COSEWIC
Assessment and Update Status Report

on the

Cryptic Paw
Nephroma occultum

in Canada

SPECIAL CONCERN
2006

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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Previous report:

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Cryptic Paw Lichen —. Photo by Stephen Sharnoff.

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COSEWIC
Assessment Summary

Assessment Summary – April 2006

Common name
Cryptic paw

Scientific name
Nephroma occultum

Status
Special Concern

Reason for designation
This foliose lichen is endemic to western North America where it is known in Canada from 45 locations, however there are likely more undiscovered locations. The Canadian sites account for more than 50% of the global range with only 5 locations protected from forest harvesting. The species has restricted habitat requirements and grows in mid to lower canopy of old growth coastal and interior humid cedar-hemlock forest. It reproduces only by vegetative propagules with limited dispersal distance. The species is vulnerable to forest harvesting, changes in understory humidity, insect defoliation (hemlock looper), and fire.

Occurrence
British Columbia

Status history
Designated Special Concern in April 1995 and in April 2006. Last assessment based on an update status report.

COSEWIC
Executive Summary

Cryptic paw
Nephroma occultum

Species information

Nephroma occultum is a rare lichen, endemic to Western North America. It is strongly associated with humid old growth forests and is characterized by a yellowish, greenish, or bluish-grey upper surface with net-shaped ridges, and a hairless tan to sometimes blackish lower surface. It is commonly is 2-7 cm broad and has rounded lobes 4-12 mm wide. It produces many asexual propagules, called soredia, along the margins and the ridges of the upper surface, and lacks apothecia, the spore-producing sexual stage of reproduction.

Distribution

The global distribution of *Nephroma occultum* is captured within the geographic boundaries of Alaska (6 localities), British Columbia (45), Washington (8) and Oregon (182). The Canadian portion of the range accounts for more than 50% of the total spatial distribution, and coincides with the intermontane valleys of the Coast Range and the Columbia Mountains.

Habitat

In Canada, *Nephroma occultum* is confined to moist old growth forests at elevations below 1200 m. All Canadian populations occur in the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone of the British Columbia Biogeoclimatic Ecosystem Classification system (Meidinger and Pojar 1991). Avoidance of summer drought is a key attribute of *N. occultum* habitat. In coastal localities the macro-climate provides sufficient moisture for *N. occultum* to inhabit the upper forest canopy. In inland regions where the macro-climate is often too dry, *N. occultum* is restricted to the lower canopy of humid old growth forests.

Biology

Nephroma occultum produces large numbers of asexual soredia which are thought to be dispersed by wind, rain and animals. The soredia of *N. occultum* are larger than those of most lichens, and poor propagule dispersal appears to be a factor which limits distribution. *N. occultum* does not have sexual structures (apothecia) and may have low genetic variation. Furthermore, *N. occultum* is a poor competitor and is displaced by mosses or liverworts where these are the dominant epiphytes.

Population sizes and trends

As of 2004, the global distribution of *Nephroma occultum* comprises approximately 241 known extant populations, of which 45 are located in Canada. Extirpation at two sites within Canada is attributable to forest harvesting. Populations vary in size among extant localities from single thalli to 40 or more within a single stand. With a conservative estimate of 10 thalli per stand, there are probably more that 2,410 individuals of *Nephroma occultum* worldwide.

Limiting factors and threats

Nephroma occultum is limited by the availability of suitable habitat (humid old growth forests) and poor dispersal efficiency. Humid, old growth cedar-hemlock forests have diminished in abundance in step with the progressive expansion of forest harvesting. Additional threats from hemlock looper infestations and fire are predicted to increase in severity and frequency as mean annual temperatures rise, reflecting global warming. Cumulative effects of harvesting, climate change, insect infestations and fire are expected to have a negative influence on remaining *N. occultum* habitat.

Special significance of the species

Nephroma occultum is endemic to western North America, and Canada accounts for more than 50% of the entire global range. Only five Canadian populations are protected from forest harvesting. *N. occultum* is a “flagship” species among a suite of rare and uncommon lichens and bryophytes that are dependent upon humid, old growth forests, many of which exhibit an unusual coastal-inland disjunct distribution. Where regulations require rigorous lichen surveys (for instance, in Oregon), the discovery of this lichen has led to progressive forest management practices encouraging the retention of remnant old growth tree patches. However, throughout the Canadian portion of the range, *N. occultum* habitat is in progressive decline, primarily due to forest harvesting. This trend is most pronounced in the inland areas where suitable habitat is geographically restricted by the availability of forests with humid micro-climates.

Existing protection or other status designations

Nephroma occultum was designated a species of Special Concern by COSEWIC in 1995 based upon recommendations from the initial status report (Goward 1995a). In British Columbia it is ranked S2S3 and is not protected by provincial legislation. Five Canadian localities for *N. occultum* are situated within parks or protected areas. The remaining populations occur on Crown Land and are not protected from forest harvesting or other disturbances. In Washington (S1) and Oregon (S3), *N. occultum* is a listed species on the Northwest Forest Plan, meaning that developers must survey and manage for this species according to the plan’s guidelines. *N. occultum* also occurs in Alaska where it is not protected.

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 5th 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 (2006)

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 it 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 Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

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

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2006

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SPECIES INFORMATION

Name and classification

Scientific name:	*Nephroma occultum* Wetm.
Synonyms:	None
Common names:	Cryptic paw lichen, Cryptic kidney lichen
Family name:	Nephromataceae
Major group:	Lichens (lichenized Ascomycetes)
Bibliographic citation:	Bryologist 83: 243-247 (1980)
Type specimen:	Oregon, Lane County, 11.2 km NE of Blue River, H.J. Andrews Experimental Forest, February 19, 1978, *Scott Sundberg* 120. Holotype: University of Minnesota (MIN). Isotypes: National Museum of Natural Sciences, Ottawa (CANL). Oregon States University, Corvallis (OSC). Swedish Museum of Natural History, Stockholm (S). Smithsonian Institution, Washington, D.C. (US).

Morphological description

Nephroma occultum is a rounded, loosely appressed, foliose (leaf) lichen 2-7 cm broad with lobes 4-12 mm wide (Brodo *et al*. 2001). The upper surface is dull, naked, pale yellowish grey to greenish or bluish grey, and is distinctly net-ridged throughout. The lower surface is also dull and naked, but is finely wrinkled, and varies in colour from pale tan at the margins to sometimes blackish toward the centre. The lobe margins are even and distinctly rounded in outline. Coarse, granular soredia, 80-330 µm diameter, are present along the lobe margins, and later develop also on the ridges of the upper surface. The medulla is white and is UV + pale yellow, and the cortex is KC yellow. The photobiont is a cyanobacterium (*Nostoc*). Apothecia and pycnidia are unknown.

According to White and James (1988), *Nephroma occultum* produces the secondary chemical products nephroarctin, phenarctin, usnic acid, zeorin and an unidentified triterpenoid. These results are based on material from the holotype locality, in west central Oregon. Six further specimens from different parts of British Columbia have now been tested with two-dimensional chromatography, and have yielded two additional accessory unidentified triterpenoids (Goward 1995a).

Technical descriptions are found in Wetmore (1980) and White and James (1988).

Field characteristics that help identify *Nephroma occultum* include the foliose habit, net-ridged upper surface, sorediate ridges, pale yellowish grey to bluish grey colour, and naked lower surface. Some forms of *N. parile* (Ach.) Ach. are similar, but in that species the upper surface is usually brownish and is at most weakly wrinkled, never net-ridged (Goward 1995a).

The name *Nephroma occultum* is derived from the Latin "*occultus*", which means hidden (Wetmore 1980); the earliest collections of this species were found hidden in the uppermost branches of large old trees in Oregon.

Illustrations of *Nephroma occultum* are found in Wetmore (1980: holotype), White and James (1988: isotype), McCune and Geiser (1997), Brodo *et al*. (2001), and Figures 1, 2 and 3 of this report.

Figure 1. *Nephroma occultum* (photo: Stephen Sharnoff).

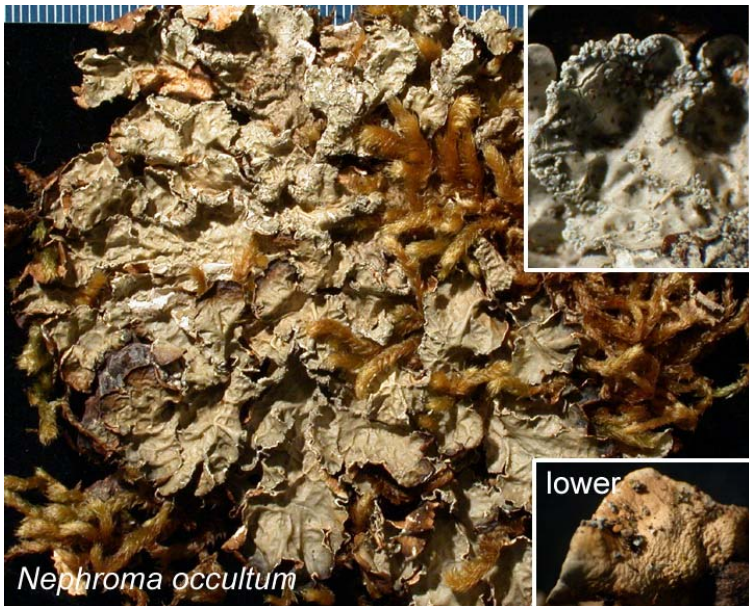

Figure 2. *Nephroma occultum* (photos: Bruce McCune).

Figure 3. *Nephroma occultum* (photo: Patrick Williston).

Genetic description

Nephroma occultum has not been the subject of genetic investigation to date; however, other species in the genus have been studied in recent cladistic analyses using ITS sequencing (Stenroos *et al*. 2003, Maidlikowska and Lutzoni 2004). These studies have shown the genus *Nephroma* to be a monophyletic group, implying that the genus should remain taxonomically stable.

DISTRIBUTION

Global range

Nephroma occultum is a western North American endemic known from Alaska, British Columbia, Washington and Oregon. The northernmost known population is Mile 9 of the Richardson Highway, Alaska (64°47' N 147°22' W), the southernmost is near Roseburg, Oregon (43°27'N 122°54' W), the westernmost is near Seward on the Kenai Peninsula, Alaska (60°33' N 151°16' W), and the easternmost is near the Duncan River, British Columbia (50°42' N 117°06'W).

In 1994, *Nephroma occultum* was known from five localities in Oregon, two from Washington and 21 from British Columbia (Goward 1995a). In 1994, *N. occultum* was included on the suggested list of species to be surveyed and managed for in the federal

forests of Washington and Oregon (FEMAT 1993, USDA and USDI 1994, USDA and USDI 2003). This resulted in the discovery of many new stations and today there are 182 documented localities in Oregon and eight in Washington. In contrast, in British Columbia where lichen surveys are not required for forest harvesting, there have been 24 new populations recorded since 1994. More populations will likely be found in British Columbia as opportunities for lichen surveys in the appropriate habitat opportunistically arise. In Alaska, six populations have been documented, all within the last 10 years (Geiser *et al*. 1994, Zavarzin and Timdal 2004, S. Sharnoff pers. comm. 2005, C. Derr pers. comm. 2005, and K. Dillman pers. comm. 2005). As of 2004, there are a total of approximately 241 documented populations of *Nephroma occultum*, worldwide.

Figure 4 shows the world distribution of *Nephroma occultum*. While most localities (including the type locality) are in Oregon, more than 50% of the range occurs within Canada. NatureServe (2005) suggests that “it seems to have its center of distribution in Oregon”; however, Figure 4 clearly demonstrates that Oregon represents the southern limit of the range (see also Appendix 1).

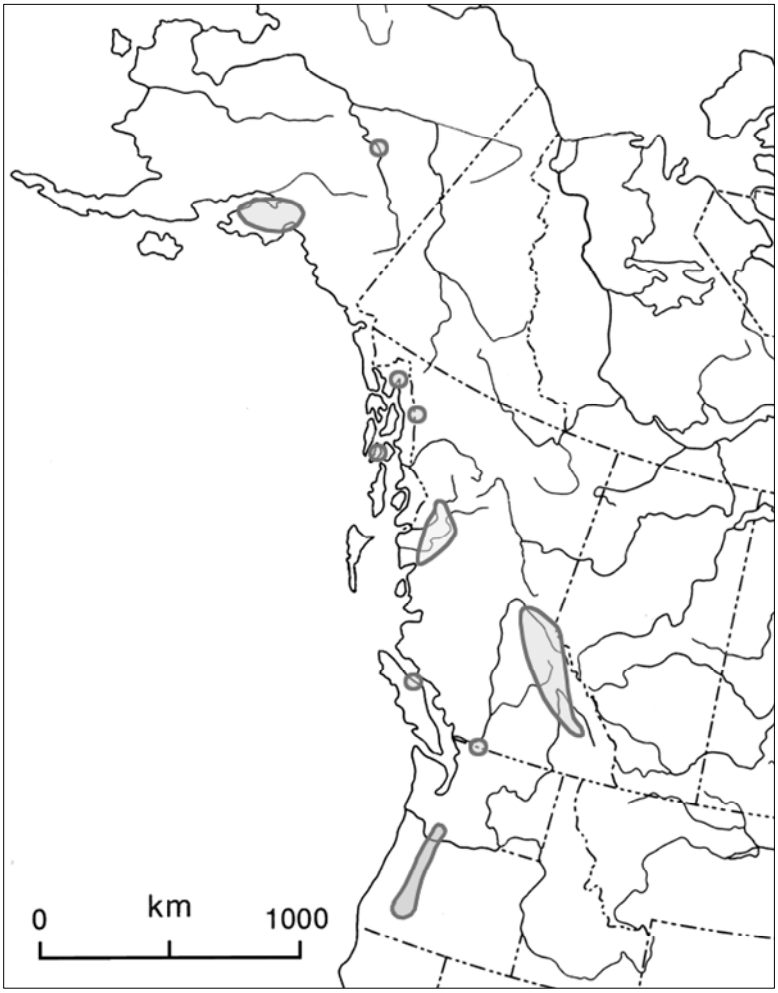

Figure 4. Global distribution of *Nephroma occultum*.

Canadian range

Within Canada, *Nephroma occultum* is restricted to the province of British Columbia where it is known from 45 localities. The distribution of this lichen can be thought of as two zones that run from the northwest to the southeast (this alignment is the dominant geographic pattern of British Columbia and reflects the tectonic development of the western mountain ranges, which influence regional climate; Figure 5). The largest zone is defined by intermontane valleys of the Coast and Cascade Ranges, from the Taku (58°40'N) to the international border near Chilliwack (49°03'N). This zone is discontinuous north of 56°N, and collections are sparse or absent where the lack of roads limits access, which is true for much of this rugged area. Disjunct populations are also known along an inland zone that coincides with the Columbia Mountains. The inland range is entirely within British Columbia and spans from the upper Fraser River (53°43'N) in the north, to the Duncan River (50°42'N) in the south.

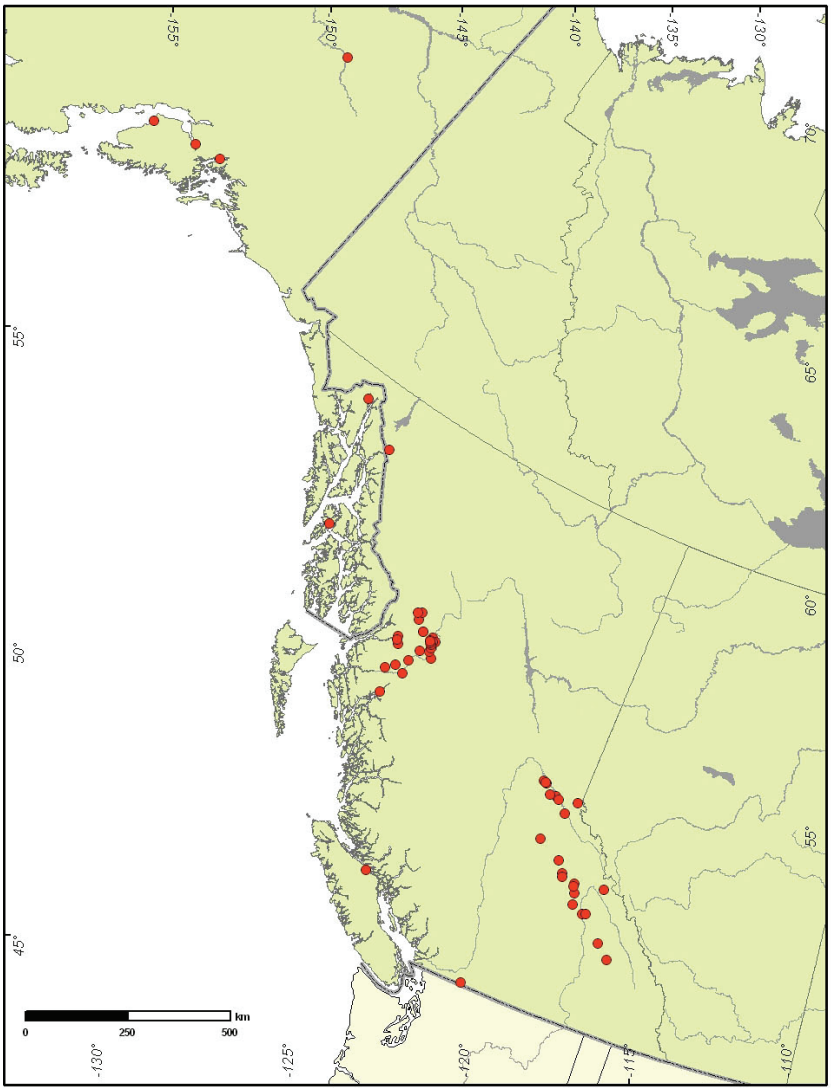

Figure 5. Distribution of *Nephroma occultum* in Canada and adjacent Alaska.

Throughout most of its Canadian range, *Nephroma occultum* is primarily restricted to old growth forests in very humid intermontane regions at lower elevations. *N. occultum* is able to colonize younger forests where the macro-climate is sufficiently humid and source populations are nearby. Assuming the existence of the appropriate habitats, *N. occultum* can be expected to occur throughout the range shown as the shaded area in Figure 4.

HABITAT

Habitat requirements

Nephroma occultum is confined to moist forested regions at elevations below 1200 m (most populations occur between about 400 and 800 m). In Canada, all populations occur in the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone of the British Columbia Biogeoclimatic Ecosystem Classification system (Meidinger and Pojar 1991). No other zones are colonized, nor do extreme maritime (hypermaritime) portions of the Coastal Western Hemlock Zone appear to support this species. Climatic variables common throughout the range of *N. occultum* are: 1) rather continuous high humidity; and 2) moderate summer temperatures. Its absence from the hypermaritime is not easily explained, but could possibly involve either a sensitivity to salt spray or an inability to withstand strong competition from epiphytic bryophytes.

In Canada, *Nephroma occultum* usually occurs in old growth forests characterized by high humidity, stable environmental conditions and nutrient-rich soils. These forests provide stable conditions for slow dispersing lichens such as *N. occultum* and also provide protection from summer drought, one of the key distribution constraints of this species. Within such forests, trees of all age classes are colonized. In Oregon, however, *N. occultum* has been occasionally found in younger forests (McCune and Geiser 1997). Young stands in humid macro-climates like the Oregon Cascades (which feature frequent summer fog) support *N. occultum* where soredia are able to disperse from neighbouring older forests. A humid macro-climate may also explain why *N. occultum* inhabits the upper forest canopy of coastal ecosystems, whereas in inland localities this species is essentially restricted to the lower forest canopy where humidity is maintained throughout the summer by shading and moisture retention from older trees and associated vegetation (Goward 1995b).

In the Canadian portion of its range, *Nephroma occultum* tends to grow on living branches, usually near the branch tips among live needles. It is less common or absent over large branches or on the trunks of trees. In Oregon, however, it is often on larger branches near the trunk (Wetmore 1980, Rosso *et al*. 2000), which may reflect the humid macro-climate and competition from bryophytes.

Nephroma occultum is an acidophytic species which colonizes a broad range of trees. The major phorophytes, as reported by Goward (1995a), are listed here in decreasing order of importance: *Abies lasiocarpa*, *Tsuga heterophylla*, *Picea sitchensis*,

Abies amabilis, *Picea glauca*, *Tsuga mertensiana* and *Betula papyrifera*. In Oregon it is also known from *Pseudotsuga menziesii* and *Acer macrophyllum* (Wetmore 1980, Rosso *et al*. 2000), and at one B.C. locality, from a shady mossy outcrop (Goward 1995a).

Habitat trends

The preferred habitat of *Nephroma occultum*, humid old growth cedar-hemlock forests, is threatened by both natural and human caused disturbances. Both sources of disturbance are causing a progressive decline in the remaining *N. occultum* habitat.

The primary natural source of *Nephroma occultum* habitat loss is defoliation of old growth forests by hemlock looper (*Lambdina fiscellaria lugubrosa*). This is especially true of inland cedar-hemlock forests where canopy defoliation reduces understory humidity, causing mortality among moisture sensitive lichens such as *N. occultum* (Goward 1995a). Hemlock looper infestations do not always result in complete canopy tree mortality; some infected stands are able to recover within years and may continue to support *N. occultum*. Rates of defoliation attributed to hemlock looper in cedar-hemlock stands (in British Columbia) were approximately 44,277 ha in 2002, 42,542 ha in 2003, and 5,750 ha in 2004 (Westfall 2002, 2003, 2004); the total area of the Interior Cedar-Hemlock zone is 5,035,476 ha (Marvin Eng pers. comm.). The rates varies in response to a four-year life history cycle. In comparison, fire consumed 5,179 ha (2002), 33,331 ha (2003), and 210,008 ha (2004) across the entire province. Ecologists speculate that outbreaks of hemlock looper are facilitated by warmer than average mean annual temperatures. If true, then temperature changes predicted by climate models will cause an even greater prevalence of hemlock looper infestation in the years to come (Sutherland *et al*. 2004). This poses a considerable threat to the habitat of inland populations of *N. occultum*.

Climate change has significant potential to negatively influence *Nephroma occultum* habitat throughout its range. In British Columbia, mean annual temperatures are expected to increase 1-4°C within the next decade (Fraser 2002). This may lead to larger and more frequent outbreaks of hemlock looper, but will also certainly lead to greater forest fire frequencies. Most *N. occultum* populations occur in old growth forests where moisture conditions are reflected in fire return intervals of hundreds of years or longer. While historically a minor threat, a changing fire regime may become significant determinant of *N. occultum* distribution.

Global warming will influence patterns of precipitation throughout the range of *Nephroma occultum*. Models generally predict a greater amount of total precipitation (up to 40% greater), but also an increase in the duration of summer drought (Fraser 2002, Sutherland *et al*. 2004). The absence of summer drought is thought to be a key determinant in the distribution of *N. occultum* (see Growing conditions below). Changes to existing climatic conditions are certain; it is unclear how *N. occultum* will respond.

Forest harvesting is the largest current source of disturbance to *Nephroma occultum* habitat throughout its range from Alaska to Oregon. In Canada, the rate and

location of forest harvesting is dependent upon international wood markets, the prevalence of insect outbreaks, and the proximity of mills in operation. For example, the rate of harvesting in the Kispiox Valley (where there are several known populations of *N. occultum*) has decreased considerably in the 2000s owing to the softwood dispute with the United States of America and the subsequent closure of two mills in the region. However, even in the Kispiox Valley there has been a significant loss of *N. occultum* habitat (Williston 2001), largely because cedar-hemlock forests are among the most commercially viable forest types in the Kispiox region, even under poor market conditions (Ken Smith pers. comm.).

Current management plans for this region do not adequately address the habitat requirements of this lichen. For example, in the Kispiox Landscape Unit (which is 56,659.1 ha in size and supports several different forest types), 9% (2,923.5 ha) of the humid cedar-hemlock forest (ICH-mc2 subzone) is planned to be managed as old growth forest (Roberts and Turney 2004). Of this, 1071.4 ha is situated in non-commercial forests (with low value as lumber, for example swampy forests). The remaining old growth (1,852.1 ha) will be secured through the recruitment of stands that are presently younger (due to historical disturbances such as forest harvesting or fire). An additional 6,138.8 ha of old growth forest remains in the timber-harvesting landbase and is unprotected (total historic old growth cover is not stated). This approach to forest management could lead to the regional extirpation of *Nephroma occultum*. Similar methods of planning are used throughout the Canadian portion of the range.

In contrast, where forest harvesting occurs on federal land in Washington and Oregon, *N. occultum* is among the seven lichens included in pre-disturbance surveys (USDA and USDI 2003). This has resulted in the development of protected areas and forest harvesting that emphasizes partially cutting (rather than clear-cutting). It has also contributed to a better understanding of the distribution and habitat availability of *N. occultum* in the southern portion of its range.

Forest harvesting, hemlock looper and fire (and cumulative effects among all three) continue to diminish the prevalence of old growth forests, the primary habitat of *Nephroma occultum*. This trend is expected to intensify as the demand for natural resources grows and mean annual temperatures increase in accordance with global warming.

Habitat protection/ownership

In Canada, most known populations of *Nephroma occultum* occur on provincially owned Crown land and, as such, are not protected by either provincial or federal legislation. Five populations are within parks or protected areas. One locality (41; see pages 9 to 12) is situated within a designated sensitive area (Williston 2002) and is protected as part of the Forest Development Plan for the McCully Creek drainage (a partially logged side-drainage of the much larger and heavily logged Kispiox Valley). Three other localities (11, 17 and 18) are within Wells Gray Provincial Park and a fifth population is protected within an ecological reserve (3).

Two additional populations (36 and 37) are adjacent to Glacier National Park and are situated in very old, old growth forests with humid, stable environmental conditions and rare species habitat, which mark them as high priority for national park expansion.

The remaining populations are in areas that are managed for forestry revenue, and barring the creation of additional parks and protected areas, many will be harvested. For example, in 1996 T. Goward identified 14 lichen-rich old growth forests in the McCully Creek watershed (several of which harboured *Nephroma occultum*); four years later, eight (57%) had either been logged or were designated for harvesting (Williston 2001). In effect, the protection of most *Nephroma occultum* habitat is determined by economics (the high costs associated with road building) and geography (the rugged topography of British Columbia), not by conservation measures.

BIOLOGY

General

Nephroma occultum is a moisture-sensitive cyanolichen endemic to western North America. *N. occultum* is limited by an inefficient dispersal mechanism, and increasingly by the availability of suitable habitat. Within Canada, its habitats are humid old growth forests in the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone. These forests are do not experience summer drought, which appears to be another important limitation for distribution for this species. *N. occultum* is a poor competitor and is susceptible to displacement by epiphytic bryophytes in very humid localities.

Reproduction

Nephroma occultum reproduces via asexual soredia composed of clusters of cyanobacterial cells surrounded by fungal hyphae. The soredia of *N. occultum* are coarsely granular, and occasionally intermixed with isidia. These vegetative structures are abundant on most specimens, including those in early development, and are present in virtually all thalli larger than 1.0 cm in width (Goward 1995a). Soredia arise on lobe margins, and eventually on ridges of the upper surface of older individuals.

Sexual structures (apothecia) are not known for *Nephroma occultum*, and it is assumed that genetic recombination is infrequent and variation is low. This suggests that *N. occultum* is poorly suited to adapting to rapid changes in the environment.

At most sites, *Nephroma occultum* was found on or near the extreme branch tips of understory conifers. The branch tips were estimated to be less than 5 years old indicating that *N. occultum* is presently successfully regenerating at all known localities. Growth rates for this species have not been measured; however, an estimate based upon the size of specimens and their proximity to the growing tips of branches suggests a growth rate range of between 1-10 mm/yr along the longest axis, with an average of approximately 5-6 mm/yr.

Dispersal

On observing the inconsistent distribution of the lichen within a single tree, and among trees within a single stand, Rosso *et al*. (2000) hypothesized that *Nephroma occultum* is dispersal limited. *N. occultum* relies upon the dispersal of asexual soredia for reproduction. In this species, the soredia are coarsely granular (70-330 µm broad), and may be too large to disperse efficiently. Poor dispersal capability is recognized as a characteristic of old growth dependent lichens (Sillett *et al*. 2000). Vectors that might assist in distributing the large soredia of *N. occultum* include water, wind and animals.

Rain splash probably helps distribute lichen soredia within a forest stand; however, this could only account for short distance dispersal and would not allow lichens to disperse across spatial barriers (such as inappropriate habitat) measuring more than a few metres.

Wind is almost certainly an important vector for dispersing soredia (Torno *et al*. 2001, Muñoz *et al*. 2004). Goward (1994) suggests that wind may be important in coastal localities where *Nephroma occultum* occurs in the upper canopy, but is probably not a factor in inland sites where this lichen grows in the sheltered lower-canopy. While the lower-canopy is protected by boundary layer effects, penetrating gusts from occasional storms could potentially distribute lichen soredia considerable distances, particularly from the edges of stands. The coarse, granular soredia of *N. occultum*, however, are probably less easily transported by wind than the soredia of many other lichens.

Animals vectors, and birds in particular, are a possible source for the medium and long distance dispersal of *Nephroma occultum* (Goward 1995a). One study (Bailey and James 1979) demonstrated that lichen propagules adhered to the feet of birds, potentially resulting in the establishment of new lichen colonies elsewhere. Dispersal by birds would help explain the irregular distribution of *N. occultum* within and among suitable habitats.

While poor soredia dispersal appears to be an important factor in determining the limited distribution of this species, the diminishing availability of suitable habitat is an increasingly important constraint.

Growing conditions

The specific growing conditions preferred by *Nephroma occultum* have been described in detail by Goward (1995a) and are briefly summarized here.

In Canada, *Nephroma occultum* grows where the mean annual temperature is between 4-10 °C, with an annual mean temperature range of about 15-26 °C, depending on latitude. These conditions occur in the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone of British Columbia (Meidinger and Pojar 1991).

One of the key attributes of the Canadian localities of *Nephroma occultum* is the absence of summer drought. Both the Coastal Western Hemlock Zone and the Interior Cedar-Hemlock Zone receive at least 75 mm/month during the summer months. In contrast, *N. occultum* is seldom seen in regions that have little or no precipitation during summer. Summer fog allows *N. occultum* to occur in southern localities (Oregon for example) which receive less rainfall.

Nephroma occultum is an nutriphytic lichen which grows on a range of nutrient-enriched conifers, but is rarely found growing on deciduous trees (with the exception of *Betula papyrifera* and *Acer macrophyllum*). This lichen most frequently occurs in forests with nutrient-rich soils, typically with toe-slope topography where soils are enhanced by moisture and nutrient additions from surrounding elevated landforms.

Adaptability and competitive interactions

Nephroma occultum is intolerant of summer drought and produces soredia that disperse inefficiently. These biological attributes are common among several old growth dependent lichens (see Goward 1994, 1995b; Goward and Pojar 1998; and Sillett *et al*. 2000) and signify adaptation to the stable environmental conditions associated with very old forests. In particular, inland populations of *N. occultum* are intolerant of disturbances that dramatically alter humid micro-climates. The dynamic environmental conditions of young managed stands do not provide protection from summer drought and are unsuitable habitat where the macro-climate is dry. Where the macro-climate is suitable, for instance in coastal regions or in Oregon, protecting representative individuals in remnant old growth patches as sources for short distance soredia dispersal may be an effective conservation strategy for maintaining *N. occultum* in younger managed stands.

Nephroma occultum is a poor competitor. Goward (1995a) suggests that it is displaced by mosses and liverworts, especially in coastal ecosystems where bryophytes are the dominant epiphytes. *N. occultum* may persist in coastal ecosystems by colonizing recent growth on branch tips or by occupying branches higher in the canopy, habitats that are less favourable to bryophytes.

POPULATION SIZES AND TRENDS

Search effort

Most Canadian populations of *Nephroma occultum* occur on unprotected Crown Land which is subject to forest harvesting. Fieldwork in 2004 by P. Williston focused on determining the condition of unprotected populations of *N. occultum* in the Kispiox Valley, a region known to support several documented localities of this lichen, and which also is subject to active forest harvesting. Two days (September 23 and 24, 2004) were spent relocating previously documented localities and searching for new ones. The surveys took place along the Date Creek and Helen Lake Forest Service Roads in the Kispiox Valley, approximately 16 kilometers north of Hazelton, British Columbia. Representative collections and photographs were taken at most sites. Measurements of

thallus lengths were recorded at four sites to better understand the population structure and GPS coordinates were recorded wherever cryptic paw lichen was found.

Lichenologists have collected macro-lichens in many parts of British Columbia. Sites visited by lichenologists as part of non-targeted surveys are shown in Figure 6 and are mapped against the CWH and ICH biogeoclimatic zones where potential habitat for the species may exist.

In Canada, where lichen surveys are not required in forest harvesting plans even in areas with habitat for rare species, there have been 24 newly discovered populations of *Nephroma occultum* since 1994. In Oregon, where lichen surveys have been integrated into forest harvesting practices, 182 populations of *N. occultum* have been documented in the past 10 years (see Appendix 1. Figure 7).

Populations

The populations listed in Table 1 combine those from the initial report (Goward 1995a) with those discovered after it was published. Included are populations documented during the field work carried out in 2004 by P. Williston, as well as data from additional discoveries by Trevor Goward and Toby Spribille since 1994. Twenty-four new locations have been documented in Canada since 1994 and two populations have been extirpated due to forest harvesting. As of December 2004, there are 45 extant populations of *Nephroma occultum* in Canada. These are listed in Table 1, arranged by date of the most recent observation at each location. There are also 6 populations known from Alaska, 8 from Washington and 182 from Oregon, for a global total of 241. Populations range in size from 1 to about 40 individuals. With a conservative approximation of 10 individuals (a single thallus represents one individual) per population, we can estimate there to be at least 450 individuals within Canada, and approximately 2,410 worldwide. Given the low search effort throughout most of the Canadian portion of the range, it is highly probable that the actual total number is considerably greater.

Extirpations

Two extirpations of *Nephroma occultum* populations have been documented and are listed below (dates refer to when the population was first recognized as extirpated). Both extirpations resulted from forest harvesting. It is highly likely that many additional populations have been extirpated in the past from the same cause. Localized extirpations almost certainly continue today throughout much of the Canadian portion of this species's range wherever harvesting occurs in humid, old growth cedar-hemlock forests.

1. Hazelton area. Lat./Long. 55°18'N 127°37'W. Elevation 400 m. 24 August 1992. T. Goward. Due to forest harvesting.

2. Kispiox area, Helen Lake Forest Service Road. Lat./Long. 55°31'18"N 127°58'08"W. Elevation ca 500 m. 24 August 2004. P. Williston. Due to forest harvesting.

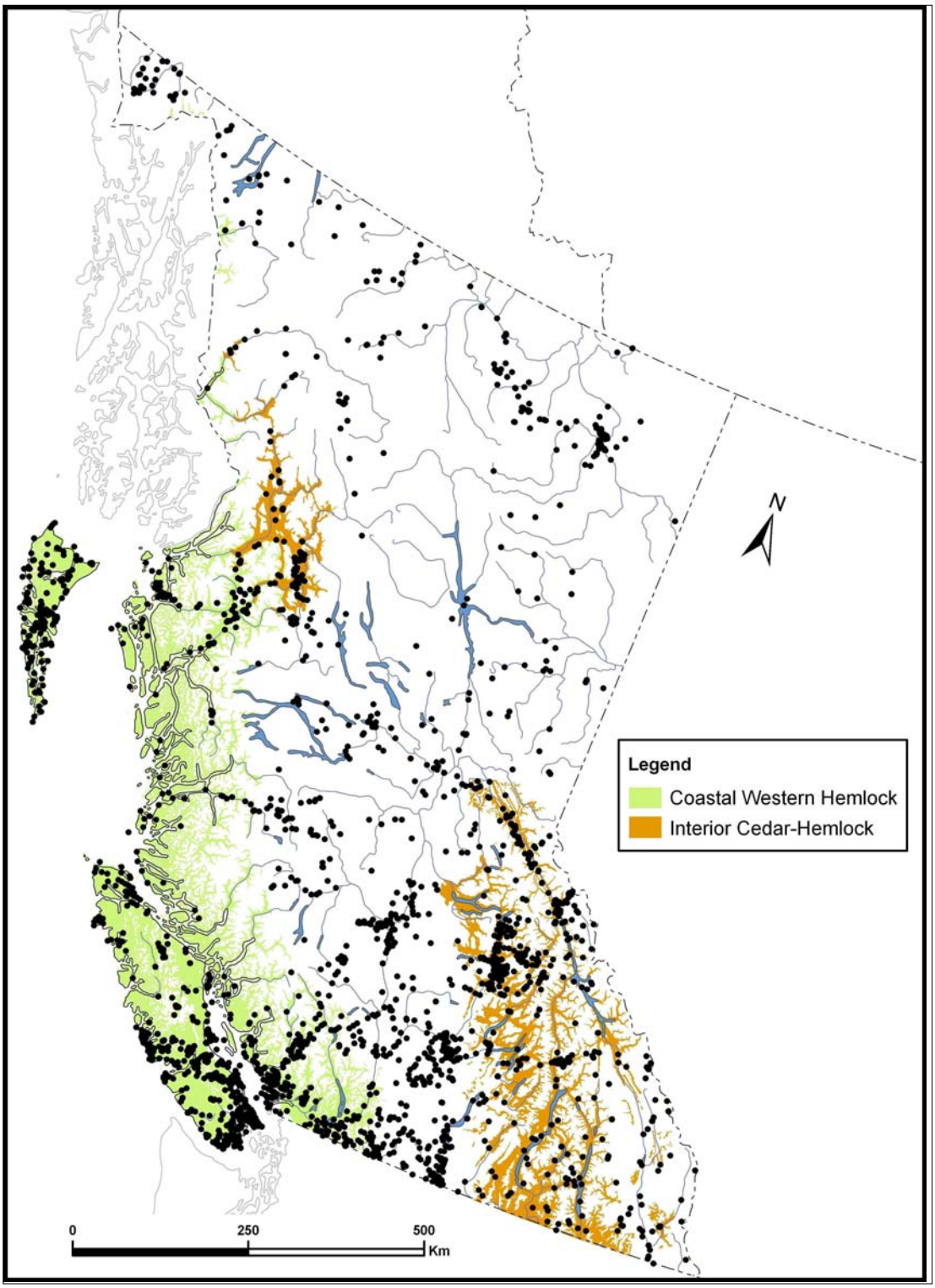

Figure 6. General collecting localities for macro-lichens in British Columbia, based on specimen data at the Cryptogamic Herbarium, University of British Columbia. Coloured polygons are CWH and ICH biogeoclimatic zones.

Table 1. Extant locations of *Nephroma occultum* in Canada, arranged by date of the most recent observation at each location.

Location number	Locality	Elevation	Collection date	Collector
1.	Hazelton area.	730 m.	19 August 1981.	T. Goward 81-1876.
2.	New Aiyansh area.	60 m.	24 August 1981.	T. Goward 81-2003.
3.	Taku River.	150 m.	10 July 1982.	T. Goward.
4.	Sayward area.	100 m.	7 July 1991.	T. Goward 91-704.
5.	Kispiox area, near Date Creek.	450 m.	23 August 1991.	T. Goward 91-932.
6.	Terrace area.	375 m.	25 August 1991.	T. Goward 91-1064.
7.	Terrace area.	200 m.	26 August 1991.	T. Goward.
8.	Kitimat Village.	0-10 m.	28 August 1991.	T. Goward 91-1240.
9.	Shames Creek.	700 m.	31 August 1991.	T. Goward 91-1392.
10.	Kispiox area.	510 m.	19 July 1992.	T. Goward.
11.	Azure Lake.	650 m.	5 August 1992.	T. Goward.
12.	Upper Fraser River north of McBride, Slim Creek.	750 m.	17 August 1992	T. Goward 92-1224.
13.	Upper Fraser River north of McBride.	800 m.	17 August 1992.	T. Goward 92-1246.
14.	Upper Fraser River north of McBride.	750 m.	17 August 1992.	T. Goward 92-1210.
15.	Upper Fraser River north of McBride.	800 m.	18 August 1992.	T. Goward 92-1305.
16.	Chilliwack Lake area.	650 m.	25 August 1992.	T. Goward.
17.	Murtle Lake.	1100 m.	9 September 1992.	T. Goward 92-1396.
18.	Murtle Lake.	1170 m.	10 September 1992.	T. Goward.
19.	Upper Adams River.	900 m.	17 September 1992.	T. Goward 92-1432.
20.	Upper Adams River.	700 m.	22 September 1992.	T. Goward 92-1474.
21.	Upper Adams River.	750 m.	23 September 1992.	T. Goward 92-1516.
22.	Robson Valley.	875 m.	4 June 1995.	T. Goward 95-99a.
23.	Kispiox area, near Carrigan Creek.	785 m.	2 July 1995.	T. Goward 95-228.
24.	Kispiox area, near Skeena River.	745 m.	3 July 1995.	T. Goward 95-300.
25.	Kispiox area, near Helen Lake.	550 m.	4 July 1995.	T. Goward 95-390.
26.	Cranberry Junction, near Octopus Lake.	680 m.	4 July 1995.	T. Goward 95-399.
27.	White Swan Lake area.	515 m.	5 July 1995.	T. Goward 95-450.
28.	Cranberry Junction, near Octopus Lake.	680 m.	4 July 1995.	T. Goward 95-399.
29.	Meziadin Lake area.	660 m.	6 July 1995.	T. Goward 95-457.
30.	Meziadin Lake area.	650 m.	7 July 1995.	T. Goward 95-530.
31.	Mt. Bell-Irving area.	445 m.	8 July 1995.	T. Goward 95-576.
32.	Hazelton area.	645 m.	9 July 1995.	T. Goward 95-605.
33.	Seymour River near Blais Creek.	875 m.	7 August 1995.	T. Goward 95-831.
34.	Seven Sisters area.	240 m.	21 June 1996.	T. Goward 96-47.
35.	Cummins River Valley.	825 m.	23 July 1997.	T. Goward 17792.
36.	Selkirk Mountains, along Incomappleux River, near confluence with Battle Brook.	ca 600-50 m.	14 September 2002.	T. Spribille 12293.

Location number	Locality	Elevation	Collection date	Collector
37.	Selkirk Mountains, near upper end of Duncan Lake, along Hall Creek just above confluence with Duncan River, just above main upper forestry Duncan Road.	ca 690 m.	15 September 2002.	T. Spribille 12418.
38.	Kispiox area, Date Creek Forest Service Road, 1200 Branch.	664 m.	23 September 2004.	P. Williston 4686.
39.	Kispiox area, Date Creek Forest Service Road, near interpretive parking area.	487 m.	23 September 2004.	P. Williston.
40.	Kispiox area, Date Creek Forest Service Road, creek at Km 19.	528 m.	23 September 2004.	P. Williston.
41.	Kispiox area, Botrychium Basin Sensitive Area, Date Creek Forest Service Road.	537 m.	23 September 2004.	P. Williston 4702, 4719.
42.	Kispiox area, Helen Lake Forest Service Road.	496 m.	24 September 2004.	P. Williston 4722.
43.	Kispiox area, Helen Lake Forest Service Road.	505 m.	24 September 2004.	P. Williston 4715.
44.	Kispiox area, Helen Lake Forest Service Road.	ca 500 m.	24 September 2004.	P. Williston.
45.	Kispiox area, Helen Lake Forest Service Road.	ca 500 m.	24 September 2004.	P. Williston 4707.

Rescue effect

In the event of extirpation, Canadian populations would not likely benefit from the rescue effect (immigration from an outside source) for three reasons: 1) Canadian populations (particularly inland localities) are spatially distant from neighbouring populations in the United States; 2) populations in neighbouring states are few in number (Alaska has 6 and Washington 8); and 3) *Nephroma occultum* is recognized as having poor dispersal capabilities.

LIMITING FACTORS AND THREATS

Nephroma occultum is limited by poor dispersal capabilities and the availability of suitable habitat, namely humid old growth cedar-hemlock forests. These forests have diminished in abundance in step with the progressive expansion of forest harvesting. Forest harvesting has resulted in two documented extirpations, and is very likely responsible for many more; it is a serious threat to this species. Additional threats from hemlock looper infestations and fire are predicted to increase in severity and frequency as mean annual temperatures rise, a reflection of global warming. Global warming may also lead to an increase in the prevalence of summer drought conditions, which is an important habitat limitation. Cumulative effects of harvesting, climate change, insect

infestations and fire are expected to have a negative influence on remaining *N. occultum* habitat.

The development of a provincial Old Growth Management Policy, which provides targets for managing designated Old Growth Management Areas (OMGAs) at the landscape level, may aid in the conservation of rare lichens on unprotected provincial lands (British Columbia Ministry of Forests 1995). One important limitation of this policy is that OGMAs are often "recruited" from forests which have been previously harvested. Harvested OGMAs are ineffective refuges for dispersal-limited lichens such as *Nephroma occultum*. While the Old Growth Management Policy may recognize the importance of old growth forests, in failing to differentiate between original old growth forests and recruited old growth forests, the efficacy for conservation will be compromised, at least for lichens.

SPECIAL SIGNIFICANCE OF THE SPECIES

Nephroma occultum is endemic to western North America. Canada accounts for more than 50% of the range of this species. Only five Canadian localities are protected from forest harvesting. *N. occultum* is among a suite of rare and uncommon lichens and bryophytes that are dependent upon humid, old growth forests, and exhibit an unusual coastal-inland disjunct distribution. Throughout its range, the habitat of *N. occultum* is in progressive decline due to forest harvesting and insect infestation. This trend is most pronounced in the inland areas where suitable habitat is already geographically restricted by climate.

With its recognition in Canada and the United States of America as a species requiring special conservation consideration (Goward 1995a, FEMAT 1993), *Nephroma occultum* has received substantial attention from lichen researchers. Several ecological studies and distribution extensions on *N. occultum* have been published in the past 10 years (Goward 1994, 1995a, 1995b; Sillett 1995; Sillett and Neitlich 1996; Goward and Pojar 1998; Sillett and Goslin 1999; Rosso *et al*. 1999, 2000; McCune *et al*. 2002; Zavarzin and Timdal 2004). Among lichens, *Nephroma occultum* has become one of the very few "flagship" species, and has acted as a focal species for the conservation of many rare and endangered old growth dependent lichens, bryophytes, vascular plants, and even entire forests. Formal protection relating to forest management in the United States of America (which requires lichen surveys; FEMAT 1993) has led to the discovery of over 190 new populations since 1994. Federal listing in Canada by COSEWIC did not result in mandatory lichen surveys in regions with potential *N. occultum* habitat where forest harvesting was planned; in contrast, only 24 populations have been discovered in Canada in the past 10 years.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Nephroma occultum is nationally ranked a species of Special Concern by COSEWIC (2004), based upon recommendations from the initial status report (Goward 1995a). In British Columbia, it is ranked S2S3 and is not protected by provincial legislation (NatureServe 2005).

Five Canadian localities for *Nephroma occultum* are situated within parks or protected areas; the remaining populations occur on Crown land and are not protected from forest harvesting or other disturbances. Even in protected areas, *N. occultum* habitat is threatened by climate change, fire and hemlock looper outbreaks. Prohibiting forest harvesting in *N. occultum* habitat is key for the conservation of this species; however, it will not provide absolute security for the long-term survival of every population.

In Washington and Oregon, *Nephroma occultum* is protected under the Northwest Forest Plan (USDA and USDI 1994). It is not protected in Alaska.

NatureServe (2005) reports the following rankings for its global distribution:

Global Status:	G3
Last Reviewed:	June 17, 2004
British Columbia:	S2/S3
Alaska:	SNR (not ranked)
Washington:	S1
Oregon:	S3

TECHNICAL SUMMARY

Nephroma occultum
cryptic paw lichen cryptique
Range of Occurrence in Canada: British Columbia

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **the Canadian EO as approximated from a map of the known distribution**	Approx. 498,000 km^2
• *Specify trend in EO*	Unknown
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* **assuming that the average population occupies approximately 25m^2 (5 m x 5 m) and there are 45 populations known in Canada, the total area of occupancy is approximately 1,125 m^2.**	1,125m²
• *Specify trend in AO*	Unknown
• *Are there extreme fluctuations in AO?*	Unknown
• *Number of known or inferred current locations (in Canada)*	45
• *Specify trend in #*	Unknown, but possibly decreasing; 2 original sites lost
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Extent of potential habitat declining
Population Information	
• *Generation time (average age of parents in the population)*	Unknown
• *Number of mature individuals (in Canada)*	Approx. 450
• *Total population trend:*	
• *% decline over the last/next 10 years or 3 generations.*	Unknown – most original sites not re-surveyed
• *Are there extreme fluctuations in number of mature individuals?*	Unknown
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Unknown, but possibly declining because of continued forest harvesting
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each: approximately 45 populations in Canada with a range of 1-40 individuals per population.	
Threats (actual or imminent threats to populations or habitats)	
- Continued forest harvesting, particularly in inland cedar-hemlock forests. - Hemlock looper infestations. - Forest fire. - Lengthened summer drought related to climate change.	
Rescue Effect (immigration from an outside source)	Unlikely
• *Status of outside population(s)?* **USA: 6 populations in Alaska; 8 in Washington; 182 in Oregon.**	
• *Is immigration known or possible?*	Unlikely
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Yes, though in decline
• *Is rescue from outside populations likely?*	No

Quantitative Analysis	Not applicable
Current Status COSEWIC: Assessed as Special Concern in 1995. Status was re-confirmed in 2006.	

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code**: Not applicable
Reasons for Designation: This foliose lichen is endemic to western North America where it is known in Canada from 45 locations, however, there are likely more undiscovered locations. The Canadian sites account for more than 50% of the global range with only 5 locations protected from forest harvesting. The species has restricted habitat requirements and grows in mid to lower canopy of old growth coastal and interior humid cedar-hemlock forest. It reproduces only by vegetative propagules with limited dispersal distance. The species is vulnerable to forest harvesting, changes in understory humidity, insect defoliation (hemlock looper), and fire.	

Applicability of Criteria

Criterion A: (Declining Total Population): Does not meet criterion. Data insufficient to document population decline.

Criterion B: (Small Distribution, and Decline or Fluctuation): Not known. Although the species meets AO criteria for Endangered and Threatened, and a continuing decline can be shown for area, extent and/or quality of habitat, there is uncertainty on decline in population size, fluctuation, and fragmentation.

Criterion C: (Small Total Population Size and Decline): Does not meet criterion. Total population size and decline are unknown.

Criterion D: (Very Small Population or Restricted Distribution): The population size at all sites is unknown. Does not satisfy Threatened, D2, because it cannot be shown that the species is prone to extirpation by anthropogenic effects in a short period of time.

Criterion E: (Quantitative Analysis): Not applicable.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Patrick Williston is a botanist living in Smithers, British Columbia. He is a partner in *Gentian Botanical Research*, a consulting business focused on applying field-based botanical knowledge to improving ecosystem stewardship and rare plant conservation. His recent work has focused on rare plant biology (floristics and distributional patterns) and lichen ecology (as air pollution monitors, antique forest indicators, and forage for caribou in forests affected by mountain pine beetles). He also is active in fern research, studying the taxonomy of the genera *Polystichum* (holly ferns) and *Botrychium* (moonworts). In 2001, he wrote a small booklet describing the distribution of the genus *Botrychium* in Alberta (*The Botrychiaceae of Alberta*).

Patrick received a master's degree in 1999 from the University of British Columbia, completing a thesis which examined the ecology of microbiotic crusts in the semi-arid inland region of British Columbia. He first began studying lichens and bryophytes in 1994.

COLLECTIONS SUBMITTED

1. P. Williston 4715. Kispiox area, Helen Lake Forest Service Road. Elevation 505 m. 24 September 2004.

2. P. Williston 4707. Kispiox area, Helen Lake Forest Service Road. Elevation ca 500 m. 24 September 2004.

3. P. Williston 4722. Kispiox area, Helen Lake Forest Service Road. Elevation 496 m. 24 September 2004. Note: the nationally rare fern *Botrychium montanum* (6 plants) also found at this location.

4. P. Williston 4702. Kispiox area, Botrychium Basin Sensitive Area, Date Creek Forest Service Road. Elevation 537 m. 23 September 2004.

5. P. Williston 4719. Kispiox area, Botrychium Basin Sensitive Area, Date Creek Forest Service Road. Elevation 537 m. 23 September 2004. Note: thallus found growing on downed wood.

6. P. Williston 4686. Kispiox area, Date Creek Forest Service Road, 1200 Branch. Elevation 664 m. 23 September 2004. Note: this site is known as "Locus Classicus".

Appendix 1. The Distribution of *Nephroma occultum* in the United States of America.

Nephroma occultum occurs in three American states: Alaska, Washington and Oregon. In Washington and Oregon, *N. occultum* is listed as a species to survey and manage as part of the Northwest Forest Plan (USDA and USDI 1994). Information about the distribution of this lichen, including a map and a listing by county, can be found at the following website: http://www.or.blm.gov/ISSSP/Conservation_Planning-and-Tools.htm. A map of the 190 known localities in Washington and Oregon is shown below (Figure 7).

In Alaska, *Nephroma occultum* is presently known from the six localities listed in the table below.

Table 2. Known Alaskan localities for *Nephroma occultum* to 2004.

Locality	Source of Information
Chilkoot Lake State Recreation Area	S. Sharnoff pers. comm. 2005
Chugach National Forest, College Fjord, Prince William Sound	C. Derr pers. comm. 2005
Chugach National Forest, Turnagain Arm, near Girdwood	C. Derr pers. comm. 2005
Kuiu island, Tebenkof Wilderness	K. Dillman pers. comm. 2005
Kenai Peninsula, Seward	Zavarzin and Timdal 2004
Richardson Highway, Mile 9	Zavarzin and Timdal 2004

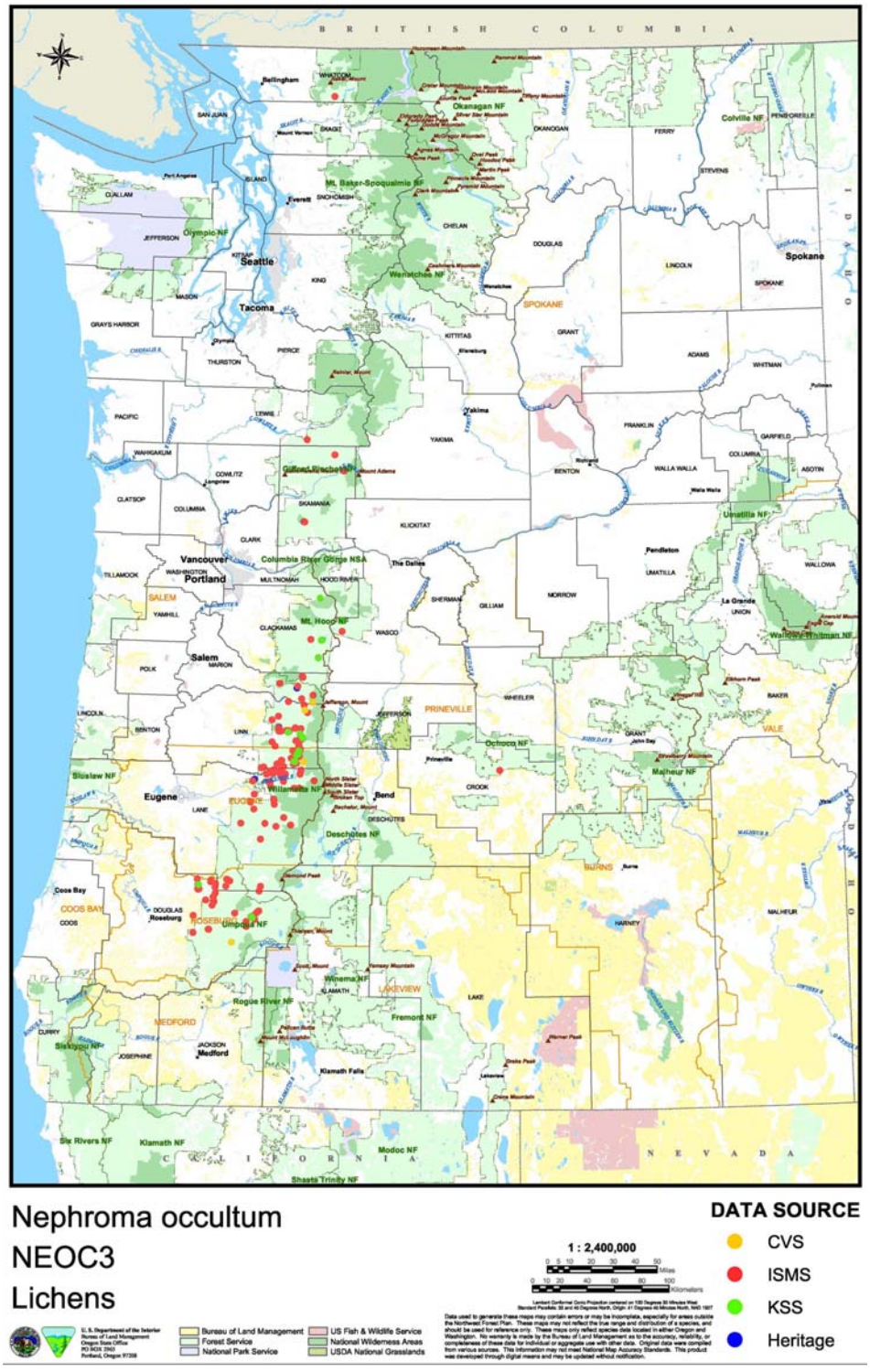

Figure 7. Distribution of *Nephroma occultum* in Washington and Oregon (USDI Bureau of Land Management).