COSEWIC
Assessment and Status Report

on the

Rigid Apple Moss
Bartramia stricta

in Canada

ENDANGERED
2009

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2009

Common name
Rigid Apple Moss

Scientific name
Bartramia stricta

Status
Endangered

Reason for designation
This species is found in western North America in British Columbia, Washington and California. In BC, the species occurs at 5 sites on southern Vancouver Island and adjacent Gulf Islands, where the species is restricted to Garry Oak ecosystems. The species grows on either well-drained, shallow, compacted soil, or on meta-igneous rock outcrop faces. The species is closely associated with seepage areas. Threats include weed invasion, trampling, changes in land use that affect grazing patterns, and urbanization of Garry Oak ecosystems.

Occurrence
British Columbia

Status history
Designated Threatened in April 1997. Status re-examined and designated Endangered in May 2000 and November 2009.

COSEWIC
Executive Summary

Rigid Apple Moss
Bartramia stricta

Wildlife species description and significance

Bartramia stricta is a moss belonging to the family Bartramiaceae, comprised of small to medium-sized, green to yellow-green species that grow in tufts. Within this group, *Bartramia stricta* is characterized by its glaucous green colour, spherical sporangium (subcylindrical and ribbed when dry), and linear leaves that are straight and erect either wet or dry.

The populations of *Bartramia stricta* in southwestern British Columbia represent the northern extent of the species' range in North America. Besides one known record of *B. stricta* in Washington, the species shows a significant gap in its western North American distribution. Canadian populations are disjunctive with those in California, where it occurs more frequently, and which appears to be the centre of its distribution in North America. The habitat type associated with *Bartramia stricta* (i.e. rock outcrops, and grasslands with shallow soils associated with Garry Oak ecosystems) is also rare within Canada; it is limited to southwestern British Columbia. Many additional endangered or vulnerable taxa are associated with *Bartramia stricta* sites. The potential sensitivity of *B. stricta* to global climate change (i.e. having a narrow niche tolerance, and occurring at the northern edge of its range) suggests that it may be a useful indicator species in this regard.

Distribution

Bartramia stricta shows wide disjunctions in its world range, occurring in Europe, Asia, Africa, Australia, and North and South America. In North America, the species is generally restricted to low elevation, Mediterranean-like climates. It is most prominent in California, where it is not considered rare; single populations have also been observed in Washington, New Mexico, and Texas. In Canada, the species is known only from British Columbia, where it occurs in a small area comprising southeastern Vancouver Island and the adjacent Gulf Islands.

Habitat

Populations of *Bartramia stricta* occurring in the western part of North America are typically associated with open grasslands with shallow soils, where there are frequent rock outcroppings, and scattered oak woodlands. Sites are generally dry and warm, having a southern aspect. Canadian populations of *B. stricta* show bimodal microhabitat preferences, growing well on either well-drained, shallow, compacted soil, or on meta-igneous rock outcrop faces (in crevices or under small overhanging lips). Californian populations are found most frequently on shallow soil, and less frequently growing on rock faces. Although the species is associated with a xeric site moisture regime, *B. stricta* populations are closely associated with large and fine-scale seepage patterns, often occurring in or close to intermittently and/or seasonally moist outflow paths. The species appears to require sites which are free of competition from grasses and herbs; all Canadian sites are associated with moderate to high grazing pressure.

Biology

The primary means of dispersal and reproduction by *Bartramia stricta* is via spores. *B. stricta* is a small, acrocarpous moss, producing the sporophyte at the terminal end of stems or branches. It is synoicous, having male and female reproductive structures in the same cluster, on the same plant. At Canadian sites, the species appears to produce sporophytes successfully and regularly. Reports indicate that California populations are also frequently observed with sporophytes.

Population sizes and trends

Bartramia stricta was previously known from only two sites in Canada. Current data indicate that it occurs in at least five but in each case it is considered uncommon; colonies are small, and scattered across the landscape. Trends in the size and density of *B. stricta* are difficult to estimate owing to the incomplete nature of historical records. Three of the current sites are newly discovered. At the two other current sites, current colony counts cannot be compared to the past colony data as the latter lack geographical reference.

Threats and limiting factors

Limited availability of potential habitat combined with destruction and alteration of this habitat are the main limiting factors for *Bartramia stricta*. Canadian populations of *B. stricta* are associated with narrowly defined microhabitats within the context of rock outcrop and grassland ecosystems with shallow soil, occurring in Mediterranean-like climates of the southwestern part of British Columbia. In recent years these areas have undergone significant destruction and alteration owing to urban development. Landscape developments that alter site or microsite seepage patterns, or destroy available habitat (e.g. residential or road development, hiking trails) comprise the greatest threat. In addition, changes to grazing pressure by goats and deer will likely lead to the disappearance of soil microhabitats required by the species. Owing to its close association with macro- and micro-climatic patterns, *B. stricta* is likely to be sensitive to global climate change.

Protection, status, and ranks

Bartramia stricta is listed as Endangered under *SARA* and is protected on federal land at three sites. In B.C., it is characterized as critically imperiled (Red-listed), owing to its extreme rarity and receives some protection outside of federal land on provincially or otherwise monitored areas, including within a BC Parks Ecological Reserve (one site), and within an Islands Trust Fund Conservation Covenant area (one site).

TECHNICAL SUMMARY

Bartramia stricta
Rigid Apple Moss Bartramie à feuilles dressées
Range of occurrence in Canada (province/territory/ocean): BC

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 an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
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?	N/A
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	2070 km²
Index of area of occupancy (IAO) based on 2x2 km grid.	28 km²
Is the total population severely fragmented?	Yes
Number of "locations∗"	5
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Stable
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations?	No
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Stable to declining (ecosystem type at risk)
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?	Unknown, but not likely

∗ See definition of location.

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	Refer to Appendix 1
Total	> 667 colonies

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)

Landscape development (urban, residential, roads); changes in grazing intensity; Land use (e.g. hiking trails) Climate change

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? nearest occurrence in WA where known from one site, otherwise main distribution in CA	
Is immigration known or possible?	Unknown (probably not frequent)
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Unlikely (very fragmented, patchy)
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC: Threatened (1997), Endangered (2000, 2009)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B1ab(iii)+2ab(iii)
Reasons for designation: This species is found in western North America in British Columbia, Washington and California. In BC, the species occurs at 5 sites on southern Vancouver Island and adjacent Gulf Islands where the species is restricted to Garry Oak ecosystems. The species grows on either well-drained, shallow, compacted soil, or on meta-igneous rock outcrop faces. The species is closely associated with seepage areas. Threats include weed invasion, trampling, changes in land use that affect grazing patterns, and urbanization of Garry Oak ecosystems.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets criterion B1 for Endangered (EO < 5000km²) and B2 for Endangered (IAO < 500 km²); meets subcriterion for (a) < 5 locations; meets subcriterion (b) for (iii) observed continuing decline in quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although there are fewer than 2500 individuals, the population is not declining.
Criterion D (Very Small or Restricted Total Population): Meets criterion D1 for Threatened (< 1000 individuals).
Criterion E (Quantitative Analysis): None available

PREFACE

Bartramia stricta is a small moss, restricted to southwestern British Columbia, where its habitat is within the Garry Oak ecosystem. This ecosystem is well known for being at risk in Canada. *B. stricta* was first assessed by COSEWIC in 2000, when it was listed as Threatened, based on small number of locations, and threats of invasion by Scotch Broom. At the time of assessment, the species was known from two sites, both on federal land. An additional site (Pedder Bay) was thought to have been extirpated.

Since the last assessment, *Bartramia stricta* has been included in the recovery plan for Garry Oak ecosystem. Also, research by Kella Sadler on vegetation ecology of rock outcrop ecosystems included identification and documentation of several species at risk found in these systems, including *B. stricta*. As a result of this work, three additional locations and many additional colonies were located, all within the Garry Oak ecosystem. The Pedder Bay site was intensely surveyed for *B. stricta*, and not found at this site. The extent of occurrence was expanded slightly as was the index of area of occupancy. Moreover, the autecology of the species was more precisely delimited and showed *B. stricta* to be restricted to microhabitat patches of exposed soil or portions of partly shaded cliffs that are subject to intermittent seepage. Sadler's work has shown the importance of moderate to intense grazing by deer (native and alien) and feral sheep and/or goats in the maintenance of the soil patches required by the species. The main threat to the species in the past was thought to be invasion of the species' habitat by Scotch Broom, a plant known to be a threat to other plants in the Garry Oak ecosystem. Sadler has shown that *B. stricta* prefers microhabitats in grazed landscapes (i.e. shallow, compacted soils), where encroachment by Scotch Broom, and/or other deeper-soiled vascular plant species (both native and invasive) is restricted. The main threats now include also changes in the management of the grazers, as well as any other changes that may influence landscape and local seepage patterns, including recreational use of the Garry Oak sites, as well as urban development.

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 (2009)

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

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

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

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

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

COSEWIC Status Report

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Rigid Apple Moss

Bartramia stricta

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2009

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Scientific name:	*Bartramia stricta* Bridel
Bibliographic citation:	Musc. Rec. 2(3) : 132. 1803.
Pertinent synonyms:	none
Common name:	Rigid Apple Moss
Family name:	Bartramiaceae
Major plant group:	Mosses

There are only four species of *Bartramia* in Canada: *Bartramia ithyphylla* Brid., *B. halleriana* Hedw., *B. pomiformis* Hedw., and *B. stricta* Brid. All four species occur in British Columbia.

Morphological description

General: Plants erect, in dense, mostly glaucous to brownish-green tufts, 1-3 cm high, tomentose below. Stems 0.7-2 cm long, sometimes branched.

Leaves: Stiffly erect-appressed when dry, erect-spreading when moist, 2.5-4 mm, lanceolate to linear-lanceolate, gradually and evenly narrowed from the base to the narrow apex, the base not sheathing; lamina bistratose in upper part; margins bistratose or unistratose, recurved except at base and apex, serrulate above; midrib relatively slender, ca. 50 µm wide, not filling the leaf tip, excurrent.

Leaf cells: Median and upper leaf cells rectangular (12-20 µm x 4-6 µm), strongly papillose, the papillae at both ends of the cells; basal cells longer (25-40 µm x 7-10 µm), or short at the insertion, smooth or faintly papillose, thin-walled throughout.

Seta: 1-1.5 cm long, straight.

Capsule: Erect, radially symmetric; nearly spherical and smooth when young, ovoid to short-cylindric when mature (ribbed with narrow grooves or furrows when dry), the urn 1.5-1.8 mm long; operculum conic convex.

Sexuality: Synoicous (bisexual, both male and female reproductive structures on the same plant).

Peristome: Single; teeth lanceolate, about 250-300 µm long, reddish-brown, finely papillose in lines proximally, smooth above.

Spores: Subspherical, 22-26 µm, warty-papillose.

Illustrations: Habit sketches from Flora of North America Association (2008), Figure 1a; close-up photo of *Bartramia stricta*, showing young sporophytes from McIntosh (2008a), Figure 1b.

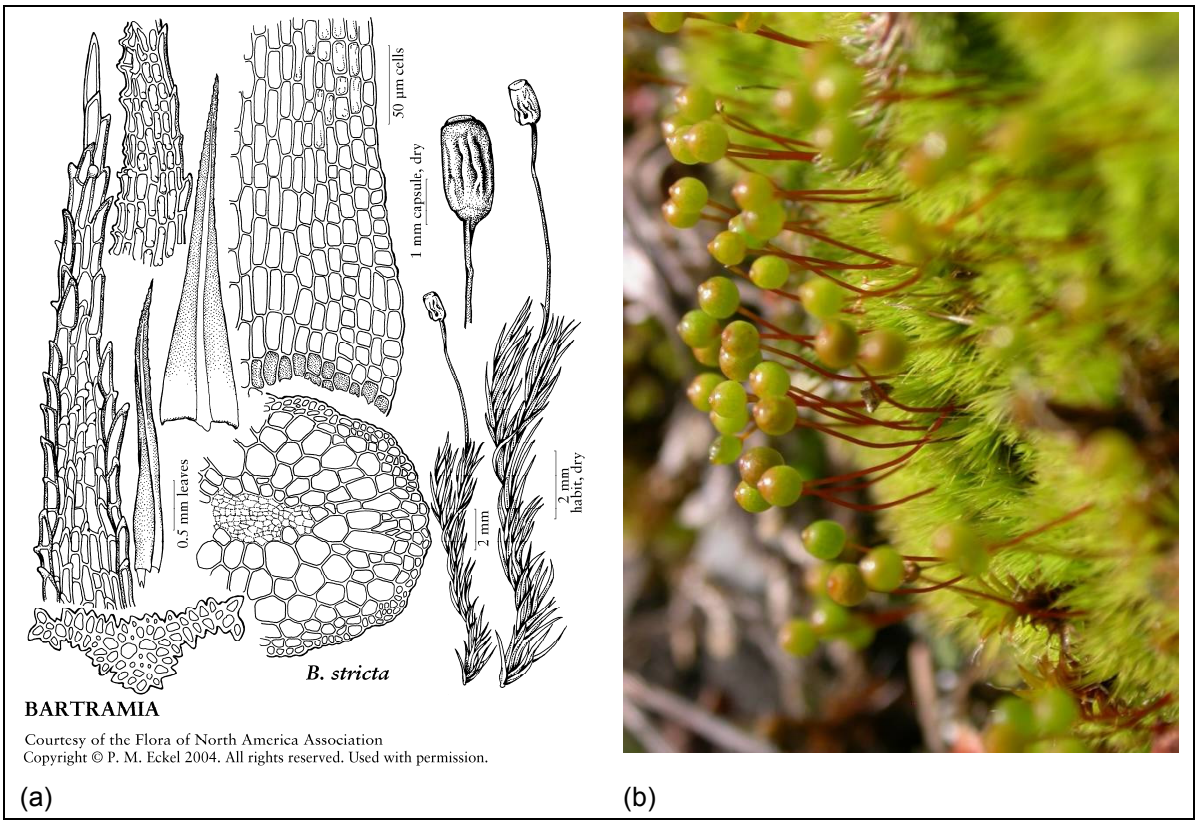

Figure 1. Habit of *Bartramia stricta*: (a) illustration of *B. stricta* (from Flora of North America Association 2008) showing size and characteristics of leaves and sporophytes, and (b) close-up view of *B. stricta*, showing sporophytes with young, spherical capsules (photo from McIntosh 2008a, used with permission).

The furrowed, globose capsule (sporangium) is a distinctive feature of the mosses belonging to the family Bartramiaceae, which is represented by five genera in Canada. All five are found in British Columbia. The genus *Bartramia* can be distinguished from the other four genera in this family by morphological and habitat features: (a) erect spreading leaves, in contrast with *Conostomum*, (b) linear-lanceolate leaves with papillose leaf cells, in contrast with *Plagiopus*, (c) occurrence in dry habitats, in contrast with *Philonotis*, and (d) lack of densely covering reddish-brown rhizoids on the stem, which are characteristic of *Anacolia*.

Having a similar appearance and habitat, some forms of the species *Anacolia menziesii* are possibly confused with *Bartramia stricta*; microscopic examination may be required to accurately distinguish them. In addition to the absence of matted rhizoids on the stem, *Bartramia stricta* plants are generally small (1-3 cm), with straight stems. Leaves are never curved when dry, and upper leaf cells are usually strongly papillose,

with papillae at the ends of cells. In contrast, *Anacolia menziesii* plants are larger (3-5 cm), often with curving stems, matted with rhizoids. Its leaves are occasionally curved when dry, and upper leaf cells are smooth to papillose, with papillae at the ends of cells (T. McIntosh, pers. comm. 2008, Griffin 2003, Lawton 1971). Confusion of *Bartramia stricta* with *Anacolia laevisphaera* may also occur, particularly with sterile material (Griffin 2003).

The relatively small size, straight erect leaves wet or dry, and non-clasping leaf bases distinguish *Bartramia stricta* from the three other species of *Bartramia* found in British Columbia. From *B. halleri* and *B. pomiformis*, *B. stricta* differs in its much smaller size, and erect, non-crisped leaves. From the similarly sized *B. ithyphylla*, *B. stricta* is differentiated by the presence of non-clasping leaf bases, and by its habitat; *B. stricta* is strictly a low elevation species, whereas *B. ithyphylla* is a subalpine/alpine species found mainly at high elevations. The characteristically straight erect leaves, and the green, spherical, smooth young sporangium of *Bartramia stricta* contribute to its common name (Rigid Apple Moss).

Genetic description

There is no current information available about genetic population structuring for *Bartramia stricta* in Canada. However, this species has been included in some phylogenetic studies, and DNA sequences for several different genes are known (i.e. Cox & Hedderson 1997; Cox *et al.* 2004; Hedderson *et al.* 1997; Quandt *et al.* 2004; Quandt 2007; Stech & Frey 2007). *Bartramia stricta* populations in British Columbia represent the northern edge of its known range. Its increased prominence in southern parts of the Pacific Coast (i.e. California) and apparent narrowing of niche breadth in northern sites suggests that ecological barriers may influence reproductive isolation for individual populations.

Designatable units

One designatable unit is recognized for *Bartramia stricta* as the species is known from only one ecozone.

Special significance

Populations of *Bartramia stricta* in southwestern British Columbia represent the northern extent of its range in North America. Other than one record from Washington state, *B. stricta* has a significant gap in its western North American distribution, between its centre of distribution in California and the disjunct populations in BC. In Canada, it is a rare species, occurring within a rare habitat type which is also at the northern extent of its range (i.e. rock outcrops, grasslands with shallow soils, and associated with Garry Oak ecosystems in the Coastal Douglas Fir (CDF) Zone). The potential sensitivity of *B. stricta* to global climate change (i.e. having a narrow niche tolerance, and occurring within a small geographic area at the northern edge of its range) suggests that it may be a useful indicator species.

It should be noted that several additional vascular plant and bryophyte taxa considered to be provincially endangered, threatened, or vulnerable, are associated with *Bartramia stricta* sites. For example, at the Notch Hill site, the vascular plants *Meconella oregana* and *Allium geyeri* var. *ternerum* have been documented to occur, as well as provincially rare or uncommon mosses *Bryum torquescens*, *Funaria muehlenbergii*, *Entosthodon fascicularis*, *Ptychomitrium gardeneri*, and *Tortula laevipila* var*. meridionalis*. Additional rare or uncommon mosses found at Sidney Island and Lasqueti Island sites (Sadler 2007) include *Bryum canariense*, *Bryum muehlenbeckii*, *Grimmia alpestris*, *Grimmia longirostris*, *Grimmia leibergii*, *Homalothecium arenarium*, *Racomitrium affine*, *Scleropodium colpophyllum*, and *Tortula papillosissima*.

DISTRIBUTION

Global range

Bartramia stricta has wide disjunctions in its world range. The species is widely distributed in the Mediterranean region of Europe (occurring in west, central, and southern parts of the continent), Asia (i.e. Syria, Turkey), north and central Africa, and Australia (Smith 1980; Griffin 2003). There are also unconfirmed records of *B. stricta* from South America, and the Canary Islands (N. Lederer, pers. comm. 2008).

In North America, *Bartramia stricta* occurs mainly along the western part of the continent (Figure 2); it has been documented in southwestern British Columbia, Washington, and California (particularly in northern parts of the state), where it occurs much more frequently. Griffin (2003) reviewed and confirmed *B. stricta* collections from New Mexico and Texas, although Kella Sadler was unable to locate more detailed location and habitat information for these records. Lederer (2008, pers. comm.) cites one record of *B. stricta* from New Mexico (Black Range, near Emory Pass).

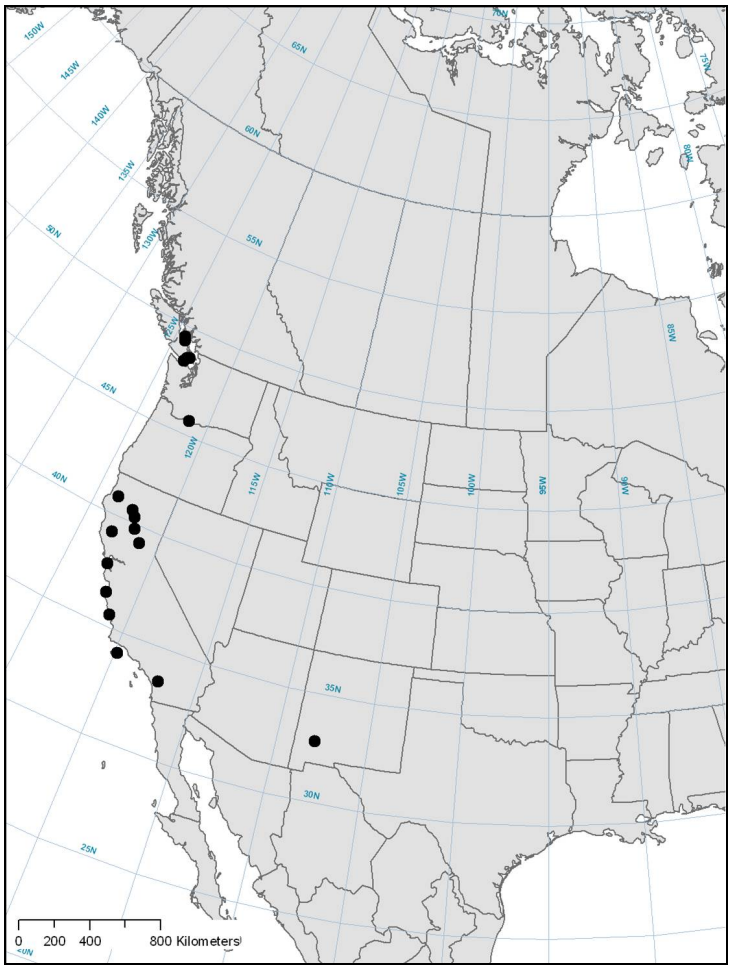

Figure 2. North American distribution of *Bartramia stricta*. Californian localities (most from Norris & Shevock, 2004a) have been selected to represent the species range, rather than to represent all populations, owing to the fact that *B. stricta* occurs much more frequently in that state.

Lawton (1971) reported *Bartramia stricta* in Idaho, Montana, and Colorado. However, subsequent examinations have shown the Montana record to have been incorrectly determined, and the Idaho and Colorado reports to have been in error (J. Christy, pers. comm. 1996 *in* Belland 1997). To date, no further collections of *B. stricta* are known from these states (N. Lederer, R. Hastings, R. Belland, J. Christy, D. Toren, & J. Shevock, pers. comms. 2008).

Canadian range

In Canada, *Bartramia stricta* is known from only five sites in a small area of southwestern British Columbia: the Nanaimo area (Notch Hill), the southeastern tip of Vancouver Island (Mary Hill, Observatory Hill), and two Gulf Islands (Lasqueti Island, Sidney Island) (Figure 3). The species was recently collected and/or observed at each of these localities in 2007 (Nanoose) and 2008 (all other sites). Distribution information for current *B. stricta* sites in Canada is summarized in Table 1. Nationally, the current extent of occurrence for the species is 2070 km^2, and the index of area of occupancy is 28 km^2.

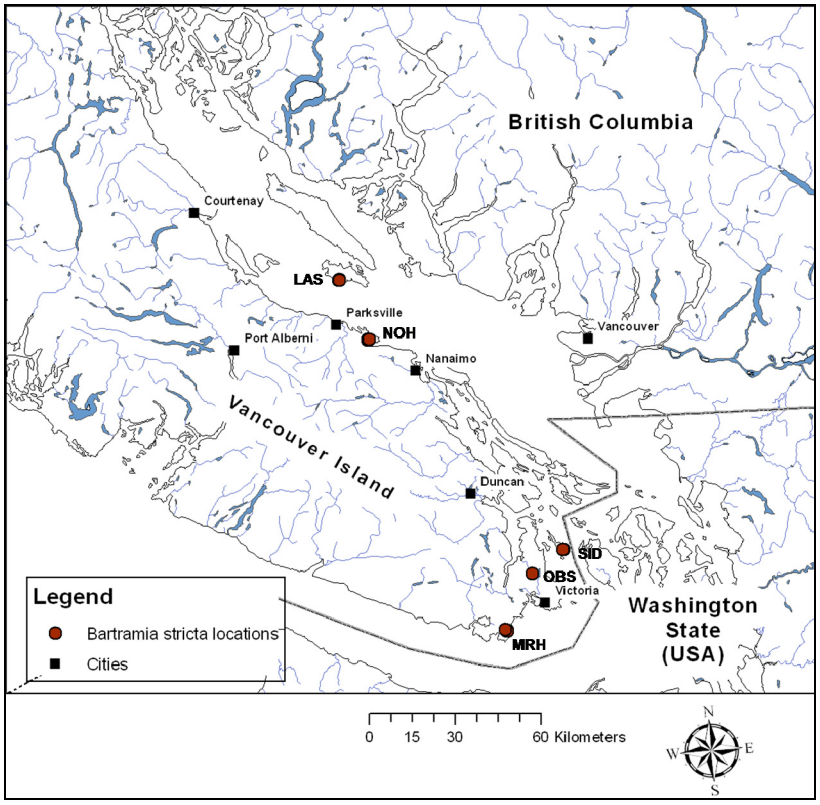

Figure 3. Canadian distribution of *Bartramia stricta*.

Table 1. Summary of distribution information for current *Bartramia stricta* sites in Canada.

CODE	Site Location	First Observed	First Observer	Recent Survey	Associated References
LAS	BC Parks Ecological Reserve (and area west of ER), Lasqueti Island BC	2001	K.D. Sadler	2008	McIntosh (2008a), Sadler (2007)
NOH	Notch Hill (CFMETR), near Nanoose, Vancouver Island BC	1975	W.B. Schofield	2007	Fairbarns (2008a), Sadler (2007)
SID	Wymond Point, Sidney Island BC	2002	K.D. Sadler	2008	Sadler (2007)
OBS	Observatory Hill, near Saanich, Vancouver Island BC	2008	M. Fairbarns	2008	Fairbarns (2008b)
MRH	Mary Hill (CFMETR), near Metchosin, Vancouver Island BC	1997	M. Ryan	2008	McIntosh (2008b), Byrne *et al.* (2005), Belland (1997)

Ryan (1996) listed a sixth site for the species at Pedder Bay, which is close to the Mary Hill site. The identity of the Pedder Bay *Bartramia stricta* voucher specimen in the University of British Columbia herbarium (collected in 1974 by W.B. Schofield and W. Parker) was confirmed by Sadler. However, searches by Belland (1997) and others in 2008 (McIntosh 2008, pers. comm.) did not relocate any populations of *B. stricta* at this site. It is likely that the Pedder Bay plants have been extirpated. Additional sites surveyed for this study did not yield any further records.

Search effort

Southwestern British Columbia has been the focus of intensive bryological exploration since the early 1960's, and there have been many collections of mosses made in this area since that time. While many of the collections result from general surveys, the distribution and moss flora of the region is one of the best known in Canada (Figure 4).

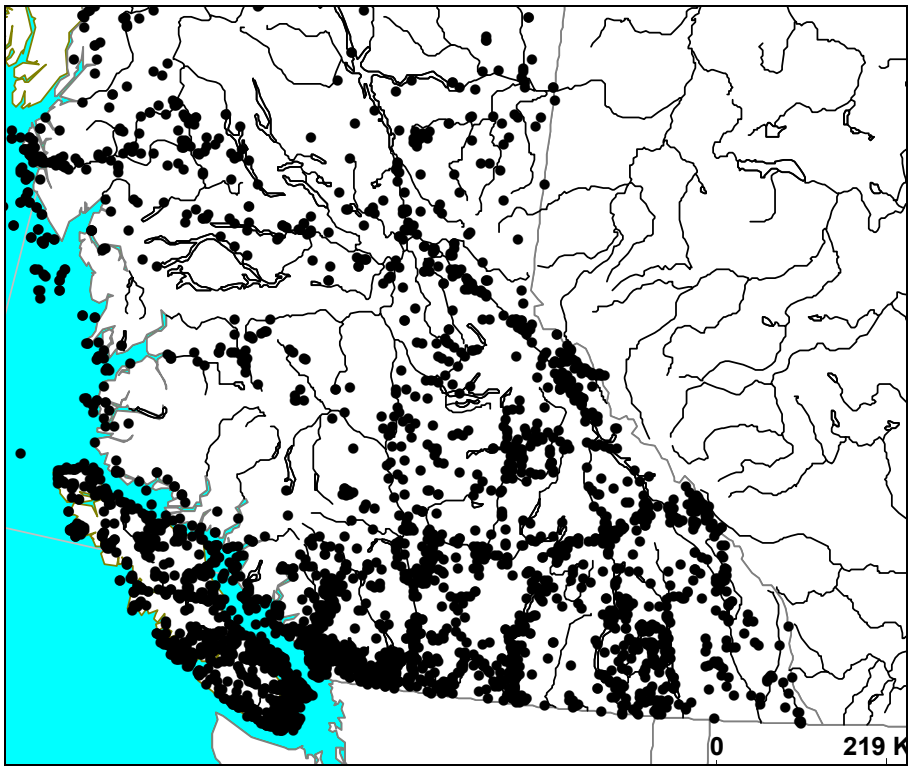

Figure 4. Locations of non-targeted searches for mosses in southwestern British Columbia. Data from the Cryptogramic Herbarium at University of British Columbia, University of Alberta Devonian Botanic Garden, and Cryptogamic Herbarium at University of Alberta.

HABITAT

Habitat requirements

Recent interest in *Bartramia stricta* has improved our understanding of the distribution and ecology of this species in Canada, and also has provided a better context for Canadian populations within North America. In areas of California with Mediterranean-like climates, *Bartramia stricta* is reported to be fairly common in open grasslands and oak woodlands of cismontane parts of the state (J. Shevock 2008, pers. comm.). *B. stricta* is described as preferring areas that are dry most of the year, occurring in grasslands and woodlands (Blue Oak savannas) away from the fog influence of the immediate coast. Californian populations are reported to occur mainly on gravelly and rocky soils or thin soil over rocks, but only occasionally on bare rocks (Shevock 2008, pers. comm.). Soils are described as typically compacted and well drained. In California, *B. stricta* is reported to occur most commonly over sedimentary rock parent material, though it also can be found on meta-volcanic rocks, e.g. in the Coast ranges. It is described as a low-elevation species (suggested to be potentially temperature sensitive), and it is rarely found in large or continuous colonies within the state (D. Toren 2008, pers. comm.).

Bartramia stricta appears to be restricted to Mediterranean-like climates (Schofield 1976). Tthus it is not surprising that the only known sites for this species in Canada occur in southwestern British Columbia, within the Coastal Douglas-fir (CDF) Biogeoclimatic Zone of the province. The CDF Zone lies in the rainshadow of Vancouver Island and the Olympic mountains, a geographic position that results in a regional climate characterized by warm, dry summers and mild, wet winters (Nuzdorfer *et al.* 1991). This climatic region represents only 0.3% of BC's land base; it includes the southeastern portion of Vancouver Island, the Gulf Islands located in the Strait of Georgia (north to Savary Island), and the mainland coast southward to the Fraser River delta (Harpel 1997).

Bartramia stricta sites in BC are characterized as open grasslands with shallow soil, associated with scattered Garry Oak (*Quercus garryana*) woodlands, Arbutus (*Arbutus menziesii*), and occasional intervening stands of Douglas-fir (*Pseudotsuga menziesii*) (Figure 5 a,b). At a landscape level, site features indicate the most xeric portion of the CDF Zone; the local climate and moisture regime are the warmest and driest of the biogeoclimatic gradient. Sites are moderate to steeply sloping, with a south-facing aspect component, generally at a mid-slope position, at low elevations (i.e. below 200 m). All of the sites in BC are associated with moderate to high grazing intensity; *B. stricta* appears to require sites which are free of competition from grasses and herbs, and/or favours the quality of soil associated with grazing usage (i.e. thin, compacted). In contrast with Californian sites, all BC sites for *B. stricta* have meta-volcanic rock parent material (to date, no sites are known that have sedimentary rock parent material). Harpel (2009, pers. comm.) described the Washington site as volcanic rock, and with similar habitat characteristics to sites observed in BC (shallow soil, sloping).

(a) Wymond Point, Sidney Island

(b) Mary Hill, Vancouver Island

Figure 5. Examples of two *Bartramia stricta* sites in Canada: (a) Wymond Point (Sidney Island), and (b) Mary Hill (Vancouver Island). Photos by K. Sadler, 2008.

Bartramia stricta populations in British Columbia occur in microhabitats which have minimal, indirect, or no shade; e.g. sunlight is filtered by Scotch Broom (*Cytisus scoparius*) growing in close proximity, or from a nearby tree (Garry Oak or Douglas-fir). *B. stricta* populations are closely associated with site seepage patterns. Within the xeric landscape setting described, it occurs in close proximity to large and fine-scale seepage flows, growing very near to (but typically not directly within) drainage pathways (Figure 6). For example, it is common to find *B. stricta* on exposed rock faces above seepage plateaus. A comparable site-level or microhabitat association with seepage patterns was not reported for California populations. As was described for *B. stricta* in California, BC populations are typically small and scattered across landscapes which support the species. *B. stricta* is rarely found in large or continuous colonies greater than 5000 cm^2; colonies are usually less than 500 cm^2.

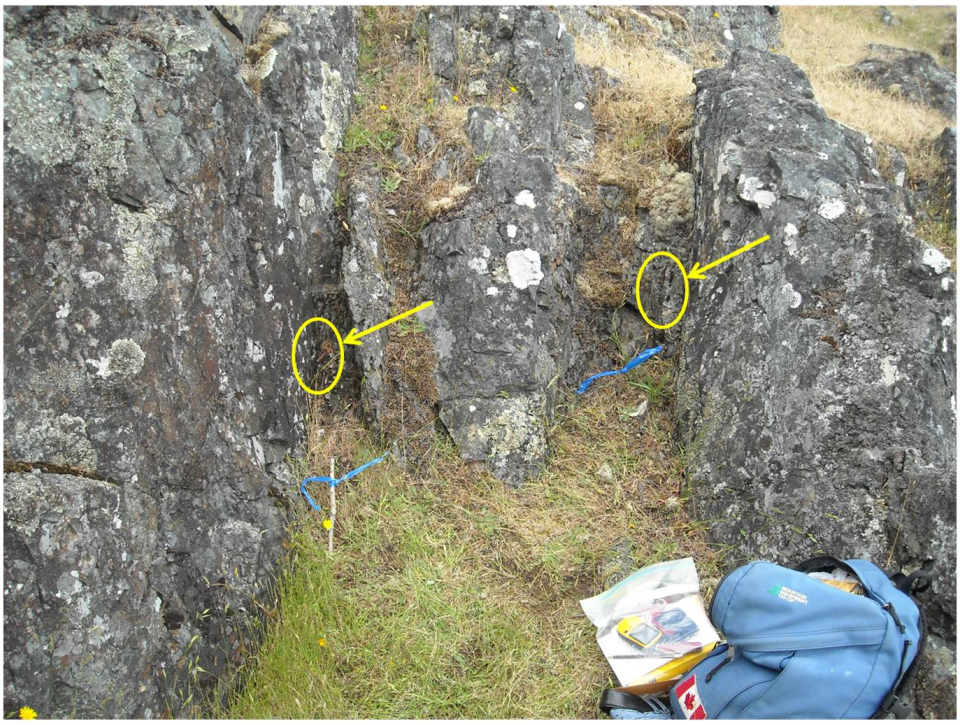

Figure 6. Example of *Bartramia stricta* habitat: near rock outcrop bases, associated with local drainage patterns. Circled areas indicate placement of two *B. stricta* colonies. Photo by K. Sadler, 2008.

Bartramia stricta populations in British Columbia show bimodal microhabitat preferences (Figure 7 a,b). The species occupies one (or both) of two types of microhabitats in each site: (a) on well-drained, shallow soil that typically appears to be compacted or disturbed, and/or (b) on meta-igneous rock outcrop faces; often in crevices, or under small overhanging lips. *B. stricta* in British Columbia is apparently more frequent in the latter type of microhabitat than populations observed in California (J. Shevock, D. Toren 2008, pers. comms.). This microhabitat shift (i.e. toward a slightly more xeric substrate and/or exposed placement, affording higher temperatures and

more direct sunlight) may relate to climatic preferences associated with the species approaching its northern distributional limit. The observed close association of *B. stricta* with seepage (i.e. sensitivity to fine-scale humidity) at BC sites may be in compensation for this trend toward increased exposure, reflecting a narrowing range of microhabitat tolerance.

(a) *B. stricta* growing on shallow soil

(b) *B. stricta* growing on rock surfaces.

Figure 7. Examples of *Bartramia stricta* populations, growing (a) on shallow soil (from McIntosh 2008a, used with permission), and (b) in crevices and under small overhangs, on rock surfaces (photo by K. Sadler, 2008).

Bartramia stricta populations are often associated with scattered (non-dominant) patches of invasive grass species such as *Vulpia*, *Anthoxanthum*, *Cynosurus*, *Bromus*, and *Aira*. Colonies of *B. stricta* are often edged with *Selaginella* or lichen, and may be directly or indirectly associated with vascular plants such as *Mimulus guttatus*, *Saxifraga integrifolia*, *Opuntia fragilis*, *Sedum spathulifolium*, and *Pityrogramma triangularis*. The species has been observed growing near or intermingled with other mosses, including *Grimmia trichophylla*, *Racomitrium heterostichum*, *Bryum capillare*, *Polytrichum juniperinum*, *Polytrichum piliferum*, and *Didymodon vinealis* (in drier microhabitats), and *Bryum miniatum* and *Scleropodium touretii* (more directly in seepage pathways).

Habitat trends

Bartramia stricta is associated with Garry Oak meadows, grasslands with shallow soils, and rock outcrop ecosystems. These ecosystem types are increasingly being developed, e.g. for residential areas; therefore potential habitats are decreasing rapidly at the landscape level. It is unlikely that any future warming trends would offset this habitat loss substantially.

At the local scale, *Bartramia stricta* occurs in sites which appear to be moderately disturbed. Moderate to intense grazing pressure was observed at every site, particularly on Lasqueti Island, where feral sheep graze the landscape in addition to native deer populations. Constant grazing pressure may sustain or increase the microhabitats required by *B. stricta*, i.e. compact, thin soils, and open landscapes with low to moderate shrub encroachment.

In British Columbia, *Bartramia stricta* only occurs over meta-volcanic rock parent material. This rock type is less porous than sedimentary rock types (e.g. sandstone, and conglomerate rock), and is likely to facilitate the species receiving the benefit of ephemeral seepage; i.e. water pools or runs over the rock, rather than being absorbed into the spaces between sediments. Appropriate microhabitats (and *B. stricta* populations) are fragmented within the landscape. Suitable microhabitats are linked to large- and fine-scale seepage patterns; therefore microhabitat availability will be affected by any development within sites, or in adjacent areas.

BIOLOGY

General

Bartramia stricta is a small, green to brownish-green perennial moss that grows in erect tufts, scattered in small colonies in rock outcrop and shallow soil grassland landscapes. There is no published information about the general biology and reproductive capacity of *Bartramia stricta*, with the exception of field observations on microhabitat (see Habitat), and remarks (e.g. observations on sporulation frequency) obtained from herbarium vouchers and personal communications with contacted authorities.

Reproduction and dispersal

As with many species of moss, the primary means of dispersal and reproduction is by spores. *Bartramia stricta* has a synoicous sexuality, meaning that both male and female reproductive structures are found in the same inflorescence on the same plant. This situation facilitates successful fertilization and consequent production of sporangia and spores. *Bartramia stricta* appears to produce sporophytes regularly throughout its range in both British Columbia and California (D. Toren, J. Shevock, pers. comms. 2008). *B. stricta* can also reproduce vegetatively, by fragmentation. The spore-dispersal abilities for this species are unknown, but owing to its disjunctive distribution pattern, outbreeding (associated with higher genetic variation, and higher genetic fitness) is probably infrequent.

Interspecific interactions

Within appropriate landscapes, *Bartramia stricta* is commonly found in small, scattered populations. Narrow microhabitat preferences likely prevent it from achieving large, continuous colonies; it is not a competitively dominant species within its environment. Encroaching herbs and shrubs associated with higher soil development reduce appropriate habitat qualities, and competitively exclude *B. stricta* by occupying available space. In addition, *B. stricta* may have negative competitive interactions with other mosses; fine-scale distributions are often observed to be scattered, with individual plants growing among other bryophyte taxa.

POPULATION SIZES AND TRENDS

Sampling effort and methods

Each of the five *Bartramia stricta* sites were surveyed most recently in 2007 and 2008. The Lasqueti Island site was surveyed by McIntosh (2008a) with the assistance of A. Gaensbauer, S. Wheeler, and P. Wheeler, on three days in May-June, 2008. The Notch Hill site was surveyed (Fairbarns 2008a) on three days in March-April, 2007. The Wymond Point (Sidney Island) site was surveyed by K. Sadler on June 17, 2008. The Observatory Hill site was surveyed by M. Fairbarns and K. Sadler (April 22, and Aug. 7, 2008, respectively). Surveys of the Mary Hill site (approximately 90 person-hours of effort) were completed during April-October, 2008. Further surveys of Mary Hill and Observatory Hill were undertaken after the completion of this report, in March 2009 (McIntosh 2009, Sadler 2009, respectively).

At each site, surveys were undertaken by walking transects in areas considered to be suitable habitat for *Bartramia stricta*. Within open grasslands with shallow soil and rock outcrop landscapes, rock crevices, overhangs, and thin-soiled flats close to rock bases were searched for the species. Where *B. stricta* was observed, notes were taken to describe the surrounding landscape (aspect, slope, shade, GPS location), and individual colonies (size, substrate characteristics, associated species). Photographs were taken to document pertinent site features and *B. stricta* populations. It should be noted that potential habitats at the Sidney Island site (over 18 ha) and at the Observatory Hill site were too large to survey. More detailed surveys for *B. stricta* need to be undertaken at these sites.

Potential *Bartramia stricta* habitat at Lone Tree Hill Regional Park (on Vancouver Island) was examined, although no populations were found there. McIntosh (2007) searched Rocky Point (located near Mary Hill) for the species. Other potential *B. stricta* sites (i.e. rock outcrop and grasslands with shallow soils ecosystems within or near the current range of the species) were surveyed in 2000-2002 (Sadler 2007): Cape Roger Curtis (Bowen Island), Channel Ridge, Mt. Maxwell, Reginald Hill, and Mt. Tuam (Saltspring Island), Discovery Island, Bluffs Park and Mt. Galiano (Galiano Island), Mt. Warburton Pike (Saturna Island), Helliwell Provincial Park (Hornby Island), Mouat Pt. (Texada Island), northeast coast of Valdes Island, South Winchelsea Island, Home Bay (Jedediah Island), southwest Jervis Island, George Hill and Mace Pt. (Savary Island). No *B. stricta* populations were found at these sites.

Abundance

The small size of *Bartramia stricta* makes it impossible to document every plant at a site. As with many mosses, this species grows as a group of individuals (i.e. tuft-forming), which occur in colonies on their substrate. *B. stricta* occurs in small, scattered colonies within landscapes that support the species; it rarely occurs in large or continuous populations. Current records for *B. stricta* populations are shown in Table 2; colonies growing in close association were counted as one record. To determine the population health of *B. stricta*, the number and sizes of colonies within sites were summarized. Owing to the growth habit of the species (i.e. occurring in many, small, scattered colonies), estimating population number and size is difficult. Therefore, it should be emphasized that values represent conservative estimates, particularly for Observatory Hill and Sidney Island sites.

Table 2. Extant populations of *Bartramia stricta* in British Columbia; number (N) and size (cm^2) of colonies associated with each site. Historical sizes (from Belland 1997, and Byrne *et al.* 2005) are included for reference. Site abbreviations are in accordance with Table 1.

Site	Current N Records	Current N Colonies	Historical Tot. Size (cm^2)	Current Tot. Size (cm^2)
LAS	7	41+	0.0	>13383.0
SID	4	9	0.0	>29.0
OBS	3	13	0.0	>144.5
NOH	34	409+	14970.5	>4297.0
MRH	38	258+	920.0	>9521.25
Total:	86	667+	15890.5	>27374.8

Fluctuations and trends

Trends in the size and density of *Bartramia stricta* populations are difficult to estimate, owing to the incomplete nature of historical records (Table 2). Three of the current sites for *B. stricta* (Lasqueti Island, Sidney Island, and Observatory Hill) are recent discoveries for which we have no trend data. Population estimates were previously recorded at the other two current sites for *B. stricta* (i.e. Notch Hill, and Mary Hill), but specific colony comparisons are unreliable, owing to lack of detailed geographic reference for most of the constituent colonies. The number and size of *B. stricta* populations appear to have increased within the region and at the Mary Hill site; however this can be attributed to increased search effort for the species. The most recent survey of Notch Hill (Fairbarns 2008a) focused on collecting GPS data for colony occurrences. The absence of size information for most current colonies can account for the apparent decline at Notch Hill since Belland's (1997) report (i.e. NOH, Table 2). To date, there has been insufficient baseline survey information to make adequate estimations about population fluctuations of *B. stricta* in British Columbia.

Rescue effect

In North America, *Bartramia stricta* occurs predominantly in southwestern British Columbia and California, with one isolated population in Washington. Potentially suitable habitat for *B. stricta* is limited in Washington (J. Harpel, pers. comm. 2009). The San Juan Islands occurring in northwestern Washington, are geographically close to and provide similar habitats to sites where *B. stricta* has been observed in British Columbia. Harpel (1997) surveyed this area extensively, but *B. stricta* has not been recorded. Increased search may reveal more populations in Oregon, particularly in Oak savanna and/or grasslands with shallow soils habitats which are similar to those found in California.

Bartramia stricta populations are small and patchy within landscapes, and localized in specific microhabitats (particularly in BC). Due to the potential for misidentification (e.g. with a form of the more common *Anacolia menziesii*), the species may be missed in surveys. It is possible that *B. stricta* has additional scattered, occurrences between British Columbia and California but current records suggest it is disjunctive. Based on current data, propagule migration between Canadian sites and those in the United States is probably infrequent.

THREATS AND LIMITING FACTORS

Suitable habitat appears to be the limiting factor for the survival of this species in British Columbia (and Canada). *Bartramia stricta* is a temperate (Mediterranean) species requiring warm, mainly xeric sites. While the species is not known to be specifically associated with Garry Oak (*Quercus garryana*) stands elsewhere within its range, such vegetation is characteristic of the conditions preferred by *B. stricta* in Canada. This vegetation type is restricted in Canada to southeastern Vancouver Island

and some of the Gulf Islands. Presently, intense pressure from urban expansion and development threatens many *Q. garryana* stands and associated ecosystems, thus severely limiting potential establishment of *B. stricta* in this habitat. While *Q. garryana* stands on rocky slopes (similar to those at documented *B. stricta* sites) are less at risk, they are increasingly being developed as urbanization pressures increase and land prices rise.

Alteration or prevention of grazing pressure is also likely to impact the frequency and abundance of *Bartramia stricta*, owing to its narrow niche tolerance and minimal competitive ability. If grazing deer (and other grazers) are removed (e.g. in order to promote deeper-soiled, Garry Oak meadow ecosystems), subsequent soil development and associated encroachment by grasses and shrubs may reduce potential habitat for *B. stricta*.

Some protection is afforded to the species by virtue of current site ownerships (i.e. within federal and provincial land reserves, and within a property protected by a conservation covenant). However, any developments within or near these sites are likely to affect *B. stricta* populations. For example, residential development, hiking trails, or road construction will directly reduce potential habitat area for the species. Concurrently, negative impacts may be indirect through development of adjacent areas, for example by altering drainage patterns through sites (which are closely tied to *B. stricta* populations).

PROTECTION, STATUS, AND RANKS

Legal protection and status

Bartramia stricta is currently listed as Endangered in Schedule 1 of the Canadian *Species at Risk Act* (*SARA*) and is afforded protection on federal lands.

Non-legal status and ranks

Bartramia stricta has not yet been assigned a global rank by NatureServe, or by the B.C. Conservation Data Centre. The national rank for *B. stricta* in Canada is N1 (critically imperiled). In the USA, *B. stricta* has a national ranking of N1N2 (critically imperiled to imperiled), although it is not yet ranked in its states of occurrence. Contacted authorities do not consider the species to be rare or endangered in California (J. Shevock, D. Toren, pers. comms. 2008). Its recent single documentation in Washington (collected by W.B. Schofield & J. Harpel in 2002) indicates that it may soon be classified as rare within that state.

In British Columbia, *B. stricta* is provincially ranked as an S1 species by the Conservation Data Centre (BC CDC 2008). This ranking indicates that the species is considered “Critically imperiled because of extreme rarity (i.e. often 5 or fewer occurrences) or because of some factor(s) making it especially vulnerable to extirpation

or extinction." *B. stricta* is included on the British Columbia Ministry of Environment (MOE) "Red List", making this moss a candidate for legal designation as endangered ("Any indigenous species, subspecies, or variety facing extirpation or extinction in British Columbia"), or threatened ("Any indigenous species, subspecies, or variety likely to become endangered if limiting factors are not reversed").

In addition, several Garry Oak plant communities are included on the British Columbia Ministry of Environment "Red List", and thus also face possible extirpation or extinction, or are considered threatened in British Columbia. The communities and their rankings (CDC ranking/MOE ranking) are as follows: Douglas-fir-Garry Oak-oniongrass (S1/Red), Garry Oak-Arbutus (S1/Red), Garry Oak-Brome (S1/Red), Garry Oak-Ocean Spray (S1/Red). *Bartramia stricta* populations have been observed in all of these community types. It is stressed here that the plant community types in which *B. stricta* occurs are themselves considered to be threatened.

In British Columbia, *Bartramia stricta* is not currently protected by legislation or regulations for the protection of rare or endangered species. However, *B. stricta* is somewhat protected by virtue of its presence in federally or provincially monitored areas. The species occurs in fenced or restricted federal land (three sites), within a BC Parks Ecological Reserve (one site), and within an Islands Trust Fund Conservation Covenant area (one site).

Habitat protection and ownership

Three of the five sites for *Bartramia stricta* are on federally owned land (i.e. Canadian Forces Maritime Experimental and Testing Ranges): Notch Hill, Observatory Hill, and Mary Hill. The first is protected from the public somewhat by fencing; the latter is protected by fencing and reduced accessibility. The site on Lasqueti Island occurs (in part) in a BC Parks Ecological Reserve; the area is not fenced, but it is relatively remote, and public use is minimal at present. The site on Sidney Island (Wymond Point) is located within an Islands Trust Fund Conservation Covenant area. It is currently owned by a strata corporation. Much residential development of the site has occurred since the species was first observed there in 2002 (Sadler 2007). A detailed survey of the Sidney Island site is required before assessing the sufficiency of its current level of protection; this site is probably the most at-risk for potential habitat and population loss.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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University of British Columbia herbarium. Kella Sadler is grateful to James Shevock and David Toren for distribution and ecological information for *Bartramia stricta* in California. Thanks to Alain Filion for map preparation and distribution area calculations.

Authorities contacted

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CEO, Senior Scientist
Northwest Botanical Institute, Eugene, OR

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Dr. Kella Sadler has 14 years' experience in plant ecology research. She has studied vegetation – habitat relationships in a variety of ecosystems, with a particular focus on bryophytes occurring in southwestern BC. In 1999, she completed her M.Sc. research, describing terrestrial bryophyte assemblages (and associated vascular plant vegetation) in subalpine forests of the North Shore Mountains in BC. Her subsequent Ph.D. research investigated the vegetation ecology of rock outcrop ecosystems, using a multi-scale approach to generate a classification scheme, characterize conservation priorities, and identify several species at risk, including *Bartramia stricta*. As a consultant, she has been involved with, designed, and/or implemented a variety of vegetation research projects, including ecological assessments and botanical surveys. She has also worked as a data analyst for 10 years, using multivariate statistics to interpret vegetation and wildlife ecological data.

COLLECTIONS EXAMINED

The following institutions and individuals were consulted regarding current herbarium records for *Bartramia stricta*:

Royal Alberta Museum Herbarium
Edmonton, AB
Contact: Roxanne I. Hastings, Curator of Botany

Royal British Columbia Museum Herbarium
Victoria, BC
Contact: John Pinder-Moss, Botany Collections Manager

University of Alberta Herbarium
Edmonton, AB
Contact: René Belland

University of British Columbia Herbarium
Vancouver, BC
Contact: Olivia Lee, Collections Manager

University of Colorado Herbarium
Boulder, CO
Contact: Nan Lederer, Collection Manager

All vouchers of *Bartramia stricta* available at the University of British Columbia (UBC) Herbarium, and the Royal British Columbia (RBCM) Herbarium were examined. In addition, all recent USA specimens (i.e. since Belland's 1997 COSEWIC status report on *B. stricta*) were examined from these collections. Only confirmed vouchers of *Bartramia stricta* are listed (i.e., misidentified specimens omitted).

British Columbia Specimens (UBC Herbarium):

B13534 - Location: Vancouver Island; head of Pedder Bay, cliff above sea Habitat: seepy outcrop near oak woodland Lat/Long: 48°20'N, 123°29'W Coll: W.B. Schofield & W. Parker Coll. Date: April 16, 1974 No.: 55393

B35135 - Location: Vancouver Island; Nanoose Hill, Nanoose Bay Habitat: grassy terrace of exposed outcrop slope Coll: W.B. Schofield (& Botany 500 class) Coll. Date: May 5, 1975 No.: 57676

B35136 - Location: Vancouver Island; Nanoose Hill, Nanoose Bay Habitat: dry outcrop slope Lat/Long: ca. 49°20'N, 124°10'W Coll: W.B. Schofield Coll. Date: April 26, 1976 No.: 60308

B35137 (c.fr.) - Location: Vancouver Island; Nanoose Hill Habitat: earth on outcrop slope Coll: W.B. Schofield Coll. Date: May 2, 1977 No.: 63799(2)

B35138 (c.fr.) - Location: Vancouver Island; Nanoose Hill, near Nanaimo Habitat: earth among annual grasses of slope Coll: W.B. Schofield Coll. Date: May 3, 1978 No.: 68459

B133327 - Location: Vancouver Island; Nanoose Hill, N. of Nanaimo Habitat: rock cliffs on S-facing slope Lat/Long: 49°17'N, 124°10'W Coll: G.B. Straley Coll. Date: May 3, 1977 Det: W.B. Schofield No.: 1302

B159189 - Location: Vancouver Island; Nanoose Hill; W part of S-facing slope on Dept. of National Defence property Habitat: open grassy slope, on bare soil among grasses, 35° slope, southern exposure UTM: 10U 4173 54580 Lat/Long: 49°16.25'N, 124°09.25'W Elev: ca. 100m Coll: N. Djan-Chékar & R. Belland Coll. Date: 1996-10-01 Det: NDC, Oct. 1996 No.: 2170

B159192 - Location: Vancouver Island; Nanoose Hill; W part of S-facing slope on Dept. of National Defence property Habitat: open grassy slope, on bare soil among grasses, 35° slope, southern exposure UTM: 10U 4173 54580 Lat/Long: 49°16.25'N, 124°09.25'W Elev: ca. 100m Coll: N. Djan-Chékar & R. Belland Coll. Date: 1996-10-01 Det: NDC, Oct. 1996 No.: 2173

B165395 - Location: Southern Vancouver Island; Mary Hill Habitat: at base of S-facing rock face on shallow soil; slightly open and exposed rocky knoll Lat/Long: 48°20'N, 123°32'W Elev: ca. 75m Coll: M. Ryan

United States Specimens (UBC Herbarium):

B189913 - Location: USA (Washington); Catherine Creek, Columbia River National Scenic Area; Co.: Klickitat Habitat: shallow soil of outcrop slope Lat/Long: 45°42'N, 121°21'W Elev: 350 ft. Coll: W.B. Schofield, J. Harpel Coll. Date: Apr. 12, 2002 Det: W.B. Schofield No.: 119401

B189922 - Location: USA (Washington); Catherine Creek, Columbia River National Scenic Area; Co.: Klickitat Habitat: damp slope of field Lat/Long: 45°42'N, 121°21'W Elev: 350 ft. Coll: W.B. Schofield, J. Harpel Coll. Date: April 12, 2002 Det: W.B. Schofield No.: 119413

B198640 - Location: USA (Monterey County, California); 3.7 miles from bridge crossing of Carmel River. T17S, R1E, Section 1. Habitat: on exposed sandstone rock bank in grassland with *Quercus agrifolia*; on soil/rock wall of road bank in full sun Lat/Long NAD 27: 36°29'02"N, 121°48'22"W Elev: 1075 ft. Coll: James R. Shevock, with Ken Kellman Coll. Date: 19 Feb. 2007 Det: Jim Shevock iii 2007 No.: 29443

Appendix 1. Summary of distribution details for *Bartramia stricta* colonies in Canada. Site labels correspond with those shown in Table 1. Abbreviations are as follows: Observers TTM=Terry McIntosh, KDS=Kella Sadler, MF=Matt Fairbarns. Colonies are described by number of colonies (# colonies), size (TpSize=Total colony size), and habitat (RO=on rock outcrop, soil=on soil). Records (Rec.) denoted with an asterisk represent the most recent populations, i.e. data received after preparation of this update status report, and not included in the document text, or in the area calculations: *87-*123 from McIntosh 2009, *124-*128 from Sadler 2009).

				Colonies - overall:		*Colonies - by habitat type:*			
Rec.	**Site**	**Date**	**Obs.**	**# colonies**	**TpSize(cm^2)**	**# colonies - RO**	**(cm^2) - RO**	**# colonies - soil**	**(cm^2) - soil**
1	LAS	Jun. 26-08	TTM	2	15.0	2	15.0	0	0.0
2	LAS	Jun. 26-08	TTM	4	4408.0	1	35.0	3	4373.0
3	LAS	Jun. 26-08	TTM	2	8100.0	0	0.0	2	8100.0
4	LAS	Jun. 27-08	TTM	24+	? (large)	(few)	?(small)	(most?)	(most?)
5	LAS	May 10-08	TTM	7	784.0	7	784.0	0	0.0
6	LAS	May 10-08	TTM	1	76.0	1	76.0	0	0.0
7	LAS	Jun 18-01	KDS	1	(fragment)	-	?	-	?
8	SID	Jun. 17-08	KDS	1	10.0	1	10.0	0	0.0
9	SID	Jun. 17-08	KDS	4	14.0	4	14.0	0	0.0
10	SID	Jun. 17-08	KDS	3	5.0	3	5.0	0	0.0
11	SID	May 11-02	KDS	1	(fragment)	-	?	-	?
12	OBS	Apr. 22-08	MF	1	100.0	1	100.0	0	0.0
13	OBS	Aug. 7-08	KDS	1	12.0	1	12.0	0	0.0
14	OBS	Aug. 7-08	KDS	6	32.5	6	32.5	0	0.0
15	NOH	Apr. 12-07	MF	1	+	1	+	0	0.0
16	NOH	Apr. 12-07	MF	>1	(small colonies)	0	0.0	>1	(small colonies)
17	NOH	Apr. 12-07	MF	>1	+	0	0.0	>1	+
18	NOH	Apr. 12-07	MF	>1	(small colonies)	>1	(small colonies)	0	0.0
19	NOH	Apr. 12-07	MF	1	+	-	?	-	?
20	NOH	Apr. 12-07	MF	1	+	-	?	-	?
21	NOH	Apr. 12-07	MF	1	+	1	+	0	0.0
22	NOH	Apr. 12-07	MF	>1	+	>1	+	0	0.0
23	NOH	Apr. 25-07	MF	>1	+	-	?	-	?
24	NOH	Apr. 25-07	MF	1	+	-	?	-	?
25	NOH	Apr. 25-07	MF	>1	+	-	?	-	?
26	NOH	Apr. 25-07	MF	>1	+	-	?	-	?
27	NOH	Mar. 12-07	MF/TTM	>1	(small colonies)	-	?	-	?
28	NOH	Mar. 12-07	MF/TTM	1	400	1	400.0	0	0.0
29	NOH	Mar. 12-07	MF/TTM	1	300.0	1	300.0	0	0.0
30	NOH	Mar. 12-07	MF/TTM	>1	(small colonies)	0	0.0	>1	(small colonies)
31	NOH	Mar. 12-07	MF/TTM	1	600.0	0	0.0	1	600.0
32	NOH	Mar. 12-07	MF/TTM	1	(small colony)	-	?	-	?
33	NOH	Mar. 12-07	MF/TTM	1	(small colony)	-	?	-	?
34	NOH	Mar. 12-07	MF/TTM	1	(large colony)	-	?	-	?
35	NOH	Mar. 12-07	MF	1	+	-	?	-	?
36	NOH	Mar. 12-07	MF	1	+	-	?	-	?
37	NOH	Mar. 12-07	MF/TTM	1	+	-	?	-	?
38	NOH	Mar. 12-07	TTM	1	+	-	?	-	?
39	NOH	Mar. 12-07	MF	1	+	-	?	-	?
40	NOH	Mar. 12-07	MF/TTM	1	+	-	?	-	?
41	NOH	Mar. 12-07	MF	1	+	-	?	-	?

Rec.	Site	Date	Obs.	*Colonies - overall:* # colonies	TpSize(cm^2)	*Colonies - by habitat type:* # colonies - RO	(cm^2) - RO	# colonies - soil	(cm^2) - soil
42	NOH	Mar. 12-07	MF	1	+	-	?	-	?
43	NOH	Mar. 12-07	TTM	3	>600.0	>1?	600.0	?	?
44	NOH	Mar. 12-07	TTM	13	2397.0	2	676.0	11	1710.0
45	NOH	Apr. 12-07	MF	1	+	-	?	-	?
46	NOH	Apr. 12-07	MF	1	+	-	?	-	?
47	NOH	Apr. 12-07	MF	1	+	-	?	-	?
48	NOH	Apr. 12-07	MF	1	+	-	?	-	?
49	MRH	Apr. 24-08	TTM/KDS	26	751.0	26	751.0	0	0.0
50	MRH	Apr. 24-08	TTM/KDS	5	95.0	4	91.0	1	4.0
51	MRH	Apr. 24-08	TTM/KDS	4	117.0	2	95.0	2	22.0
52	MRH	Apr. 24-08	TTM/KDS	13	>929.0	12	>927.0	1	2.0
53	MRH	Apr. 24-08	TTM/KDS	1	270.0	1	270.0	0	0.0
54	MRH	Apr. 24-08	TTM/KDS	9	>448.0	9	>448.0	0	0.0
55	MRH	Apr. 24-08	TTM/KDS	3	228.0	2	222.0	1	6.0
56	MRH	Apr. 24-08	TTM/KDS	3	30.0	3	30.0	0	0.0
57	MRH	Apr. 24-08	TTM/KDS	3	201.0	3	201.0	0	0.0
58	MRH	Apr. 24-08	TTM/KDS	6	120.0	5	75.0	1	45.0
59	MRH	Apr. 24-08	TTM/KDS	7	34.0	7	34.0	0	0.0
60	MRH	Apr. 24-08	TTM/KDS	1	70.0	1	70.0	0	0.0
61	MRH	Apr. 24-08	TTM/KDS	25	>156.0	25	>156.0	0	0.0
62	MRH	Apr. 24-08	TTM/KDS	15	>355.0	15	>355.0	0	0.0
63	MRH	Apr. 24-08	TTM/KDS	1	16.0	1	16.0	0	0.0
64	MRH	Apr. 24-08	TTM/KDS	2	23.0	2	23.0	0	0.0
65	MRH	Apr. 24-08	TTM/KDS	3	21.0	3	21.0	+	>0.0
66	MRH	Apr. 24-08	TTM/KDS	>4	>2000	>4	>2000	0	0.0
67	MRH	Apr. 24-08	TTM/KDS	1	84.0	1	84.0	0	0.0
68	MRH	Apr. 24-08	TTM/KDS	13	>102.0	13	>102.0	0	0.0
69	MRH	Apr. 24-08	TTM/KDS	20	>198.0	20	>198.0	0	0.0
70	MRH	Apr. 24-08	TTM/KDS	3	6.3	3	6.3	0	0.0
71	MRH	Apr. 24-08	TTM/KDS	4	22.0	3	18.0	1	4.0
72	MRH	Apr. 24-08	TTM/KDS	2	6.0	0	0.0	2	6.0
73	MRH	Apr. 24-08	TTM/KDS	2	36.0	2	36.0	0	0.0
74	MRH	Apr. 24-08	TTM/KDS	2	117.0	2	117.0	0	0.0
75	MRH	Apr. 24-08	TTM/KDS	2	21.0	1	9.0	1	12.0
76	MRH	Apr. 24-08	TTM/KDS	2	132.0	2	132.0	0	0.0
77	MRH	Apr. 24-08	TTM/KDS	1	15.0	1	15.0	0	0.0
78	MRH	Apr. 24-08	TTM/KDS	9	>263.0	8	>260.0	1	3.0
79	MRH	Apr. 24-08	TTM/KDS	3	60.0	2	56.0	1	4.0
80	MRH	Apr. 24-08	TTM/KDS	3	406.0	3	406.0	0	0.0
81	MRH	Apr. 24-08	TTM/KDS	21	>916.0	21	>916.0	0	0.0
82	MRH	Apr. 24-08	TTM/KDS	9	>369.0	9	>369.0	0	0.0
83	MRH	Apr. 24-08	TTM/KDS	20(?)	>438.0	20(?)	>438.0	0	0.0
84	MRH	Apr. 24-08	TTM/KDS	8	>194.0	8	>194.0	0	0.0
85	MRH	Apr. 24-08	TTM/KDS	1	272.0	1	272.0	0	0.0
86	MRH	Apr. 24-08	TTM/KDS	>1(?)	>0.0	>1(?)	>0.0	0	0.0
*87	NOH	Feb/Mr-09	TTM+	3	297.5				
*88	NOH	Feb/Mr-09	TTM+	2	46.0				
*89	NOH	Feb/Mr-09	TTM+	13	>85.0				
*90	NOH	Feb/Mr-09	TTM+	1	130.0				
*91	NOH	Feb/Mr-09	TTM+	1	72.0				
*92	NOH	Feb/Mr-09	TTM+	>1	162.5				
*93	NOH	Feb/Mr-09	TTM+	>1	>1.0				
*94	NOH	Feb/Mr-09	TTM+	>1	>1.0				
*95	NOH	Feb/Mr-09	TTM+	>14	>2121.0				
*96	NOH	Feb/Mr-09	TTM+	4	49.0				

Rec.	Site	Date	Obs.	*Colonies - overall:* # colonies	TpSize(cm^2)	*Colonies - by habitat type:* # colonies - RO	(cm^2) - RO	# colonies - soil	(cm^2) - soil
*97	NOH	Feb/Mr-09	TTM+	1	+				
*98	NOH	Feb/Mr-09	TTM+	11	>25.0				
*99	NOH	Feb/Mr-09	TTM+	11	+				
*100	NOH	Feb/Mr-09	TTM+	5	298.7				
*101	NOH	Feb/Mr-09	TTM+	7	481.0				
*102	NOH	Feb/Mr-09	TTM+	1	54.0				
*103	NOH	Feb/Mr-09	TTM+	10	>635.0				
*104	NOH	Feb/Mr-09	TTM+	9	>3135.0				
*105	NOH	Feb/Mr-09	TTM+	2	306.0				
*106	NOH	Feb/Mr-09	TTM+	>5	>1316.0				
*107	NOH	Feb/Mr-09	TTM+	9	>320.0				
*108	NOH	Feb/Mr-09	TTM+	>50	>2013.0				
*109	NOH	Feb/Mr-09	TTM+	4	90.0				
*110	NOH	Feb/Mr-09	TTM+	1	+				
*111	NOH	Feb/Mr-09	TTM+	1	+				
*112	NOH	Feb/Mr-09	TTM+	50	>1008.0				
*113	NOH	Feb/Mr-09	TTM+	60	>161.0				
*114	NOH	Feb/Mr-09	TTM+	1	75.0				
*115	NOH	Feb/Mr-09	TTM+	>4	7004.0				
*116	NOH	Feb/Mr-09	TTM+	>1	+				
*117	NOH	Feb/Mr-09	TTM+	1	+				
*118	NOH	Feb/Mr-09	TTM+	5	>317.0				
*119	NOH	Feb/Mr-09	TTM+	>1	>266.0				
*120	NOH	Feb/Mr-09	TTM+	2	4300.0				
*121	NOH	Feb/Mr-09	TTM+	3	163.0				
*122	NOH	Feb/Mr-09	TTM+	1	+				
*123	NOH	Feb/Mr-09	TTM+	1	+				
*124	OBS	Mar. 09	KDS+	>1	8.0				
*125	OBS	Mar. 09	KDS+	>1	208.0				
*126	OBS	Mar. 09	KDS+	>1	75.0				
*127	OBS	Mar. 09	KDS+	>1	433.0				
*128	OBS	Mar. 09	KDS+	>1	255.0				