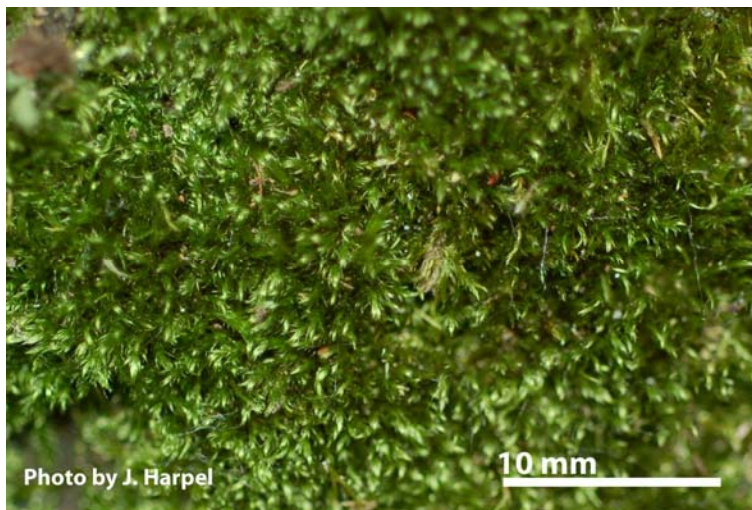


COSEWIC
Assessment and Status Report

on the

Roell's Brotherella Moss
Brotherella roellii

in Canada



ENDANGERED
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Production note:

COSEWIC acknowledges Judith A. Harpel for writing the provisional status report on the Roell's Brotherella Moss, *Brotherella roellii*, prepared under contract with Environment Canada. The contractor's involvement with the writing of the status report ended with the acceptance of the provisional report. Any modifications to the status report during the subsequent preparation of the 6-month and 2-month interim status reports were overseen by René Belland, COSEWIC Mosses and Lichens Specialist Subcommittee Co-chair.

For additional copies contact:

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

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
<http://www.cosewic.gc.ca>

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Roell's Brotherella Moss — Photo by J. Harpel.

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COSEWIC Assessment Summary

Assessment Summary – November 2010

Common name

Roell's Brotherella Moss

Scientific name

Brotherella roellii

Status

Endangered

Reason for designation

This moss is endemic to western North America, where all known extant populations occur in the densely populated southwestern mainland area of British Columbia. Extensive collecting within and beyond this region has shown this species to occur only on hardwoods and rotten logs in remnant second-growth stands within urban areas. Twenty-nine individuals are known from nine of the 26 extant locations that have recently been verified. The species is subject to pressures from recreational use, road construction and urban, agricultural, resource and industrial development, all of which threaten the quantity of its preferred habitat and host trees and logs, as well as the quality of these habitats in terms of moisture levels and air quality.

Occurrence

British Columbia

Status history

Designated Endangered in November 2010.



COSEWIC
Executive Summary

Roell's Brotherella Moss
Brotherella roellii

Wildlife species description and significance

Roell's Brotherella Moss (*Brotherella roellii*) is a small, yellow to golden green, shiny moss that forms turf-like mats; leafy shoots small, ca. 0.5 mm, somewhat flattened, (not complanate); reproduction is via spores or occasionally deciduous flagelliferous shoots. Populations of Roell's Brotherella Moss in British Columbia currently represent the only known extant sites in the world.

Distribution

Roell's Brotherella Moss is a Western North American endemic known only from southwestern British Columbia and Washington State. Today Roell's Brotherella Moss is known from only 26 current and 4 historical records, isolated locations within the Lower Mainland of the Fraser River and Howe Sound area. There are only six known locations in Washington State, all historical, thus *B. roellii* may now be endemic to Canada.

Habitat

In Canada, Roell's Brotherella Moss occurs in cool, humid mixed deciduous and conifer, second-growth forests on stream terraces, swampy floodplains, and occasionally in ravines with creeks. Many of the current locations occur within city parks. The primary substratums include: alder, big leaf maple, dogwood trees, rotten logs and stumps.

Biology

This species needs high levels of humidity in order to survive as evidenced by the species' microhabitat: rotten wood, which holds moisture well, and on tree trunks in floodplain areas or along creeks. Reproduction is via spores or deciduous flagelliferous shoots.

Population sizes and trends

Twenty-seven locations and 4 historical locations are reported for Roell's Brotherella Moss in Canada after 134 years of collections. The four historical sites are considered extirpated. In addition, two extant locations have been severely damaged and one colony at one location has been destroyed. Nine new locations have been recently discovered. The population size and trends for the remaining 15 locations have not been confirmed because detailed locality information was not available.

Threats and limiting factors

Threats to this species include: urbanization, industrialization, agricultural development, mining, construction of pipelines, roads, trails, and air pollution. The highly fragmented nature of its distribution indicates that dispersal may be limited despite this plant's ability to produce spores.

Protection, status and ranks

Roell's Brotherella Moss had a global rank of G3 (vulnerable) in 2003 according to NatureServe. It has not been ranked nationally in either Canada or the United States. In Washington it is listed as SH (historical occurrences only but still expected to occur) by the Washington Natural Heritage Program (2009). In British Columbia, Roell's Brotherella Moss is listed as S3 [vulnerable in the province due to a restricted range, relatively few populations, (often 80 or fewer), recent and widespread declines or other factors making it vulnerable to extirpation] and was placed on the B.C. Blue List by the Conservation Data Centre (BC CDC 2009).

TECHNICAL SUMMARY

Brotherella roellii

Roell's Brotherella Moss

Brotherelle de Roell

Range of occurrence in Canada: B.C.

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	Unknown
Is there a continuing decline in number of mature individuals?	Yes. Observed and inferred based on surveys of known locations
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	4445 km ²
Index of area of occupancy (IAO) (Always report 2x2 grid value; other values may also be listed if they are clearly indicated (e.g., 1x1 grid, biological AO)).	40 km ²
Is the total population severely fragmented?	Possibly, but more study required
Number of "locations*"	26 extant, 4 historical
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes (loss of Southlands)
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Yes (loss of Southlands; loss of colonies at Ruby Ck and Bridal Falls)
Is there an [observed, inferred, or projected] continuing decline in number of locations?	Yes (loss of Southlands; destruction of habitat at Ruby Ck and Bridal Falls)

* See definition of location.

Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes (loss of Southlands; destruction of habitat at Ruby Ck and Bridal Falls)
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
See Table 1	29
Total	29

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A
--	-----

Threats (actual or imminent, to populations or habitats)

Imminent threats include urbanization, industrialization, mining, recreational pressure, park maintenance and management.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Six historical sites in Washington State that have not been relocated; no new populations have been found in spite of search efforts.	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Possibly
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Designated Endangered in November 2010.
--

Additional Sources of Information:

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: C2a(i); D1
Reasons for designation: This moss is endemic to western North America, where all known extant populations occur in the densely populated southwestern mainland area of British Columbia. Extensive collecting within and beyond this region has shown this species to occur only on hardwoods and rotten logs in remnant second-growth stands within urban areas. Twenty-nine individuals are known from nine of the 26 extant locations that have recently been verified. The species is subject to pressures from recreational use, road construction and urban, agricultural, resource and industrial development, all of which threaten the quantity of its preferred habitat and host trees and logs, as well as the quality of these habitats in terms of moisture levels and air quality.	

* See definition of location.

Applicability of Criteria

<p>Criterion A (Decline in Total Number of Mature Individuals): Not applicable: no data on population decline.</p>
<p>Criterion B (Small Distribution Range and Decline or Fluctuation): Although meets thresholds for EN B1 (EO < 5000 km²; actual = 4445 km²) and EN B2 (IAO < 500 km²; actual = 40 km²), there are no extreme population fluctuations and severe fragmentation cannot be applied because almost half of extant populations have not been relocated and the limited data available on area and mature individuals is insufficient to apply severe fragmentation.</p>
<p>Criterion C (Small and Declining Number of Mature Individuals): Meets threshold for EN C: total number of individuals is certainly < 2500 (actual = 29). Meets threshold for C2a(i): a continuing decline at known sites has been observed and is inferred in numbers of individuals (no estimates of rates) and there are no populations estimated to contain >250 individuals (actual: no populations are known to have >2 colonies).</p>
<p>Criterion D (Very Small or Restricted Total Population): Meets threshold for EN D1 since the total population is estimated to have <250 individuals (only 29 colonies are known). While 15 locations were not surveyed because of inadequate location information to verify the populations, it is expected that no more than 50 colonies might be found at these locations based on the very low numbers of colonies documented at the surveyed locations.</p>
<p>Criterion E (Quantitative Analysis): Not applicable: no quantitative analyses have been completed.</p>



COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS (2010)

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

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

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

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



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

COSEWIC Status Report

on the

Roell's Brotherella Moss

Brotherella roellii

in Canada

2010

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SPECIES INFORMATION

Name and classification

Scientific name: *Brotherella roellii* (Ren. & Card. in Röhl) Fleisch.

English common name: Roell's Brotherella Moss

French common name: Brotherelle de Roell

Basionym: *Rhaphidostegium roellii* Ren. & Card.

Synonyms: *Pylaisiadelpha roellii* (Ren. & Card.) Buck

Bibliographic citation: Botanisches Centralblatt 44: 423. 1890.

Type specimen: Enumclaw, Washington, Julius Röhl, 435, 7 July 1888 (WB)

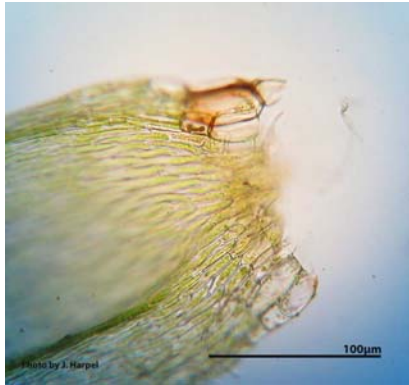
Morphological description

Plants small, yellow to golden green, growing in shiny turf-like mats; leafy shoots small ca. 0.5 mm, somewhat flattened, (not complanate); occasionally forming deciduous flagelliferous shoots: stem cortical cells large, up to 15 μ m wide; stem leaves \pm falcate, secund, ovate-lanceolate, acuminate, concave, 0.8-1.2 x 0.2-0.36 mm; margins plane or recurved at base, serrate at apex; costa short, double or nearly lacking; alar cells large, bullate, yellow to orange; branch leaves somewhat smaller: Autoicous; seta 0.6-1 cm long, capsule cylindrical, suberect, 1-1.5 mm long, operculum rostrate, as long as the urn; peristome perfect, annulus wanting; spores 13-17 μ m. See Figure 1a-1d.

Brotherella roellii can be confused with *Hypnum circinale* which often occurs mixed in with some populations. *Hypnum circinale* can be separated from *B. roellii* by having dull, grey-green shoots, and a strongly falcate "ropy" appearance. *Brotherella canadensis*, a recently described species (Schofield 2006), also occurs within the range of *B. roellii* but is distinguished by its medium-sized shoots (up to 1.00 mm wide), lack of deciduous flagelliferous shoots and inclined capsule. Additional descriptions and illustrations of *B. roellii* can be found in Lawton (1971), Conard (1944), and Grout (1932).

Genetic description

There is no information available concerning genetic population structuring for *B. roellii*. While a search of the National Center for Biotechnology Information (NCBI) (info@ncbi.nlm.nih.gov) by J. Harpel in 2009 revealed several genetic studies on *Brotherella fauriei*, *Brotherella nakanishikii*, *Brotherella henonii* and *Brotherella recurvans*, *B. roellii* was not listed in their Taxonomy Browser. Shaw *et al.* (2005) looked at the molecular structure of *B. recurvans* but did not include *B. roellii* in their study. Because the current extant populations of *B. roellii* are very fragmented, genetic out crossing between populations seems unlikely.



1a.



1b.



1c.



1d.

Figure 1. 1a. *Brotherella roellii* swollen bullate alar cells at the base of the leaf, 1b. stem cross-section, 1c. stem leaves, 1d. deciduous shoots.



2a



2b.

Figure 2. 2a *Brotherella roellii* deciduous shoots, 2b. sporophytes.

Designatable units

Only one designatable unit is recognized for *Brotherella roellii*. All locations occur within the COSEWIC National Ecological Areas, Pacific region, and the Coastal Western Hemlock (CWH) Biogeoclimatic Zone of British Columbia (Krajina 1965). It is likely that genetic differentiation between populations would be minimal.

DISTRIBUTION

Global range

Brotherella roellii is a Western North American endemic known only from the Lower Mainland region of the Fraser River and Howe Sound regions of southwestern British Columbia, as well as Washington State. All six known U.S. locations that are scattered throughout the Puget Sound area and lower Cascade Mountains are historical. The last known collection in Washington was made in October 1913. *Brotherella roellii* was also reported from Alaska by Harvill (1950) and Worley (1972) but when the collection was located it was determined to be misidentified (Figure 3).

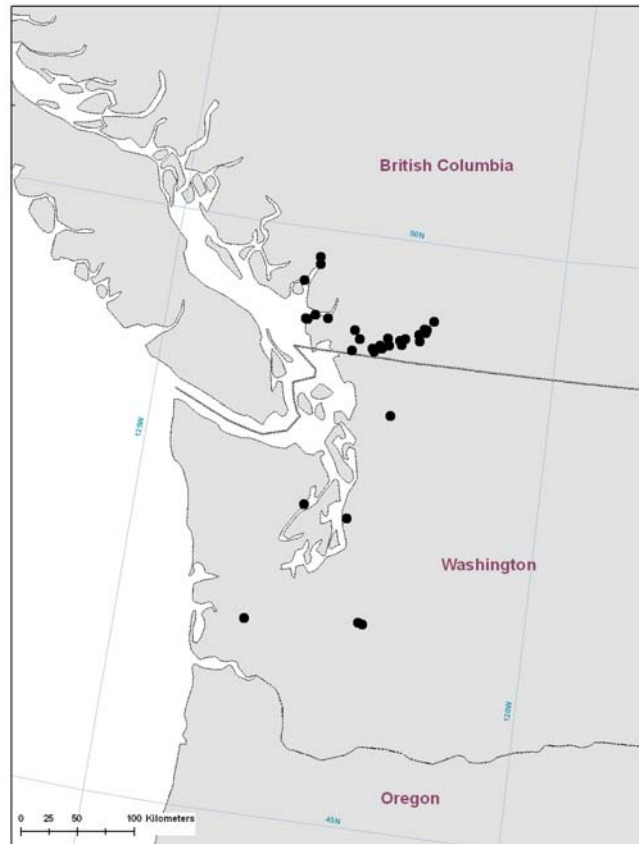


Figure 3. Global distribution of *Brotherella roellii*. All six U.S. locations are historical.

Canadian range

In Canada *Brotherella roellii* was first collected by Macoun on May 11, 1875 from “the Cascades at Yale”. A review of Macoun’s autobiography (Macoun 1922) to determine the exact location indicated that he was not in the Yale area on the day the collection was made. Although the specimen is without doubt *B. roellii*, it appears that the label information is incorrect and we do not know exactly where this first collection came from. Today *B. roellii* is known from only 26 isolated locations within the Lower Mainland of the Fraser River and Howe Sound area of southwestern British Columbia. Four historical locations are known: from Hastings (presently Gastown within the city of Vancouver), Brackendale, Agassiz, and the putative Yale location. In the Lower Mainland, scattered sites occur between Point Grey on the western end of Vancouver and as far east as Ruby Creek. In Howe Sound all of the sites are clustered in the Squamish area and there is one collection from Brackendale (see Table 1). A New Brunswick Macoun collection of *B. roellii* (deposited at New York Botanical Garden herbarium) was determined to be *Brotherella recurvans*, a common eastern North American species. A collection from Vancouver Island was determined to be *Brotherella canadensis* by Schofield (2006). All of the populations occur within the Coastal Western Hemlock (CWH) Biogeoclimatic Zone of British Columbia (Figure 4).

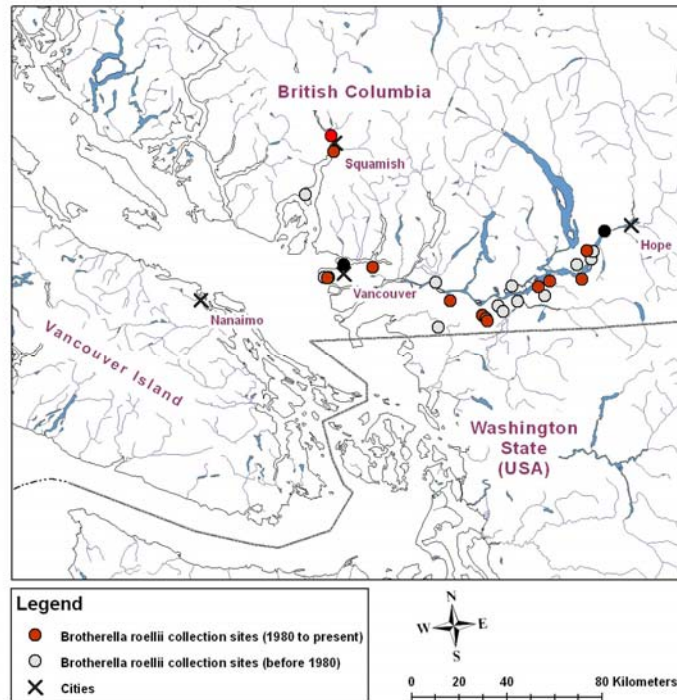


Figure 4. Canadian distribution of *Brotherella roellii*. Two historical locations are indicated with black circles; the other two are not shown as the exact locations are not known.

Table 1. Canadian occurrences of *Brotherella roellii*. An occurrence is a place where trees or rotten logs occupied by *B. roellii* are greater than 0.5 km apart.

* = May be an older Schofield site.

** = May or may not be the same 1916 location

General location	Occurrence	Year located	Most recent survey	Search status	No. of colonies
Fraser River Valley area	Abbotsford Century Park	2007	2007	found	3
	Abbotsford Downes Bowl Park	2007	2009	found	~ 9
	Abbotsford Ravine Park	2007	2007	found	3
	Agassiz	1889	2009	historical-extirpated	-
	Arnold	1982	1982	precise location unknown	?
	Bridal Veil Falls Prov. Park	1969	2004	precise location unknown	?
	Chilliwack	2009	2009	found *	2
	Little Mountain Park	2010	2010	found	3
	Kanaka Creek	1976	1976	precise location unknown	?
	Near Sardis	1970	1970	precise location unknown	?
	Near Cheam View	1971	1971	precise location unknown	?
	Norrish Creek	1975	1975	precise location unknown	?
	Near Aldergrove	1969	1969	precise location unknown	?
	5 mi. E. of Popkum	1968	1968	precise location unknown	?
	Ruby Creek	1969	2009	found	2
	Seabird Island	1985	1985	precise location unknown	?
	Sumas Mt. escarpment area	1968	1968	precise location unknown	?
	Sumas Mt. Matsqui area	1967	1967	precise location unknown	?
	Sumas Mt. Straiton area	1966	1966	precise location unknown	?
	Sumas Mt., Joya site	2010	2010	found *	2
Point Grey area	Near golf course	1990	1999	precise location unknown	?
	Southlands area	1966	2009	extirpated	-
	Fraser Monument	1969	1969	precise location unknown	?
Vancouver area	Hastings	1889	2009	historical-extirpated	-
Burnaby area	Squint Lake Park	2009	2009	found	2
Langley area	West Creek, Wood Duck Lake	2007	2007	found	?
	Anvil Island	1969	1969	precise location unknown	?
Howe Sound area	Brackendale	1916	2006	found **	1
	Squamish (Rotary Park)	1970	2009	found *	2
	Squamish Highway	1970	2009	extirpated	-

HABITAT

Habitat requirements

Brotherella roellii sites are characterized as cool, humid, mixed deciduous and conifer, second-growth forests on stream terraces, swampy floodplains, and occasionally in ravines with creeks. Incidental light, after hardwoods drop their leaves in the fall may also be important for this species. It has been collected on the boles and trunks of red alder (*Alnus rubra*), big leaf maple (*Acer macrophyllum*), dogwood (*Cornus nuttallii*), birch (*Betula* spp.), and coarse woody debris. Habitat information from collection labels also includes: on rotten log on open maple-alder slope, rotten log in swampy alder-poplar thicket, on rotten log in alluvial forest of floodplain, stumps near field margin, rotten log of big leaf maple open woodland on boulder slope, on damp end of rotten log, and on rotten log in alluvial forest of floodplain. Based on estimates made with Google Earth, elevation for the locations ranged between 4 metres and 100 metres.



Figure 5. Habitat photo of *Brotherella roellii* on *Betula* spp.

Habitat trends

Brotherella roellii occurs in remnant stands of second-growth forests found within city parks and in areas unsuitable for urban development or in floodplain regions along waterways. Although several new locations have recently been discovered in area parks, they are surrounded by urban and agricultural development (Figures 6 & 7). These parks are often subject to heavy use by hikers, mountain bicycle riders, trail maintenance, vandalism, and sometimes changes in land use patterns. Because

B. roellii obtains water and nutrients by intercepting and absorbing solutes in rainwater, cloud and mist droplets, and airborne dust through their shoots (Proctor 2000), it is likely that air pollution could impact this species since it grows in such highly developed urban areas. In 2003 the Fraser Valley Regional District Official Community Plan was developed for the Sumas Mountain, Electoral Area “H”. This plan was adopted on Oct. 26th 2004 (FVRD 2004). The plan lays out the future needs for development throughout the Straiton area of the City of Abbotsford and Sumas Mountain. This plan comments that the “valley’s population could double over the next twenty to thirty years to approximately 450,000.” Continued urban development could lead to increased levels of air pollution, which may affect known populations, and the loss of existing or potential habitat. The urban development discussed above is consistent with what is occurring throughout most of the Lower Mainland area. Within the Howe Sound area, the limited potential habitat is being altered by road construction, new housing development, and recreational activities.

The six historical locations within Washington State have vague and general location information (i.e. Cascades of Washington) on the labels. While extensive surveys have been carried out in and around many of the locations, J. Harpel was not able to confirm the presence of the moss at any of the historical sites. Potential suitable habitat has also been surveyed yet no new locations have been found. It is likely that habitat loss from extensive logging and urban development has eliminated or restricted the distribution of *B. roellii*.

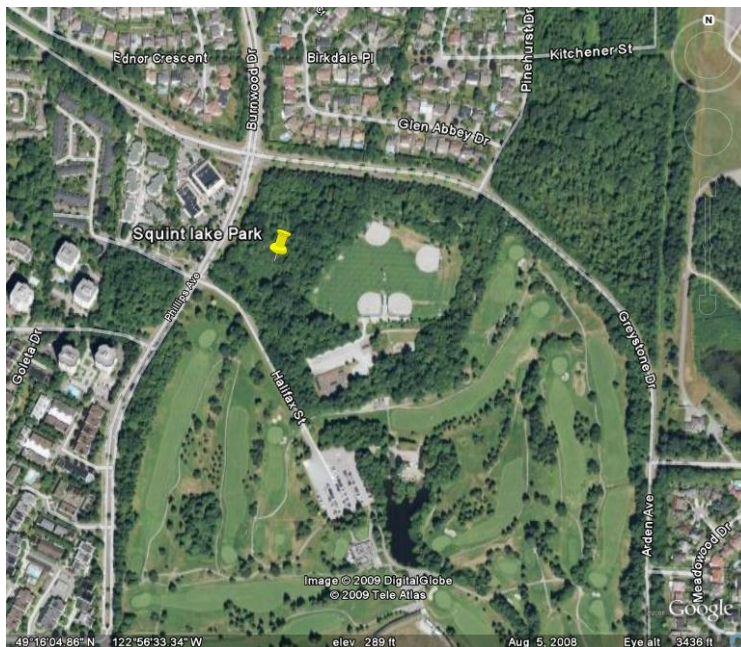


Figure 6. Squint Lake Park, Burnaby.

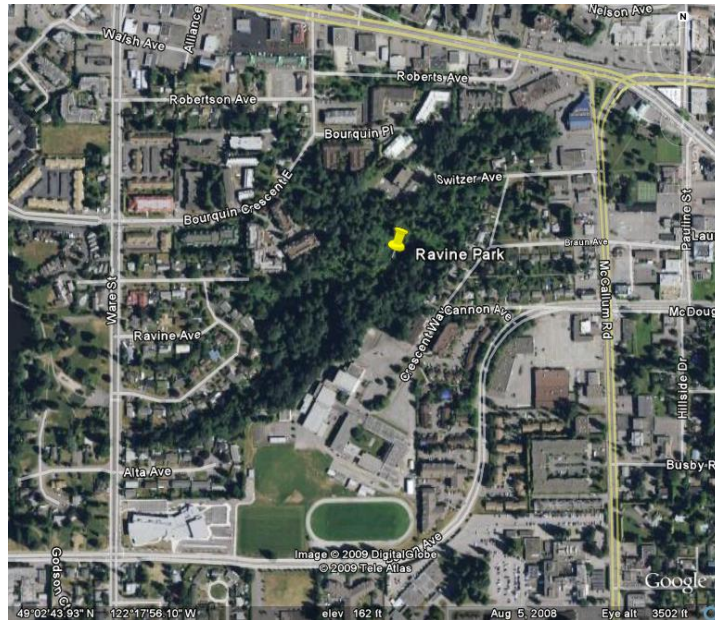


Figure 7. Ravine Park, Abbotsford.

Habitat protection/ownership

Of the nine new extant locations, three are owned by the city of Abbotsford, one by the city of Burnaby, one is located on the Skwahla Indian Reserve 2 near Chilliwack, one is owned by the City of Chilliwack, one is owned by the city of Squamish, one is part of Glen Valley Regional Park and one is within Sumas Mountain Regional Park. One location is within Bridal Veil Falls Provincial Park. Three sites on Point Grey are all located within the University of British Columbia Endowment Lands. The Ruby Creek location appears to be on or near the Ruby Creek Indian Reserve 2 but it is difficult to determine if it is within the road right of way or on the reserve. In 2010, S. Joya made two collections in the Sumas Mountain area less than 0.5 km apart from each other. One of these collections was on private property and the other was just inside the Sumas Mountain Regional Park boundary. Because precise location information is missing from Schofield's earlier Sumas Mountain collections, it is difficult to know if the 2010 sites represent revisits to the older locations. Ownership patterns and habitat protections are not clear for the remainder of the historical sites because of poor location information.

BIOLOGY

Life cycle and reproduction

In general bryophytes rely on the presence of water for fertilization to take place and the production of spores for dispersal. Unlike other members of this genus in North America, *Brotherella roellii* is autoicous, having both male and female gametes on the same plant. This increases the chance for successful fertilization and production of sporophytes. Of the 56 vouchers that were examined by J. Harpel only 14 (25%) had sporophytes. This suggests that sporophytes may not be common or that they are not produced every year and thus were not present when the collection was made. Because some populations of *B. roellii* produce deciduous flagelliferous shoots (a form of asexual reproduction) cloning of populations may result and could also provide another mechanism for dispersal.

Physiology

Bryophytes generally obtain water and nutrients by intercepting and absorbing solutes in rainwater, cloud and mist droplets and airborne dust through their shoots. This ability allows them to occupy sites that are limited in nutrients but also makes them vulnerable to air pollution. The species likely requires high levels of humidity in order to survive since it is often found on rotten wood, which holds moisture well, and on tree trunks in floodplain areas or along creeks. According to Proctor (2000) all bryophytes have some shade-plant characteristics in their photosynthetic physiology. In shade-loving species, photosynthesis is commonly saturated at 5-10% of full sunlight (Proctor 2000). Since *B. roellii* grows in forested areas, the amount and duration of sunlight may influence where this species can survive.

Dispersal

While bryophytes produce spores that are usually wind-dispersed, successful colonization is dependent on the availability of inoculums from nearby populations. Because host specificity in bryophytes has been demonstrated by Palmer (1986) and Schmitt and Slack (1990), it is important that the right tree species or coarse woody debris be present before a spore can become established. According to Snall *et al.* (2003) the long-term ability of a species to track the host substratum determines their long-term persistence and local extinction can be driven by patch destruction. Although bryophyte spores have been "trapped" up to 15 metres away from the source population (Stoneburner *et al.* 1992) they need to land on the right substratum to become established. Populations occurring in deep ravines may have limited dispersal capabilities because wind patterns within ravines are often restricted. This restriction could limit the spores from being dispersed very far from the existing parent population. A study by Kuusinen & Penttinen (1999) in Finland, using *Neckera pennata* (a rare epiphytic species), suggested that the clustered pattern exhibited by *N. pennata* could be explained by the high establishment probability close to a patch already colonized by the species because the spores were being deposited only a few metres away. Their

study may explain why *B. roellii* is more abundant at some locations, and not frequent at other sites. Dispersal via the deciduous flagelliferous shoots is also possible and is an effective way to clone a new colony, but these shoots are large and not easily distributed. Limited long-range dispersal could make small populations vulnerable to extirpation by either anthropogenic or stochastic events. Additionally, the likelihood of spores being distributed between the scattered locations throughout the Lower Mainland seems unlikely due to the large urban and agricultural barriers surrounding the known populations.

Interspecific interaction

Within suitable habitat *B. roellii* is often found scattered among several trees or rotten logs and stumps. At some sites only one log or tree may have a small population on it. In the right microhabitat conditions it may form rather robust patches but it never forms huge pure continuous mats. Epiphytic and rotten log or stump populations are often mixed with *Hypnum circinale* and occasionally with smaller liverworts. On rotten logs or stumps this small species does not compete well with larger, coarser moss species such as *Rhytidiadelphus triquetrus* or *Rhytidiadelphus loreus*.

POPULATION SIZES AND TRENDS

Search effort

Southwestern British Columbia has been extensively collected by Wilfred Schofield (Figure 8) and many of his students. *Brotherella roellii* was first discovered by Peggy Schofield who found the Southlands school population in the University Endowment Lands in 1966. W.B. Schofield then started to look for this species throughout the region and by 2007 had discovered 19 of the extant 26 sites. Attempts were made by J. Harpel and others to document as many as possible of the previously known sites during 2008 and 2009. This process was limited by the lack of good location information on many of the herbarium labels. The best historical sites that were revisited were ones that Schofield had shown to students. With the help of these individuals J. Harpel was able to relocate several of the older sites. Search effort was focused on each of the general geographic areas scattered throughout the range of the species because of the lack of good location information.

Recent search efforts between 2007 and 2010 by Steve Joya has resulted in 9 new sites: 3 in Abbotsford, 1 in Burnaby, 1 in Glen Valley Regional Park, 2 in Chilliwack, 1 on Sumas Mountain; it is difficult to know if the Chilliwack and Sumas Mountain sites are new or just two of Schofield's older sites. One new site found by J. Harpel in the Squamish area again may or may not be a former Schofield site as it was difficult to determine his exact locations. Additional surveys in suitable habitat and continued survey of previously known locations will help to better understand the condition and distribution of this species. Finally although this species is small, with appropriate training most botanists could distinguish *B. roellii* from other similar looking species. Potential habitat and known locations that have been surveyed during preparation of this report are summarized in Table 2.

Table 2. Additional areas surveyed for *B. roellii* since 2007.

Locality	Present / not present
Rotary Nature Trail, Hope	found
Spanish Banks, Pacific Spirit Park, Vancouver	not found
Golden Ears Provincial Park	not found
Shannon Falls Provincial Park	not found
Stawamus Chief Provincial Park	not found
Murrin Provincial Park	not found
Sumas Mountain Regional Park	found
Downes Bowl Park, Abbotsford	found
Century Park, Abbotsford	found
Ravine Park, Abbotsford	found
West Creek, Wood Duck Lake, Langley	found
Chilliwack area	found
Little Mountain Park, Chilliwack	found
Pioneer Cemetery, Yale	not found
Museum and visitor centre area, Yale	not found
Rose Park, Squamish	not found
Stanley Park, Vancouver	not found
parts of Pacific Spirit Park, Vancouver	not found
Confederation Park, Burnaby	not found
Robert Burnaby Park, Burnaby	not found
Confederation Park, Burnaby	not found
George Derby Conservation Area	not found
Byrne Creek Ravine, Burnaby	not found
Frogger Creek, N. side Burnaby Lake	not found
Stoney Creek Park	not found
Mundy Lake Park, Coquitlam	not found
Squint Lake Park, Burnaby	found
Brackendale river bank area	not found

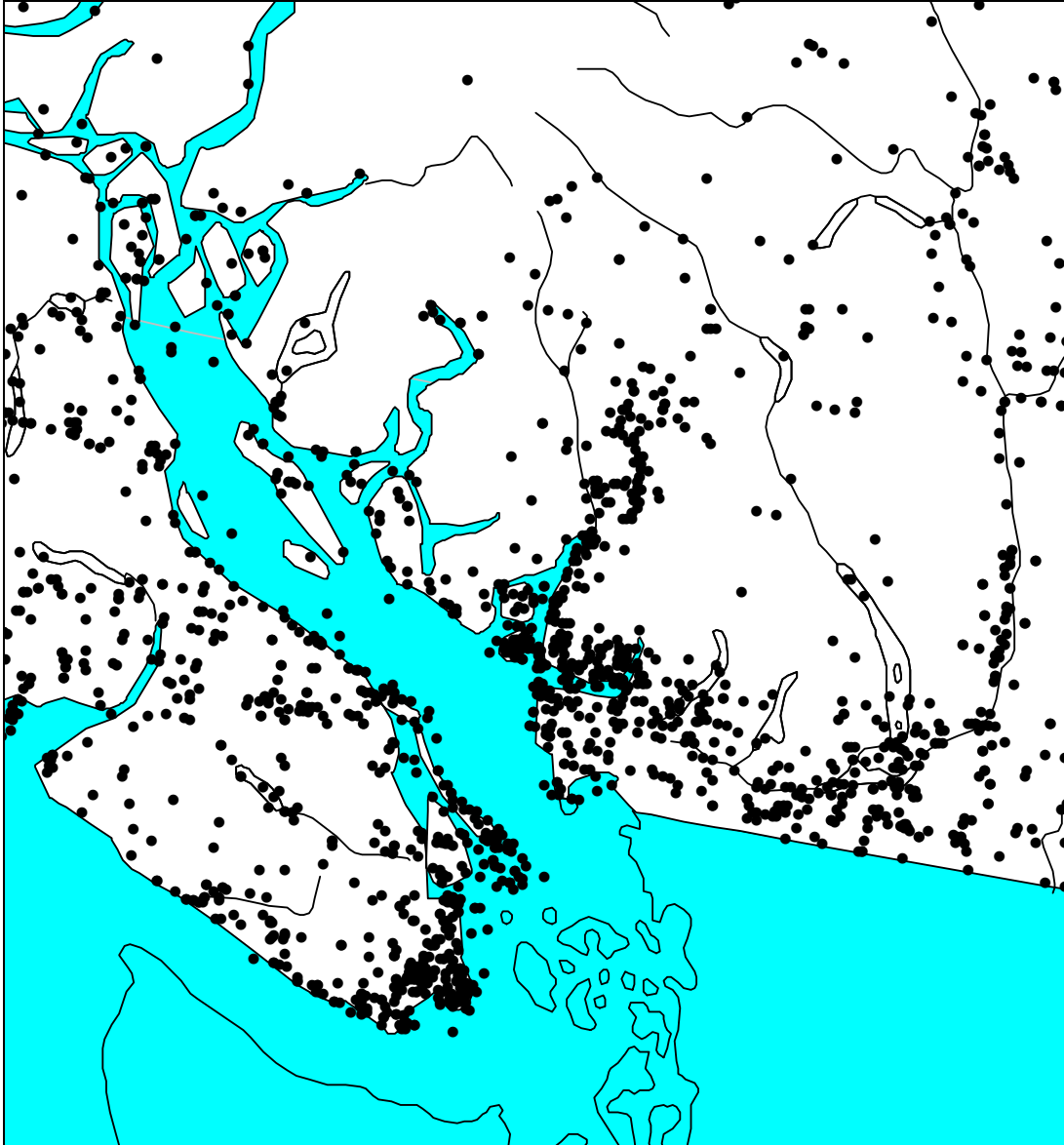


Figure 8. Search effort for bryophytes in southwestern British Columbia.

Abundance

According to Schofield (2006), “Although the species (*B. roellii*) is widely distributed within a restricted area of southwestern British Columbia, it is never common in spite of the fact that most populations occur in second-growth forest.” This comment is reiterated by O.D. Allen, on a handwritten note found in a Feb. 1903 collection of *B. roellii* from the Cascades of Washington. He comments that “I know but one locality. It grows on sides of large much decayed logs in woods, probably rare.”

Using the recommendation of Hallingbäck *et al.* (2000) a single discrete colony of moss is counted as one individual. With the exception of the Downs Bowl Park site in Abbotsford which had about 9 colonies most of the populations were restricted to one to three colonies on trees or rotten stumps or logs. Within Downs Bowl Park there were two large populations that occurred on alder and birch trees and the other smaller colonies were scattered on adjacent trees and one rotten log. The Squamish Rotary Park site was restricted to two small colonies on rotten logs near the trail.

Fluctuations and trends

The historically broad distribution of this species suggests that at one time it may have been widespread throughout southwest British Columbia and Washington State, thus the current sites may represent relics of a broader distribution. If the species had been more widespread at one time, then it would seem likely that more than 29 known occurrences would have been found over the last 134 years.

Four of the earliest collections by Macoun are likely extirpated (Agassiz, Brackendale, Hastings, Yale). According to Macoun (1922), on May 14th 1875, he took a steamer from Victoria to New Westminster and commented, "Our approach to the mouth of the Fraser was indicated, before we reached the light-ship, by the muddy appearance of the water, while extensive mud banks and low marshy ground gave evidence of the immense quantities of detritus brought down by the Fraser. As we passed up, marsh gave place to meadow, and soon the meadow, to a thick jungle of willow and other bushes which gradually merged into forest that would vie with a tropical one for luxuriance." The next day they left the area and reached the Harrison River about dark. This suggests that his Yale collection dated 11 May 1875 actually may have been collected somewhere in what is now the Vancouver or Delta area. His 1889 Hastings site is now part of Gastown in downtown Vancouver, and the 1889 Agassiz site appears to have been replaced by agricultural and urban development. Although the exact location of the Brackendale population is unclear it is likely that it was in the floodplain area next to the town. Today a large dike separates the river from the town and the former floodplain area has been converted into a large open grassy park.

The Ruby Creek site was first discovered by W.B. Schofield in 1969. He revisited the site during the following years: 1976, 1982, 1989, and 1998, each year finding the species in good condition. In March 2000, J. Harpel and Schofield returned to the site. At that time the primary population formed scattered patches on a large rotten log approximately 2 metres long. In addition to the log there was a population on a big leaf maple tree near the log. When this site was revisited in June 2009, the site was very different. The large rotten log population was gone, covered by slash and other debris and the big leaf maple tree had been cut down. A small population about the size of a "loonie" was found on the very end of the log and another small population was found on a tree adjacent to the cliffs. Further investigation into this location revealed that in December of 2000 a new mainline high pressure gas pipeline had been installed adjacent to this area. Thus the Ruby Creek population, once considered the largest in the valley has now been reduced to just a couple of small patches.

Two populations within the University Endowment Lands, Southlands Schools area were revisited by J. Harpel and both sites are gone. The rotten log site had been covered by a recently fallen tree which eliminated the *B. roellii* population. The alder tree with a small population on the base had been cut down during a trail widening project.

In 1969 Schofield collected *B. roellii* in Bridal Falls Provincial Park. Although both D.H. Vitt and Hermann made single collections of *B. roellii* in 1971 and 1974, Nathalie Djan-Chékar documented only one population in the Park during her bryophyte flora study (Djan-Chékar 1993). In 1990 Schofield showed J. Harpel a large rotten log that had a moderate-sized population of *B. roellii* growing on it. When this log was revisited in 2004 by Schofield and Harpel it had been replaced with a new restroom building.

In the Squamish area one of the Schofield sites that was shown to J. Harpel, in November 1998, along the highway is now gone as a result of the widening of the roadway in preparation for the 2010 Winter Olympics. Although there are several collections by Schofield from the Squamish area that cite the location as “alluvial forest of floodplain” it is difficult to know the exact location of these collections. During the 2009 survey by Harpel a population was found along the nature trail in Rotary Park just north of Squamish. This site may or may not be new as it is unclear as to exactly where Schofield’s earlier locations were.

Nine new locations have been found scattered throughout the Lower Mainland area, all occurring within city parks which are surrounded by urbanization. At the present time the populations at these new locations appear to be stable, but because they all are located in heavily urbanized areas their long-term viability is unknown.

For the remainder of the earlier locations, it is difficult to determine what the fluctuations and trends are because of the poor location information. Until these sites are relocated it is not known if they are extant or not.

Rescue effect

The possibility of rescue effect for *B. roellii* is very low. The species is endemic to southwestern British Columbia and Washington State. However, no extant sites have been found within Washington State recently which could serve as source populations for Canada. Search efforts within Washington State have focused on trying to relocate the historical sites. Although there are known sites in Canada near the United States border, extensive agricultural development along the Washington State side limits potential habitat for this species.

LIMITING FACTORS AND THREATS

The primary threats to *B. roellii* are urbanization, industrialization, and agricultural development. All of the remaining locations are either adjacent to or near a highly urbanized area (see Figures 6 & 7). Threats to populations within city parks can be significant. According to the City of Burnaby, Parks, Recreation and Culture Commission February 7th 2007 meeting minutes, the commissioners approved expenditure of \$300,000 dollars to upgrade the entry road to Squint Lake Park. Routine trail construction or maintenance, playground development, vandalism, mountain bikers and hikers potentially could impact populations within the parks. Also changes in horticulture, i.e., replacing native tree species with unsuitable introduced species, could eliminate known populations or prevent future colonization.

Mining may also be a significant threat to *B. roellii*. North Pacific Alloys Limited submitted the Cogburn Magnesium Project report to the B.C. Environmental Assessment Office in November 2004 proposing to develop a quarry and construct a magnesium processing facility near Ruby Creek. Currently the proponent has requested a hold on this project until after the 2010 Olympics. The development of both a quarry and processing plant could change the hydrology of Ruby Creek and potentially serve as a large stationary source of air pollution. According to Bates (2000) sulphur dioxide air pollution is very damaging to bryophytes. It is likely that air pollution poses a threat to *B. roellii* where they occur along major highways or within urban areas. The addition of a large stationary source of air pollution in the Ruby Creek area could pose a significant threat to this population.

Golf courses, road construction, pipeline installation, and changes in hydrology all pose threats. Changes in light level and microclimate caused by removal or thinning of the canopy could effect populations. Cutting of firewood and removal of coarse wood debris at locations could impact populations. Finally the highly fragmented nature of distribution appears to indicate that dispersal may be limited despite this plant's ability to produce spores.

SPECIAL SIGNIFICANCE OF THE SPECIES

Populations of *B. roellii* in southwestern British Columbia represent the only known extant occurrences in the world. Because the six historical sites in Washington State have not been relocated in spite of search efforts, *B. roellii* is effectively endemic to Canada.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Brotherella roellii was ranked as G3 (vulnerable) in 2003 according to NatureServe. It has not been ranked nationally in either Canada or the United States. In Washington it is listed as SH (historical occurrences only but still expected to occur) by the Washington Natural Heritage Program (2009) In British Columbia *B. roellii* is listed as S3 [vulnerable in the province due to a restricted range, relatively few populations, (often 80 or fewer), recent and widespread declines or other factors making it vulnerable to extirpation] and was placed on the B.C. Blue List by the Conservation Data Centre (BC CDC 2009). It has not been listed on the Canadian *Species at Risk Act* (SARA) schedule.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Dr. Judith Harpel has worked with bryophytes for the last 32 years and served as the Regional Interagency Bryologist for the U.S. Forest Service between 1997 and 2005. Currently she is the Associate Curator of Bryophytes at the University of British Columbia. She completed her Ph.D. degree at the University of British Columbia on studies of the ecology and phytogeography of the mosses within the San Juan Islands, Washington State and an M.S. degree from California Polytechnic University, Pomona for research on the bryophyte flora of the San Jacinto Mountains of southern California. Dr. Harpel has been working on bryophyte rarity for a number of years and developed the first working list of rare species for Washington State. She is a U.S. bryophyte representative to the IUCN/IAB Bryophyte Conservation Committee and a current member of the COSEWIC Subcommittee for Mosses & Lichens.

COLLECTIONS EXAMINED

All specimens collected and or examined during the preparation of this report are listed in Appendix 1.

Appendix 1. Collections examined by location, date and repository.

sn = no collection number was given to the collection ** = currently an extant site

Location	Collector	Collection no.	Date	Repository
Abbotsford, Downes Bowl Park **	Harpel	47395, 47397	17 June 2009	Harpel Priv.
Abbotsford, Century Park **	Joya	sn	10 May 2007	UBC
Abbotsford, Downes Bowl Park **	Joya	sn	28 May 2007	UBC
Abbotsford, Ravine Park **	Joya	sn	30 May 2007	UBC
Agassiz		sn	1889	NY
Agassiz	Macoun	787	8 May 1889	WTU
Anvil Island, N. shore (Howe Sound)	Schofield	38010	22 Feb. 1969	UBC
Arnold	Schofield	77215	14 Mar. 1982	UBC
Brackendale	Macoun	484	June 1916	UBC
Brackendale **	Joya	sn	2006	Joya Priv.
Bridal Veil Falls	Djan-chekar	91-507	5 Oct. 1991	UBC
Bridal Falls	Harpel	3735	3 April 1990	Harpel Priv.
Bridal Veil Falls	Schofield	92881	19 Mar. 1989	UBC
Bridal Falls	Schofield	76041	21 Mar. 1981	UBC
Bridal Falls	Schofield	sn	? Feb. 1980	UBC
Bridal Falls	Hermann	25859	20 Aug. 1974	WTU
Bridal Falls	Vitt	4664	21 Nov. 1971	ALTA
Bridal Veil Falls	Schofield	38700	15 April 1969	UBC
Chilliwack **	Joya	sn	14 June 2009	UBC
Little Mountain Park, Chilliwack **	Joya	sn	January 2010	UBC
Fraser River Valley near Sardis	Schofield	40582	21 Feb. 1970	UBC
Near Sardis, Fraser River Valley	Schofield	95241	1 April 1970	UBC
Fraser Valley ca. 5 mi. E. of Popkum	Schofield	37918, 37918a	16 Oct. 1968	UBC
Hope (near Cheam view etc.)	Schofield	43843, 43861, 48363	31 Mar. 1971	UBC, NY
Hope (near Cheam view etc.)	Jamieson	3483	31 Mar. 1971	UBC
Kanaka Creek, E. of Haney	Schofield	59629	9 April 1976	UBC
Near Aldergrove, on Hwy. 401	Schofield	38695	15 April 1969	UBC
Ruby Creek **	Joya	sn	17 June 2009	UBC
Ruby Creek	Harpel	22344	2 March 2000	Harpel Priv.
Ruby Creek	Schofield	113993, 114008	2 March 2000	UBC
Ruby Creek	Schofield	38789	27 April 1969	UBC
Ruby Creek	Schofield	112047, 112048, 112049	22 Nov. 1998	UBC
Ruby Creek	Schofield	77242	14 Mar. 1982	UBC, NY
Ruby Creek	Schofield	93234	18 April 1989	UBC
Seabird Island	Schofield	82738	2 Mar. 1985	UBC, NY
Squamish	Schofield	40419	15 Oct. 1969	UBC
Squamish	Schofield	74533	16 April 1980	UBC
Squamish	Schofield	43231	17 Oct. 1970	UBC
Squamish, Rotary Park **	Harpel	47428	18 June 2009	UBC
Suicide (Norrish) Creek, Dewdney Area	Schofield	58075	13 June 1975	UBC
Sumas Mt. (escarpment)	Schofield	75983	7 Feb. 1981	UBC
Sumas Mt. (escarpment)	Schofield	59607	27 Mar. 1976	UBC
Sumas Mt. (near Chilliwack)	Schofield	35892	10 Mar. 1968	UBC

Location	Collector	Collection no.	Date	Repository
Sumas Mt. (near Matsqui)	Schofield	33358	23 April 1967	UBC
Sumas Mt. (Straiton area)	Schofield	28454, 28458	27 Feb. 1966	UBC, NY
Sumas Mountain Regional Park **	Joya	sn	6 Feb. 2010	UBC
Point Grey	Schofield	112102	14 Mar. 1999	UBC
Pacific Spirit Park (UBC Endowment Lands)	Schofield	sn	3 Mar. 1990	UBC
Pacific Spirit Park	Schofield	100570	27 Feb. 1994	UBC
University Endowment Lands, Southlands area	Schofield	87581	23 Feb. 1987	UBC
University Endowment Lands, Southlands area	Schofield	sn	31 Mar. 1984	UBC
University Endowment Lands	Schofield	67796	4 Mar. 1978	UBC, NY
University Endowment Lands, Southlands area	Schofield	43611	2 Nov. 1970	UBC
University Endowment Lands	Schofield, P	sn	19 May 1968	UBC
University Endowment Lands, Southlands area	Schofield	37062	31 May 1968	UBC, NY
University Endowment Lands	Schofield, P	sn	16 Jan. 1966	UBC
Southlands area	Schofield	28435	12 Feb. 1966	NY
Marine Drive	Schofield	38735	20 April 1969	UBC
Hastings	Macoun	sn	19 April 1889	NY
Squint Lake Park **	Joya	sn	18 July 2009	UBC
West Creek, Wood Duck Lake, (Langley area) Frazer Valley	Schofield	125888	17 April 2007	UBC