COSEWIC
Assessment and Status Report

on the

Smoker's Lung Lichen
Lobaria retigera

in Canada

THREATENED
2018

COSEWIC
Committee on the Status of Endangered Wildlife in Canada

COSEPAC
Comité sur la situation des espèces en péril au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2018. COSEWIC assessment and status report on the Smoker's Lung Lichen *Lobaria retigera* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 61 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Production note:
COSEWIC would like to acknowledge Darwyn Coxson and Curtis Björk for writing the status report on Smoker's Lung Lichen, *Lobaria retigera*, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by David Richardson, COSEWIC Mosses and Lichens Specialist Subcommittee co-chairs.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Lobaire réticulée (*Lobaria retigera*) au Canada.

Cover illustration/photo:
Smoker's Lung Lichen — Photo provided by author.

Catalogue No. CW69-14/766-2018E-PDF
ISBN 978-0-660-27876-6

COSEWIC
Assessment Summary

Assessment Summary – April 2018

Common name
Smoker's Lung Lichen

Scientific name
Lobaria retigera

Status
Threatened

Reason for designation
This lichen is strongly associated with humid old growth forests in British Columbia and is a "flagship" species for a suite of rare and uncommon lichens and bryophytes. More than 50% of the North American range is in Canada. The Canadian population comprises three subpopulations; however, nearly all remaining individuals (>90%) are found in the Northwestern subpopulation (Kispiox and Skeena valleys). The threats to this species in Canada are extensive forest harvesting, both past and present, leading to declines in the population from the direct impacts (removal of host trees), as well as indirect impacts (edge effects) in adjacent habitats. Predicted climate change may lead to further declines in the remaining populations of this lichen.

Occurrence
British Columbia

Status history
Designated Threatened in April 2018.

COSEWIC
Executive Summary

Smoker's Lung Lichen
Lobaria retigera

Wildlife Species Description and Significance

The Smoker's Lung Lichen is a rare cyanolichen, strongly associated with humid mature to old growth forests and is characterized by a net-ridged/reticulate dark upper surface and abundant grain-like vegetative propagules called isidia. The lower surface is tomentose (dark pigmented tangled hyphae), and the tomentum is interrupted by white patches that give a characteristic contrasting dark-light pattern. The spore-bearing fruit bodies, apothecia, are unknown in North American populations. Smoker's Lung Lichen is a "flagship" species among a suite of rare and uncommon epiphytic lichens and bryophytes that depend on humid, old growth forests in British Columbia (B.C.), many of which exhibit an unusual coastal-inland disjunct distribution.

Distribution

The North American distribution of Smoker's Lung Lichen is wholly within the geographic boundaries of Alaska and British Columbia. The Canadian portion of the range accounts for more than 50% of the total spatial distribution in North America. Smoker's Lung Lichen is also found in tropical and subtropical areas of Asia, the Indian subcontinent, Oceania, and Africa. Within Canada, the core range for Smoker's Lung Lichen falls within the Kispiox region of northwestern British Columbia.

Habitat

In Canada, Smoker's Lung Lichen is confined to moist mature to old forests at elevations below 1000 m. Avoidance of summer drought is a key attribute of Smoker's Lung Lichen habitat. In British Columbia, this requirement is met in mature to old growth forests growing in oceanic and humid continental regions. The three Canadian subpopulations occur in the Coastal Western Hemlock (CWH) and the Interior Cedar-Hemlock (ICH) biogeoclimatic zones. The lichen colonizes twigs and branches of Western Hemlock, as well as leaning snags and dead trunks, but can be found on other coniferous species, including Western Redcedar, Subalpine Fir, and Amabilis Fir. It is occasionally found on older alder and willow trees, especially those that have rough bark.

Biology

Smoker's Lung Lichen produces asexual propagules, isidia, which are thought to be locally dispersed by rain and animals. Dispersal of isidia may be a limiting factor for Smoker's Lung Lichen as in North America it does not form sexual structures (apothecia), so long distance dispersal of the fungal component by ascospores does not occur. In coastal forests, the lack of available substrata, due to the competing cover of mosses and/or liverworts, is also a major constraint. The photosynthetic partner of the Smoker's Lung Lichen is *Nostoc,* a cyanobacterium.

Population Sizes and Trends

The Canadian distribution of Smoker's Lung Lichen is limited to three geographic regions in B.C.: (1) ICH biogeoclimatic zone of interior B.C.,(2) the ICH biogeoclimatic zone of northwestern B.C., and (3) the CWH biogeoclimatic zone in Coastal B.C. The estimated number of thalli in the three subpopulations is ca. 150, 58,000 and 100 respectively, based on enumerated thalli and habitat modelling. The number of thalli at each occurrence varied from single thalli to over 2000 thalli at the most abundant site in northwestern B.C, which is the core range for this lichen. Evidence suggests that extirpation has occurred at three occurrences, with another 21, mostly in northwestern B.C. being at risk within the next two to three generations (40-60 years) due to logging and associated edge effects. Many trees on which the Smoker's Lung Lichen was found to be abundant in the 2015 and 2016 preharvest surveys of planned cut blocks in the Kispox valley have been designated for placement in wildlife tree patches (with a 35 m buffer placed around the trees). However, the survival of these thalli is uncertain, as this lichen species is highly sensitive to microclimate changes associated with edge effects.

Threats and Limiting Factors

Smoker's Lung Lichen is limited by the availability of suitable habitat (humid mature and old growth forests) and poor dispersal efficiency. Humid, wet, mature or old growth, cedar-hemlock forests have diminished in abundance with the progressive expansion of forest harvesting. Additional threats are from Hemlock-looper infestations and fire which are predicted to increase in severity and frequency due to rising mean annual temperatures as a result of global warming. The cumulative effects of these threats: harvesting, climate change, insect infestations and fire, are expected to lead to a decline in the number of mature individuals of Smoker's Lung Lichen over the next two to three generations.

Protection, Status and Ranks

Smoker's Lung Lichen is a Blue-listed species in British Columbia. Fifteen extant Canadian occurrences of Smoker's Lung Lichen are situated within parks or protected areas, eight of which are found in the newly designated Ancient Forest/Chun T'oh Whudujut Provincial Park in the upper Fraser River watershed. The remaining forty-one occurrences are on Crown Land, where most do not have long-term protection from forest harvesting or other disturbances. Some have limited protection in designated Old Growth Management Areas (OGMAs) and/or Wildlife Tree Retention patches. The Smoker's Lung Lichen also occurs in Alaska where it is ranked S2S3 (Imperilled or Vulnerable).

TECHNICAL SUMMARY

Lobaria retigera

Smoker's Lung Lichen

Lobaire réticulée

Range of occurrence in Canada: British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	Uncertain, from 15 to 30 years. 20 years has been used for calculation purposes.
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, projected. The decline in the number of mature individuals (both known individuals in previously surveyed sites and unknown individuals, estimated from habitat based projections) is projected to be at least 40% within three generations (40-60 years). The pace of logging in Smoker`s Lung Lichen habitat is expected to accelerate in coming decades due to the severe shortfall in B.C.'s mid-term (20-50 years) timber supply resulting from the Mountain Pine Beetle epidemic.
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations.	>30% over the next two generations (40 years) due to the loss, of host trees as a result of logging, and indirect affects on thalli in adjacent uncut forest or in small retained forest patches. Logging pressures are expected to intensify during this period due to the shortfall in B.C.'s mid-term timber supply. These effects may be exacerbated by climate change.
Reduction in total number of mature individuals over the last [10 years, or 3 generations].	Unknown Over 90% of the known individuals of Smoker's Lung Lichen are in Kispiox Region (Northwestern subpopulation). Of the 30 stands surveyed in 2015 and 2016, prior to planned logging, seven have been logged as of the spring of 2017.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	At least a 40% reduction is projected over the next 3 generations (60 years). See comments above.

Estimated percent reduction in total number of mature individuals over a 3 generations period into the future.	At least a 40% reduction is projected over the next three generations (60 years). (see above)
Are the causes of the decline a. clearly reversible, and b. understood, and c. ceased?	a. yes b. yes c. no Forest harvesting is the principal cause of past and projected future decline. It is an impact that can be managed. The loss of habitat due to forest harvesting is projected to increase in coming decades due to the mid-term timber supply shortage. Edge effects are also important as thalli in adjacent uncut forest stands (and in small retained forest patches within clearcuts) are negatively affected by high light levels, reduced humidity and other microclimate changes. Declines due to climate change are uncertain and less well understood. Mitigation of its effects is less likely.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	241,811 km^2 The EOO may decline by ca. 30% if outlier occurrences in the B.C. Southern Interior (Adams River and Incommapleaux) are extirpated. Occurrences in Wells Gray and Ancient Forest/Chun T'oh Wudujut Parks are expected to persist, and so the EOO will still cover a large area, from the Coast to Interior mountain ranges.
Index of area of occupancy (IAO) (Always report 2x2 grid value).	300-350 km^2 (This estimate includes possible new occurrences in the Kispiox and Skeena Valley area). The currently known IAO is 204 km^2. This will be counterbalanced by loss of known occurrences, as sites are logged and outlier occurrences are extirpated.
Is the population "severely fragmented" i. e. , is >50% of its total area of occupancy is in habitat patches that are: (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Unknown

Number of "locations"[1] (use plausible range to reflect uncertainty if appropriate)	30-40 is the most plausible range when forestry activity is considered the main threat. However, the minimum number of locations could be as low as three if climate change leads to severe and widespread summer droughts (but see comments below)
Is there an [observed, inferred, or projected] decline in extent of occurrence? Projected based on loss of old forests to logging and climate change in next 3 generations	Yes, projected Estimates of habitat loss (direct and indirect) as a result of logging over the next 3 generations are likely to lead to a decline in the extent of occurrence. 23 of 56 known occurrences are in stands that have been proposed for logging.
Is there an [observed, inferred, or projected] decline in index of area of occupancy? Projected based on loss of old forests to logging and climate change in next 3 generations	Yes, projected See comments above.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No. Some occurrences will persist in each of the Interior, Northwestern, and Coastal B.C. subpopulations, though with a reduced abundance.
Is there an [observed, inferred, or projected] decline in number of locations?	Yes, projected as a result of forestry activity and climate change. See comments in boxes above
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat? Explain in a word or two projected decline in habitat quality.	Yes, there is a projected decline due to logging of suitable old forests and associated edge effects.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	Number of Mature Individuals
Occurrences in the Interior B.C. geographic region.	150 is a plausible number, 129 thalli have been enumerated. The lichen is not common in this area.

[1] See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Occurrences in the Northwestern B.C. geographic region.	57,757 (known and estimated) individuals occur in the Kispiox region (Northwestern subpopulation) based on habitat estimates, surveys of harvest blocks and other observations. 9,943 thalli are estimated to occur in the planned cut blocks. Seven of these 30 blocks have been logged since they were surveyed.
Occurrences in the Coastal B. C. geographic region.	100 is a plausible number of thalli in this region, There are 31 known individuals. Survey efforts in this region have been limited, but observations suggest that habitat in this area is marginal.
Total Number of Individuals	60,000.

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not done

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

i Biological Resource Use (logging & wood harvesting)
ii. Climate Change and Severe Weather (drought, temperature extremes, storms)
iii. Natural Systems Modification (fire)
iv. Transportation & service corridors (roads and railroads, utilities and service lines)
v. Pollution (air-borne)

Was a threats calculator completed for this species? Yes, in 2017

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada. S2S3 (Imperilled or vulnerable) in Alaska	
Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	possibly
Are conditions deteriorating in Canada?[2]	Yes
Are conditions for the source population deteriorating?[1]	Unknown
Is the Canadian population considered to be a sink?[1]	Unknown
Is rescue from outside populations likely?	No

[2] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Threatened in April 2018.

Status and Reasons for Designation

Status:	**Alpha-numeric codes:**
Threatened	A3c+4c
Reasons for designation: This lichen is strongly associated with humid old growth forests in British Columbia and is a “flagship” species for a suite of rare and uncommon lichens and bryophytes. More than 50% of the North American range is in Canada. The Canadian population comprises three subpopulations; however, nearly all remaining individuals (>90%) are found in the Northwestern subpopulation (Kispiox and Skeena valleys). The threats to this species in Canada are extensive forest harvesting, both past and present, leading to declines in the population from the direct impacts (removal of host trees), as well as indirect impacts (edge effects) in adjacent habitats. Predicted climate change may lead to further declines in the remaining populations of this lichen.	

Applicability of Criteria:

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A3c+4c, as a reduction of over 30% of the known and estimated individuals of this lichen species is projected primarily due to the recent and future impacts of logging, over the next three generations. There are uncertainties about the impacts of predicted climate changes but they could exacerbate this loss.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. The number of locations in relation to the main threat from forestry activities is greater than five and there is no evidence for extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Total population exceeds 10,000 mature individuals.
Criterion D (Very Small or Restricted Population): Not applicable. Number of mature individuals and IAO exceed the threshold.
Criterion E (Quantitative Analysis): Not performed.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2018)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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Lobaria retigera

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2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Lobaria retigera* (Bory) Trevisan

Synonyms: None in common use

Common names: Smoker's Lung lichen

French Name: Lobaire réticulée

Family name: Lobariaceae

Major group: Lichens (lichenized Ascomycetes) Bibliographic citation: Lichenotheca Veneta 75. 1869.

Type specimen: The type is from Réunion, held in the Natural History Museum of Paris.

Morphological Description

Lobaria retigera is a medium to large stratified foliose lichen that has isidia, cortical outgrowths mostly on ridges on the upper surface. These are cylindrical, often branched, and less than 0.5 mm tall providing a means for vegetative dispersal. The upper surface is brown (less often greyish or greenish) when wet, grey-brown when dry, shiny to dull and ridged or reticulate (Figure 1). The lower surface is blackish with a tomentum (a short fuzz or hairs) interspersed with white naked patches (Jordan 1973, Goward 1994a). The tomentum is dense, often extending to the margin, becoming black and longest near the edges of naked areas. Rhizines are generally restricted to the central part of thalli. Apothecia have not been seen on North American material. The photobiont is a cyanobacterium (*Nostoc*) (Rikkinen 2003). Illustrations of *L. retigera* are found in Goward (2017).

Chemistry: Spot tests on *L. retigera* indicate that the thallus is K-, C-, KC-, P- but that the tomentum is K+ and contains thelophoric acid (which is also often in the lower cortex). Other major secondary products in the thallus of *L. retigera* include retigeric acids A and B, as well as minor amounts of stictic and norstictic acids. These were reported by Cornejo *et al*. (2009) who hypothesized that the populations in Canada, Madagascar, Bhutan, Yunnan (China), and Sakhalin (Russia), evolved separately over very long time periods and may be evolutionarily distinct.

Figure 1. Smoker's Lung Lichen (*Lobaria retigera*) growing on Western Hemlock (*Tsuga heterophylla*) in proposed harvest cutblock TSL HAda18A in the Northwestern Region in the Kispiox Valley (photo by P. Bartemucci).

Population Spatial Structure and Variability

Habitat mapping in B.C. is generally based on the biogeoclimatic zones developed by Meidinger and Pojar (1991). *L. retigera* is solely within two biogeoclimatic zones, in three distinct regions of the province (Figure 2). These are:

1 Wet subzones of the Interior Cedar Hemlock (ICH) biogeoclimatic zone within the Columbia Mountains region of interior B.C., hereafter referred to as the Interior region, with a major centre of distribution in the Robson Valley (the reach of the upper Fraser River watershed located in the Rocky Mountain trench, roughly between Prince George and McBride) (Figure 3) including watersheds such as the Adams (Figure 4) and Incomappleux.

2 The Interior Cedar Hemlock (ICH) biogeoclimatic zone in northwestern B.C., hereafter referred to as the Northwestern region, with a major centre of distribution in the Kispiox and upper Skeena River watersheds (Figure 5).

3 The Coastal Western Hemlock (CWH) biogeoclimatic zone which occurs on the B.C. Coast and along major coastal inlets, hereafter referred to as the Coastal region (Figure 2).

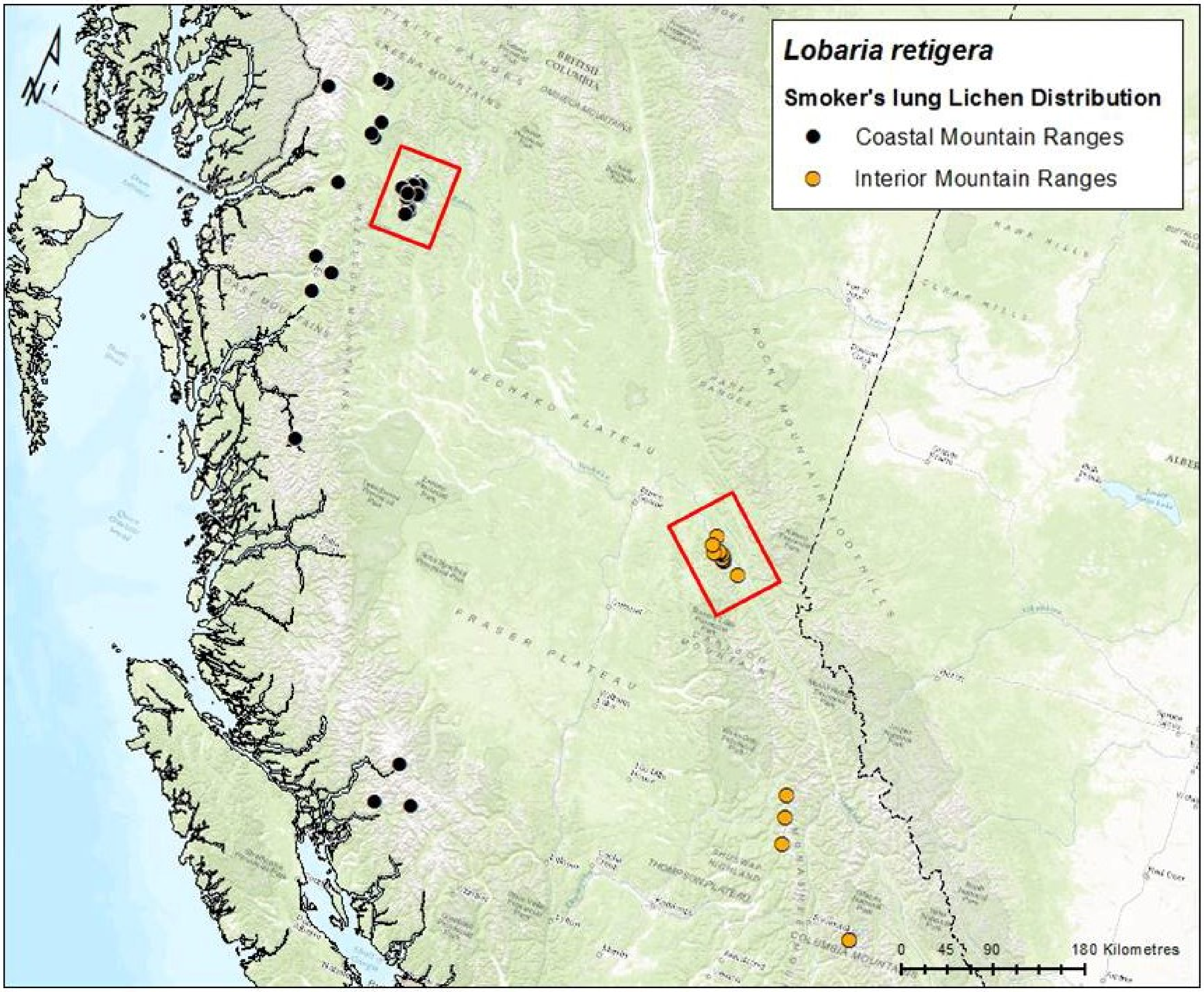

Figure 2. Map of Smoker's Lung Lichen (*Lobaria retigera*) occurrences in British Columbia, showing where the lichen is found in the Coastal Mountain Ranges (black dots) and in the Interior Mountain Ranges (yellow dots). The red inset boxes on the map indicate two areas for which more detailed maps are provided (Figures 3 and 5), for the Robson Valley in the Interior Region (lower red box) and the Kispiox Valley, Northwestern Region (upper red box).

Figure 3. Map of known Smoker's Lung Lichen (*Lobaria retigera*) occurrences in the Interior Region in the Robson Valley (upper Fraser River valley), British Columbia interior. See Figure 2 for more information and the scale. Base image © Google Earth (2014 satellite image). Pin numbers refer to data in Table 1.

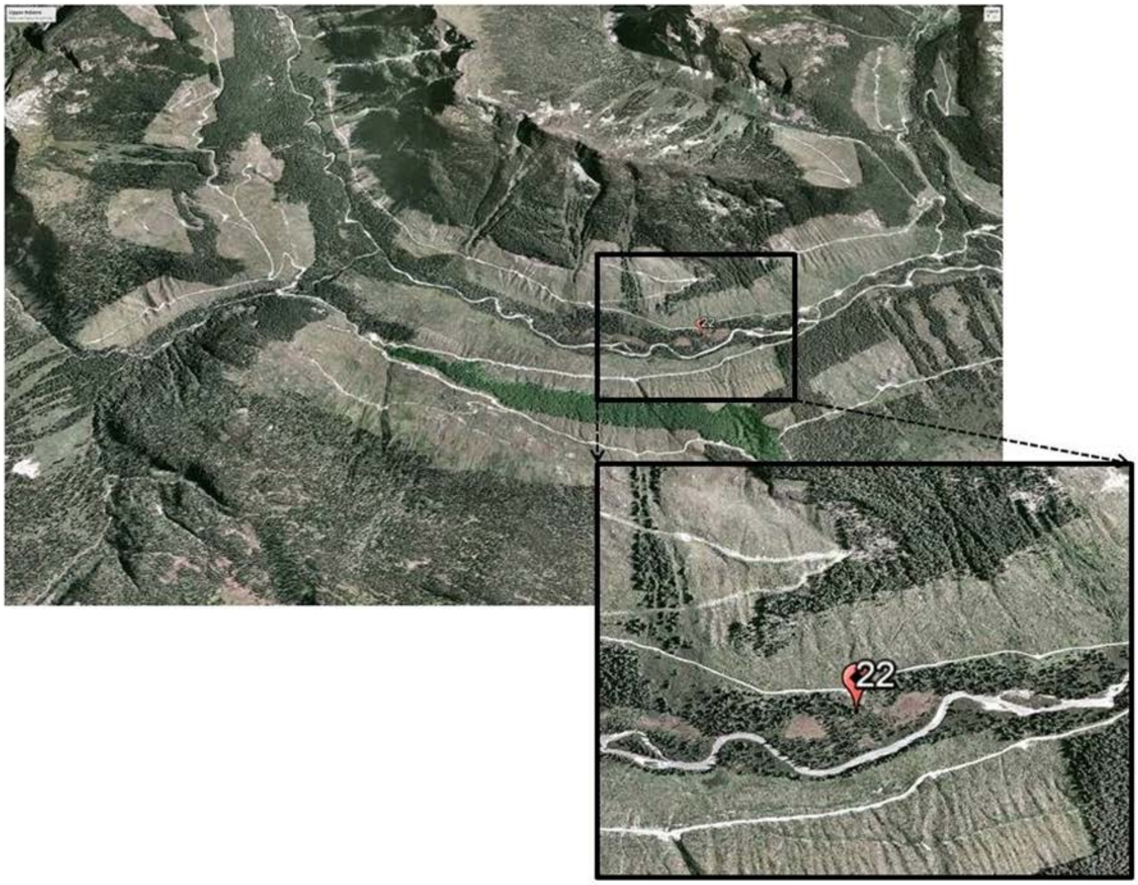

Figure 4. Smoker's Lung Lichen (*Lobaria retigera*) collection site denoted by red pin (#22) in the Interior Region in the Upper Adams River, B.C. Interior. The light green shaded forest patch in the foreground is currently scheduled for logging (Chytyk 2014). Base image © Google Earth (2006 satellite image).

Areas of suitable habitat for the interior region occurrences (*i.e.,* wet, ground water receiving valley bottom sites) are widely separated one from another by mountain topography (Radies *et al.* 2009). This separation has been exacerbated by logging, where remnant old forest habitat patches are surrounded by early seral stands (see Figures 4 and 6). Within suitable habitats, repeated small scale colonization and death of old thalli likely occur on individual trees. Thalli in the Northwestern region, which are generally found in and around small wet inclusions in forest stands, in so-called Puddle forests, are likewise often separated in the landscape by areas of drier, disturbed, or otherwise unsuitable forested habitats.

Designatable Units

The B.C. population of *L. retigera* is considered to be one designatable unit as the species in Canada is dispersed only by vegetative propagules. As a result, genetic recombination is infrequent or absent and variation is low. To date there has been no genetic analysis of *L. retigera* to examine subpopulations from the different areas.

Special Significance

Lobaria retigera generally co-occurs with a suite of temperate rainforest lichens. Among the better known species in this suite are *Cavernularia hultenii*, *Hypogymnia vittata*, *Lobaria oregana*, *L. pulmonaria*, *L. silvae-veteris*, *Nephroma isidiosum*, *N. occultum*, *Platismatia norvegica*, P*seudocyphellaria anomala*, *Sticta fulginosa*, *S. oroborealis*, *S. wrightii*, *Sphaerophorus tuckermanii*, and *S. venerabilis*. *Lobaria retigera* could therefore serve as a flagship species for them and several are Blue-listed species in B.C. under the B.C. Conservation Data Centre listings (Goward 1994b, Goward and Spribille 2005; COSEWIC 2006; Coxson *et al*. 2012).

DISTRIBUTION

Global Range

Globally, *L. retigera* has a wide distribution and occurs as a tropical-subtropical lichen in Asia and in Oceania. There are at least 255 known occurrences of *L. retigera* worldwide (GBIF 2017). In North America, this lichen is confined to British Columbia and Alaska. The northernmost (and also most westerly) known North American occurrence is in Prince William Sound, Alaska (60.38°N, 146.44°W). The southernmost occurrence is near Toba River, B.C., on the B.C. coast (50.68°N, 159.0°W, 123.97°W), while the southernmost interior (and most easterly) occurrence is from the Incomappleux River Valley (50.98° N, 117.58° W).

In Alaska, 15 occurrences have been documented (Consortium of Pacific Northwest Herbaria 2017), most on the Alaskan panhandle, adjacent to B.C.'s north coast (Figure 7). This is the result of the lower temperatures at high latitudes and the very steep gradient from the Alaska panhandle to the colder continental climates of Interior Alaska. Thus, many of the British Columbia temperate rainforest species, both trees and lichens, that occur in mid-elevation and inland sites further south, are confined to the coast in Alaska.

Canadian Range

The three geographic areas where occurrences of *L. retigera* have been found in Canada are within in two biogeoclimatic zones are as follows:

<u>Interior Region</u>

The interior B.C. occurrences of *L. retigera* are located predominantly in the Columbia mountains in wet Interior Cedar-Hemlock (ICH) subzones (Very Wet Cool ICH – ICHvk; and Wet Cool ICH - ICHwk), from the upper Fraser River watershed in the north, south to near Revelstoke, B.C., in the Incomappleux River Valley (ICHvk) (Figures 3 and 4). The greatest numbers of thalli in B.C.'s interior are found in the Robson Valley (Figure 3) but even there the lichen is uncommon.

Northwestern Region

The northwestern occurrences are found in the Skeena and Nass River watersheds in wet Interior Cedar-Hemlock (ICH) subzones (Moist Cold ICH – ICHmc; Very Wet Cold ICH transition - ICHvc), from approximately New Hazelton in the south, to Meziadin Junction in the north (Figures 5 and 6). This area contains the majority of known occurrences and is the core range of *L. retigera* in Canada.

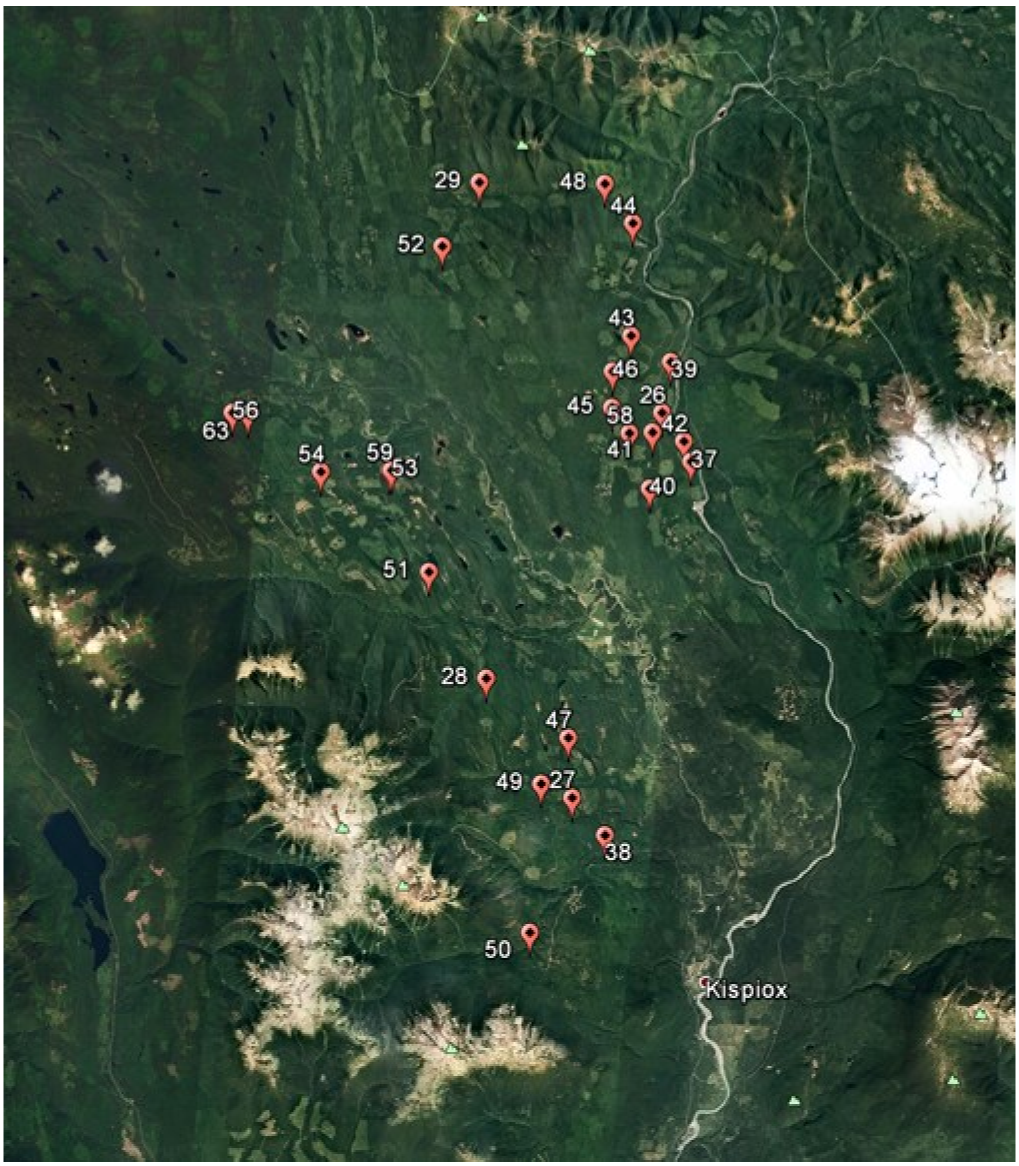

Figure 5. Map of known Smoker's Lung Lichen (*Lobaria retigera*) occurrences in the Kispiox Valley, Northwestern Region, British Columbia interior. See Figure 2 for more information and the scale. Base image © Google Earth (2006 satellite image).

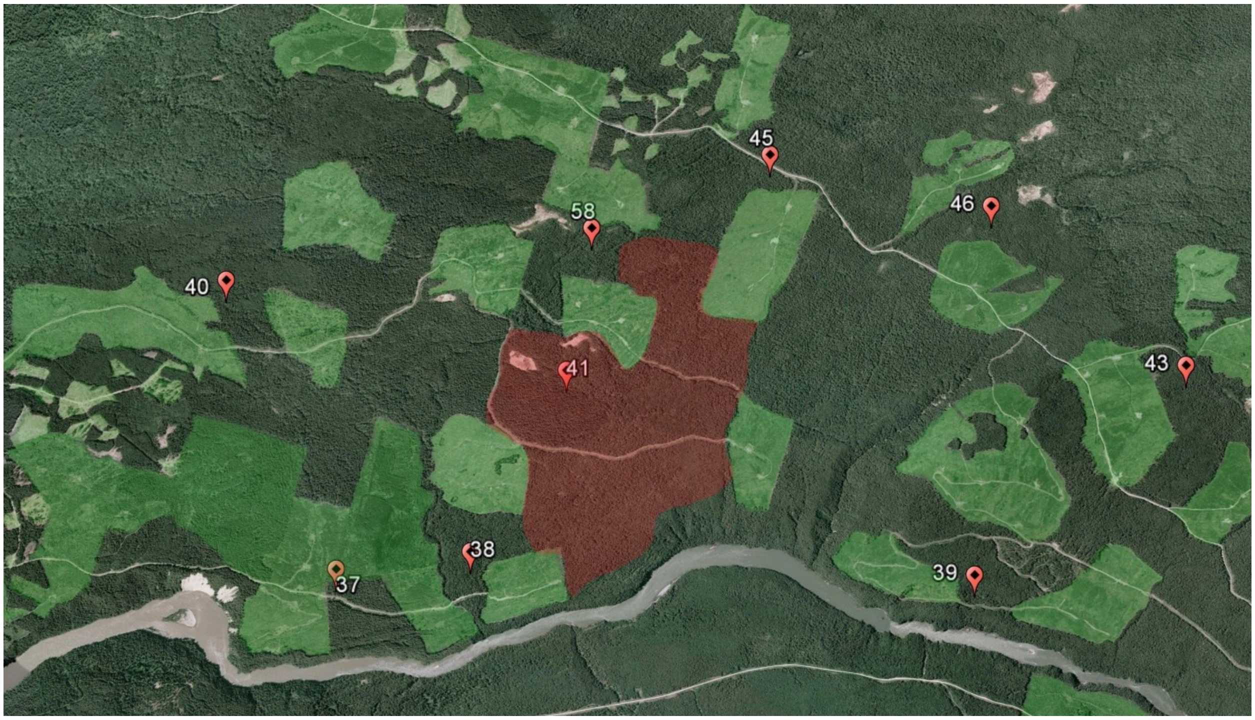

Figure 6. Smoker's Lung Lichen (*Lobaria retigera*) collection sites denoted by red pins in the Interior Region, in the Upper Skeena River. The light red shaded patch was planned for logging in 2014 (Chytyk 2014). Base image © Google Earth (2006 satellite image).

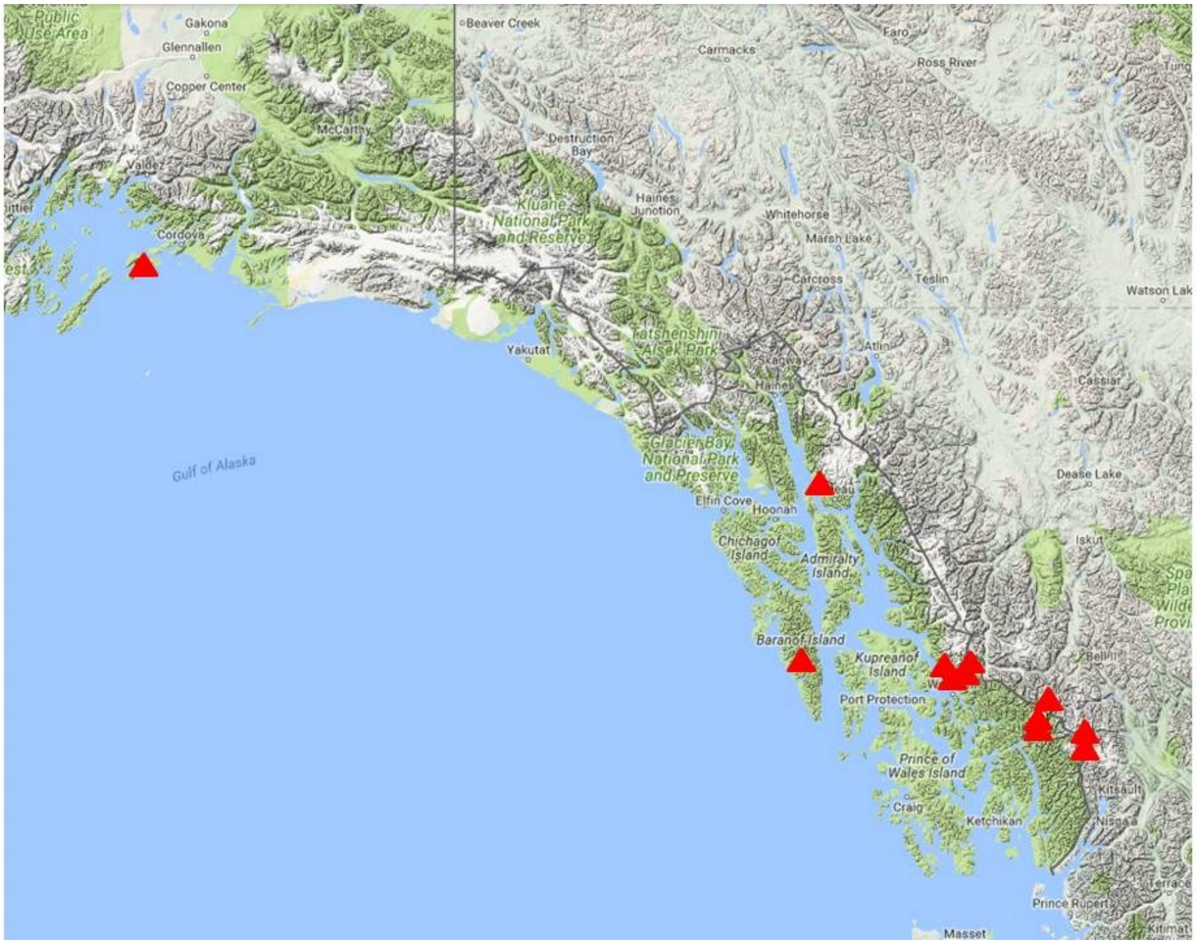

Figure 7. Occurrences for Smoker's Lung Lichen (*Lobaria retigera*) in Alaska. Data Source: Consortium of Pacific Northwest Herbarium (http://www.pnwherbaria.org/, accessed May 15, 2017).

Coastal Region

The coastal occurrences of *L. retigera* occur in the CWH biogeoclimatic zone from Stewart, B.C. in the north (Close to Alaskan populations), south to Bute Inlet on B.C.'s central coast (Figure 2). There are very few known occurrences in this region, usually at the head of major inlets or river valleys, often at forest edge locations. Foliose cyanolichens such as *Nephroma occultum* and *L. retigera* are not common and thought to be susceptible to displacement by epiphytic bryophytes in very humid coastal forests, especially in the hypermaritime zone on B.C.'s west coast (Goward 1995).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) for all B.C. *L. retigera* subpopulations is 241,811 km^2 (Figure 8).

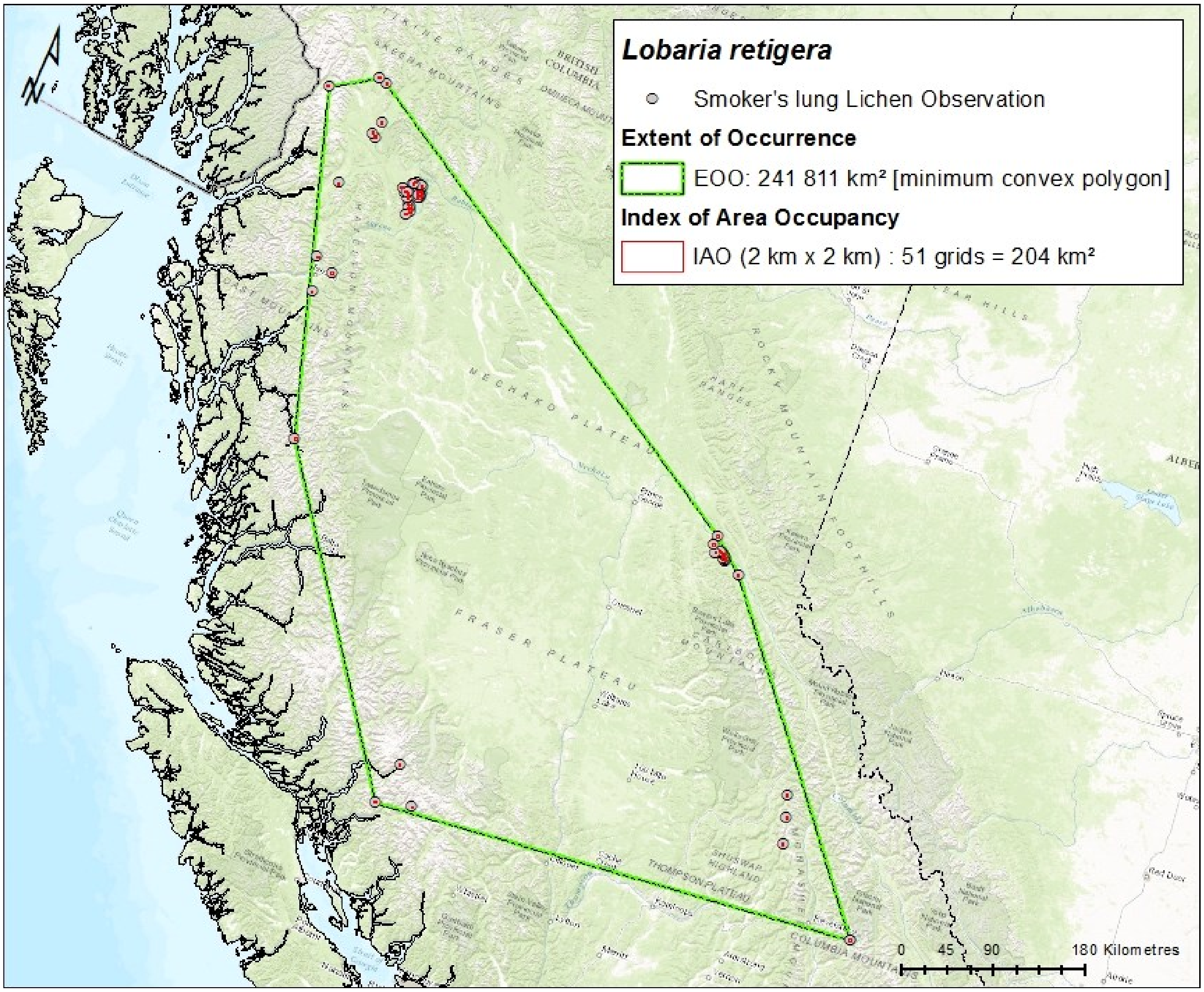

Figure 8. Map of known Smoker's Lung Lichen (*Lobaria retigera*) occurrences in British Columbia and the extent of occurrence and index of area of occupancy.

The minimum index of area of occupancy (IAO), based on a 2x2 km grid placed around collection way points is 204 km^2. If *L. retigera* is found in un-surveyed but suitable habitat in the Kispiox and Skeena Valley area, the IAO could be 300-350 km^2.

Search Effort

Lichenologists have collected macrolichens in many parts of British Columbia. Sites visited by lichenologists as a part of non-targeted surveys. Extensive collecting and surveying efforts have been undertaken in the Northwestern and Interior regions, in the past.

The importance of the Kispiox area in the Northwestern region as the core habitat for oceanic inland rainforest lichens such as *L. retigera* in British Columbia was first deduced by Goward and Burgess (1996). A series of targeted surveys by P. Bartemucci in proposed cutblocks in the Kispiox region has subsequently increased our knowledge of the number of thalli in the Kispiox region (Bartemucci 2015a-i; 2016 a-m). These surveys point to the importance of this region as the core area for *L. retigera*. Bartemucci located 22 new occurrences for *L. retigera* within the boundaries of proposed cutblocks in the Kispiox region (Table 1). Stand level estimates for the number of thalli in these surveys ranged from 10 thalli in timber sale licence (TSL) HAmu025 to an estimated 2500 or more thalli in TSL HAda028. Further occurrences of *Lobaria retigera* are likely to be found in the Northwestern ICH zone to the north of the Kispiox valley (Bartemucci pers. comm. 2017a). Collections have also been made recently in the adjacent upper Nass watershed (see records by Spribille and Simon in Table 1), and in the Highway 37 corridor near Meziadin Junction (see Goward and Miege records in Table 1).

Table 1. Extant and extirpated occurrences of Smoker's Lung Lichen (*Lobaria retigera*) in Canada.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
1	97301	SEYMOUR RIVER	51.597252	-118.927437	Seymour River: approximately 15 km north of Blais Creek.	Goward and Arsenault 95830	8/7/1995	Low	Located within Upper Seymour River Provincial Park.
2		Slim Creek Park	53.740882	-121.170701	Ca. 0.3 km N Hwy 16, 1.1 km W Slim Creek Bridge	Bjork photo observation	9/29/2016	Low	Occurrence is in protected area. 1 thallus
3		Ancient Forest/Chun T'oh Whudujut Park	53.752272	-121.182508	Ca. 1.0 km N Hwy 16, 16.3 km E Penny Access Rd	Bjork 40313	6/17/2016	Low	Occurrence is in protected area. 12 thalli at 4 placemarks.
4		Ancient Forest/Chun T'oh Whudujut Park 13	53.764919	-121.190109	Ca. 1.6 km N Hwy 16, 15 km E Penny Access Rd	Bjork photo observation	7/17/2016	Low	In protected area. 2 thalli
5	97286	SLIM CREEK, 1.2 KM WEST OF	53.754869	-121.196139	McBride area, 80 km northwest of town just off Highway 16, 3 km north of Slim Creek.	Goward and H. Knight 92-1193	8/16/1992	Low	Located within Slim Creek Provincial Park.
6		Ancient Forest/Chun T'oh Whudujut Park	53.758163	-121.198758	Ca. 0.6 km N Hwy 16, 15 km E Penny Access Rd	Bjork photo observation	7/17/2016	Low	In protected area. 17 thalli at 2 placemarks
7		Ancient Forest/Chun T'oh Whudujut Park	53.792764	-121.231968	Ca. 1.6 km N Hwy 16, 11 km E of Penny Access Rd	Bjork photo observation	6/24/2016	Low	In protected area. 1 thallus.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
8	97288	SLIM CREEK, 3.7 KM WEST OF	53.793748	-121.265496	Fraser Plateau, Robson River valley, between Prince George and McBride. Shortly north of Highway 16, between Slim Creek and Driscoll Creek, west of Slim Creek.	Bjork, MacDonald and Coxson 22488	5/1/2011	Low	Located within Ancient Forest/Chun T'oh Whudujut Park.
9		Ancient Forest/Chun T'oh Whudujut Park	53.788233	-121.270809	On S side Hwy 16, 9 km E Penny Access Rd	Bjork 41772	9/21/2016	Low	In protected area. 5 thalli.
10		Ancient Forest/Chun T'oh Whudujut Park	53.801492	-121.290809	On N side Hwy 16, 7.1 km E of Penny Access Rd	Bjork 40685	6/23/2016	Low	In protected area, 37 thalli at 4 placemarks
11		Ancient Forest/Chun T'oh Whudujut Park	53.776721	-121.348804	Ca. 1.6 km N Papoose Lake	Bjork 41842	9/23/2016	Low	In protected area. 1 thallus.
12		Longworth	53.91145	-121.4104	4.2 km E of Longworth, on N side of CN line	Coxson photo observation	4/1/2010	Low	In Old Growth Management area. 1 thallus.
13		Ancient Forest/Chun T'oh Whudujut Park	53.839115	-121.421539	2.8 km W Penny Access Road on N side Hwy 16	Bjork photo observation	9/24/2016	Low	In protected area. 2 thalli at 2 placemarks.
14	97269	TAHUMMING RIVER	50.597420	-124.468939	Between Bute and Toba Inlets, Tahumming River valley.	Bjork and Kohler 19665	9/12/2009	Low	No proposed developments identified for the immediate area (Chytyk 2014).
15	97191	KLEANZA CREEK, TERRACE	54.600666	-128.399306	20 km northeast of town on lower slopes of Bornite Mountain and 16 km northeast of town in Kleanza Creek Provincial Park.	Ohlsson 2719	7/27/1970	Low	Located within Kleanza Creek Provincial Park. Note revised GPS coordinates.
16	97189	FURLONG BAY, LAKELSE LAKE	54.385083	-128.540973	Terrace area: 18 km south of Terrace at Lakelse Provincial Park (Furlong Bay).	Goward and Knight 91-1182	7/24/1970	Low	Resurveyed by C. Bjork, Sept. 2015. Located within Lakelse Lake Provincial Park. Note revised GPS coordinates.
17	97282	SUGARBOWL CREEK	56.285755	-129.02819	Rocky Mountain Trench, Viking Flats, Robson River valley, Sugarbowl Grizzly Den Provincial Park, Highway 16, approximately 70 km east of Prince George (5 km west of Hungary Creek).	Goward and Knight 91-1703	9/4/1991	Low	Resurveyed by C. Bjork, Sept. 2015. Located within SugarbowlGrizzly Den Provincial Park. Note revised GPS coordinates.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
18	97168	BELL-IRVING RIVER	56.296972	-129.165911	Mount Bell-Irving area: 6 km northeast of summit.	Goward and Knight 95-574	7/8/1995	Low	No proposed developments identified for the immediate area (Chytyk 2014).
19		Stewart, Bitter Creek	56.023367	-129.823208	North Coast Ranges, About 14 km NE of town of Stewart, Bitter Creek drainage, slope on south side of the creek	Bjork 42728	7/5/2016	Low	1 thallus.
20	97306	INCOMAPPLEUX RIVER	50.983329	-117.583337	West Kootenays, Incomappleux River rain forest.	Björk, Spribille and Pettit 9544	9/12/2004	Medium	< 80 m from cutblock edge
21		Incomappleux River - clearcut	50.98781667	-117.5860667	Selkirk Mountains, Incomappleux River primeval forest: along Incomappleux River between last clearcut and confluence with Battle Brook; azure spring area	Spribille 22258	8/14/2006	Medium	< 400 m from cutblock edge
22	97293	ADAMS RIVER, 15 KM NORTH OF TUMTUM LAKE	52.010099	-119.099710	Adams River: 15 km north of Tumtum Lake. 1 km north of Finn Creek Forest Service Road, Upper Adams River.	Goward and Knight 92-1545	9/22/1992	Medium	< 75 m from cutblock edge. A 50 ha proposed cutblock A56291 is located 1.0 km to the northwest of the mapped observation (Chytyk 2014).
23	97291	PTARMIGAN CREEK	53.669392	-120.899322	Highway 16, 2 km north of Ptarmigan Creek.	Goward and Knight. 92-1233	8/17/1992	Medium	< 250 m from cutblocks on 2 sides
24	97273	TOBA RIVER/DALGLEISH CREEK	50.687159	-123.974834	Coast Ranges, Toba Valley, avalanche chute in upper Toba Valley.	Bjork and Kohler 14480	6/1/2007	Medium	Located approximately 0.5 km from the proposed Upper Toba powerhouse and 0.1 km from proposed transmission lines (Chytyk 2014).
25	97271	SOUTHGATE RIVER/BISHOP RIVER	50.980831	-124.363332	Coast Ranges, Southgate River valley. N side of the mouth of the Southgate Canyon, upstream from confluence with Bishop River.	Bjork and Hope 14568	6/1/2007	Medium	Proposed Southgate River 1 powerhouse and associated transmission lines are located within 0.2 km of the mapped location (Chytyk 2014).
26		Kispiox Valley	55.55886	-127.74533	end of Muldoe Forest Service Road just above Skeena River.	Spribille, not numbered yet	8/27/2012	Medium	< 50 m from adjacent cutblock

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
27	97220	DATE CREEK, KISPIOX	55.407215	-127.787223	18 km N Kispiox on Date Creek FSR	Goward and and Knight 91-960/978	8/23/1991	Medium to high	Population resurveyed by C. Bjork, Sept. 2015. Ca. 350 m from nearest cutblock. 4 proposed cutblocks are within the mapped observation area: 88 h cutblock A681489 at the mapped observation, 12 ha cutblock A82743 1.4 km to the southwest, 24 ha cutblock A83441 1.2 km to the southwest, and 40 ha cutblock A80632 0.9 km to the southsouthwest (Chytyk 2014). Note revised GPS coordinates.
28		Kispiox, Westside Road	55.45096667	-127.8520333	Kispiox, Westside Road	Spribille 22634	8/26/2002	Medium	< 750 m from adjacent cutblock, 12 new cutblocks nearby on Westside Rd.
29	97212	CARRIGAN CREEK, KISPIOX AREA	55.642861	-127.882639	35 km north-northwest of Kispiox, south of Mount Pope, south above Carrigan Creek.	Goward and Miege 95-247	7/2/1995	Medium	Population resurveyed by C. Bjork, Sept. 2015. < 50 m from adjacent clearcut. Note revised GPS coordinates.
30	97186	GLACIER CREEK, TERRACE	54.669611	-128.722223	Camp Creek (just north of Glacier Creek), 15 km north-northwest of town.	Goward and Knight 91-1142	8/26/1991	Medium	Population resurveyed by C. Bjork, Sept. 2015. Major expansion of cutblocks on adjacent old river terraces from 2005 to 2016, now ca. 1 km away. Note revised GPS coordinates.
31	97181	BROWN BEAR LAKE, SWAN LAKE AREA	55.827777	-128.783889	Immediately north-northwest of Brown Bear Lake.	Goward and Miege 95-415	7/5/1995	Medium	Population resurveyed by C. Bjork, Sept. 2015. Location is near boundary of Swan Lake PP, but < 300m from cutblock edge (2005 image), with new 70 ha proposed BCTS cutblock TEBB009 0.6 km to the west (Chytyk 2014). Note revised GPS coordinates.
32	97183	BONNEY CREEK, MEZIADIN LAKE AREA	55.961916	-128.809584	1 km west of Fred Wright Lake.	Goward and Miege 95-458	7/6/1995	Medium	Population resurveyed by C. Bjork, Sept. 2015. Location <500m from cutblock edge (2016 image). Note revised GPS coordinates.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
33	97176	LITTLE PAW CREEK	55.846083	-128.855445	Meziadin Lake area: 35 km northwest of Cranberry Junction.	Goward and Miege 95-534/535	7/7/1995	Medium	Population resurveyed by C. Bjork, Sept. 2015. Location <200m from cutblock edge (2016 image). New 48 ha proposed BCTS cutblock TEWN005 located 3.4 km to the southeast of the mapped observation (Chytyk 2014). Note revised GPS coordinates.
34		Dragon Lake, Kispiox area	55.327344	-128.951066	Ca. 6 km N Nass Camp on West side of Nisgaa Hwy	Spribille and Simon	9/29/2016	Medium	Forest patch < 150 wide with cutblock clearings both sides
35		OLIVER CREEK	51.822641	-119.014745	Upper Oliver Creek, Upper Adams River drainage.	Goward and Knight 92-1443	9/17/1992	Medium-High	< 75 m from cutblock edge. there are 10 proposed cutblocks nearby: 4 ha cutblock 1.6 km N, 22 ha cutblock 1.1 km N, 59 ha cutblock 1.8 km S, 4 ha cutblock 2.8 km S., 4 ha cutblock 3.5 km S, 2 ha 3.8 km S, 2 ha cutblock 4.0 km S, 8 ha cutblock 4.0 km S, 4 ha cutblock 4.3 km S, and 32 ha cutblock located 4.6 km S (Chytyk 2014).
36		Kispiox, TSL HAmu030	55.62332015	-127.9255493	Ca. 33 km NW Kispiox, at 1.7 km on the Skeena-Carrigan FSR (off Kuldo FSR at 5.7 km)	Bartemucci tba	10/17/2015	High	Occurrence is in planned cutblock. Ca. 50 clumps at 6 placemarks.
37		Kispiox, TSL A69880	55.54072101	-127.7229161	22 km north of Kispiox Village at 13.2 km on the Muldoe Forest Service Road.	Bartemucci tba	4/19/2016	High	Occurrence is in planned cutblock. Ca. 270 clumps at 32 placemarks. All clumps will be preserved in retention areas with 35 m buffers except for three colonies at the north end of the block, close to the Muldoe FS Road.
38		Kispiox, TSL M14	55.54841428	-127.7288645	sample 61, 22 km north of Kispiox Village, at approximately 12.5 km on Muldoe Forest Service Road	Bartemucci tba	10/14/2015	High	Occurrence is in planned cutblock. Ca. 225 clumps at 33 placemarks.
39		Kispiox, TSL A64009	55.5788	-127.7419	Ca. 40 km N Hazelton at 2.5 km on the Pope 800 FSR	Bartemucci tba	7/4/2015	High	Occurrence is in planned cutblock. Ca. 60 clumps at 9 placemarks.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
40		Kispiox, TSL A75288	55.52910352	-127.7498857	Sample 44, 19 km north of Kispiox Village at 3.4 km on the Muldoe 1000 Forest Service Road.	Bartemucci tba	4/18/2016	High	Occurrence is in planned cutblock. Ca. 55 clumps at 11 placemarks.
41		Kispiox, TSL A88763	55.55097496	-127.750868	approximately 21 km north of Kispiox Village, at 0.5 to 2.5 km on the Muldoe 1000A Road.	Bartemucci tba	9/25/2015	High	Occurrence is in planned cutblock. Ca. 600 clumps at 60 placemarks.
42		Kispiox, TSL HAdaR14	55.39348349	-127.762863	6 km northwest of Kispiox Village at 3 km on the Date 400 Road	Bartemucci tba	5/7/2016	High	Occurrence is in planned cutblock. Ca. 300 clumps at 26 placemarks.
43		Kispiox, TSL A64010	55.587816	-127.770488	40 km north of Hazelton, BC, at 9.5 km on the Pope Forest Service Road	Bartemucci tba	7/1/2015	High	Occurrence is in planned cutblock. 10 clumps at 1 placemark.
44		Kispiox, TSL HAmu025	55.6315023	-127.7750411	33 km north of Kispiox Village at approximately 16 km on the Pope Forest Service Road	Bartemucci tba	5/13/2016	High	Occurrence is in planned cutblock. Ca. 100 clumps at 9 placemarks.
45		Kispiox, TSL HAmu017	55.55936975	-127.7799105	20 km north-northwest of Kispiox Village at approximately 5.5 km on the Pope Forest Service Road	Bartemucci tba	8/14/2016	High	Occurrence is in planned cutblock. Ca. 700-1000 clumps at 31 placemarks.
46		Kispiox, TSL HAmu028	55.57346456	-127.7813322	23 km north-northwest of Kispiox Village at approximately 7.5 km on the Pope Forest Service Road	Bartemucci tba	8/17/2016	High	Occurrence is in planned cutblock. Ca. 200 clumps at 13 placemarks.
47		Kispiox, TSL HAda18A	55.4303413	-127.7928689	Sample 40, 11 km northwest of Kispiox Village at 4.5 km on the Sunday Lakes Forest Service Road.	Bartemucci tba	5/8/2016	High	Occurrence is in planned cutblock. Ca. 10 clumps at 8 placemarks.
48		Kispiox, TSL HAmu024	55.64596961	-127.7963464	34 km north of Kispiox Village at 17 km on the Pope Forest Service Road	Bartemucci tba	4/26/2016	High	Occurrence is in planned cutblock. Ca. 650 clumps at 47 placemarks. Thirteen placemarks with greater than 220 colonies will be preserved in currently proposed retention areas with 35 m buffers.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
49		Kispiox, TSL HAda028	55.41168395	-127.8090593	9 km north-northwest of Kispiox Village at approximately 13 km on the Date Creek Forest Service Road	Bartemucci tba	9/13/2016	High	Occurrence is in planned cutblock Ca. 2500 thalli clumps at 35 placemarks.
50		Kispiox, TSL A67762	55.35371573	-127.8091205	Sample 10, 6 km west of Kispiox Village, BC, at 12 km on the Date Creek 400 Road, which originates at 4.3 km on the Date Creek Forest Service Road	Bartemucci tba	7/31/2015	High	Occurrence is in planned cutblock. Ca. 100 clumps in 30 placemarks.
51		Kispiox, TSL HAhe051A	55.49033988	-127.8967898	20 km north-northwest of Kispiox Village at approximately 7 to 8 km on the Helen Lake Forest Service Road	Bartemucci tba	9/12/2016	High	Occurrence is in planned cutblock. Ca. 300 clumps in 37 placemarks.
52		Kispiox, TSL HAmu031.	55.6169339	-127.9047796	33 km north of Kispiox Village at 1.6 km on the SC300 spur at approximately 3.2 km on the Skeena-Carrigan Forest Service Road	Bartemucci tba	4/25/2016	High	Occurrence is in planned cutblock. 23 clumps at 2 placemarks
53		Kispiox, TSL A67542	55.52861324	-127.9277544	Ca. 25 km N Kispiox at 3 km on the Helen 900 Road, off the Helen Lake FSR	Bartemucci tba	9/16/2015	High	Occurrence is in planned cutblock. Ca. 300 clumps at 5 placemarks.
54		Kispiox, TSL HAhe046 & TSL HAhe047	55.52591241	-127.9760933	27 km north-northwest of Kispiox Village at approximately 14 to 15 km on the Helen Lake Forest Service Road	Bartemucci tba	9/6/2016	High	Occurrence is in planned cutblock. Ca. 2400 clumps at 112 placemarks.
55		Kispiox, TSL A67763	55.54612861	-128.029194	30 km northwest of Kispiox Village, at 18.2 km on the Helen Lake Forest Service Road	Bartemucci tba	9/18/2015	High	Occurrence is in planned cutblock. Ca. 200 clumps at 26 placemarks.
56		Kispiox, TSL A67764	55.54615666	-128.0397684	30 km northwest of Kispiox Village, at 1.5 to 2 km on the Helen 2000 Road (off Helen Lake FS Road at approximately 20 km	Bartemucci tba	9/25/2015	High	Occurrence is in planned cutblock. Ca. 200 clumps at 37 placemarks.

#	CDC Shape ID#	Site (CDC Site Labels Capitalized)	Latitude	Longitude	Directions	First Collection ID#	First Collection Date	Risk at Site	Comments
57	97241	KITLOPE RIVER	53.164686	-127.748633	Kitlope River, approximately 45 km south of Kemano.	Goward 91-1352	8/29/1991	Local occurrence extripated?	Search of collection location by Bjork and Coxson in Aug. 2016 did not locate population.
58	97232	MURDER CREEK	55.549997	-127.766660	Kispiox area: 25 km north of Kispiox, 1 km southwest of Skeena River.	Goward and Miege 95-345	7/3/1995	Local occurrence extripated?	Population possibly extripated. 2016 aerial image shows cutblock on previous collection location. 3 proposed cutblocks are also within the mapped observation area: 86 ha cutblock A67188 0.3 km to the north, 62 ha cutblock A72505 0.6 km to the west, and 77 ha cutblock D83372 1.5 km to the west (Chytyk 2014). The proposed TransCanada Prince Rupert Gas Transmission Pipeline is also located approximately 0.3 km to the southwest of the mapped location (Chytyk 2014).
59	97218	HELEN LAKE, 3.5 KM NORTHWEST OF, KISPIOX AREA	55.528611	-127.929321	25 km northwest of village	Goward and Miege 95-394/395	7/4/1995	Local occurrence extripated?	Population not found in survey by C. Bjork, Sept. 2015. 67 ha proposed cutblock A69989 (Chytyk 2014) at edge of mapped observation, this site has likely been logged.

In the B.C. interior region, stand level abundance of *L. retigera* is much lower. MacDonald and Coxson (2013) conducted lichen surveys in the ICHvk2 biogeoclimatic subzone in the Robson Valley, searching the trunk and main branches of mature to old Alder (*Alnus incana*) along small first-order streams. This search found new, but infrequent, *L. retigera* occurrences in the four drainage systems explored, typically 1 or 2 thalli each on widely dispersed *Alnus incana* trees. Thalli were limited to mature to old trees with rough textured surface bark.

In 2015, Björk revisited each of the previously documented occurrences of *L. retigera* in the Nass, Skeena and Kispiox drainages locating 10 of the 12 previously known regional occurrences (Björk 2016); the two not found were deemed to be extirpated by logging. Most of these thalli were in and around puddle forest patches as described above, on branches, trunks, and snags of Western Hemlock.

Björk also conducted targeted searches in suitable habitat within the newly designated 12,500 ha Ancient Forest/Chun T'oh Whudujut B.C. Provincial Park and Protected area and in the adjacent Slim Creek Provincial Park in summer 2016. These searches resulted in eight new occurrences (Table 1), these were also in wet "toe-slope" positions, growing on branches, trunks, and leaning snags of Western Hemlock and Western Redcedar (*Thuja plicata*).

Coxson found one new *L. retigera* occurrence on a Western Redcedar trunk on the north side of the Fraser River Valley near Longworth, B.C. in 2010; the first find on the drier south facing side of the upper Fraser River Valley. No thalli were found in subsequent searches of other old forest patches on the south side of the Fraser River Valley.

An occurrence of *L retigera* was found in the Incomappleux Valley in a Western Redcedar forest stand in 2006 and has proved to be the southernmost interior site for this species (Spribille pers. comm. 2016).

In August 2016 Coxson and Björk revisited the *L. retigera* collection site of Trevor Goward in the Kitlope River Valley. Thalli at this site were previously found on Pacific Crabapple (*Malus fusca*) near the shoreline of the Kitlope River estuary. However, Coxson and Björk were unable to relocate this occurrence, despite having detailed instructions to find the site.

The success of the intensive stand-level surveys of Bartemucci in the Kispiox region reinforces the point made in the status report for the Cryptic Paw Lichen (*Nephroma occultum*) (COSEWIC 2006) that the use of stand-level lichen surveys as a routine part of selecting and mapping harvest cutblocks provides valuable data on the status of rare lichens in B.C. This approach has been used for the Boreal Felt Lichen (*Erioderma pedicellatum*) in Nova Scotia (Cameron *et al*. 2013; Environment and Climate Change Canada 2016). The work of Björk provides a model for intensive surveys within B.C. protected areas (Björk and Goward 2017).

Based on the search effort to date, the greatest potential for finding new occurrences of *L. retigera* exists in the Kispiox Valley region which is the centre of occurrences in the Northwestern region, and in the area between Kispiox and Meziadin Junction.

HABITAT

Habitat Requirements

Lobaria retigera typically grows within stands located in wet groundwater receiving sites. These sites often contain small wet depressions in the forest floor surface, where S*phagnum* and other wet site indicator plants occur (Figures 9 and 10). Stands within B.C.'s inland rainforest with this mosaic of small wet microsites on the forest floor surface are commonly referred to as "puddle" forests. These low elevation topographic positions have traditionally been logged first in mountain environments due to their higher commercial value and easy road access. These stands containing *L. retigera* occur at elevations below 1000 m, with most *L. retigera* occurrences being found between 400 and 800 m. In Canada, all subpopulations occur in the CWH or the ICH biogeoclimatic Zones.

Climatic variables common in *L. retigera* habitat are: 1) high canopy humidity during the growing season, often facilitated by "puddle" forest habitat attributes, and 2) moderate summer temperatures. Its absence from the coastal CWH stands in the hypermaritime zone may reflect its sensitivity to salt spray and/or an inability to withstand competition from epiphytic bryophytes. Coastal sites where *L. retigera* has been found are usually at the head of major inlets or fjords.

Figure 9. Western Hemlock forest with Devil's Club and abundant epiphytes in proposed harvest cutblock HAhe046 in the Kispiox Valley, Northwestern Region (photo by P. Bartemucci).

Figure 10. Large leaning moss-covered trunks and snags provide important habitat for Smoker's Lung Lichen (*Lobaria retigera*) in the Robson Valley, Interior Region, B.C. (photo by D. Coxson). Note: Leaning trees are often removed for safety if associated with forestry activities.

Lobaria retigera usually occurs in mature (>125 years of age) or old growth (>250 years age) forests characterized by stable environmental conditions and abundant groundwater availability. These forests provide site continuity for slow dispersing lichens and confer protection from summer drought, one of the presumed key constraints on this species. It should be noted that current B.C. forest inventory mapping has a high degree of inaccuracy in distinguishing between mature and old forests (Coxson and Radies 2008). Thalli have occasionally been found on young trees (< 25 years old), both in natural regenerating sites with small wind-throw gap disturbance openings in the Robson Valley (Coxson, unpublished data), and on planted trees in small gaps created by partial-cutting harvest systems, as at Date Creek in the Kispiox area (Bartemucci pers. comm. 2017a). These habitat conditions, however, are very different from those of young trees in larger cutblocks or fire-origin stands. This is because fast-growing young trees in such situations provide unsuitable habitats, as the canopy closes and trunks becomes too shaded to support *L. retigera*. Only thalli on old trees in unfragmented forest stands are likely to have the population-level stability that enables them to act as source populations.

In the Canadian portion of its range, *L. retigera* grows epiphytically on both living branches and on upright and leaning snags (Figure 10). Alaskan and B.C. collections have been made from both coniferous and deciduous trees and in Canada, MacDonald and Coxson (2013) found thalli on the branches and trunks of tree-sized Gray Alders (*Alnus incana*) within the riparian zone of small streams in the ICHvk2 biogeoclimatic zone.

Common host trees for the Northwestern subpopulation are Western Hemlock and sometimes Amabilis Fir (*Abies amabilis*). Common substrates for *L. retigera* in old growth forests of the upper Fraser River watershed include branches, trunks and leaning snags of Western Hemlock and Western Redcedar, as well as old alder trunks, and leaning mossy snags (Figures 10).

Coastal (CWH) collections of *L. retigera* thalli have been found on old deciduous trees such as Pacific Crabapple (*Malus fusca*), often at the edge of forest stands or canopy gaps. Within closed-canopy coastal CWH forest stands, branches are typically dominated by thick mosses which appear to prevent *L. retigera* colonization.

In the Alaskan panhandle, similar epiphytic substratum preferences have been noted by collectors (e.g. University of Alaska Museum of the North Herbarium, Coll. Linda Geiser, No. 5978). However, *L. retigera* collections have also been made from beach logs and rock substrata in the Alexander Archipelago and Prince William Sound (e.g. University of Alaska, Museum of the North Herbarium, Coll. Karen Dillman, No. 53492).

Habitat Trends

The landscapes inhabited by *L. retigera* in the CWH and ICH biogeoclimatic zones were historically characterized by stand destroying events such as fire, while disturbance from insect outbreaks such as the Western Hemlock Looper (*Lambdina fiscellaria lubrosa*), created a complex mosaic of old forests.

The impact of these disturbances over time can be assessed by using natural range of variability estimates (NRV) which predict the natural range of variability that has occurred in a given ecological attribute over a defined historical time period. Using the NRV concept, the proportion can be estimated of the regional landscapes that would historically have been covered in old forests, and how much variation would have occurred in this proportion over long time periods. Estimates of NRV for old ICH forests in the Robson Valley calculated by Delong (2007) predicted that the cover of old ICH forests (> 140 years) was historically between 76 and 84%.

Current estimates of old forest cover in the Robson Valley suggest that about 60% of the landscape currently retains old forest cover. In response to these findings the B.C. Ministry of Forests put in place regulations requiring that a minimum of 53% of the ICHvk2 landscape be retained in old forest stands greater than 140 years in age (British Columbia Integrated Land Management Bureau 2004). This would seem to ensure that abundant *L. retigera* habitat will be retained into the future in the upper Fraser River watershed. However, a major factor that must be considered when evaluating *L. retigera* habitat is the quality of these retained habitats.

Stevenson and Coxson (2008), using a series of transplant studies in the Robson Valley, found that *Lobaria retigera* was highly sensitive to edge effects. Thalli placed along transects leading back from clearcut edges showed 100% mortality along the forest edge, with reduced growth rates apparent at any site where canopy openness exceeded 30%. This sensitivity to edge effects was verified by Gauslaa *et al.* (2018), who found that all *Lobaria retigera* thalli within 20 m of clearcut edges in the Kispiox Valley had severe bleaching of their photobiont. As in the case of marine corals, the loss of a functional photobiont in lichens typically leads to bleaching and death of this symbiotic organism (Sachs and Sims 2006). Gauslaa *et al*. (2018) further postulated that interior habitat attributes were not reached for *L. retigera* thalli in the Kispiox Valley until 120 m from the clearcut edge. Current Wildlife Tree Patches created for lichen retention (15 m buffer from lichen rich trees) in the Kispiox would accordingly be entirely edge habitat for *L. retigera* and would not be expected to support long-term populations.

This sensitivity to edge effects is highly significant, as most of the retained old forest habitats in both the Interior and Northwestern regions occur within highly fragmented landscapes (*e.g.* see Figures 4 and 6). The above observations suggest that much of the currently known *Lobaria retigera* habitat will be subject to severe edge effects, especially during periods of summer drought, which can exacerbate edge effects and result in loss of *Lobaria* populations (Ellis 2013, Gauslaa and Solhaug 1999, Gu *et al.* 2009, Nascimbene *et al.* 2016, Wolseley and James 2000). The current regulations for old forest retention patches and the associated buffers would result in only about 21% of the future landscapes in the Robson Valley (the northernmost part of the Interior region) remaining suitable for *L. retigera* (Coxson and Radies 2008)

A further factor that must be considered in estimating future *L. retigera* habitat availability is the site conditions (moisture and groundwater availability) in retained old-forest stands. Many of the stands designated for the purposes of meeting old forest retention quotas occur in sites that have limited commercial forest harvesting values. In the wet interior ICH zone this often means hemlock dominated stands growing on steep slopes with rocky nutrient-poor soils. These sites typically have limited potential to support *L. retigera sub*populations and other oceanic epiphytic macrolichens (Goward and Burgess

1996). Wet valley-bottom forests, the primary habitat for *L. retigera*, comprise only an estimated 8% of the ICHvk2 landscape (130,571 ha). This is a reduction from 30% or more prior to the start of industrial logging (2002 map data) (Radies *et al.* 2009). An example of the preferential logging of wet forests in valley bottom topographic positions can be seen in the Adams and McGregor River Valleys, respectively, tributaries of the North Thompson and upper Fraser River (Figures 6 and 11).

There are fewer metrics published on the retention of old low elevation forests in the Northwestern region, in areas such as the Kispiox valley. The status report on *Nephroma occultatum* (COSEWIC 2006) notes that there has been a significant loss of habitat for epiphytic macrolichens, largely because northwestern cedar-hemlock forests remain commercially viable even under poor market conditions. This 2006 status report further notes that only 9% (2,923 ha) of humid cedar-hemlock forests in the Northwestern region are planned for retention as old growth forest. Williston (pers. comm. 2016) reports that as a result of mill closures since 2006, harvesting rates have declined in the past decade. However, this trend is now reversing, as cedar prices rise and mills re-open.

BIOLOGY

Lobaria retigera is a moisture-sensitive cyanolichen that in western North America is restricted to humid forests in British Columbia and coastal Alaska. Its fungal symbiont is an ascomycete of the Lobariaceae; its photosynthetic symbiont is the cyanobacterium *Nostoc* (Jordan 1973; Rikkinen 2003). The lichen is limited by an inefficient dispersal mechanism, and increasingly by the lack of available suitable habitat.

Life Cycle and Reproduction

Lobaria retigera reproduces via asexual isidia, composed of clusters of cyanobacterial cells surrounded by fungal hyphae and encased in a cortex. Isidia arise on ridges of the upper surface. Sexual structures (apothecia) are not known for *L. retigera* collections in North America, and it is assumed that genetic recombination is infrequent or absent and variation is low (Jordan 1973). Apothecia are commonly found on Asian collections (Jordan 1973).

The life cycle of *L. retigera* has not been studied. However, studies in the boreal rainforests of Norway on the Textured Lung Lichen (*Lobaria scrobiculata*), which also has a cyanobacterial photobiont, found a generation time of between 15 and 22 years (Larsson and Gauslaa 2011). Life cycle studies on the Tree Lungwort (*Lobaria pulmonaria)* from temperate rainforest sites in B.C.'s interior ICH, suggest a generation time of 15 years or more. However, *L. pulmonaria* has a dominant green-algal photobiont, so any comparisons should be made with caution (MacDonald and Coxson 2013). The generation time for *L. retigera* is therefore estimated to be 20 years. Growth rate measurements on mature thalli of *L. retigera* (Stevenson and Coxson 2008) suggest that under optimal conditions in B.C.'s interior a 10% dry weight gain per year can occur. Rates of juvenile growth and mortality in *L. retigera* have not been studied, a major knowledge gap, as these factors have been postulated as a key constraint on the establishment of cyanolichens (Hilmo *et al.* 2011).

Physiology and Adaptability

As with other oceanic cyanolichens in B.C., a key constraint on the growth of *L. retigera* is its presumed intolerance of both summer drought and exposure to high temperatures. Both the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone receive frequent rain during the summer months (Stevenson *et al.* 2011). This is critical, given the requirement for cyanolichens to be wetted by liquid water before photosynthesis can begin, unlike green algal lichens, which can begin to photosynthesize after acquiring moisture from humid air (Lange *et al.* 1986).

Lobaria retigera most often occurs in wet sites or those with standing water (Radies *et al.* 2009). The higher humidity within the canopy of forest stands in wet toe-slope sites with "Puddle" forests attributes (see **Habitat Requirements**) is likely an important factor in prolonging periods of metabolic activity after wetting by precipitation or dewfall.

Dispersal and Migration

Lobaria retigera is dispersal limited, relying solely on asexual isidia which are too large to disperse efficiently. Poor dispersal capability is recognized as a characteristic of many old growth dependent lichens (Sillett *et al.* 2000). Using genetic analysis of thalli on adjacent trees, Jüriado *et al.* (2011) found that the vegetative dispersal distance between the host trees of the Tree Lungwort, *L. pulmonaria*, was only 15–30 m. while Ockinger *et al.* (2005) estimated the dispersal distance of this lichen's soredia as 35-70m. Hilmo *et al.* (2011) concluded that soredia, the other means of vegetative dispersal in temperate rainforest cyanolichens, typically have a narrow habitat specificity. The status report on Cryptic Paw Lichen (COSEWIC 2006) also concludes that poor vegetative propagule dispersal appears to be one key factor in determining the limited distribution of temperate rainforest species. The diminishing availability of suitable habitat is also an increasingly important constraint.

Interspecific Interactions

A major limiting factor for *L. retigera* and other canopy cyanolichens may be finding suitable uncolonized substrata (Goward 1995). Competition by bryophyte mats is an important factor, especially in CWH zone forest stands in coastal hypermaritime environments (Sillet and Antoine 2004). Lichens such as *L. pulmonaria* and *L. oregano,* which often dominate the canopy, can limit the available substrata for colonization by *L. retigera*.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Widespread general lichen collections have been made in B.C. by lichenologists within the range of both the Interior and Northwestern regions, as both areas have extensive road networks which facilitate access by collectors. Given the easily recognized appearance of *L. retigera*, it is likely that past collections fully delimited the range of this species in areas that were searched. Within the Northwestern and Interior subpopulations all of the known drainages with occurrences (known and predicted) have resource road or recreational trail access.

Targeted survey efforts by Björk and co-workers in the Robson Valley in 2016 have provided new records for the B.C. Interior region, as have intensive searches by Bartemucci in the Northwestern Kispiox region (see **Search Effort** for details). The latter, provide some of the first detailed information on the abundance and distribution of *L. retigera* within the Northwestern region. Within the Interior Subpopulation, few new thalli are anticipated to be found, whereas, in the Northwestern Subpopulation, the total number of thalli is estimated to be as high as 60,000 thalli.(see **Abundance)**.

The Coastal Subpopulation of *L. retigera* in B.C. is less well known. There has been general sampling for lichens on the B.C. Coast but most of the examined sites are on the outer coast, in the hypermaritime zone. *Lobaria retigera* has not been found in this zone. The major river valleys, such as the Skeena and the Nass, where *L. retigera* is rare, have been examined but very few north and central coast inlets have been surveyed. Search effort in the Kitlope watershed, however, suggests that unsearched areas of the coastal region will not contain significant numbers of new thalli.

Abundance

<u>Northwestern Region.</u>

When attempting to estimate abundance of *L. retigera* and the number of mature individuals in the Kispiox region, the core area for this lichen, it is critical to consider the amount of suitable habitat. This can be done by examining surrogate measures of habitat type. One such surrogate within the Kispiox Timber Supply Area (TSA) (1.22 million ha) is land that falls within the ICHmc1 and ICHmc2 biogeoclimatic zones, specifically productive sites with old forest cover. This is the biogeoclimatic subzone and age class within which most of the 2015 and 2016 Bartemucci surveys were conducted. Analysis shows that 8,326 ha of this site type remains within the Kispiox Timber Supply Area (Burger pers. comm. 2017). Of this 3,862 ha falls within the timber harvesting land base (THLB), and 4,464 ha falls outside of the currently defined THLB. It should be noted that thalli do not uniformly occur throughout this surrogate habitat; rather they occur sporadically within wet forest inclusions.

Based on these data, estimates of the total population of *L. retigera* can be made based on the following assumptions:

1) This species in the Kispiox is limited to productive ICHmc1 and ICHmc2 forest types.
2) The total area of these habitat types is 8,326 ha, 4,464 ha of which falls outside of the currently delimited timber harvesting land base.
3) Lichen surveys in planned cut blocks provide a detailed survey of abundance in these habitat types, with median estimates of abundance calculated as 6.937 thalli per ha (Table 1).

If extrapolated, this works out to 57,757 thalli in the entire landscape assuming no logging, with an estimated 30,966 thalli being found in the non-timber harvesting part of the landscape (Table 2).

Table 2. Calculations of the projected possible declines *of L. retigera* based on data in Table 1 for the Kispiox region in areas within and outside the timber harvesting landbase (THLB).

Kispiox TSA Timber Supply Area	Thalli in THLB	Thalli outside THLB	Total	Cumulative % Decline
Current	26,790	30,966	57,757	
Lost in 3 generations from logging	16,000			
Remaining after logging (direct habitat loss, based on optimistic estimate of 40% survival of thalli in wildlife tree retention patches)	10,790	30,966	41,756	38
Lost in 3 generations from being adjacent to clear cuts (indirect habitat loss)	10,790 x 0.20 = 2158	30,966 X 0.20 = 6,193		
Cumulative remaining after including clearcut adjacency loss	8, 632	24,773	33,405	43
Decline in 3 generations due to increase in summer droughts optimistic 30% survival, 70% mortality (indirect habitat loss)	8,632 x 0.70 = 6,042	24,773 x 0.70 = 17,341		
Cumulative remaining in 3 generations after	2,590	7,432	10,022	83

Of the c. 27,000 thalli in the timber harvesting landbase (THLB), it is reasonable to assume that most or all of these thalli will be lost within 3 lichen generations (60 years) and probably many within the next ten years. This reflects three major factors: 1) the predicted severe mid-term (20-50 years from now) timber supply shortfall in the B.C. interior, due to the past impacts of the Mountain Pine Beetle (*Dendroctonus ponderosae*) outbreak (British Columbia Ministry of Forests, Lands and Natural Resource Operations 2012); 2) the areas where *L. retigera* and other inland rainforest epiphytic macrolichens preferentially occur are located in wet groundwater receiving “toe-slope” topographic positions (Goward and Burgess 1996; Radies *et al.* 2009). These areas have traditionally been harvested first due to easy road access and their higher quality timber supply (Goward and Burgess 1996; Radies et al. 2009); and 3) timber supply projections generally assume a transition from old to second growth forest stands within the THLB in the next 40-50 years (Figures 12 and 13), placing severe pressure on remaining *L. retigera* habitat (British Columbia Ministry of Forests, Lands and Natural Resource Operations 2012).

The number of thalli in already designated cut blocks in the Kispiox area is estimated at around 27,000 of which about 11,000 will remain after logging in the timber harvesting land base (THLB). Even with set-asides in Old Growth Management Areas (OGMA) and Wildlife Tree Retention Patches, there will be edge effects and thallus declines of around 43% may be experienced (Table 2). Indeed, although considerable uncertainties are involved, it is possible that about 80% of the total *L. retigera* population could be lost within 3 generations (60 years), and perhaps sooner, due to combined effects of direct habitat loss (removal of host trees), indirect habitat loss (edge effects and problems with small retained patches) and climate change (summer droughts etc.). Additionally, stands currently mapped in the non-THLB may be incorporated into future cut blocks, as these designations (THLB vs. non-THLB) are based solely on operability standards, which have changed significantly in the past (see below).

With respect to edge effects, many of the forest stands in the non-THLB areas will suffer severe impacts in areas adjacent to clear cuts as conditions become unsuitable habitat for *Lobaria retigera* (Gauslaa *et al.* 2018). There are no current published metrics on the proportion of edge versus interior habitat in the Kispiox timber supply area; however, comparable data for wet-cool sub-boreal spruce stands in the Robson Valley, which are facing similar harvest pressure from dispersed cut blocks in face of the mid-term timber supply crisis, found that the two major components of regulations controlling old-forest retention (total old forest and proportion of interior old forest) will result in only 21% of wet-trench landscapes being retained as interior old forest habitats (Coxsons and Radies 2008). Taking these factors into account a minimum loss of 20% of thalli in the non-THLB is predicted over the next sixty years. This could result in the loss of another 6,000 thalli. In total this amounts to a decline of just over 50% in the number of mature individuals over the next three generations or 60 years. It should be emphasized that this does not take into account losses due to climate change and drier summers (see **Climate Change & Severe Weather**) to which this lichen is very sensitive (see **Habitat Trends**). These calculations are summarized in Table 2.

With respect to Wildlife Tree Patches, all indications are that a 35 m buffer around them is insufficient for thalli, in an isolated patch, to survive a summer drought event. However, if all thalli in future cutblocks were placed in wildlife tree patches and all survived for 60 years, then there is a potential for an extra 16,000 thalli to survive in the Kispiox area after 60 years. This is highly unlikely – it would be remarkable if even 30% of thalli in Wildlife Tree Patches survive after 60 years, given the known sensitivity to edge effects (Gauslaa *et al*. 2018), and the predicted increase in the severity of future summer drought events. It is more likely that 10% of *Lobaria retigera* metapopulations in Wildlife

Tree Patches located in cutblocks at most might survive (see **Logging & Wood Harvesting**). In addition, Wildlife Tree patches, provide only limited forms of protection. For example, forest road construction is an allowed use of Old Growth Management areas (Environmental Law Centre 2013), and can result in significant habitat disturbance and loss of thalli. This is hard to quantify, but an the estimate of even 20,000 thalli remaining in non-THLB Kispiox landscapes after 60 years is probably too high.

These landscape level calculations have two main sources of uncertainty. On the one hand, they may overestimate the future abundance of *L. retigera* thalli in the Kispiox TSA (Timber Supply Area), as the distinction between THLB and non-THLB sites relies on current assessments of operability. Determinations of which forest stands are operable (i.e., economic to harvest) have changed many times in the past, as changing technology (e.g. use of feller bunchers in the 1960s), fibre utilization (e.g. utilization of biomass for pellets in the mid-2000 period), or pricing, contribute to changing definitions of THLB vs. non-THLB. On the other hand, these estimates may underestimate the number of *L. retigera* thalli in sites where “puddle” forest inclusions are surrounded by stands of lower site productivity (typically more xeric) or younger stands. The complex mosaic of stands with “puddle” forest attributes and surrounding habitats can be difficult to assess using standard forest inventory mapping (Radies *et al.* (2009). The best way to resolve this in the Kispiox region would be the use of aerial photo interpretation to identify wet forest sites in toe-slope positions, as was done for the Robson Valley by the British Columbia Integrated Land Management Bureau (2008). The report of Goward and Burgess (1996) is the closest we have to a comprehensive identification of high quality lichen habitats in the Kispiox, identifying 37 old growth stands as antique forests, many of which have now been lost to logging (Bartemucci 2017).

<u>Interior Region.</u>

Surveys of epiphytic macrolichens in the Robson Valley confirm that *L. retigera* is largely limited to wet ground-water receiving toe-slope positions and is quite rare within the larger landscape, found in less than 3% of survey plots overall (Radies *et al.* 2009). Based on an estimate of 5 thalli per collection site (Radies *et al.* 2009, unpublished survey data), it is unlikely that the population exceeds more than about 150 individuals.

<u>Coastal Region.</u>

Based on an average of 10 thalli per occurrence (reflecting the abundance of *L. retigera* thalli seen at collection sites visited by Björk), except where known, the number of individuals in the Coastal region is estimated as 31 thalli and even taking into account unsurveyed areas, it is unlikely the number exceeds 100 (see **Fluctuations and Trends**).

Known populations of *Lobaria retigera*

The total population of *L. retigera* in Canada is around 60,000. A summary of the known occurrences was compiled by Chytyk (2014), in a report for the B. C. Conservation Data Centre. Björk (2016), visited previously known collections of *L. retigera* in the Skeena, Nass, and Kispiox watersheds. The data for occurrences in Canada, from recent surveys, are assembled in Table 1. The compilation of Chytyk (2014) is valuable as it includes information on adjacent resource developments, both past and proposed.

Fluctuations and Trends

Forest stands within which *L. retigera* grows in B.C. were historically characterized by long site continuity. Radies *et al*. (2009), for instance, found that ancient cedar stands supporting *L. retigera* occurrences in the Robson Valley were restricted to wet toe slope positions, where melt water from winter snowpack maintains groundwater supplies and creates conditions of high humidity within the canopy during the midsummer period (Dery *et al*. 2014). Evidence from Sanborn *et al*. (2006) suggests that fire return intervals on south-facing toe-slope positions may reach 1600 years or more.

Once established within old forest stands *L. retigera* thalli can probably persist for long time periods. Small coniferous branches on which individual thalli of temperate rainforest lichens often grow can be suitable habitat for 20-30 years (MacDonald and Coxson 2013), leading to a pattern of repeated small scale colonization and dieback on the branches of individual trees, similar to metapopulation dynamics described for Scandinavian populations of *L. pulmonaria* by Snall *et al.* (2005).

Within the past decade detailed measurements have been taken of the status of individual *L. retigera* thalli on trees in several sites. These include:

- 2015 and 2016 surveys of Bartemucci in proposed Kispiox cutblocks;
- 2009 surveys of Radies in wet toe-slope stands of the Robson Valley;
- 2013 surveys of MacDonald and Coxson on mature Alder (*Alnus incana*) in Slim Creek Provincial Park in the Robson Valley;
- 2016 surveys of Björk in the Ancient Forest/Chun T'oh Whudujut and Slim Creek Park and Protected Area in the Robson Valley.

Studies that revisit known occurrences can provide valuable evidence for predicting future population trends. However, to date no long-term monitoring plots for *L. retigera* have been set up. Significantly, the majority of plots established by Radies *et al*. (2009) and MacDonald and Coxson (2013) have been included within the newly designated Ancient Forest/Chun T'oh Wudujut Provincial Park, so they should be available for future re-assessments. Other occurrences of *L. retigera* in the Interior region, however, face a trend of declining abundance due to habitat loss over the next three generations (60 years) within the THLB (see **Threats and Limiting Factors**).

In the Northwestern region of B.C, 7 out of 30 planned blocks have been logged as of spring 2017 (Bartemucci pers. comm. 2017c). A large proportion of *L. retigera* thalli surveyed within the harvest blocks have been retained within Wildlife Tree Patches (see **Habitat Trends**); however, the existing buffer size of 35 m (distance from retained lichen rich trees to the cutblock edge) of these wildlife tree patches exposes retained thalli to edge effects (Stevenson and Coxson 2008). Recent data on another cyanolichen, *Erioderma pedicellatum*, has shown that even a buffer of 100 m is insufficient protection for very sensitive species (Cameron *et al.*, 2013; Environment and Climate Change Canada 2016). The limited size of buffer zones is of special concern as the impact is over three generations (60 years), and as any edge effects will be exacerbated by future summer droughts (see **Climate Change**). One mitigating factor may be the fact that many of these retained thalli occur in stands with “puddle” forest attributes where higher canopy humidity may provide buffering against edge effects. However, predicted impacts of summer climate change and the sensitivity of this species to edge effects may mitigate against this (see **Threats**). Experimental studies are needed to determine the viability of thalli retained in wildlife tree patches in the Kispiox region.

The long-term survival of thalli in non-THLB areas is also vulnerable to climate change, as many non-THLB stands are subject to edge effects. This is because the landscape is a complex matrix of interspersed harvested and non-harvested stands. Furthermore, changing definitions of operability and utilization mean that a non-THLB designation cannot be relied upon as a long-term protection. As noted below relatively few of the known thalli are located within parks and protected areas. Other designations, such as Old Growth Management Areas, provide only limited protection against resource road and other types of non-logging development (see **Legal Protection and Status**).

Rescue Effect

In the event of extirpation, Canadian subpopulations would likely not benefit from the rescue effect (immigration from an outside source). Canadian occurrences (particularly at inland localities) are spatially distant from one another. Occurrences in the Interior region, for instance, are 800 to 1,000 km from the known Alaskan occurrences, while occurrences in the Northwestern region are 100 to 300 km from Alaskan occurrences. Occurrences in the Northwestern and Interior regions are both separated from Alaskan occurrences by the Coast Mountain ranges, with the Interior region further isolated by dry interior-plateau habitats. Additionally, *L. retigera* relies on large asexual propagules, which limits dispersal capability. Finally, the major threat faced by Canadian populations, i.e*.,* the continuing loss of habitat, would greatly reduce the effectiveness of any rescue effort.

THREATS AND LIMITING FACTORS

The Threats Calculator assessment was very high to high, with the main threats being Logging & Wood Harvesting and Climate Change, although there were also less serious concerns. These are dealt with below in the same sequence as the threats calculator.

Transportation & Service Corridors (4)

The expansion of transportation corridors is a major risk for *L. retigera* populations. This is especially the case within the Ancient Forest / Chun T'oh Whudujut Provincial Park, where many of the ancient Western Redcedar stands containing *L. retigera* are located immediately adjacent to the highway corridor. The Robson Valley is also transected by a B.C. Hydro transmission line right of way, which if developed would pose a similar risk to *L. retigera* populations.

Northwestern B.C. has been proposed as the site for multiple new oil and gas pipelines, with upwards of twelve proposals potentially crossing ICH and CWH forests in Northwestern B.C. Potential impacts range from direct loss of habitat where right of way corridors are developed, to indirect impacts, with many factors interacting, including construction of roads and changes in hydrology. Both the Prince Rupert Gas Transmission Project (Pacific Northwest LNG) and the Westcoast Connector Gas Transmission Project (Prince Rupert LNG) proposed routes would cross core *L. retigera* habitats in the Skeena and Nass River watershed with known occurrences in Figure 2. Chytyk (2014) notes that the proposed TransCanada Prince Rupert Gas Transmission Pipeline is located approximately 3.0 km to the southwest of the mapped location of the Carrigan Creek *L. retigera* occurrence and 0.3 km from the Murder Creek occurrence.

Logging & Wood Harvesting (5.3)

<u>Interior Region.</u>

The primary threat to populations of *L. retigera* is loss of habitat due to industrial logging. The same habitats that support *L. retigera*, i.e., wet valley-bottom ground water receiving stands, have been preferentially selected for harvesting, in part due to the high timber value of stands in the productive valley bottom sites, and in part due to the lower costs of accessing timber on level terrain near valley bottom roads. The pattern of harvesting in both the Adams and McGregor River valleys (Figures 4 and 11) illustrates these points, with road access and associated logging concentrated in the flat toe-slope position above the valley bottom riparian zone. The analysis of Radies *et al.* (2009) in the very wet cool subzones of the ICH (ICHvk2) in the Robson Valley, an area of 130,571 ha, found that more than two-thirds of potential *L. retigera* habitat had already been logged especially in the wet toe-slope habitats at the base of mountain slopes as shown in Figure 11.

Old growth management areas (OGMAs) can provide limited protections.

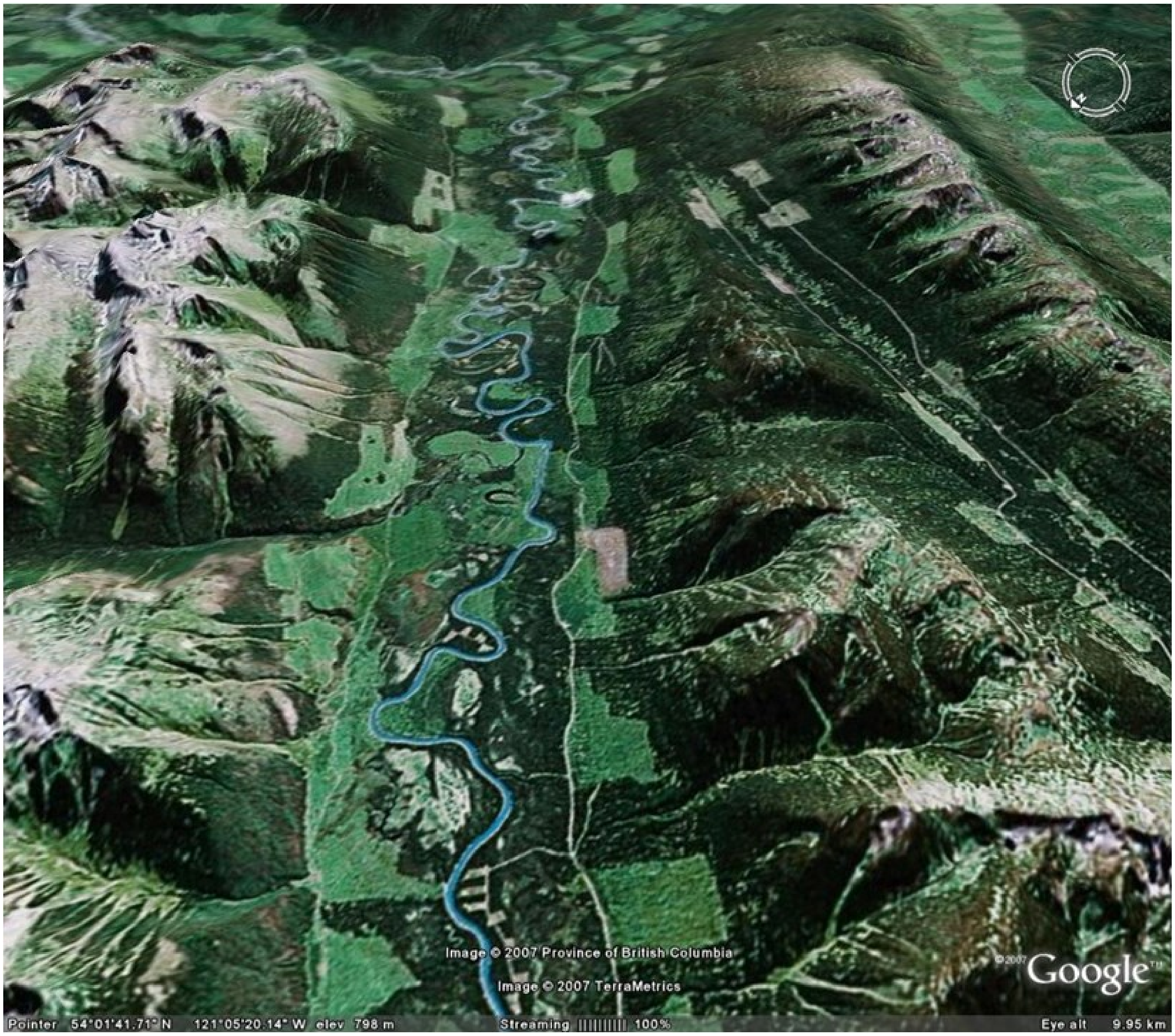

Figure 11. Valley bottom logging in the Interior Region in the very wet, cool interior cedar hemlock (ICHvk2) biogeoclimatic zone, This is in the McGregor River Valley, a tributary of the upper Fraser River. Base image © Google Earth (2007 satellite imagery). The logging occurred mainly on the wet toe-slope positions upslope from the forestry access road, This was verified with foresters familiar with the valley prior to logging. They confirmed that the logged stands were cedar-hemlock forests.

However, most of the OGMAs are both quite small and often elongate/sinous in shape, so the area of suitable interior habitat will be much less than the actual area protected. Several have already been compromised by other resource uses, e.g. forestry roads, gravel extraction, adjacent clearcuts, all of which are allowed uses. The same size and shape considerations apply to the wildlife retention patches. Efforts were made to designate OGMAs in the Robson Valley from 2006-2008 led by the University of Northern British Columbia. This resulted in the establishment of some 5000 ha of new OGMAs, most of which were ultimately incorporated into the new Ancient Forest park. One of the largest remaining OGMAs outside of parks in the Robson Valley has now been seriously compromised as lichen habitat, namely the Longworth OGMA, which had a road built down its long axis (Figure 14). Within approved cut blocks in the Robson Valley, clumps of 2-3 large cedars are sometimes left as wildlife tree patches in the middle of clearcuts. However, these trees are so exposed that any lichens left on them die quickly and the trees themselves often do not survive more than 4-5 years as they are subject to high rates of windthrow.

A major contributing factor to future harvesting pressure on *L. retigera* habitat in interior B.C. is the impact of the Mountain Pine Beetle epidemic, which destroyed much of the available timber supply in the B.C. central-interior plateau. During the past 15 years mills in central-interior B.C. increased production to process beetle-killed wood. That supply, however, is now coming to an end. The required alternative supply will have to come primarily from wet mountain forests in B.C.'s ICH zone (British Columbia Ministry of Forests, Lands and Natural Resource Operations 2012). Furthermore, within the THLB planned harvest rotation intervals of 90-120 years will result in a gradual depletion of existing old forest stands greater than 250 years in age capable of supporting *L. retigera* populations (Figure 12), while recruitment of "new" old stands will be capped by the future age of stands at the time of harvest. The impacts of this change in timber supply under planned harvest rotation intervals of 90-120 years will be especially evident in 50-60 years' time, when available old-growth timber supply is largely depleted, replaced with timber from second-growth stands (British Columbia Ministry of Forests, Lands and Natural Resource Operations 2012) (see Figures 12 and 13).

Figure 14. The Fraser Flats forestry access road, built through the long-axis of Old Growth Management areas that had previously been designated to protect ancient cedar stands in wet toe-slope positions (photo by D. Coxson).

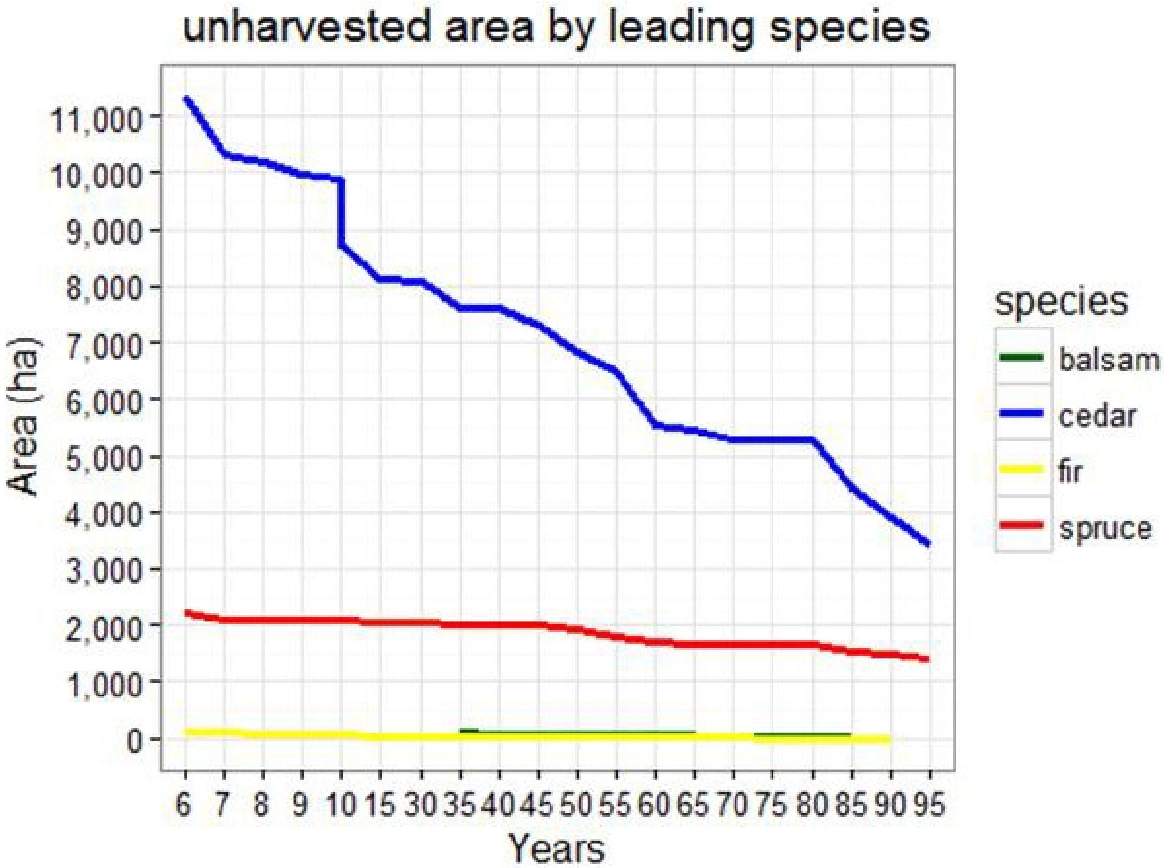

Figure 12. Projected changes in old forests (> 250 years in age) in the very wet cool interior cedar hemlock (ICHvk2) biogeoclimatic zone in the Robson Valley area, by tree species for the next 95 years, based on the assumptions of the current timber supply review (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2016b). This is the major habitat for Smoker's Lung Lichen (*Lobaria retigera*) in this area. Figure supplied courtesy of Kelly Izzard, Timber Supply Forester, Forest Analysis and Inventory Branch. Wet valley bottom.

Northwestern Region.

A similar analysis of the future availability of old forests is not available for Northwestern region, with a timber supply review of the Kispiox Timber Supply Area (TSA) planned for fall/winter 2017-2018 (Izzard, pers. comm. 2017).

The understanding of the distribution of *L. retigera* thalli in the northwestern region is strongly dependent on the surveys since 2015 (**see Search Effort**) that were mostly in the planned BCTS (British Columbia Timber Sales) harvest blocks. Where the surveys found trees within the proposed harvest blocks that had high numbers of *L. retigera* thalli, the trees were generally included in planned wildlife tree retention patches (Bartemucci pers. comm. 2017b). Wildlife tree patches were introduced as a part of regulations in the 1990s and for certification requirements. However, unlike the special management practice in Nova Scotia which requires all forestry activities on crown land to have pre-harvest surveys of proposed cut blocks for the Boreal Felt Lichen, *Erioderma pedicellatum*, the establishment of wildlife tree retention patches in B.C. is voluntary. In addition, preharvest surveys for *L. retigera* and placement of Wildlife Tree Patches for lichens in B.C. (with a 35 m buffer zone) have only been applied in the Kispiox area. This was initially a response by BC Timber Sales to the COSEWIC report on the lichen Cryptic Paw Lichen, *Nephroma occultum,* in the area.

The ability of these wildlife tree patches to protect *L. retigera* over the next 60 years is highly uncertain because a 35 m buffer is likely insufficient to mitigate edge effects, especially considering the predicted increase in the frequency of summer drought in this region to which this lichen and cyanolichens in general are very sensitive (Essen and Renhorn 1998, Gauslaa and Solhaug 2000; Gauslaa *et al.* 2001; Lange *et al*. 1986; Stevenson and Coxson 2008). Burton (2002), in studies at Date Creek in the Kispiox Valley, found that edge effects, primarily increased irradiance within the canopy, extend 65-70 m into the canopy (from edges) on south-facing slopes but considerably less on north-facing slopes. Furthermore, tree loss only increased by 27% on N-facing edges but by 216% on S-facing edges. Such edge effects will cause at least a reduction in growth rates if not survival in *L. retigera* thalli, at most, if not all of the retained patches. Edge effects will also negatively influence thalli growing in surrounding old forest matrix habitats adjacent to cut blocks. This will be especially apparent after first-pass harvesting (Figure 6), where matrix forest occurs in close proximity to cutblock edges. These edge effects may be mitigated in sites with standing water, as in stands with “puddle” forest attributes.

Although numerous old growth management areas have been designated in the Kispiox TSR, many fall in mid- to high elevation habitats, e.g. on Hazelton Peak, Sidema Mtn, Kispiox Mtn, Kuldo Mtn, above the habitat area of the Smoker’s Lung Lichen. Low elevation OGMA sites are also vulnerable to disturbances from resource road construction (see **Legal Protection and Status - Non-Legal Status and Ranks**). Furthermore, leaning trees on which the lichen is common (Figure 10) can be removed for safety in relation to forestry activity.

Coastal Region.

About half of the estimated *L. retigera* habitat in B.C. falls within the timber harvesting land base (THLB), the other half is outside of the timber-harvesting landbase (non-THLB). There is no legal protection for non-THLB forest stands. Their designation is simply based on estimates of which forest stands are currently operable (commercially viable) and which are not, given constraints of topography, road access, etc. Changing technology and/or markets for wood fibre can result in new logging in formerly non-THLB sites. This has happened in some areas in the central interior, as more areas became available for logging following the construction of new wood pellet plants (biomass fuels).

Current analysis suggests that remaining natural-origin old forests in the CWH Mid-Coast THLB will all have been harvested within the next 5-6 decades (Figure 13). To quote the ministry report that presents this figure, “the chart shows that the remaining old-growth Western Redcedar volume in the THLB will essentially be harvested by the end of the sixth decade" (British Columbia Ministry of Forests, Lands, and Natural Resource Operations. 2011). At this point, old forests will only remain in parks and protected areas, including Old Growth Management Areas and other reserves.

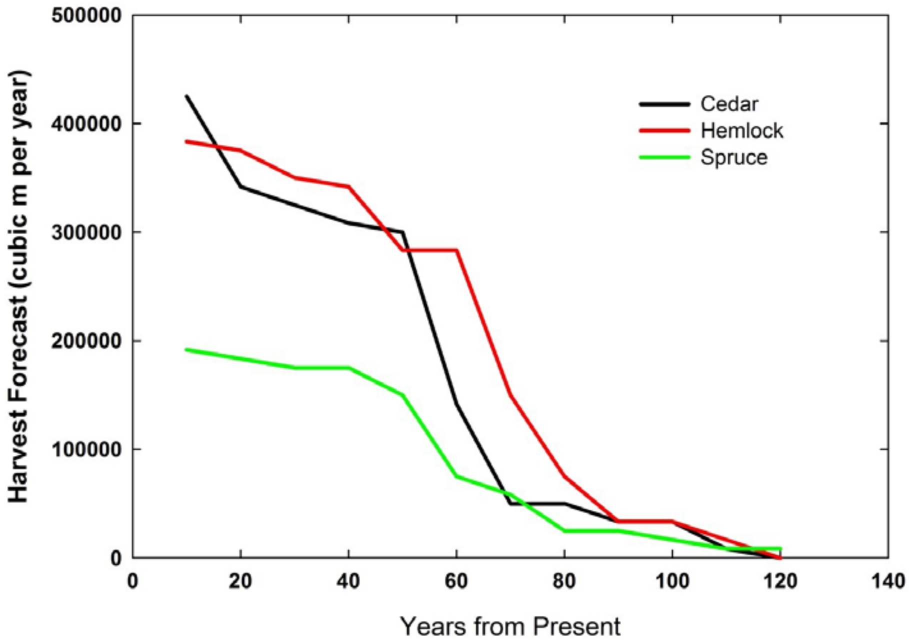

Figure 13. Forecast harvest availability by tree species volume in the Mid-Coast Timber Supply Area (TSA). The Timber Harvesting Landbase (THLB) is 13 percent of the total forest area. Adapted from the 2010 Timber Supply Review base case forecast. From British Columbia Ministry of Forests, Lands, and Natural Resource Operations *et al.* (2011).

A further contributing factor to the resurgence of logging activity in both ICH and CWH forests are changes in the price of Western Redcedar, which has been rebounding since a low in 2009-2010 (Williston pers. comm. 2016).

Fire & Fire Suppression (7.1)

Although the average fire return interval in the Robson Valley has been estimated to range from 130 (Wong *et al.* 2003) to as much as 800 to 1200 years (Sanborn *et al.* 2006), reductions in winter snowpack are already occurring (Déry *et al.* 2014) and climate change models suggest an increase in fire risk (Stevenson *et al.* 2011). This is also the case for the Kispiox region, where fires could have a major impact on future *L. retigera* habitat (Hebda 1997).

Other Ecosystem Modifications (7.3)

The Western Hemlock looper, a defoliating insect, and fires are the dominant large-scale stand replacement disturbances in the inland rainforest, but both occur infrequently. The timing of the next Western Hemlock Looper outbreak is unknown but there is a high probability that it could be within the next ten years. Within the Robson Valley approximately 39,000 ha were attacked by the Western Hemlock Looper in the 1990s (Taylor 1996). Other less severe outbreaks recorded in the area since record-keeping began in 1940 occurred in 1952-57, 1963-65, and 1983 (Alfaro *et al*. 1999). Past outbreaks in the northwestern B.C. ICH include outbreak episodes in the Terrace-Kitimat area and Skeena and Nass River valleys in 1966 (Unger and Humphreys 1982).

Airbourne Pollutants (9.5)

A major impact that could arise from proposed LNG projects in the Kitimat area (see Roads and Utility lines, and Pipelines, above) is emissions from new gas fired power generation stations (Knox 2013). These would augment existing emissions from the aluminum smelter there. Species of the genus *Lobaria* are sensitive to acidification and sulphur dioxide emissions (Geiser andNeitlich 2007).

A relatively new proposal that may pose risks to the Interior subpopulation is the newly approved plan to build a limestone smelter at Giscome, B.C. (Graymont 2016). This would represent a large point source of acidic emissions immediately upwind of the Robson Valley occurrences (permitted for 730,000 t CO2 e/year). At the present time the fuel source for the smelter (coal or natural gas) has not been finalized. A coal fired plant would pose major risks to lichens in the region (Geiser and Neitlich 2007).

Climate Change & Severe Weather (11)

Current climate projections for the B.C. interior suggest that the climate envelope for much of the southern ICH area will contract from its current mid-slope positions, “migrating” upslope into more nutrient-poor rocky habitats (Stevenson *et al.* 2011). This will reduce suitable habitat available for *L. retigera*. In contrast, the projected climate envelope for northern ICH stands, expands westward towards Prince George (Wang *et al.* 2012) (Figure 15). These landscapes, however, have been extensively harvested and will not develop old forest ICH conditions for many centuries. These projections suggest that Robson Valley ICH stands have a good chance for conserving oceanic lichen species in the B.C. interior.

The Kispiox ICH (Northwestern region) is wetter on an annual basis than the Robson Valley ICH (Interior region) but this is not the case for the critical mid-summer period and so major drought events are likely to occur in the Kispiox Valley. The impact on *L. retigera* could be severe as it is very sensitive to summer drought.. For this area, the climate change models are at their weakest when it comes to precipitation forecasts. The outputs range from forecasts of drier conditions (Wang *et al.* 2012, the most widely used model for BC) to forecasts of unchanged or slightly wetter conditions. However, all of the models reliably predict much warmer future conditions. So even if precipitation is unchanged or even slightly increased, the risks of more severe summer drought are still very high for lichens (and for the forests in which they reside). This is due to increased evapotranspirative demand and lichens are especially affected as they have much higher rates of evaporation from thalli after rainfall events under warmer temperatures.

Furthermore, all of the models reliably predict lower winter snowfall, so more of the yearly precipitation will fall as rain. This has major consequences for *L. retigera* and other cyanolichens which grow in the wet toe-slope positions where groundwater recharge from winter snowmelt is critical. Any summer drought with reduced groundwater recharge poses major threat to canopy cyanolichens due to lower canopy humidity and increased wildfire threat. Finally, even the models which predict the same or slightly higher precipitation suggest that more of the precipitation is likely to occur during extreme events, so the duration of hydration for canopy cyanolichens will be less especially in sites subject to edge effects. In summary, of the predicted changes, temperature will be the major driving factor and more details are provided below of the current conditions and future climate alterations.

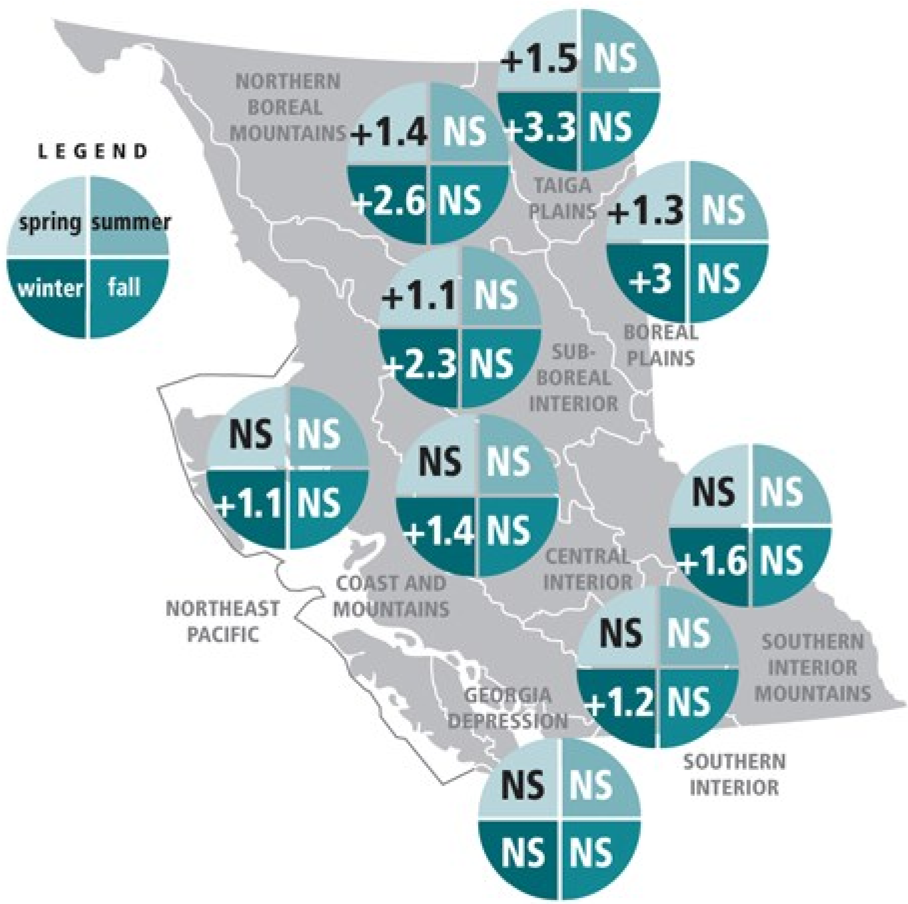

Figure 15. The change in Maximum Temperature, by season, 1900-2013 (ºC per century) across regions of British Columbia. From British Columbia Ministry of the Environment (2015).

Using Climate B.C. Version 5.40 (2016), the climate means were estimated for July and August for the period from 1961 to 1990 for *L. retigera* collection sites near Kispiox, B.C. (Northwestern region), and for collection sites near Dome Creek, B.C. (the Interior region). These comparisons show that July and August summer climate in the interior ICH near Dome Creek was cooler and wetter than that of the Northwestern region ICH near Kispiox. Specifically, mean maximum temperatures for July and August near Kispiox were 22.3 and 21.8°C respectively, compared to 21.1 and 20.4°C respectively near Dome Creek. Average July and August monthly temperatures were 15.7 and 15.1 °C respectively near Kispiox, and 14.3 and 13.8 °C near Dome Creek. The Kispiox collection sites also had lower mid-summer precipitation totals, 62 and 51 mm precipitation, respectively, compared to 83 and 81 at the Dome Creek sites. These differences are expected to intensify. B.C. Climate B.C. estimates for 2055, using the HadGEM2ES_RCP45 model, predict that mid-summer conditions in the *L. retigera* collection sites near Kispiox (Northwestern region) will be even drier and warmer than those of the Dome Creek (Interior region) collection sites. Predicted July and August mean maximum temperatures in 2055 near Kispiox were 25.4 and 23.1°C respectively, compared with 22.4 and 21.6°C respectively for Dome Creek. Predicted average monthly temperatures were 18.7 and 16.6 °C for July and August 2055 near Kispiox, but 13.0 and 15.0 °C respectively near Dome Creek. Furthermore, the Kispiox collection sites had much lower estimated mid-summer precipitation totals by 2055, at 46 and 48 mm precipitation respectively for July and August, compared with 77 and 78 mm precipitation respectively at the Dome Creek collection sites.

These comparisons between the Kispiox (Northwestern region) and Dome Creek (Interior region) indicate that the impact of climate changes will be much greater in the Kispiox Valley. This will have major impacts on any *L. retigera* thalli growing there and particularly on thalli located near forest edges. Thalli remaining in wildlife tree patches will be highly vulnerable to edge effects in future decades during mid-summer drought episodes as indicated by the experimental studies of Stevenson and Coxson (2008).

An additional impact of climate change in B.C. is changes in winter climate. It is predicted that changes in maximum mean winter temperatures in the B.C. central interior and coast regions will vary from ca. 1.1 to 3.0°C (British Columbia Ministry of the Environment 2015). There will also be a changing pattern of winter precipitation, with more early and late season winter precipitation events occurring as rain instead of snow. These changes could have a major impact on temperate rain forest lichen species such as *L. retigera*. Bjerke (2011) notes that such lichens are sensitive to a warmer and more fluctuating winter climate. Postulated mechanisms include increased respiratory demand, and accumulation of toxic metabolites during periods of ice encapsulation.

Hebda (1997) predicts that the northwest ICH and CWH ecosystems are highly vulnerable to climate change and predicts that there will be an increased frequency and intensity of summer fires in CWH forests as a result of climate changes (see **Fires & Fire Suppression**).

Number of Locations

Fifty-nine known occurrences of *L. retigera* are listed in Table 1, fifty-six of which are considered as extant occurrences. These comprise three subpopulations. Nineteen extant occurrences are within the B.C. Interior region, 34 occur in the Northwestern B.C. region, and 3 occur in the B.C. Coastal region. The major impacts are forest harvesting and climate change. As forest harvesting tends to be restricted in time and space, it is argued that each occurrence could be harvested at a different time and thus the number of locations would equal the number of occurrences, that is 56.

Of the 56 extant occurrences known at the end of 2016, forty have a medium or greater risk of extirpation due to forestry or climate change or edge effects around retained patches. Nineteen occurrences are in sites that are thought to be at low-risk of extirpation. They occur either in parks and protected areas or they are found in sites with no currently proposed developments. Another 15 occurrences have been categorized as sites where there is a medium risk of extirpation, based on the proximity of collection sites to adjacent clearcut (edge effects). They are vulnerable to dieback from edge effects and these will increase as a result of climate changes especially in the Northwestern region (see **Climate Change**). The remaining 25 occurrences occur at sites where thalli are at a medium to high risk of extirpation (see **Threats: Logging & Wood Harvesting**).

Three known occurrences are likely extirpated. Two of these have been logged and thalli could not be relocated in the surveys. A third is in a protected area (Kitlope) and may still exist but could not be found during the 2016 survey.

The impact of Climate change on *L. retigera* is uncertain, but could become a major threat in the next three generations (60 years) and would likely affect each subpopulation separately. The number of locations could then be as low as three, if a regional drought severely affected lichen thalli in a given subpopulation. However, there is a lot of uncertainty about the timing and seriousness of future summer droughts. Unless widespread, each mountain range or watershed might be affected differently and so be a separate location, in which case the number of locations would likely exceed ten.

PROTECTION, STATUS AND RANKS

Legal Protection and Status - Non-Legal Status and Ranks

<u>Status</u>

Alaska: *Lobaria retigera* in Alaska is ranked S2S3 (Imperilled or Vulnerable).

Canada: *Lobaria retigera* is Blue-listed in B.C. and is ranked S3 or vulnerable (April 2010) (B.C. Conservation Data Centre 2017).

Legal Protection

Old Growth Management Areas

Much of the remaining (outside Class A Parks) *L. retigera* habitat in the Robson Valley has been placed in Old Growth Management Areas (British Columbia Integrated Land Management Bureau 2004). Many of the Old Growth Management Areas in the Kispiox region have been placed in mid- to high-elevation forest stands, e.g. on Hazelton Peak, Sidema Mtn, Kispiox Mtn, Kuldo Mtn, where they are above the elevation limit for Smoker's Lung Lichen. When they are placed at low elevation, OGMAs are often compromised by other allowed resource uses, e.g. roads, gravel extraction, and adjacent clearcuts. Several of the most significant OGMAs for *L. retigera* in the Robson and Kispiox Valleys have been seriously compromised. The Longworth OGMA in the Robson Valley, for instance, has had a road built down its long axis (Figure 14), while the buffer zone for the Botrychium OGMA in the Kispiox has now been logged (Anon 2017; Bartemucci pers. comm. 2017d).

Provincial and National Parks

Interior Region

B.C. Interior - ICH Biogeoclimatic Zone. In the Robson Valley 12 occurrences of *L. retigera* are in Slim Creek and Ancient Forest/Chun Toh Whudujut Provincial Parks, and the Sugar Bowl Grizzly Den Provincial Park. One additional occurrence is in the Upper Seymour River Provincial Park, for a total of 68% of the Interior Region occurrences located in protected areas.

Northwestern Region

Northwestern B.C. – ICH Biogeoclimatic Zone. Three of the northwestern B.C. occurrences fall within protected areas, in Swan Lake / Kispiox River Provincial Park, in Kleanza Creek Provincial Park, and in Lakelse Lake Provincial Park (Table 1).

The Swan Lake Kispiox River Provincial Park is the only major B.C. provincial park (at 62,255 hectares) in this area. Only one occurrence is known in the park, this near the western boundary at Brown Bear Lake. A total of 11 % of the Northwestern Region occurrences are located in protected areas.

Coastal Region

B.C. – CWH Biogeoclimatic Zone. One of the formerly known CWH occurrences was located in the Kitlope Heritage Conservancy Protected Area. This occurrence could not be relocated in an August 2016 search by Björk and Coxson.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Thanks are due to the following authorities for providing information on *L. retigera* populations and habitat conditions: Toby Spribille and Antoine Simon, Paula Bartemucci and Patrick Williston from Gentian Botanical Research in Smithers, B.C.; Noreen O'Hara, Bruce Rogers, Hubert Burger, and Kelly Izzard from the B.C. Ministry of Forests, Lands and Natural Resource Operations; Jenifer Penny from the B.C. Conservation Data Centre.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Darwyn Coxson is a Professor in the Ecosystem Science and Management Program at the University of Northern British Columbia in Prince George, B.C. His research program at UNBC has focused on the ecology and conservation biology of inland temperate rainforest lichens. Dr. Coxson was a co-author on the 2011 UBC Press book Ecology, Conservation, and Management of British Columbia's Inland Rainforest.

Curtis Björk is a botanist and lichenologist with 25 years of field experience, and is co-curator of lichens at the herbarium UBC (Beaty Biodiversity Museum, Vancouver). He earned his MS in Botany from Washington State University in 2003, and currently manages Enlichened Consulting along with Trevor Goward. He has authored or coauthored numerous publications, including publication of a number of lichen and plant species new to science.

COLLECTIONS EXAMINED

Specimens of L*obaria retigera* in the UBC Hebarium, and in the private herbaria of the writers of this report, were examined when this COSEWIC status report was initiated. Information on lichen specimens that are deposited in herbaria are now readily available as a result of computerized databases. No specimens of *Lobaria retigera* were added to the UBC or other herbaria that are part of the Consortium of North American Lichen Herbaria in 2015-17.

Appendix 1. Threats Assessment Worksheet.

Species or Ecosystem Scientific Name	Smoker's Lung Lichen (*Lobaria retigera*)			
Element ID		**Elcode**		
Date (Ctrl + ";" for today's date):	14/03/2017			
Assessor(s):	Dwayne Lepitzki (moderator and Molluscs SSC co-chair), David Richardson (Mosses and Lichen SSC co-chair), Darwyn Coxson (Writer and Mosses and Lichens SSC member), Karen Golinski (SSC member), Syd Cannings (COSEWIC Member for CWS), Dave Fraser (COSEWIC Member for BC) and Angèle Cyr (COSEWIC Secretariat).			
References:	draft threats calculator; draft status report			

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	2	1
C	Medium	0	1
D	Low	3	3
Calculated Overall Threat Impact:		Very High	High
Assigned Overall Threat Impact:		**A = Very High**	
Impact Adjustment Reasons:			
Overall Threat Comments		generation is between 10-30 years (20 years for calculation purposes) therefore looking 60 years into the future.	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable. Proposed limestone smelter could significant effect Robson Valley populations and accounted for under threat category 9.5
1.3	Tourism & recreation areas						not applicable
2	Agriculture & aquaculture						
2.1	Annual & perennial nontimber crops						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.2	Wood & pulp plantations						not applicable. 40% of known populations are in sites planned for immediate logging, another 24% have close adjacent clearcuts that will compromise populations accounted for under threat category 5.3.
2.3	Livestock farming & ranching						not applicable
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	combined scope of 4.1 and 4.2 do not exceed 10%
4.1	Roads & railroads	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Expansion of Hwy 16 corridor would significantly impact Robson Valley populations and logging roads in the Northwest population range. The threat of logging and roads (including edge effect) poses a high threat to this species of those in close proximity to roads.
4.2	Utility & service lines	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Reserve for BC Hydro lines in Robson Valley and also pipelines.
4.3	Shipping lanes						not applicable
4.4	Flight paths						not applicable
5	Biological resource use	B	High	Large (31-70%)	Extreme (71-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	research and vouchers collected for DNA negligible.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting	B	High	Large (31-70%)	Extreme (71-100%)	High (Continuing)	40% of known individuals are in sites planned for immediate logging, another 24% have close adjacent clearcuts that will compromise populations. Also targetted timber removal due to Hemlock Looper.
5.4	Fishing & harvesting aquatic resources						not applicable
6	Human intrusions & disturbance						
6.1	Recreational activities						not applicable
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities						not applicable
7	Natural system modifications	D	Low	Small (1-10%)	Extreme - Moderate (11100%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Small (1-10%)	Extreme - Moderate (11100%)	High (Continuing)	Reduction of winter snowpack already occurring and modelled for future significant increases in spring fire risk. Kispiox and Interior populations particularly affects by increased fire risk.
7.2	Dams & water management/use		Negligible	Negligible (<1%)	Serious - Slight (1-70%)	High (Continuing)	some run of the river flooding both above and below Lobaria habitat.
7.3	Other ecosystem modifications		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	hemlock looper with unknown outbreak timing but high probability in the next 10 years.
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						not applicable
8.2	Problematic native species/diseases						hemlock loopers but no direct impact to the Lobaria. Scored under 7.3.
8.3	Introduced genetic material						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.4	Problematic species/diseases of unknown origin						not applicable
8.5	Viral/prion-induced diseases						not applicable
8.6	Diseases of unknown cause						not applicable
9	Pollution	D	Low	Small (1-10%)	Extreme - Serious (31100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
9.1	Domestic & urban waste water						not applicable
9.2	Industrial & military effluents						not applicable
9.3	Agricultural & forestry effluents						not applicable
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants	D	Low	Small (1-10%)	Extreme - Serious (31100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Proposed limestone smelter could significant effect Robson Valley populations causing acidification.
9.6	Excess energy						not applicable
10	Geological events		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	not applicable
11	Climate change & severe weather	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (1170%)	High (Continuing)	
11.1	Habitat shifting & alteration						Southern interior range is predicted to shift upslope into unsuitable habitat
11.2	Droughts	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (1170%)	High (Continuing)	Summer drought in combination with low winter snowpack threatens ecology of key habitat and poses greater fire risk
11.3	Temperature extremes	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (1170%)	High (Continuing)	Cynolichen is sensitive to warm summer temperature events

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms & flooding	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (1170%)	High (Continuing)	Habitat is old forest stands is vulnerable to predicted increase in severe storm events
11.5	Other impacts						not applicable

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).