government (B.C. MFLNRORD 2021) but is subject to adjustment following the pilot phase of the reintroduction (2021-2025), based on the actual annual reproductive output of captive pairs and the survival outcomes of released individuals.

(WHA) with General Wildlife Measures (GWM). Thirty-two WHAs are now in place to provide a measure of protection to known Spotted Owl territories (Government of B.C. 2019). Within the LTOHA WHAs forest harvest is largely prohibited, and within the MFHA WHAs harvest is permitted subject to conditions.

Additional regulatory measures

In addition to provincial WHAs, other protected area designations[9] provide some measure of protection for Spotted Owl habitat. These include: Provincial/Municipal/Regional Parks; Provincial Protected Areas, Recreation Areas, Ecological Reserves and Conservancy Areas; Sea-to-Sky Wildland Areas; Metro Vancouver Watersheds; Ungulate Winter Ranges, Old Growth Management Areas, and Wildlife Habitat Areas for other species; and National Wildlife Areas.

Active population management

Captive breeding and release

In 2007, the Spotted Owl Population Enhancement Team, an arm's-length independent panel that was established by the provincial government, determined that the wild population was so small and isolated that extirpation was a certainty. It therefore made the recommendation to capture either all or a subset of the remaining wild individuals and establish a captive-bred population whose offspring could be re-introduced into the wild after a period of Barred Owl removal activity (Fenger et al. 2007). The provincial government elected to capture only a subset of the remaining wild individuals (six) to establish the captive breeding program and allow a small wild population to persist. The home ranges that owls were removed from to establish the captive breeding program were all designated as LTOHAs at that time. They were then converted into WHAs in 2012.

The Spotted Owl captive breeding program has been in operation in B.C. since 2007. It has had slow initial success rates and has not released any captive-bred owls to date. However, a now younger breeding population and improvements in husbandry techniques have resulted in higher breeding output in recent years, and releases are being planned in the near term (McCulligh 2019; B.C. MFLNRORD 2021). There are 31 individuals currently in captivity (see Figure 3; J. McCulligh, pers. comm. 2021). The intent is to align release locations with operational Barred Owl control (B.C. MFLNRORD 2021).

Barred Owl control

In 2007, the provincial government initiated a Barred Owl removal program, with target sites including active Spotted Owl territories and sites planned for re-establishment through the release of captive-bred owls (Fenger et al. 2007). From 2007-2016, the provincial government removed a total of 150 Barred Owls from active and proposed Spotted Owl re-establishment sites (Gillis and Waterhouse 2020). Removals were a combination of capture and translocation (at re-establishment sites) and lethal removal via shooting (at active sites). One hundred and eight Barred Owls were captured and translocated away from proposed re-establishment sites and 42 were removed from active Spotted Owl sites using lethal methods. The combined

[9] These forms of habitat protection do not necessarily qualify as effective protection of critical habitat under SARA. Such a determination can only be made following a Critical Habitat Protection Assessment (Environment and Climate Change Canada 2016).

removal effort reduced the number of detected Barred Owls overall, but was ultimately not sufficient to overcome local re-colonization rates. Moving forward, adaptations to removal methods could improve the effectiveness of Barred Owl removal efforts in B.C. (Gillis and Waterhouse 2020). The augmentation of the wild population through the release of captive-bred owls may also increase the rate of Spotted Owl recolonization of removal sites (relative to areas in Washington and Coastal Oregon where population augmentation is not yet occurring; see Diller et al. 2016).

Inventory, monitoring, and population evaluation

Owl population inventory and monitoring

From the 1990s to 2008, inventories were conducted to determine the range, distribution, and abundance of Spotted Owl in B.C., as well as to assist in resource management decisions (Blackburn et al 2002; J. Gillis pers. comm. 2019). An organized banding program (attaching unique leg bands) was initiated in 1998 to identify individuals and monitor their movements and habitat occupancy. Between 1998 and 1999, transmitters were affixed to several breeding pairs to monitor habitat use and home range sizes (Chutter et al. 2004). Between 2003 and 2014, juvenile owls were affixed with transmitters to ascertain their dispersal movements and overwinter survival (Hobbs 2004, 2005; J. Gillis pers. comm. 2019). Beginning in 2015, inventory/monitoring efforts became focused on revisiting previously-known Spotted Owl sites to assess re-occupancy, as well as inventory of sites identified for potential re-introduction through release of captive-bred owls (Gillis 2016a&b; 2017; 2018). Starting in 2016, a pilot program was launched to assess the utility of Autonomous Recording Units (ARUs) in Spotted Owl and Barred Owl monitoring (Gillis 2016a&b; 2017; 2018).

Habitat and population evaluation

In 2007, the Canadian Spotted Owl Recovery Team (CSORT), with the support of Cortex Consultants, developed an integrated modelling framework designed to inform the Spotted Owl recovery program in B.C. and associated habitat management (Sutherland et al. 2007). The framework included models for spatial landscape projection, ecological classification, cross-scale habitat assessment, population dynamics, and reserve selection. This work informed changes / refinements in habitat protection under SOMP 2 (Government of B.C. 2009 & 2020) as well as the approach for the identification of critical habitat in this document.

6.2 Strategic Direction for Recovery

Table 4. Recovery Planning Table

Threat or Limitation	Priority[a]	Broad Strategy to Recovery	General Description of Research and Management Approaches
Habitat loss and fragmentation (IUCN #1, 3.2, 4.1, 4.2, 5.3, 7.1)	High	Habitat protection, enhancement and stewardship	Work between governments (federal, Indigenous, provincial) to establish or confirm protection[b] for identified critical habitat.
	Medium		Pursue wildfire risk-reduction efforts that align with Spotted Owl habitat requirements.
	Low		Develop/expand silvicultural guidelines to create, enhance and/or maintain suitable conditions for Spotted Owl within younger forests that fall between critical habitat patches.
	Low		Promote habitat stewardship with forest companies that operate within the Spotted Owl range in Canada.
	Low		Promote Spotted Owl population stewardship with stakeholders.
Barred Owls (IUCN #8.2)	High	Active population management	Continue the operational Barred Owl control program with annual adaptations informed by results of the B.C. program and those of similar efforts within the U.S.A.
Lack of natural recruitment	High		Continue the Spotted Owl captive breeding and reintroduction program, including post-release measures such as supplemental feeding and satellite tracking of released individuals.
	Medium		Work with government agencies within the U.S.A. to improve international coordination of Spotted Owl recovery efforts and increase the likelihood of cross-border immigration/gene flow.
Knowledge gaps	High	Research, inventory, monitoring and population evaluation	Continue to pilot new monitoring technologies such as ARUs in order to enable comprehensive inventory of the entire Spotted Owl range and timely detection/monitoring of Barred Owls.
	Medium		Establish a periodic, recurrent, standardized survey (counts by age class; number of active territories, recruitment surveys; DNA samples) to monitor the status and composition of the Spotted Owl population.
	Low		Pursue additional research on the impacts of acoustic disturbance on Spotted Owls, including impacts outside of the breeding season.
	Low		Pursue research on the relative contribution of forested habitats of different seral stages to survival of dispersing Spotted Owls, to improve management of dispersal corridors.
	Low		Pursue research to improve understanding of climate change impacts for Spotted Owls and better-integrate climate change resilience/mitigation strategies into recovery planning.

[a] *"Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the population and distribution objective for species and thus considered to be most urgently needed to ensure the species survival or of highest importance for the species' recovery. In some cases, a high priority action may need the completion of another stated high priority action before it can be accomplished. Medium priority measures may have a less immediate or less direct influence on reaching the population and distribution objectives, but are still important for recovery of the population. Low priority recovery measures will likely have an indirect or gradual influence on reaching the recovery objectives, but are considered important contributions to the knowledge base and/or public involvement and acceptance of species. This may be reflected in the timeline for completion.*

[b] *Legal or effective protection under SARA (Environment and Climate Change Canada 2016).*

7. Critical Habitat

Section 41 (1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction. This federal recovery strategy identifies critical habitat to the extent possible, based on the best available information for Spotted Owl. It is recognized that the 'acoustic' critical habitat identified below is insufficient to achieve the population and distribution objectives for the species. A schedule of studies (Section 7.2) has been developed to provide the information necessary to complete the identification of 'acoustic' critical habitat that will be sufficient to meet population and distribution objectives. For 'core' critical habitat, more precise boundaries may also be mapped, and additional 'core' critical habitat may be added in the future if additional information supports the inclusion of areas beyond those currently identified. The identification of critical habitat will be updated when the information becomes available, in a revised recovery strategy.

7.1 Identification of the Species' Critical Habitat

The Spotted Owl requires habitat for nesting, roosting, foraging and safe movement. Mature and old-growth stands already possess the attributes required to support these functions, and some previously-disturbed habitat has the potential to acquire the necessary attributes within the 50-year timeframe needed to meet the population and distribution objective. A 400-m area surrounding nesting areas must be protected from acoustic disturbance during the breeding season in order to ensure that acoustic disturbance does not result in loss of breeding habitat function. The critical habitat required by Spotted Owl for recovery is therefore comprised of two subtypes:

1. **Core critical habitat**: habitat that either already possesses, or will develop (within a 50-year period), the features required by the owls to successfully nest, roost, forage and move safely.
2. **Acoustic critical habitat**: habitat surrounding nesting areas that functions to maintain the acoustic environment within those areas during the breeding season.

The geospatial areas containing critical habitat for Spotted Owl (totalling 416,258 ha[10]) are presented in Figures 3-8. Within these geospatial areas, critical habitat is identified wherever the following biophysical attributes occur.

Biophysical features and attributes of critical habitat

A description of the known biophysical features and attributes of the species' habitat that are required to support life-cycle processes (functions) are summarized in Section 3.3, Needs of the Spotted Owl, and form the basis of the biophysical attribute description in Table 5 below.

[10] Critical habitat is identified for Spotted Owl within one Federal Protected Area: Widgeon Valley National Wildlife Area (17.7 ha).

Table 5. Functions, biophysical features, and attributes of Spotted Owl critical habitat. Attributes represented within VRI mapping act as criteria for selecting core critical habitat polygons (see Table 2). The presence of these attributes must be assessed at the scale of the component VRI polygon. Some or all of the attributes listed here are expected to either be present, or in the process of developing (within the 50-year recovery timeframe), within the core critical habitat polygons; however, owing to the scale of VRI, there can be some uncertainty, so on-the-ground verification of attributes is important. Minimum quantitative thresholds are from the minimum definition of 'moderate/suitable' habitat in Appendix 5 of Chutter et al. (2004). This should not be confused with quantitative definitions of 'superior' habitat (e.g., in Blackburn et al. 2009; Waterhouse et al. 2012; D'Anjou et al. 2015).

Type	**Function**	**Biophysical features**	**Attributes**	
			Maritime sub-region	**Sub-maritime and Continental sub-regions**
Core critical habitat	Nesting	Potential nest trees	Large* (>50 cm dbh) snags or trees with deformities (e.g., large cavities, broken tops, dwarf mistletoe infections)	Large* (>30 cm dbh) snags or trees with deformities (e.g., large cavities, broken tops, dwarf mistletoe infections)
	Roosting and safe movement	Closed, multi-storey canopy to provide thermoregulation opportunities and protection from inclement weather and predators	>60% canopy closure	>50% canopy closure
			≥2 horizontal canopy layers	
	Foraging and safe movement	An open understory structure (characteristic of stands dominated by tall, large-diameter trees) to enable efficient access to prey	Canopy dominated by overstorey trees >50 cm dbh	Canopy dominated by overstorey trees >30 cm dbh
			≥19.5 m stand height	
		Accumulations of fallen trees or other CWD and shrubs to support prey.	Abundant CWD and a diverse shrub layer	
Acoustic critical habitat	Maintenance of suitable acoustic levels within nesting areas	Anthropogenic noise level that does not interfere with life functions within nesting areas, resulting in loss of habitat availability or function.	Noise level not exceeding 90 db and/or not exceeding ambient conditions by >20 db during the Spotted Owl nesting season (February 1st to July 31st)	

*Cavity nests are more likely in trees >90 cm dbh (Waterhouse et al. 2012). Platform nests are more likely in trees at the smaller end of this range.

Within the geospatial areas mapped as **core critical habitat** only unsuitable areas that do not possess any of the features and attributes required by Spotted Owl at any time - either currently, or within the 50-year recovery timeframe - are excluded from identification as critical habitat. Examples of excluded areas include cultivated and/or landscaped areas, buildings, roads and artificial surfaces, or forested areas that have been recently harvested or subject to stand-destroying disturbance (e.g., catastrophic fire), and so will not acquire the critical features and attributes of critical habitat within the 50-year recovery timeframe (see Table 2 for stand age thresholds specific to each sub-region).

7.1.1 Information and methods used to identify critical habitat

The location and spatial configuration of critical habitat is based on three principles:

- **Quantity**:
    - *Minimum starting polygon size*: in order to support foraging and nesting, noting that the species' arboreal prey has a home range size of ~10 ha (Sutherland et al. 2007), core critical habitat must be configured around nesting class habitat polygons that are at least 10 ha in size.
    - *Overall core critical habitat area*: in order to support the long-term population objective, the summed area of core critical habitat identified must be sufficient to:
        - support the home ranges of at least 125 pairs[11] of owls, noting that the mean amount of habitat required to support a pair's home range is estimated at 3010, 2224, and 1907 ha for the Maritime, Sub-maritime, and Continental sub-regions, respectively, and that adjacent home ranges may overlap up to 25% (Chutter et al. 2004 & 2007; Sutherland et al. 2007); and
        - account for up to 207,800 ha of habitat being impacted by fire within the 50-year recovery period.
- **Support for all critical life functions (i.e., biological value)**: In order to support all critical life functions for a recovering population, habitat must be prioritized for inclusion within the core critical habitat geospatial area based on its:
    - **a)** contribution to a core patch that can support multiple home ranges and enable successful nesting, roosting, foraging, and safe movement within the patch:
        - i. vicinity/degree of connectivity to recovery origins (existing locations and proposed re-introduction sites) or historical anchors (historical locations of resident birds);
        - ii. proportion of nesting class habitat; and

[11] The 250-adult-bird population target has been translated into a critical habitat target of 125 home ranges for simplicity; however, it is acknowledged that 250 adult birds does not necessarily equate to 125 pairs. A normal population includes a certain number of adult, non-breeding, non-territorial 'floaters' whose habitat use may overlap with that of territorial breeders (Franklin 2001). Further, not all resident adults are paired, so some home ranges may be occupied by single birds. However, 125 home ranges is being interpreted as a reasonable benchmark for the amount of habitat needed to support 250 adults, in the absence of more detailed information on eventual population structure and space use by the recovered population.

iii. size; or

b) contribution to a connective corridor that can enable safe movement between core patches.

- **Representation across the three ecological sub-regions**: In order to restore pre-human-impact patterns of representation, critical habitat must be identified across all the three ecological sub-regions within the species' historical range (Maritime, Sub-maritime, Continental).

The geospatial delineation process summarized below aims to create a highly-connected critical habitat network large enough to support 125 pairs, accounting for home range overlap and anticipated fire impacts, prioritizing habitat with the potential to support all critical life functions and restore pre-human-impact patterns of representation. The geospatial delineation process is founded upon chapter 6.2 of the integrated population and habitat modelling framework developed under the direction of CSORT (Sutherland et al. 2007). It is summarized below and outlined in greater detail in an accompanying technical document (available upon request).

The information used in the geospatial delineation of critical habitat for Spotted Owl includes:

a) provincial VRI mapping (2018 version);
b) a Spotted Owl *caurina* subspecies habitat suitability classification produced by CSORT to be applied to VRI (Table 2);
c) a 50-year future projection of VRI (BC MFLNRORD 2019);
d) an energetic cost/resistance landscape created through applying the habitat-specific energetic cost categories established in Table 1 of Sutherland et al. (2007) to VRI polygons;
e) a set of contiguous habitat clusters created through:
    i. applying a connectivity analysis to link all ≥ 10-ha nesting class polygons via least-cost pathways (based on the resistance landscape);
    ii. selecting all habitat (nesting and foraging class) from the 50-year future projected VRI that intersects the least cost pathways; and
    iii. dissolving polygons to create discrete clusters; and
f) origins/anchors of recovery:
    i. habitat falling within the estimated maximum home range area of extant and historical locations of resident Spotted Owls, both within Canada (I. Blackburn, pers. comm. 2021) and in northern Washington; and
    ii. habitat falling within the estimated maximum home range area of the currently-proposed re-introduction locations for captive-bred Spotted Owls (I. Blackburn, pers. comm. 2021).

A summary of the geospatial delineation process is as follows:

1. Intersect origins/anchors with contiguous habitat clusters to delineate origin/anchor habitat patches, each of which is expected to be capable of supporting all critical life functions (i.e., potential home ranges) for ≥1 Spotted Owl pairs.
2. Identify corridors linking origin/anchor patches.
3. Assess the biological value of the contiguous habitat clusters falling outside of origin/anchor habitat patches.

4. Build core critical habitat that will accommodate 125 home ranges (accounting for 25% overlap between adjacent ranges), enable safe movement between origin patches, and remain sufficient to support home range and safe movement targets after accounting for anticipated fire impacts (up to 207,800 ha):
    a. include all functional[12] origin/anchor habitat: 272,793 ha (125 home ranges + ~65,000 ha towards fire impacts);
    b. include all functional corridor habitat linking origins/anchors: 99,585 ha (safe movement + fire impacts); and
    c. include additional contiguous habitat clusters falling outside of origin/anchor and corridor habitat, by biological value score, until the fire impact target is met: 43,387 ha.
5. Build acoustic critical habitat to counter acoustic disturbance within nesting areas:
    a. delineate nesting areas as all habitat polygons intersecting a 500-m area around nest sites (Blackburn et al. 2009); and
    b. establish a 400-m (horizontal distance) acoustic influence zone around the delineated nesting area(s).
6. Apply critical habitat sub-type classifications:
    a. designate all habitat identified through steps 1-4 as core critical habitat; and
    b. designate the habitat identified through step 5 as acoustic critical habitat.

7.1.2 Geospatial Location of Areas Containing Critical Habitat

Critical habitat for Spotted Owl is identified within three sub-regions in British Columbia (Figures 3-8):

- Overview map summary (all sub-regions): Figure 3
- Maritime sub-region: Figure 4
- Sub-maritime sub-region: Figures 5-7
- Continental sub-region: Figure 8

The 10 km x 10 km UTM grid overlay shown on these figures is a standardized national grid system that highlights the general geographic area containing critical habitat, for land use planning.

[12] Habitat polygons with insufficient interior habitat could fail to support adequate prey (see section 3.3 – Needs of the Spotted Owl). Within origin/anchor patches and dispersal corridors, an additional 100-m area of surrounding habitat was included around all polygons that had an interior area <10 ha to ensure that all habitat patches identified as critical habitat will maintain sufficient interior habitat to support prey, even if forested habitat is removed along their boundaries. Patches that were still <10 ha even after the additional surrounding habitat was added were excluded.

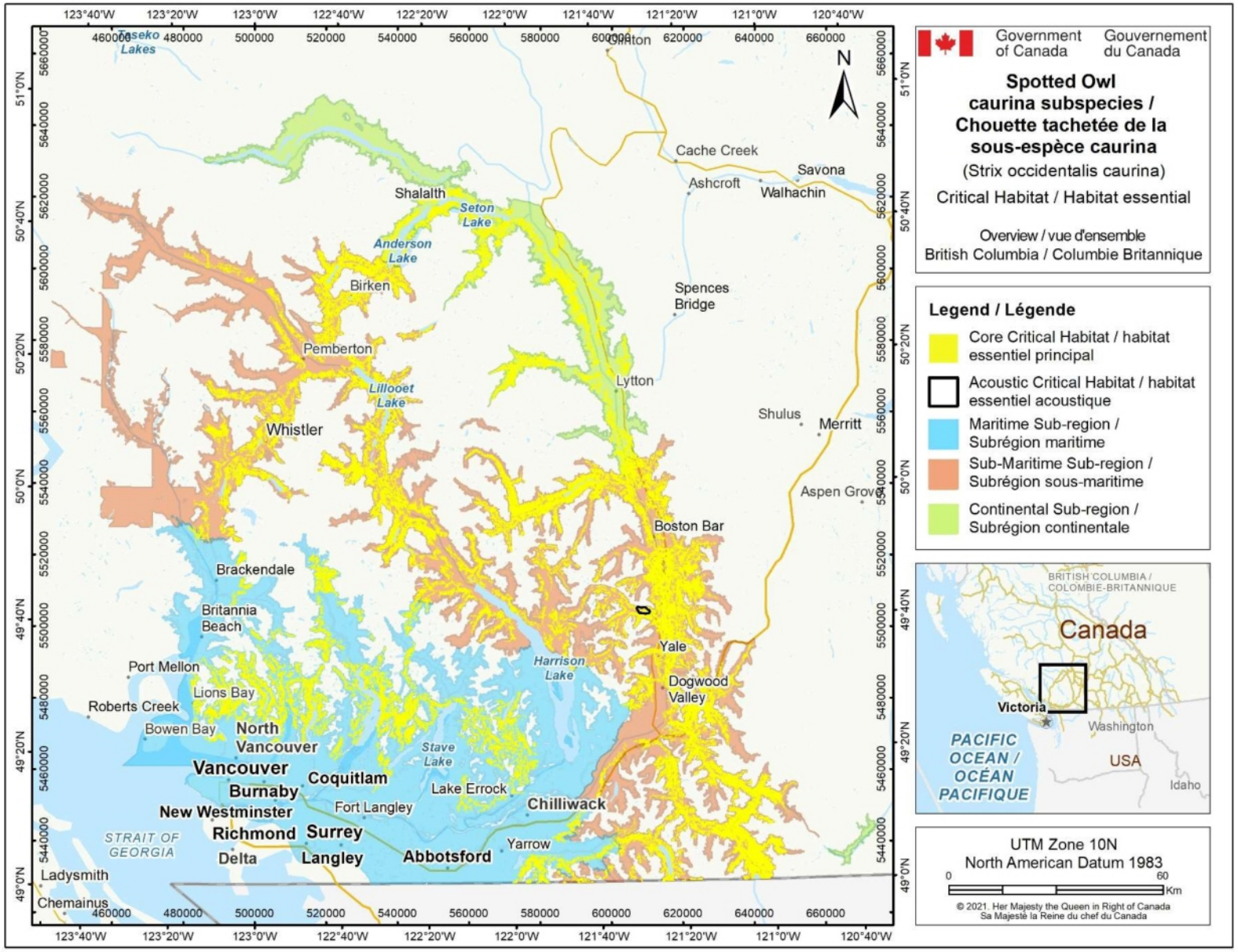

Figure 3. Overview of the critical habitat for Spotted Owl (totaling 416,258 ha) within B.C. Critical habitat is represented by the yellow and black shaded polygons where the criteria and methodology set out in this section are met. The area below the hatched line is the U.S.A. land base.

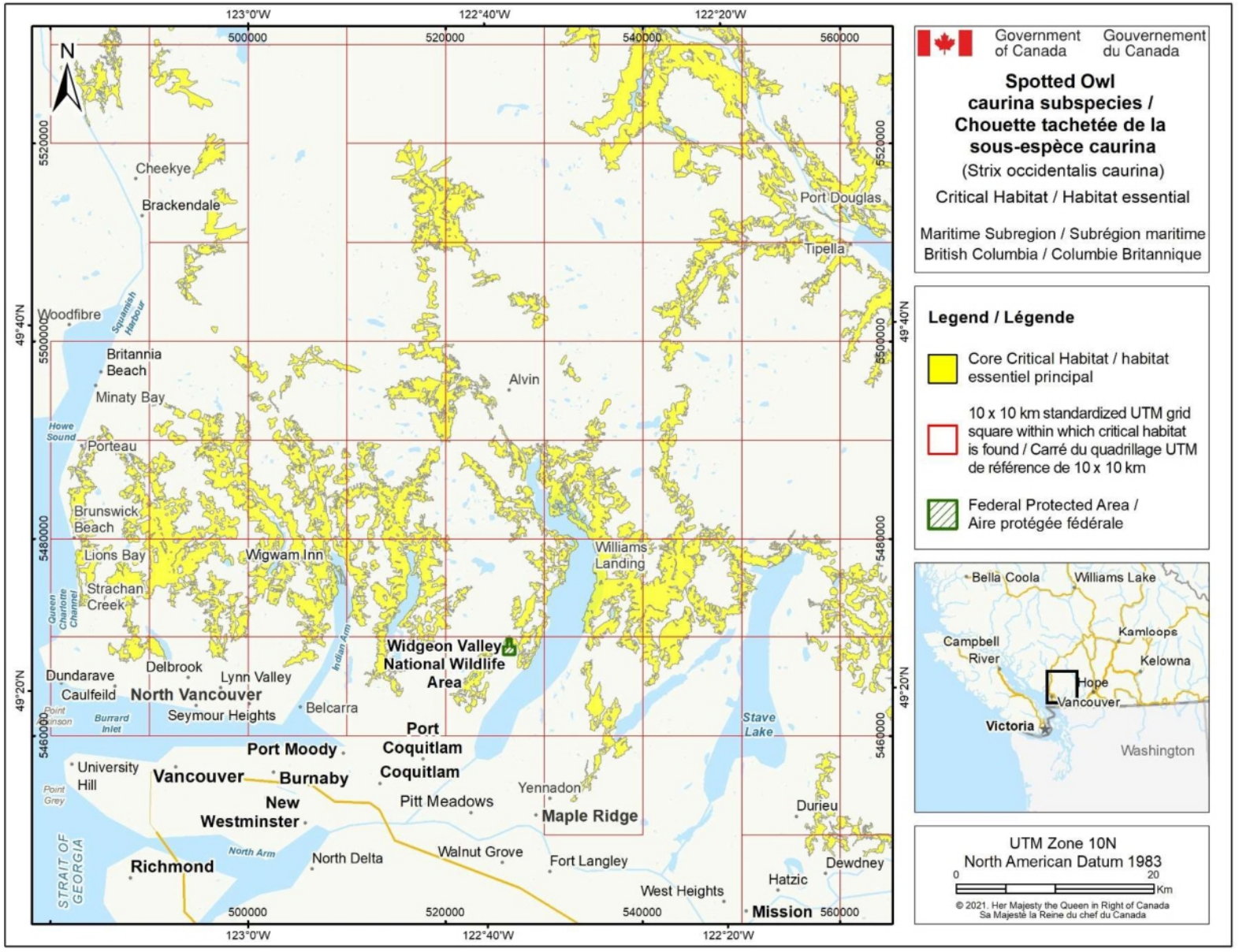

Figure 4. Critical habitat for Spotted Owl within the Maritime sub-region is represented by the yellow shaded polygons where the criteria and methodology set out in this section are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. Federal Protected Areas that overlap with critical habitat are also shown.

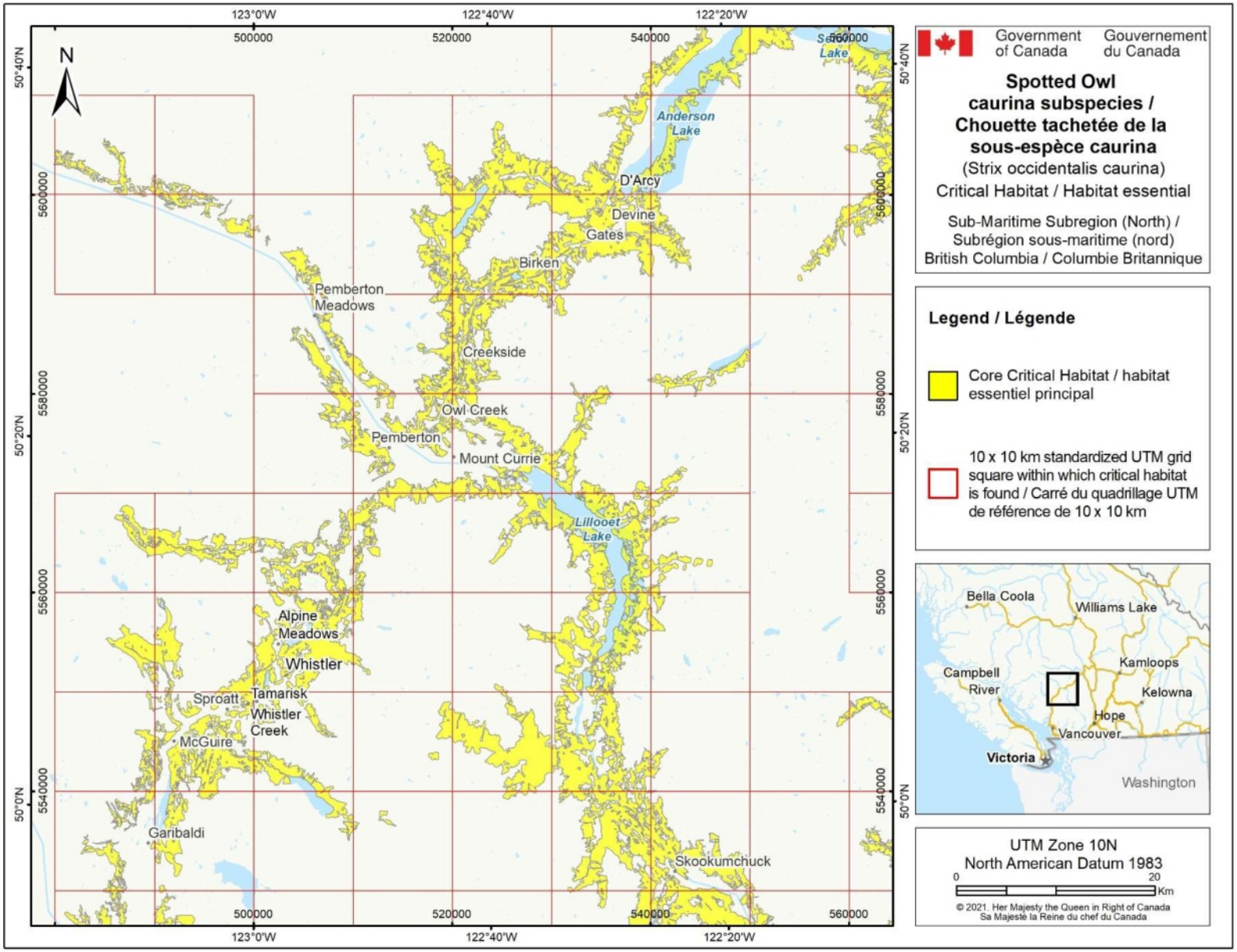

Figure 5. Critical habitat for Spotted Owl within the northern portion of the Sub-maritime sub-region is represented by the yellow shaded polygons where the criteria and methodology set out in this section are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

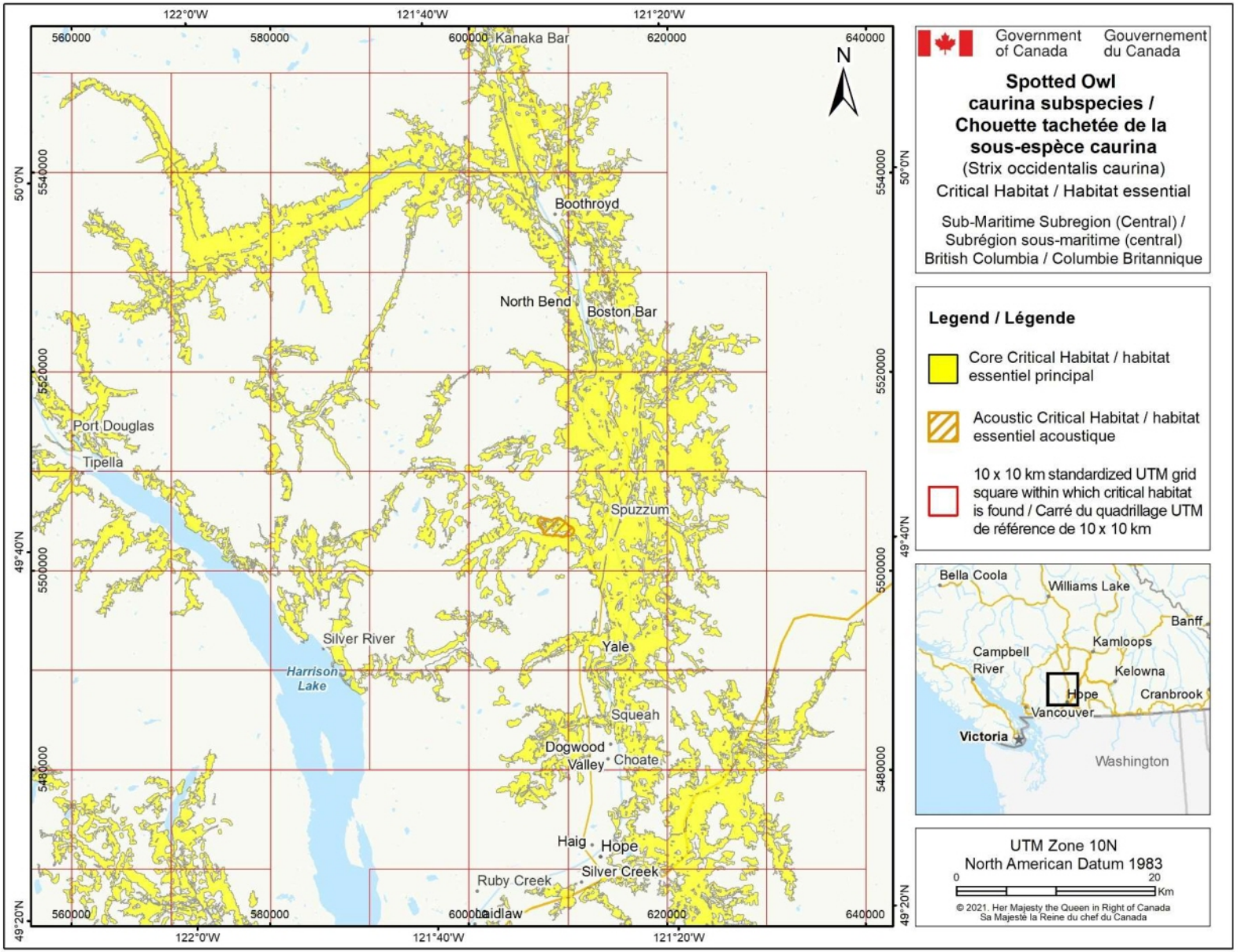

Figure 6. Critical habitat for Spotted Owl within the central portion of the Sub-maritime sub-region is represented by the yellow and orange shaded polygons where the criteria and methodology set out in this section are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

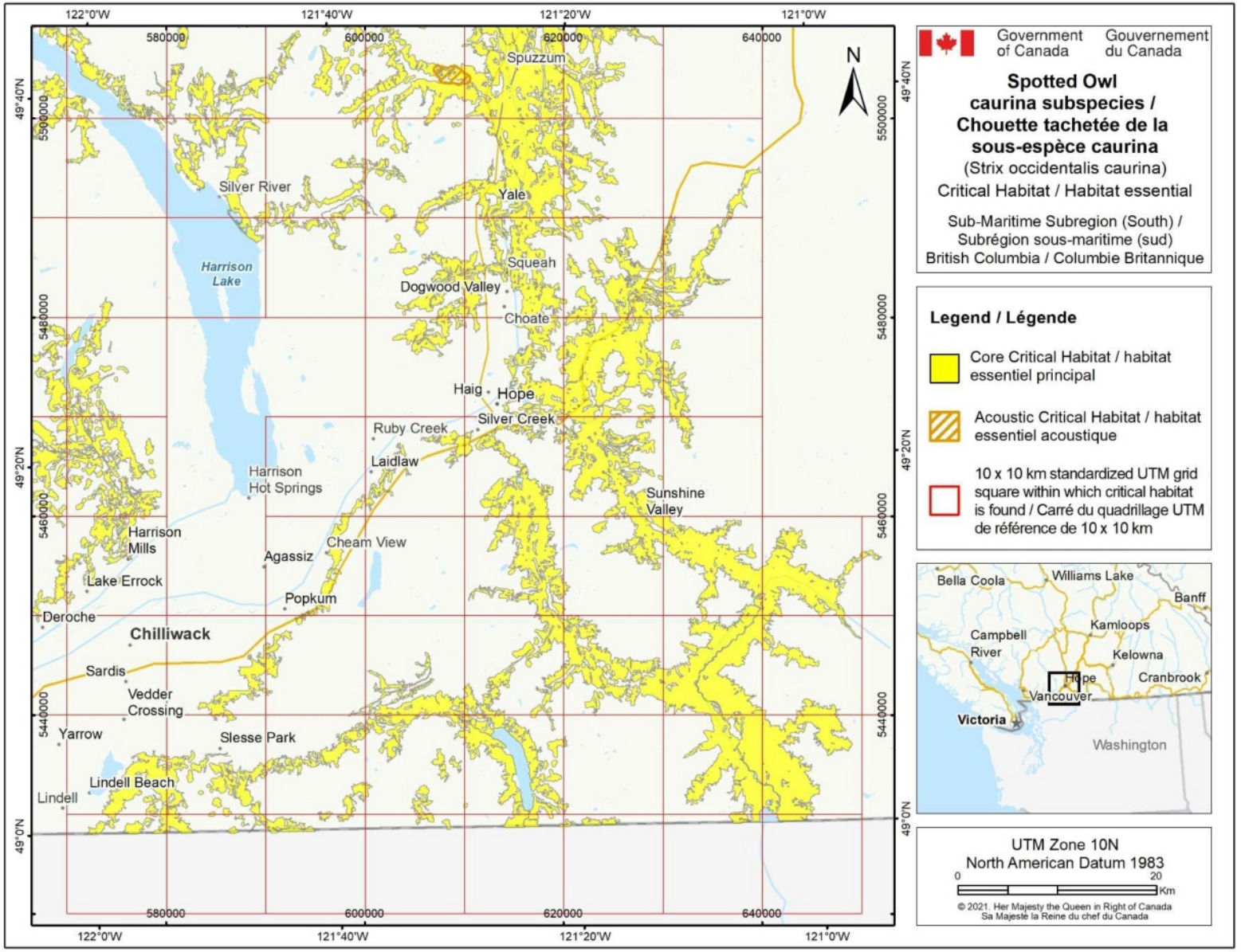

Figure 7. Critical habitat for Spotted Owl within the southern portion of the Sub-maritime sub-region is represented by the yellow and orange shaded polygons where the criteria and methodology set out in this section are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat. The hatched line in the southern extent of the map is the border with the Continental U.S.A.

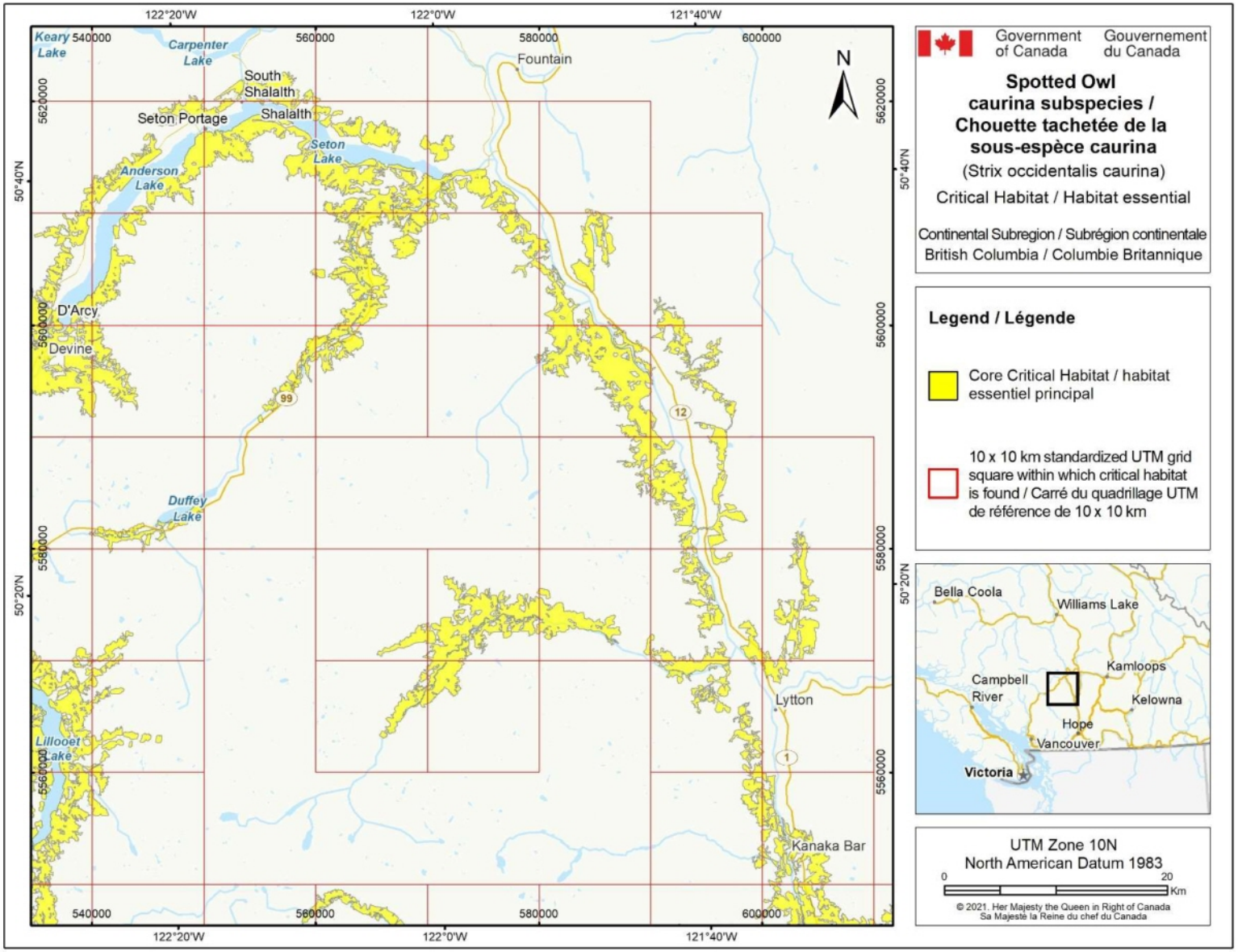

Figure 8. Critical habitat for Spotted Owl within the Continental sub-region is represented by the yellow shaded polygons where the criteria and methodology set out in this section are met. The 10 km x 10 km UTM grid overlay shown on this figure is a standardized national grid system that indicates the general geographic area containing critical habitat.

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