COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

OTTAWA, ONT. K1A 0H3
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COMITÉ SUR LE STATUT DES ESPÈCES MENACÉES DE DISPARITION AU CANADA

OTTAWA (ONT.) K1A 0H3
(819) 997-4991

STATUS REPORT ON THE OLDGROWTH SPECKLEBELLY *PSEUDOCYPHELLARIA RAINIERENSIS* IN CANADA

BY

TREVOR GOWARD

STATUS ASSIGNED IN 1996
VULNERABLE

REASON: NATURALLY RARE LICHEN, MAINLY OF OLDGROWTH FORESTS IN VARIOUS ECOLOGICAL ZONES WITH SEEMINGLY SMALL POPULATIONS.

OCCURRENCE: BRITISH COLUMBIA

COSEWIC - A committee of representatives from federal, provincial and private agencies which assigns national status to species at risk in Canada.

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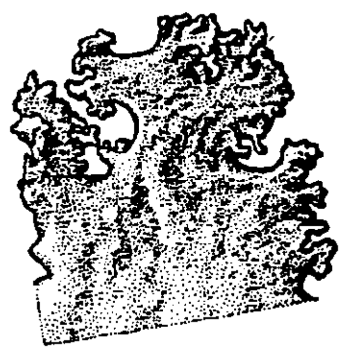
STATUS REPORT ON LICHENS AT RISK IN CANADA



Oldgrowth Specklebelly
Pseudocyphellaria rainierensis

COSEWIC
COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

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JUNE 1994

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THREATENED: (T)	A species likely to become endangered if limiting factors are not reversed.
ENDANGERED: (E)	A species facing imminent extirpation or extinction.
EXTIRPATED: (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
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STATUS REPORT ON THE OLDGROWTH SPECKLEBELLY
PSEUDOCYPHELLARIA RAINIERENSIS

IN CANADA

BY

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STATUS ASSIGNED IN 1996
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ABSTRACT

Pseudocyphellaria rainierensis (Oldgrowth Specklebelly Lichen) is an epiphytic member of the Lobariaceae endemic to western North America, and occurring in more or less sheltered sites in humid, oceanic, oldgrowth forests at low to moderate elevations. It is of distinctly localized distribution in Canada, and has been documented from a total of six localities, only one of which has been recently verified, and another of which has probably been destroyed by logging.

The author recommends a status of Endangered in recognition of this species' highly restricted distribution in Canada, its obviously specialized ecological requirements, and its extreme vulnerability to habitat destruction.

FIGURES

SECTION I : SPECIES INFORMATION

1. Classification and Nomenclature

A. Species

(1) Scientific Name

Pseudocyphellaria rainierensis Imshaug.

(2) Bibliographic Citations

Mycologia 42: 749. (1950).

(3) Type Specimen

Washington State, Mount Rainier National Park, Ohanapecosh River above Laughing Water Creek. Imshaug 722.
Holotype: University of Michigan, Ann Arbor (MICH).
Isotypes: none designated.

(4) Synonyms

None.

(5) Common Names

Oldgrowth Specklebelly Lichen.

B. Family Classification

(1) Family Name

Lobariaceae.

(2) Common Family Name

Lobaria Family.

C. Major Plant Group

Lichens (lichenized Ascomycetes).

D. Current Alternative Taxonomic Treatments

The specific distinctness of P. rainierensis has not been challenged since its description.

Pseudocyphellaria was formerly treated taxonomically within the genus Sticta. On chemical and other grounds, however, it is now assumed to be much more closely related to Lobaria than to Sticta (Galloway 1991), the latter genus now usually being referred to a separate family, Stictaceae (Eriksson 1982).

E. History of Taxon

The earliest known collection of P. rainierensis was made at the type locality in 1948. The species has remained taxonomically stable since its description in 1950.

2. Description

A. Non-technical Description

This is a large, broad-lobed, loosely attached, foliose (leaf) lichen averaging to about 5-12 (-20) cm across. The lobes are thin, stiff, brittle, 1.5-3 cm wide, short to somewhat elongate, and loosely overlapping. The upper surface is dull, naked, smooth or occasionally somewhat scabrid, pale greenish blue (except turning creamy brownish in the herbarium), and is usually weakly "dimpled" or net-ridged. The lower surface is dull, pale to becoming brownish, somewhat wrinkled, and is speckled with tiny white spots (pseudocyphellae), and more or less matted with short, dense tufts of hair (tomentum). The lobe margins are lobulate to lacerate or occasionally densely isidiate. Elongate or coral-like isidia are also often present over the upper surface, especially along stress cracks. The medulla is white. Two photobionts are present: 1) an unidentified green alga forming a more or less continuous layer; and 2) a cyanobacterium (Nostoc) confined to localized swellings called cephalodia. The cephalodia are usually internal (and then usually visible from above as small, low swellings), though in some specimens they may erupt through the upper cortex as small whitish "warts".

Pycnidia are occasionally present, and appear as small black dots over the upper surface. Apothecia have not been reported in this species, but were recently detected in two specimens from the H.J. Andrews Experimental Forest, in Oregon (Steve Sillett, pers. comm.). In the material examined, they are laminal, short-stalked, and average to 1.0 - 1.5 mm across. The apothecial rim is weakly isidiate. Spores were found to be poorly developed in these specimens.

Chemistry: Cortex K+ yellow, C-, KC-, PD-, I-, UV-; medulla K-, C-, KC-, PD-, I+ blue, UV+ white to blue or UV-.

Note: an attempt was made to determine the chemical constituents of P. rainierensis, but without success. Ohlsson (1973), however, reports the following: "A pale yellow PD+ substance (Rf 87, atranorin used as a standard with an Rf 86, Rf values reported x100). This unknown substance formed rectangular plates in G.A.o-T". Ohlsson's chromatograms were run in solvent system A, i.e., benzene: dioxane: glacial acetic acid (90:25:4).

A more technical description will be found in Imshaug (1950).

B. Local Field Characters

P. rainierensis is a highly conspicuous species, owing to its large size and pale colouration. No other North American lichen shares its combination of spotted (pseudocyphellate) lower surface, white medulla and lacerate/isidiate lobe margins.

C. Illustrations

In addition to Figure 1, the only existing published illustration of P. rainierensis remains the photograph accompanying its description (Imshaug 1950, page 750).

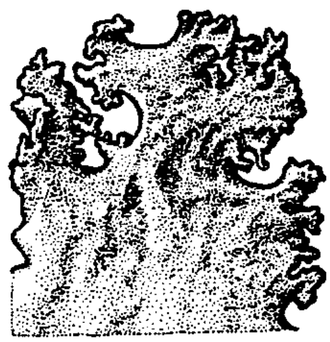

Figure 1: Pseudocyphellaria rainierensis: Habit (from Goward et al. 1994).

3. Biological and Economic Significance

A. Biological

P. rainierensis is a Pacific Northwest endemic of unusually restricted ecology. The fact that it also appears to be phylogenetically distant from other Pseudocyphellaria species occurring in the northern hemisphere, makes it of considerable phytogeographic interest. An apparently highly specialized, and possibly unique, isidial platform (= isidalium) occurs in this species (see 6 D 1). The presence of nitrogen-fixing blue-green cephalodia raises the possibility that it may contribute, albeit marginally, to the nitrogen cycle in the ecosystems in which it occurs.

B. Economic

Apparently no economic use has been made of any North American Pseudocyphellaria species to the present time. However, these lichens contain the most diverse chemistry of any lichen genus (Galloway 1991), and have already been shown to contain at least one chemical substance having antileukemic properties (Galloway 1988). The possibility thus exists that one or more of the substances in P. rainierensis may eventually be found to be of medical or industrial application.

4. Distribution

A. Summary

P. rainierensis is endemic to the Pacific Northwest of North America, spanning 14 degrees of latitude (see Figure 2). Though Imshaug (1950) predicted that this species would eventually be found in the Selkirk Mountains of British Columbia, its ecology as understood today probably restricts it to more thermally oceanic regions nearer the coast.

Figure 3 presents the known and approximate potential range of P. rainierensis in Canada, where it is of widespread, but obviously localized, distribution. Given intensive floristic studies in the Queen Charlotte Islands (Brodo, unpublished), the mainland coast (Ohlsson 1973), and Vancouver Island (Noble 1982, Goward, unpublished), its scanty distribution in this region is probably real, and not a mere artifact of undercollecting.

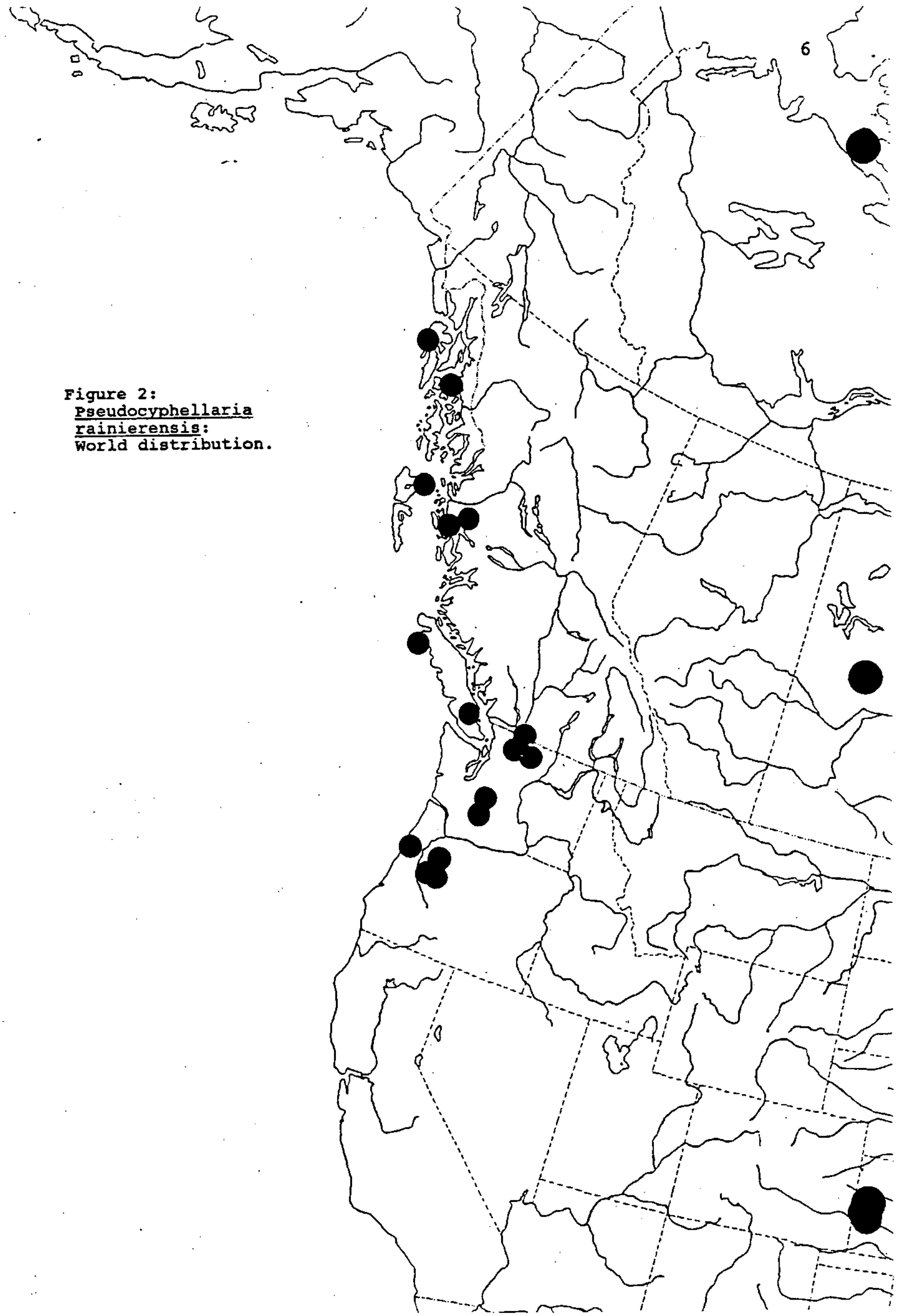

Figure 2:
<u>Pseudocyphellaria rainierensis</u>:
World distribution.

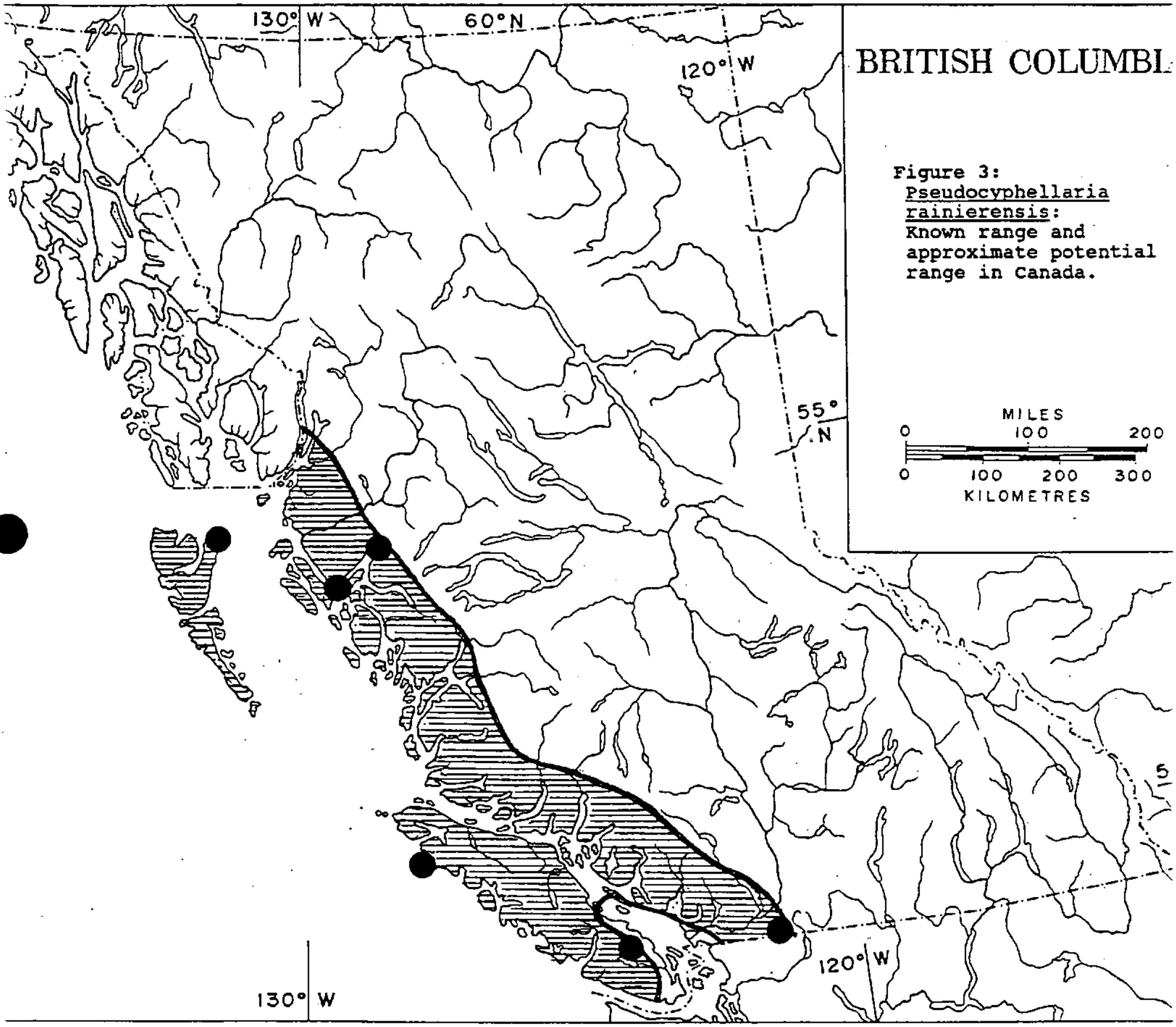

Figure 3: Pseudocyphellaria rainierensis: Known range and approximate potential range in Canada.

● = known localities

⊜ = potential range

B. Locality Citations

Precise locality data and land ownership, if known, is on file with COSEWIC and the appropriate provincial jurisdiction. This information is generally available unless the localities are considered to be publicity-sensitive.

(1) Extant Populations Currently or Recently Verified

- Locality 1. Chilliwack Lake area. (Map: 92 H/3 SW) 49°03'N, 121°25'W. Altitude: 650 m. Collector: Steve Sillett, 106. A single colony. Last visited by the collector on 25 August 1992. Last visited by the author on 25 August 1992.

(2) Extirpated Populations

- ?Locality 2. Vancouver Island, near Fourth Nanaimo Lake. (Map: 92 F/1 SW) 49°05'N, 124°11'W. Altitude ?900 m. Collector: Vladimir Krajina, 283. Last visited by the collector on 27 July 1950. Not revisited by the author.

Note: this specimen, currently housed at Michigan State University, East Lansing, apparently provided the basis for the first report of P. rainierensis for Canada (Krajina 1959), though no collection numbers were given in that publication. It was later, however, cited by Ohlsson (1973). In the absence of detailed field data for this specimen, I have not attempted to relocate the Fourth Nanaimo Lake locality, though recent satellite imagery (Sierra Club 1990) indicates that the lowland oldgrowth forests in this area have been subject to extensive clearcut logging in recent decades. It therefore seems not unlikely that P. rainierensis no longer exists at this locality. Jim Pojar (pers. comm.) reports that a few small oldgrowth stands do remain in this vicinity, though no populations of P. rainierensis were noted by him on a recent visit to the area.

(3) Historical Populations of Unknown Status

- Locality 3. Vancouver Island, Brook's Peninsula. (Map: 92 L/4 NW) 50°12'N, 127°47'W. Altitude: near ocean. Collector: Jim Pojar, s.n. Last visited by the collector on 25 June 1977. Not visited by the author.

Note: the material was situated in the shelter of a shoreline stand Picea sitchensis (Jim Pojar, pers. comm).

- Locality 4. Kitimat area. (Map: 103 I/2 SE) 54°01'N, 128°35'W. Altitude: 175 m. Collector: Karl Ohlsson, 2437. Last visited by the collector on 20 July 1970. Last visited by the author on 27 August 1991 (P. rainierensis not found).

- Locality 5. Kitimat area, west end of Douglas Channel. (Map: 103 H/6 NW, NE). 53°25'N, 129°14'W. Altitude: near sea level. Collector: Karl Ohlsson, 2447. Last visited by the collector on xxx 1970. Not visited by the author.

- Locality 6. Queen Charlotte Islands, Graham Island, Tow Hill area. (Map: 103 J/4 SW) 54°02'N, 131°55'W. Altitude: near sea level. Collector: Irwin Brodo, 18253. Last visitor by the collector on 13 July 1971. Not visited by the author.

(4) Potential Sites for Investigation

- Figure 3 presents the generalized potential range of P. rainierensis in Canada, as based on current understanding of its ecology. New localities for P. rainierensis should be looked for in sheltered, valley-bottom, oldgrowth forests within the area outlined. Though its full potential range is rather large, its actual occurrence within this range is expected to be highly localized.

(5) Erroneous Reports

- None known.

C. Status and Location of Presently Cultivated Material

- None known.

D. Biogeographic and Phylogenetic History of the Species

Approximately 200 species of Pseudocyphellaria have been described worldwide to date. Of these, only eight species occur north of the Tropic of Cancer; most of the remainder are restricted to temperate latitudes of the southern hemisphere, where they are divided among three major centres of diversity: southern South America (53 species), New Zealand (48 species), and southeastern Australia (35 species) (Galloway 1988, 1992).

Notwithstanding the comparative paucity of Pseudocyphellaria species in temperate regions of the northern hemisphere, the Pacific Northwest of North America can be recognized as at least a minor centre of diversity for this genus, supporting six of the eight species reported for this hemisphere: P. anomala Brodo & Ahti, P. anthraspis (Ach.) Magnusson, P. aurata (Ach.) Vainio, P. crocata (L.) Vainio, P. mougeotiana (Delise) Vainio and P. rainierensis). Three of these species, moreover, are endemic to this region: P. anomala, P. anthraspis and P. rainierensis.

In the absence of a world monograph of Pseudocyphellaria, it is not yet possible to assess phylogenetic relationships within this genus. Even so, P. rainierensis is clearly not closely allied to any of the other Pseudocyphellariae reported for North America or other northern regions; its closest relatives are doubtless to be sought among the species of the southern hemisphere.

Lindsay (1976) was apparently the first author to suggest that the depauperate status of Pseudocyphellaria in the northern hemisphere can be taken as evidence for a comparatively recent evolution in this genus. According to this view, the present global distribution of Pseudocyphellaria is an artifact of tectonic movements of the continents over geologic time. Whereas a number of other (more uniformly distributed) lichen genera presumably arose prior to the break-up of the supercontinent Pangaea, roughly 200 million years ago (for examples, see Sheard 1977, Hawksworth 1982, Tehler 1983), Pseudocyphellaria seems to have evolved much later, i.e., after the continents of the northern hemisphere (=Laurasia) had become widely separated from the continents of the southern hemisphere (=Gondwanaland).

Assuming this hypothesis to be correct, most if not all of the Pseudocyphellariae currently inhabiting North America would have arrived here as a result of long-distance dispersal from the southern hemisphere. In support of this, it can be observed that all but one of these lichens are "secondary" sorediate or isidiate species considered to be derived through evolution from fertile "primary species" (Poelt 1970). In general, secondary species tend to be much more widely distributed than their primary counterparts, owing to the much greater effectiveness of asexual propagules as mechanisms of establishment over long distances (Bowler & Rundel 1975). The preponderance of secondary species of Pseudocyphellaria in North America is therefore fully consonant with the hypothesis that these species became established here through long-distance dispersal.

Based on the preceding discussion, it seems likely that P. rainierensis has derived from a fertile South American precursor. Whether it had evolved to its current isidiate status prior to northward migration into North America is of course impossible to determine though, as already noted, asexual reproductive propagules are considered to be particularly effective at long-distance dispersal and establishment. The occurrence of specialized asexual reproductive structures in this species (see 6 D 1, below) can perhaps also be taken as evidence of relative evolutionary antiquity.

As an epiphyte, P. rainierensis is dependent on the prior existence of trees and shrubs. Though Lodgepole Pine (Pinus contorta) is now believed to have persisted along portions of the British Columbia coast throughout the Pleistocene (Richard Hebda, pers. comm.), it seems highly unlikely that P. rainierensis could have survived periglacial conditions behind the southern edge of the cordilleran icesheet, which at its maximum extended into northern Washington (Pielou 1991). This lichen must therefore have entered British Columbia subsequent to deglaciation, roughly 15,000 years ago. Its present highly localized distribution suggests that this process is still far from complete.

5. General Environment and Habitat Characteristics

A. Summary

In Canada, P. rainierensis is restricted to sheltered oldgrowth forest ecosystems at lowland elevations in the Coastal Western Hemlock Zone. Within this zone it occupies at least five of ten subzones, and is thus widely, though very sparsely, distributed. Throughout most of its range, however, climatic conditions can be characterized as both highly oceanic and markedly humid.

A wide assortment of trees and shrubs are colonized by this species, though it is most frequent on conifers. Though initially very slow to become established, it can become locally abundant in some American oldgrowth forests with the passage of time.

B. Climate

(1). Temperature

All six Canadian localities are situated within the Coastal Western Hemlock Zone. As outlined by Meidinger & Pojar (1991), this zone can be characterized as having "a cool mesothermal climate: cool summers (although hot dry spells can be frequent), and ... mild winters. Mean annual temperature is about 8°C and ranges from 5.2° to 10.5° among the CWH subzones".

Climatic data from a total of five long-term weather stations near known localities of P. rainierensis can be taken as broadly representative of this species' macroclimatic requirements in Canada. Spring Island and Estevan Point are thus assumed to be representative of climatic conditions at Locality 3, whereas Kitimat is representative of Locality 4, Ethelda Bay of Locality 5 and Masset of Locality 6.

The average mean temperature for the coldest month (January) varies at these stations between 1.9° and 4.4° C, compared with 14.1° to 16.8°C for the warmest month (July or August) (Environment Canada 1975a). Extreme minimum temperatures range from -23.3° C at Kitimat to -11.1° C at Spring Island, whereas extreme maximums are between 28.9° C at Estevan Point and 36.1° C at Kitimat. On average, most of these stations receive fewer than 80 days of frost per year, though

Kitimat receives 111 frost days (op. cit.). It is expected that Localities 1 and 2 likewise receive more than 100 days of frost per year.

Though actual records are lacking, most of the microsites colonized by P. rainierensis are doubtless much more oceanic than the above thermal values would suggest: first because they are located primarily in oldgrowth forest ecosystems, which are sheltered from extremes of temperature (Franklin et al. 1981); and second because most of them are situated several metres above the ground, where diurnal fluctuations in temperature are also less extreme (Kershaw 1985, Geiger 1975).

These observations suggest, but of course do not confirm, a pronounced sensitivity to extremes of either heat or cold. Indeed, continentality values throughout most of the range of P. rainierensis are among the lowest in Canada. As expressed on Conrad's Index of Continentality (Conrad 1946; see also Goward & Ahti 1992), they vary from 5 at Locality 3 to 9 at Locality 6. The Kitimat locality, however, is considerably less oceanic, with a continentality value of 23, though even this would be considered "oceanic" by, for example, Tuhkanen (1984). By comparison, continentality east of the coast ranges averages about 35, whereas east of the Rockies, at Fort Nelson, it is 55.

(2). Precipitation

P. rainierensis is restricted in Canada to a region of markedly heavy annual precipitation. At the weather stations mentioned above, measurable precipitation is received on between 195 days and 235 days per year (Environment Canada 1975b). Typical amounts range from 2825 mm at Kitimat to 3027 mm at Estivan Point, though at Masset, near Locality 6, precipition is only 1408 mm per year. Nearly all of this, moreover, falls as rain; only between 1% and 15% is snow. It must be emphasized that precipitation at these stations is heavily concentrated during the winter season, such that in December, the wettest month, values are between 387 and 435 mm (except 182 mm at Masset), compared with only 76 and 138 mm (61 in Masset) in July, the driest month. It should not be inferred from this, however, that summer is necessarily a period of relative physiological drought (see 5 B 5, below).

(3). Solar Radiation

Yorke & Kendall (1972) give solar radiation values for British Columbia ranging from 1030 hours per year at Prince Rupert, to 2180 hours at Victoria. Most of the localities at which P. rainierensis occurs can be expected to receive values closer to those at Prince Rupert than at Victoria. At Kitimat, for example, the sun shines only 1065 hours per year, whereas at Estevan Point, solar radiation values are 1690 hours.

In most of the sites colonized by P. rainierensis, however, solar radiation is offset by forest shade, and annual values would be much lower than those indicated above. Here it can be noted that in some species of Pseudocyphellaria, probably also including P. rainierensis, optimum photosynthesis has been shown to occur at very low light intensities (Green & Lange 1991). On the other hand, this species is also occasionally known to occur in somewhat well-illuminated situations (Pike et al. 1975, Steve Sillett, pers. comm.), though such sites are invariably highly sheltered, and therefore also highly humid.

(4). Wind

Wind has a pronounced dessicating effect on lichens (Kershaw 1985). It is therefore not surprising that P. rainierensis, an obvious hygrophyte, is typically restricted to rather sheltered sites (Steve Sillett, pers. comm.). Unfortunately, no data are available on the occurrence of wind at the localities colonized by this species.

(5). Humidity

As might be expected along the Pacific coast, relative humidity remains high throughout the year. During the summer months at Spring Island, for example, average humidity values vary from 91% at 04:00 PST to 80% at 16:00 PST (Canada Department of Transport 1968). Humidity values are expected to be even higher in the typically forested sites inhabited by P. rainierensis.

Net positive photosynthesis is normally achieved in lichens only through wetting and drying at more or less frequent intervals (Kershaw 1985). To judge from its occurrence in one of the most humid regions of Canada, as well as from its tendency to colonize rather sheltered sites, P. rainierensis is obviously adapted to surviving prolonged periods at full or partial hydration.

On the other hand, a few specimens have come from somewhat well illuminated situations, where they are doubtless exposed to more prolonged periods of desiccation. Interestingly, the lower surface in such specimens is covered in a dense tomentum. Snelgar & Green (1981) suggest of P. dissimilis (Nyl.) D. Galloway & P. James -- a southern hemisphere species -- that the presence of tomentum over the lower surface of such material may be an adaptation to enhance water storage and thereby prolong photosynthesis.

C. Air and/or Water Quality Requirements

Wetmore (1988) estimates that quantitative studies of lichen sensitivity to sulphur dioxide and other atmospheric pollutants have been performed on only 157 lichen species known to occur in North America. Unfortunately, P. rainierensis is not among the species examined to date. Blum et al. (1989) did, however, find significant reductions in photosynthesis in P. anthraspis when exposed to nitrate. Phytosociologically, various Pseudocyphellaria species in Britain have been placed in the Lobarion pulmonariae alliance (James et al. 1976), which is considered to be extraordinarily sensitive to some forms of air pollution, especially sulphur dioxide (Hawksworth & Rose 1970). These observations strongly suggest that P. rainierensis may also be sensitive to atmospheric pollution, though air quality in the localities from which it has been recorded can probably be rated at present as good to excellent.

D. Physiographic and Topographic Characteristics

Both in Canada and in the United States, P. rainierensis is a species of valley-bottom or other lowland situations. In the southern portion of its range, it occurs in localities to about 800 m (Steve Sillett, pers. comm.), though an altitudinal range of between roughly 500 and 600 m is more typical. Localities farther north are mostly at or near sea level, with the exception of Locality 4, which is at 175 m.

Doubtless related to this, P. rainierensis is of essentially coastal distribution in the northern portion of its range, though farther south it is apparently restricted to inland sites (see Figure 2).

E. Edaphic Factors

In Canada, P. rainierensis has been documented as occurring only on Abies sp. and Picea sitchensis, though host species in the American portion of its range are much more varied, and include Abies amabilis, A. lasiocarpa, Acer circinatum, Alnus rubra, Alnus sp. (not rubra), Cornus nuttallii, Malus fusca, Picea sitchensis, Pseudotsuga menziesii, Rhododendron sp., Taxus brevifolia, Tsuga heterophylla and T. mertensiana. With the exception of Acer circinatum and Malus fusca, all of these species can be characterized as having distinctly acidic bark.

F. Dependence on Dynamic Factors

P. rainierensis is obviously a species of oldgrowth ecosystems. As such, it is dependent on a high degree of environmental stability, and is presumably adversely affected by windstorms, fire, insect outbreaks, or any other dynamic factors that tend to disrupt on-going ecological continuity.

G. Biological Characteristics

(1). Vegetation Physiognomy and Community Structure

Community structure among epiphytic lichens is not strongly correlated with community structure in the adjacent shrub and herb layers (McCune & Antos 1981, Canters et al. 1991). P. rainierensis is therefore not expected to be associated with any obvious repeating clusters of vascular plants.

(2). Regional Vegetation Type

The Canadian localities are situated in the Pacific Coast (C. 1, C. 3 and C. 4) Forest Region of Rowe (1972). Alternatively, in the terminology of the British Columbia Ministry of Forests (Meidinger & Pojar 1991), P. rainierensis is restricted to the Coastal Western Hemlock Zone. Within this zone, however, it has been located in five of ten possible subzones: the Moist Submaritime, the Moist Maritime, the Wet

Hypermaritime, the Very Wet Maritime, and the Very Wet Hypermaritime subzones. From this it can be concluded that this species is of rather broad macroclimatic tolerance.

Krajina (1959) listed P. rainierensis as an indicator species of the Mountain Hemlock Zone which, in southern British Columbia, has a basal elevation of approximately 900 m (Meidinger & Pojar 1991). Actually this species appears, as already mentioned, to be restricted to the Coastal Western Hemlock Zone, at elevations less than 700 m. The fact that Krajina (1959) also attributed two other strictly lowland epiphytic lichens (Platismatia herrei (Imsh.) Culb. & C. Culb. and Usnea longissima Ach.) to the Mountain Hemlock Zone strongly suggests a misreading of his original data set.

(3). Frequently Associated Species

Vascular Plants

Because I have been unable to study P. rainierensis in the field, no notes on the vascular species associated with it are available. However, in addition to the host species already listed (5 E, above), and based on the species lists in Meidinger & Pojar (1991), the following species can be expected to be present in a majority of the sites: Sword Fern (Blechnum spicant), Salal (Gaultheria shallon), False Azalea (Menziesia ferruginea), Alaska Blueberry (Vaccinium alaskaense), Oval-leaf Blueberry (V. ovalifolium) and Dwarf Dogwood (Cornus canadensis).

Cryptogams

What little direct information is available on cryptogams associated with P. rainierensis derives from an examination of existing specimens, in which the following species were admixed: Antitrichia curtipendula (Hedw.) Brid., Frullania nisquallensis Sull., Isothecium stoloniferum Brid., Pertusaria sp., Porella navicularis (Lehm. & Lindenb.) Lindb., and Sphaerophorus globosus (Hudson) Vainio, A more complete, though also more generalized, listing of associated species is presented in Rhoades (1981), who lists 37 epiphytic lichens and 13 bryophytes broadly occurring with this species in northern Washington.

Pike et al. (1975) provide an even more comprehensive listing, with a total of 106 epiphytes (74 lichens and 32 bryophytes) from a locality in western Oregon. Here, however, P. rainierensis is restricted to the understory vegetation, where it is accompanied by the following macrolichen species: Alectoria sarmentosa (Ach.) Ach., Bryoria glabra (Mot.) Brodo & D. Hawksw., Cetraria orbata (Nyl.) Fink, Cladonia macilenta Hoffm., Esslingeriana idahoensis (Essl.) Hale & Lai, Hypogymnia enteromorpha (Ach.) Nyl., H. imshaugii Krog, H. inactiva (Krog) Ohlsson, H. physodes (L.) Nyl., Leptogium corniculatum (Hoffm.) Minks, L. gelatinosum (With.) Laundon, Lobaria oregana, L. pulmonaria (L.) Hoffm., Nephroma bellum (Spreng.) Tuck., N. helveticum Ach., N. laevigatum Ach., N. resupinatum (L.) Ach., Pannaria saubinetii (Mont.) Nyl., Parmelia pseudosulcata Gyelnik, Parmeliopsis hyperopta (Ach.) Arn., Peltigera aphthosa (L.) Willd., P. canina (s. lat.), P. collina (Ach.) Ach., Platismatia glauca (L.) Culb. & C. Culb., P. herrei, P. stenophylla (Tuck.) W. Culb. & C. Culb., Pseudocyphellaria anomala, P. anthraspis, Sphaerophorus globosus and Usnea sp.

(4). Dominance & Frequency of Interesting Associated Species

Given its strict association with oldgrowth forests, to which several rare epiphytic lichens are more or less restricted (see Goward et al. 1994), it would be surprising if at least some interesting cryptogams were not associated with it. No data, however, are available on this point at the present time.

(5). Successional Phenomena

Throughout most, if not all, of its range, P. rainierensis appears to be restricted to oldgrowth forest ecosystems. In such forests, it is not infrequently confined to the lower canopy (John Davis, pers. comm.), or even to the understory vegetation (e.g., Pike et al. 1975), though as Steve Sillett has recently shown (Sillett, in prep.), P. rainierensis does tend to move upward in the forest canopy with increasing forest age. Sillett's data further suggest that total biomass in this species also increases with increasing forest age, such that older oldgrowth forests (= the "antique" forests of Goward 1993) can be expected to contain a heavier concentration of P. rainierensis than younger oldgrowth forest types.

[Note: The Queen Charlotte Island locality is not in an oldgrowth forest.]

(6). Dependence on Biotic Dynamic Factors

As an oldgrowth-dependent epiphyte, P. rainierensis is apparently very slow to become established at most forested sites. It can therefore be expected to be adversely affected by any dynamic factors that tend to disrupt on-going forest succession, e.g., fungal outbreak or insect attack.

(7). Other Endangered, Threatened or Rare Species Present

No official status has yet been accorded to cryptogams in Canada. What little data is currently available on species accompanying P. rainierensis is summarized in 5 G 3, though none of the listed species are thought to be of rare occurrence in British Columbia.

6. Population Biology

A. Summary

No estimate of the total area occupied by P. rainierensis in Canada can be given at the present time. However, in at least some of the documented localities, this species appears to be present as only a single thallus. Approximately half of the Canadian specimens showed signs of environmental stress. Though numerous reproductive propagules are present in all specimens examined, existing evidence strongly suggests that P. rainierensis has very low reproductive success in Canada.

B. Demography

(1) Area of Populations

Figure 3 presents the known range and presumed total potential range of P. rainierensis in Canada. Though this species, as already noted, colonizes a wide assortment of hosts, and though it occurs across several different subzones of the Coastal Western Hemlock Zone, it is nevertheless obviously of rare occurrence throughout its range. Though no estimate of population size is currently possible, it can be noted that in at least two of the six localities for which P. rainierensis has been documented, this species appeared to be represented by only a single thallus (Irwin Brodo, pers. comm., Steve Sillett, pers. comm.).

(2) Number and Size Classes of Individuals

No field data are available, though it can be noted on the basis of herbarium material that approximately half of the Canadian specimens are of rather stressed appearance. This suggests that P. rainierensis in Canada may often occur at or near the ecological limits of its range.

(3) Density

No data available.

(4) Presence of Dispersed Seed

No data available.

(5) Evidence of Reproduction

Notwithstanding that apothecia have recently been detected in P. rainierensis (see 2 A, above), reproduction in this species appears to occur entirely asexually, i.e., through production and dispersal of isidia. As already noted, isidia (and marginal lobules) are present in all the specimens observed to date; they appear to arise early in the development of the thalli, for example in lobes as small as 4 mm wide. Virtually all lobes measuring 5 mm or more bear copious marginal isidia or lobules.

No other data on reproduction are available.

(6) Evidence of Population Expansion or Decline

No data are available, though in the absence of fire, clearcut logging or other disturbance, there is no reason to believe that any of the Canadian populations are in decline. On the other hand, my failure to relocate P. rainierensis at Locality 4 may be taken as evidence that it has disappeared from this site.

C. Phenology

Phenological patterns at the macroscopic level are rare in lichens, and were not observed in P. rainierensis. Seasonal changes in thallus physiology, however, have been reported in other lichens of temperate and boreal climates (Kershaw 1985), and can be expected to occur in this species also.

D. Reproductive Ecology

(1) Types of Reproduction

In lichens, reproduction is effected by sexual reproductive organs (apothecia, perithecia, etc.) and by vegetative propagules (usually soredia or isidia). Seldom, however, are both reproductive modes present in the same species (Bowler & Rundel 1975). Although apothecia are in fact rarely present in P. rainierensis, they do not appear to produce viable spores. Reproduction in this species seems to occur entirely through the production, dispersal and establishment of vegetative diaspores.

In some thalli, for example, poorly differentiated marginal lobules almost certainly serve as reproductive agents. In others the lobules become more lacerate, and might then be referred to as folioles (Jahns 1974) or phyllidia (Galloway 1992). P. rainierensis also often produces true isidia. When positioned along the lobe margins, isidia may become distinctly elongate and, on occasion, coralloid. In some specimens, the isidia are located also over the upper cortex, and are then usually associated with stress cracks of one form or another (i.e., including the margins of grazed areas).

Of particular interest in this species is the occurrence of a specialized isidia-bearing platform obviously analagous to a soralium. This platform, which could perhaps be termed an "isidalium", arises where the upper cortex gathers upward in a tiny, usually circular pedestal averaging to 0.8 - 1.5 mm wide by approximately 0.3 - 0.5 mm high. At the summit of this the cortex cracks, and a dense cluster of (usually granular) isidia develops along the resulting cortical margin. Such structures are occasionally associated with pycnidia, but can perhaps more typically be interpreted as a highly evolved form of stress crack.

Isidalia are common in thalli deriving from the southern portion of the range, though they are quite sparse in the British Columbia material. The fact that they appear to be further correlated with the occurrence of cortical scabrosities raises the possibility that P. rainierensis may not be genetically homogeneous throughout its range. Such differences could also possibly be related to environmental factors. This observation, at any rate, warrants further study.

(2) Pollination

Not applicable.

(3) Diaspore Dispersal

Lichen diaspores, including isidia, may be dispersed in three different ways: by wind, by water and by animals (Bailey 1976). Long distance dispersal of relatively heavy propagules of the kind produced by P. rainierensis is most likely to be effected primarily by animals, especially migratory birds (Bailey & James 1979). In this connection, it is almost certainly significant that Canadian populations of P. rainierensis bear primarily marginal isidia, which are presumably less well adapted than laminal isidia for making contact with the feet or feathers of birds. The highly localized occurrence of this species in Canada may therefore be related, at least in part, to an inherent inability to disperse effectively. On the other hand, long-distance dispersal clearly does occur in this species from time to time, as at the close of the Fraser Glaciation, when P. rainierensis was migrating northward into Canada from its presumed glacial refugia in the American Pacific Northwest.

A somewhat similar pattern of distribution has been reported in Sweden for Usnea longissima Ach. (Esseen 1983). This species is not randomly distributed in the forest ecosystems in which it occurs, but instead displays a distinctly aggregated distribution. To account for this, Esseen suggested that U. longissima, which apparently reproduces entirely through fragmentation of the thallus, is poorly adapted for dispersal. Though able to maintain itself at a given site once established, it is often unable to spread to other adjacent sites, except with the passage of considerable time. Judging from the Canadian distribution of P. rainierensis, a similar situation appears to apply in this species as well.

(4) Diaspore Biology

No data available.

(5) Seedling Ecology

No data available.

(6) Survival and Nature of Mortality

Obvious natural causes of mortality include fire, wind, insect outbreak, and any other factor seriously disrupting environmental continuity in the forests in which P. rainierensis occurs. Though no specific data are available on survival or mortality in any of the Canadian localities, a recent example of extirpation by natural causes can be cited for northern Washington State.

In the early 1980s, Rhoades (1981) documented the occurrence of P. rainierensis (as well as several other epiphytic lichens) in a mature Abies lasiocarpa stand on the southeast flank of Mt. Baker. In the same paper, Rhoades noted that many of the trees in this stand were being killed by an infestation of Balsam Woolly Aphid (Adelges piceae Ratzeburg), and offered the opinion that this outbreak "may lead to the demise of this unusual tree population". In fact most of the trees did survive the outbreak, though P. rainierensis did not: none of the former thalli could be relocated on a visit to the site in the spring of 1992 (Rhoades, pers. comm.), suggesting that P. rainierensis had been excluded here through microclimatic changes brought about by defoliation.

The possibility also exists that exceptionally prolonged periods of wet weather may be physiologically damaging to this species, for example through the establishment of a negative net carbon balance (Kershaw 1985). On the other hand, Rundel et al. (1979) found that at least some lichens of humid, shady forest sites are able to maintain near-optimal rates of carbon dioxide fixation under full thallus hydration. A similar mechanism may eventually be found to be operative in P. rainierensis, though no physiological studies have yet been performed on this species.

There can be no doubt, however, that P. rainierensis is highly sensitive to logging, and is, moreover, extremely unlikely to become established in the plantation forests now replacing the original oldgrowth forests in many portions of coastal British Columbia. As already observed (3 B 2), logging actvities are strongly suspected of having already excluded this species at the only known locality 2 on Vancouver Island. It can be noted here that harvesting practices have long been implicated in the reduction or extirpation of numerous lichen species in various parts of Europe (e.g., Rose 1976, Ahti 1977, Jørgensen 1978, Esseen et al. 1981).

(7) Overall Reproductive Success

Overall reproductive success in Canadian populations of P. rainierensis must be judged as very poor. Notwithstanding that this species has been documented to date from five different subzones of the Coastal Western Hemlock Zone, it remains a difficult lichen to locate in any portion of British Columbia. In Washington and Oregon, by contrast, P. rainierensis appears to be of somewhat more regular occurrence, at least in oldgrowth forest ecosystems (John Davis, Bruce McCune, Fred Rhoades, Steve Sillett, pers. comm.). Perhaps this observation can be accounted for by the fact, already mentioned, that laminal isidia are much more frequent in southern populations than in northern populations. This would presumably have the effect of enhancing long-distance dispersal in this species in the southern portion of its range, e.g., by migratory birds.

The possibility also exists, of course, that P. rainierensis' localized distribution in Canada is related to various ecophysiological constraints, e.g., a highly specific requirement for humidity, sensitivity to low winter temperatures, lack of suitable substrates, etc. This seems unlikely, however, given this species' rather broad latitudinal and (within the subzones of the Coastal Western Hemlock Zone) biogeoclimatic distribution.

7. Population Ecology

A. Summary

Very little is known about the population ecology of *P. rainierensis*, apart from its obvious dependence on various trees and shrubs as host species. In some localities, it is apparently to some extent limited by competition from various more aggressive epiphytic cryptogams, especially *Antitrichia curtipendula* and *Lobaria oregana* (Steve Sillett, pers. comm.). Evidence of herbivore grazing by one or more invertebrate species was noted in a few specimens.

8. Land Ownership and Management Responsibility

A. General Nature of Ownership & Management Responsibility

The only recently verified locality of *P. rainierensis* (Locality 1) is located in an Ecological Reserve, and is therefore under the jurisdiction of B.C. Parks, Victoria (see Figure 4). The other localities are on crown lands administered by the B.C. Ministry of Forests, and are subject to logging.

9. Management Practices and Experience

A. Summary

No specific attempt has been made to ensure the preservation of *P. rainierensis* in any portion of its range.

B. Habitat Management

None known.

C. Performance under Changed Conditions

D. Cultivation

Not tried.

E. Current management policies and actions.

Plants and animals occurring in Ecological Reserves are accorded strict protection under the Ecological Reserves Act (Ecological Reserves Program 1989). B.C. Forest Lands, on the other hand, receive no such protection, unless specially designated.

F. Future land use.

Ecosystems in Locality 1 will be protected from human disturbance into the forseeable future. Future land use in the other localities is unknown.

10. Evidence of Threats to Survival

A. Summary

Though Locality 1 (Figure 4) is situated in an Ecological Reserve, and is thereby protected by legislation, P. rainierensis is obviously at or near the edge of its range here, and cannot be assumed to be capable of persisting in the long term. Global warming, if and when it occurs, could very well exclude this species at this site.

Elsewhere in its range, P. rainierensis is highly vulnerable to extirpation by management practices that disrupt environmental continuity in oldgrowth forest ecosystems. The only activity therefore likely to affect its presence throughout its range is logging (Figure 5).

B. Habitat Destruction or Modification

It is important to emphasize that hygrophytic epiphytes such as P. rainierensis are threatened not only by clearcut logging, but also, in many cases, by selective harvesting. This observation has recently been supported by reciprocal transplant experiments in western Oregon, in which humid-site populations of P. rainierensis were exchanged with "dry-site" populations. The results thus far (Steve Sillett, pers. comm.) seem to indicate an inability to adapt to altered microclimatic conditions. Thus, preservation of this species at critical sites may require more or less total maintenance of undisturbed forest conditions. In the event that logging is allowed to occur adjacent to a known population, a buffer strip at least 60 m wide (Harris 1984) should be maintained in order to ensure that microclimatic conditions are not altered beyond the ecophysiological tolerance of this species.

C. Overutilization of Species

None.

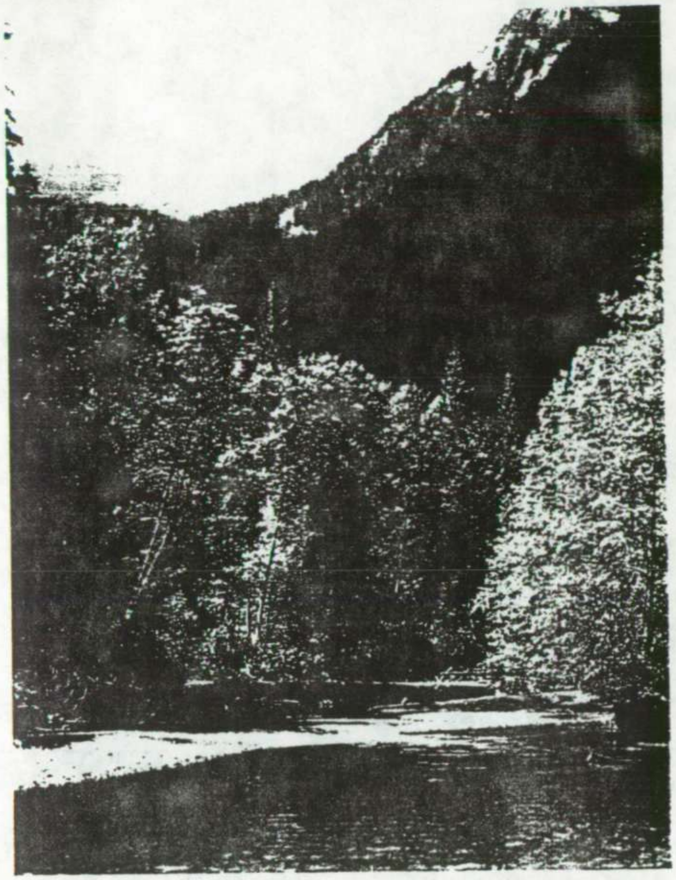

Figure 4: Locality 1: The upper Chilliwack Valley is the only recently confirmed Canadian locality for Pseudocyphellaria rainierensis.

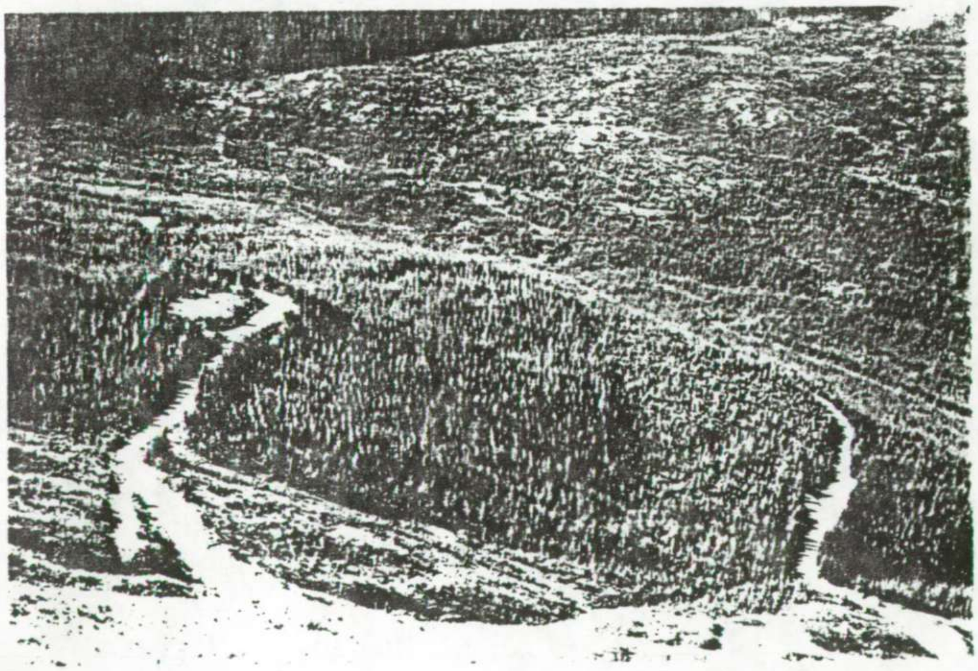

Figure 5: Pseudocyphellaria rainierensis is restricted to oldgrowth forests in valley-bottom localities. Such localities are favoured sites for clearcut logging.

D. Disease or Predation

None observed.

E. Other Natural or Manmade Factors

Deteriorating air quality constitutes a potential, though unlikely, hazard for P. rainierensis at Locality 1, adjacent to the lower Fraser Valley.

11. Present Legal or other Formal Status

A. Summary

In the Rare Lichen Project of the Smithsonian Institution, P. rainierensis has a received a G2-G3 rating. Species assigned to these categories are considered to be of intermediate rarity and endangerment status (Pittam 1991). No other formal status has yet been accorded to this species, though Goward et al. (1994) did consider it to be rare. The status of lichens in British Columbia will be reviewed by the British Columbia Conservation Data Centre in the near future (George Douglas, pers. comm.).

SECTION II : ASSESSMENT OF STATUS

12. General Assessment

P. rainierensis is a western North American endemic epiphytic lichen restricted, so far as is known, to oldgrowth forest ecosystems. It is of highly localized distribution in Canada, and has in fact been verified, in recent years, from only one locality. However, this species probably still occurs at a number of other localities documented over the past three decades.

13. Status Recommendation

I recommend that P. rainierensis be designated an Endangered Species in British Columbia and Canada, on the basis of: 1) its highly localized distribution; 2) its endemic status in the Pacific Northwest; 3) its strict association with oldgrowth forest ecosystems; and 4) its extreme vulnerability to environmental disturbance.

14. Recommended Critical Habitat

During the field studies for this report, I was able to verify only Locality 1, which therefore contains the only recently documented population of P. rainierensis in Canada. This locality should therefore receive special status as critical habitat for this lichen.

Further fieldwork will be required before it will be possible to recommend further critical habitats for the preservation of this species.

15 Conservation Recommendations

The author's recommendations for the conservation of this species have been transmitted separately to provincial and federal jurisdictions. All inquiries regarding these recommendations should be addressed to the appropriate jurisdictions or COSEWIC, and are available at the discretion of these agencies.

SECTION III : INFORMATION SOURCES

16. References Cited in Report

Ahti, T. 1977. Lichens of the boreal coniferous zone. Pp. 145-181 in M.R.D. Seaward (ed.), Lichen ecology. Academic Press, New York.

Bailey, R.H. 1976. Ecological aspects of dispersal and establishment in lichens. Pp. 215-247 in Brown, D.H., D.L. Hawksworth & R. H. Bailey (eds.), Lichenology: Progress and Problems. Academic Press, New York.

Bailey, R.H. & P.W. James. 1979. Birds and the dispersal of lichen propagules. The Lichenologist 11: 105-106.

Blum, O.B., T.H. Nash & R. Gebauer. 1989. The effect of nitrate on carbon dioxide exchange in the epiphytic lichens Ramalina menziesii Tayl. and Pseudocyphellaria anthraspis (Ach.) Magn. from central California. Pp. 181-185 in R.D. Noble, J.L. Martin & K.F. Jensen (eds.), Air pollution effects on vegetation, including forest ecosystems. U.S. Department of Agriculture. Forest Service. Northeastern Experimental Station: Broamall, Pennsylvania.

Bowler, P.A. & P.W. Rundel. 1975. Reproductive strategies in lichens. Botanical Journal of the Linnaean Society 70: 325-340.

Canada Department of Transport. 1968. Climatic Normals 4: Humidity. Toronto, Ontario.

Canters, K.J., H. Schöller, S. Ott & H.M. Jahns. 1991. Microclimatic influences on lichen distribution and community development. Lichenologist 23: 237-252.

Conrad, V. 1946. Usual formulas of continentality and their limits of validity. Transactions of the American Geophysical Union 27: 663-664.

Ecological Reserves Program. 1989. Guide to Ecological Reserves in British Columbia. British Columbia Ministry of Parks, Victoria.

Environment Canada. 1975a. Canadian Normals: 1-SI -- Temperature, 1941-1970. Atmospheric Environment Service, Downsview, Ontario.

Environment Canada. 1975b. Canadian Normals: 2-SI -- Precipitation, 1941-1970. Atmospheric Environment Service, Downsview, Ontario.

Esseen, P.-A. 1983. An analysis of horizontal distribution patterns of epiphytic lichens within three _Picea abies_ forests. Unpublished Ph.D. thesis. Umea, Sweden.

Esseen, P.-A., L. Ericson, H. Lindström & O. Zackrisson. 1981. Occurrence and ecology of _Usnea longissima_ in central Sweden. Lichenologist 13: 177-190.

Eriksson, O. 1982. Outline of the Ascomycetes - 1982. Mycotaxon 15: 203-248.

Franklin, J.F., K. Cromack, W. Denison, A. McKee, C. Maser, J. Sedell, F. Swanson & G. Juday. 1981. Ecological characteristics of old-growth Douglas-fir forests. United States Department of Agriculture (Forest Service), General Technical Report PNW-118.

Galloway, D.J. 1987. Austral lichen genera: some biogeographical problems. Bibliotheca Lichenologica 25: 385-399.

Galloway, D.J. 1988. Studies in _Pseudocyphellaria_ (lichens). I. The New Zealand species. Bulletin of the British Museum (Natural History) Botany 17: 1-267.

Galloway, D.J. 1991. Chemical evolution in the order Peltigerales: triterpenoids. Symbiosis 11: 327-344.

Galloway, D.J. 1992. Studies in Pseudocyphellaria (lichens) III. The South American species. Bibliotheca Lichenologica 46: 1-274.

Goward, T. 1993 ("1991"). Epiphytic lichens: going down with the trees. Pp. 153-158 in Rautio, S. (ed.), Community action for endangered species: a public symposium on B.C.'s threatened and endangered species and their habitat. Federation of British Columbia Naturalists, Vancouver.

Goward, T. & T. Ahti. 1992. Macrolichens and their zonal distribution in Wells Gray Provincial Park and its vicinity, British Columbia, Canada. Acta Botanica Fennica 147: 1-60.

Goward, T., B. McCune & D. Meidinger. 1994. The lichens of British Columbia: illustrated keys. Part 1 - Foliose and squamulose species. British Columbia Ministry of Forests Special Report Series. In press.

Green, T.G.A. & O.L. Lange. 1991. Ecophysiological adaptations of the lichen genera Pseudocyphellaria and Sticta to south temperate rainforests. Lichenologist 23: 267-282.

Harris, L.D. 1984. The fragmented forest: Island biogeography theory and the preservation of biotic diversity. The University of Chicago Press.

Hawksworth, D.L. 1982. Co-evolution and the detection of ancestry in lichens. Journal of the Hattori Botanical Laboratory 52: 323-329.

Hawksworth, D.L. & F. Rose. 1970. Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. Nature 227: 145-148.

Hebda, R.J. 1983. Late-glacial and postglacial vegetation history at Bear Cove Bay, northeast Vancouver Island, British Columbia. Canadian Journal of Botany 61: 3172-3192.

Imshaug, H. 1950. New and noteworthy lichens from Mt. Rainier National Park. Mycologia 42: 743-752.

Jahns, H.M. 1974 ("1973"). Anatomy, morphology, and development. Pp. 1-58 in V. Ahmadjian & M.E. Hale (eds.), The lichens. Academic Press, New York.

James, P.W., D.L. Hawksworth & F. Rose. 1976. Lichen communities in the British Isles: a preliminary conspectus. Pp. 295-413 in Seaward, M.R.D. (ed.), Lichen Ecology. Academic Press, New York.

Jørgensen, P.M. 1978. The lichen family Pannariaceae in Europe. Opera Botanica 45: 1-123.

Kershaw, K.A. 1985. Physiological ecology of lichens. Cambridge University Press, New York.

Krajina, V. 1959. Bioclimatic zones in British Columbia. University of British Columbia, Botanical Series 1: 1-47.

Lindsay, D.C. 1976. Lichens of cold deserts. Pp. 183-209 in M.R.D. Seaward (ed.), Lichen ecology. Academic Press, New York.

McCune, B. & J.A. Antos. 1981. Correlations between forest layers in the Swan Valley, Montana. Ecology 62: 1196-1204.

Meidinger, D. & J. Pojar. 1991. Ecosystems of British Columbia. British Columbia Ministry of Forests, Special Report Series 6: 1-330, Victoria.

Noble, W.J. 1982. The lichens of the coastal Douglas-fir Dry Subzone of British Columbia. Ph.D. thesis, University of British Columbia, Vancouver. 942 pp.

Ohlsson, K.E. 1973. New and interesting macrolichens of British Columbia. The Bryologist 76: 366-3878.

Pielou, C. 1991. After the Ice Age: the return of life to glaciated North America. University of Chicago Press, Chicago. 366 pp.

Pike, L.H., W.C. Culberson, D.M. Tracy, M.A. Sherwood & F.M. Rhoades. 1975. Floristic survey of epiphytic lichens and bryophytes growing on old-growth conifers in western Oregon. The Bryologist 78: 389-402.

Pittam, S.K. 1991. The rare lichens project: a progress report. Evansia 8: 45-47.

Poelt, J. 1970. Das Konzept der Artenpaare bei den Flechten. Vorträge aud dem Gesamtgebiet der Botanik, N.F. 4: 187-198.

Rhoades, F.M. 1981. Biomass of epiphytic lichens and bryophytes on Abies lasiocarpa on a Mt. Baker lava flow, Washington. The Bryologist 84: 39-47.

Rose, F. 1976. Lichenological indicators of age and environmental continuity in woodlands. Pp. 279-307 in D.H. Brown, D.L. Hawksworth & R.H. Bailey (eds.), Lichenology: progress and problems. Academic Press, New York.

Rowe, J.S. 1972. Forest Regions of Canada. Canadian Forestry Service, Department of the Environment, Ottawa.

Rundel, P.W., G.C. Bratt & O.L. Lange. 1979. Habitat ecology and physiological response of Sticta filix and Pseudocyphellaria delisei from Tasmania. The Bryologist 82: 171-180.

Sheard, J.W. 1977. Paleogeography, chemistry and taxonomy of the lichenized Ascomycetes Dimelaena and Thamnolia. The Bryologist 80: 100-118.

Sierra Club. 1990. Our Vanishing Rain Forest: Vancouver Island. Poster.

Snelgar, W.P. & T.A.G. Green. 1981. Ecologically linked variation in morphology and physiology in Pseudocyphellaria dissimilis New Phytologist 87: 403-411.

Tehler, A. 1983. The genera Dirina and Roccellina (Roccellaceae). Opera Botanica 70: 1-86.

Tuhkanen, S. 1984. A circumboreal system of climatic-phytogeographical regions. Acta Botanica Fennica 127: 1-50.

Wetmore, C.M. 1988. Lichen floristics and air quality. Pp. 55-65 in Nash, T.H. & V. Wirth (eds.), Lichens, bryophytes and air quality. Bibliotheca Lichenologica 30: 1-297.

Yorke, B.J. and G.R. Kendall. 1972. Daily Bright Sunshine, 1941 - 1970. Canadian Department of Environment, Downsview, Ontario.

17. Other Pertinent Publications

None.

18. Collections Consulted

The public collections consulted are as follows: Agriculture Canada, Ottawa (DAOM); British Columbia Ministry of Forests, Kamloops; British Columbia Ministry of Forests, Smithers; Canadian Museum of Nature (CANL); Oregon State University, Corvallis (OSC); Royal British Columbia Museum (V); Smithsonian Institution (US); University of Alberta (ALTA); University of British Columbia (UBC); University of Helsinki (H); and Western Washington State College, Bellingham (WWB).

The private collections of the following individuals were also consulted: John Davis (Carson, WA); Trevor Goward (Clearwater, B.C.); Bruce McCune (Corvallis, OR); Jim Pojar (Smithers, B.C.); and Roger Rosentreter (Boise, ID).

19. Fieldwork

During the period 27 March 1991 to 1 October 1992, I spent 77 days in the field in search of five species of rare epiphytic macrolichens, including P. rainierensis. I examined a total of 145 localities, including both oldgrowth and second-growth forests; these are summarized in Figure 6.

20. Acknowledgements and Knowledgeable Individuals

A. Acknowledgements

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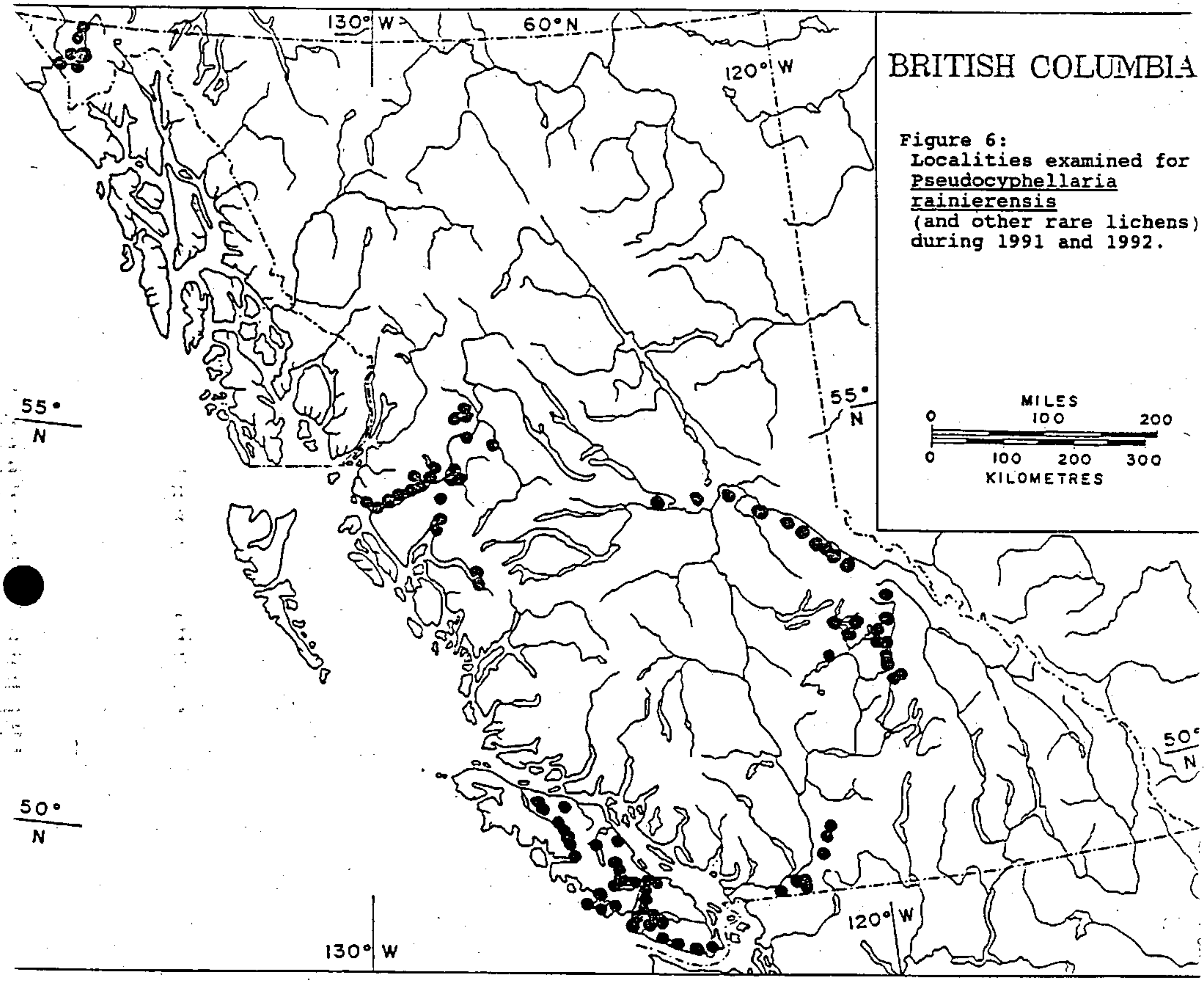

Figure 6:
Localities examined for *Pseudocyphellaria rainierensis* (and other rare lichens) during 1991 and 1992.

I am also grateful to the province of British Columbia through the Ministry of Forests and the Ministry of Environment, Lands and Parks for financial support for this project.

B. Knowledgeable Individuals

The following people have direct experience with the P. rainierensis localities listed next to their names:

Irwin Brodo, Research Division, Canadian Museum of Nature, Box 3443, Stn D, Ottawa, Ontario K1P 6P4. Locality 6.

Jim Pojar, Research, Ministry of Forests (Regional Office), Smithers, B.C. V0J 2N0. Locality 3.

Steve Sillett, Department of Botany, Oregon State University, Corvallis, Oregon 97331 U.S.A. (Locality 1).

21. Other Information Sources

None consulted.

22. Summary of Materials on File

See 16 (above) for a complete listing of all published and unpublished material examined during this project. Letters, maps (including maps of potential new localites), field data sheets, and other notes are all maintained in the author's files at: Edgewood Blue, Box 131, Clearwater, B.C. V0E 1N0. Voucher specimens are, for the most part, located at UBC.

SECTION IV : AUTHORSHIP

23. Initial Authorship of Status Report

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24. Maintenance of Status Report

The report will be maintained by the author. All corrections and new information will be gratefully received.