The lichens and bryophytes of Burns Bog, Fraser Delta, southwestern British Columbia

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Accepted October 11, 1983

The lichens (58 species), mosses (60 species) and hepatics (15 species) of Burns Bog are listed with special reference to their abundance and distribution within selected vascular plant communities. The modifying effects of vegetation structure and physiognomy on climate are considered to exert a major control over the observed distributional patterns of the cryptogams. Floristic diversity among the cryptogams is very high and has probably been enhanced by human activity in Burns Bog. At present, air pollution appears to affect lichen growth only at the bog margins. It is possible, however, that a further reduction in local air quality could significantly reduce cryptogamic diversity.

KEY INDEX WORDS: *British Columbia, bryophytes, Burns Bog, ecology, lichens, peat bog, pollution.*

Syesis, **16**:53–69 (1983)

Introduction

The plant assemblages of Burns Bog (40°08′N lat. and 123°00′W long.) in the Fraser Delta of southwestern British Columbia have been documented recently by R. Hebda and W. Biggs (1981). In their study, eight vegetation types were recognized: Heathland, Pine Woodland, Birch Woodland, Spirea Brushland, Mixed Coniferous Woodland, Salmonberry Bushland, Alder Woodland and Disturbed Heathland. Although the authors rather exhaustively characterized each of these vegetation types for vascular plants, comparatively little information on the cryptogamic component was presented. In the case of the lichens, less than 10 per cent of the actual total flora was discussed, while among the bryophytes a number of noteworthy species have been overlooked. No data were given for the unlichenized fungi.

The inclusion of cryptogams, especially bryophytes and lichens, in local floristic and vegetational accounts can significantly increase the value of these studies. For example, since many species occurring in the Pacific Northwest remain poorly known, any well documented records of their frequency may supply important ecological and distributional insights. Many cryptogamic species, moreover, are known to be sensitive to air pollution (Ferry *et al*. 1977). Once a baseline study has been completed for a given area, any later changes in species composition in the absence of overt habitat modification or destruction can normally be interpreted as indicating a change in air quality. This role in pollution monitoring may eventually prove to be a critical one in the case of Burns Bog.

The present paper has been designed to supplement the earlier study of Hebda and Biggs (1981) with a preliminary account of the lichen flora and vegetation of Burns Bog. Secondarily, we have also attempted to augment their discussion of the bryophytes. Where appropriate, notes have been included on the morphology of taxonomically difficult species. It is hoped that these notes may facilitate future floristic and vegetational studies in coastal British Columbia.

Very little previous work has been done on the lichens of Burns Bog. A few species were documented by Osvald (1933) in his classification of bog vegetation in the Pacific Northwest. More recently, Hebden (1975) listed several lichen collections from Burns Bog in her unpublished report, "Macrolichens of the Lower Mainland". Fortunately, voucher specimens exist for many of the records cited, and so it has been possible to verify them in most cases. Further important information has been gleaned both from T. Taylor's "Flora of the Richmond Nature Park" (1977) and from K. Bell's more recent collections from that area. The latest contribution to our knowledge of the Burns Bog lichens is the paper of Hebda and Biggs noted above.

The bryophyte flora of Burns Bog has been somewhat better documented, with 38 mosses and eight hepatics reported by Hebda and Biggs (1981). Although our present study of four of their recognized vegetation types has revealed a considerably larger flora (60 moss species and 15 hepatic species), we were nevertheless unable to locate five of the mosses and five of the hepatics noted by these authors. Most of these, however, were reported from vegetation types that were not explored by us.

The Study Area

Comprehensive details of physiography, geology, soils, climate, hydrology, regional vegetation and land use may all be found in the publication of Hebda and Biggs (1981). In the present connection, it is pertinent only to repeat their characterization of the local climate, a modified maritime type (the Csb of Köppen) with rather rain-free, but humid, summers, and mild and rainy winters, and to provide brief descriptions of the primary vegetation types under consideration here, namely Heathland, Pine Woodland and Birch Woodland (see Figure 1).

Heathland, in general, is restricted to the central area of Burns Bog. Here the tree layer consists mostly of well-spaced and stunted *Pinus contorta*, usually less than 3 m tall. In the drier *Ledum* subtype, the shrub layer is dominated by low ericad thickets, while in the wetter *Sphagnum* subtype, these are more or less interspersed with *Sphagnum* mats and hummocks. The water table lies within a few cm of the surface throughout the year.

Pine Woodland forms a more or less continuous band around the Heathland (Figure 1). The tree layer is again composed mostly of *Pinus*, although the trees are here generally taller (e.g., more than 4 m) and are often rather closely spaced. The shrub layer also resembles that of the Heathland, at least in the drier *Ledum* subtype, though the ericads are taller and *Gaultheria shallon* now appears as a codominant. In the wetter "transitional" subtype, the shrub layer is similar to that of the Birch Woodland, described below. The water table may drop to as much as 1 m below the surface by late summer.

Birch Woodland roughly encircles the Pine Woodland near the periphery of the bog. *Betula papyrifera* is the dominant tree species here, forming either shady copses with almost no shrub layer, or open stands which are interspersed with lush *Pteridium* brakes and *Spiraea* thickets. Although exact data are lacking, the water table here appears to remain rather near the surface throughout the year.

Methods

The present data were gathered over the course of several visits to the southwest corner of Burns Bog during 1982 and 1983. The purpose of these visits was to approximate as closely as possible the transect indicated in Figure 1 of Hebda and Biggs (1981). A brief reconnaissance of the forested northeast corner (Panorama Ridge) was also conducted, though, in keeping with the major local distributional patterns of the bryophytes and lichens, the focus of our attention was directed to the more obvious bog types, namely the Heathland, Pine Woodland and Birch Woodland communities.

Time limitations did not permit us to employ the quadrat sampling techniques of Hebda and Biggs. We relied instead on visual estimates of the cryptogamic cover. Fortunately, a subjective use of the abundance scale outlined in Table I was found for the bryophytes to produce a satisfactory approximation of the cover designations reported by Hebda and Biggs (1981) in their Table II. Our methods, though hardly statistically valid, appear to have yielded data readily conformable with and reproducible by other more stringent techniques.

Voucher specimens of most species were collected. Most of these have been deposited in the University of British Columbia herbarium (**UBC**), though a few remain in Goward's private herbarium.

Nomenclature used in the present paper largely follows Noble (1982) for the lichens; Crum, Steere, and Anderson (1973) for the mosses; and Stotler and Crandall-Stotler (1977) for the hepatics.

Species Accounts

Species marked with an asterisk (*) have not yet been collected from Burns Bog, though it is expected that they may be discovered through future exploration. The use of square brackets [ ] is meant to denote species which, admitted on the basis of earlier reports, should probably be deleted from the flora. Note also that collection numbers are given only for taxonomically difficult or otherwise noteworthy species, and refer to the collecting sequences of Goward for the lichens and Schofield for the bryophytes. The frequency terms employed are defined in Table I.

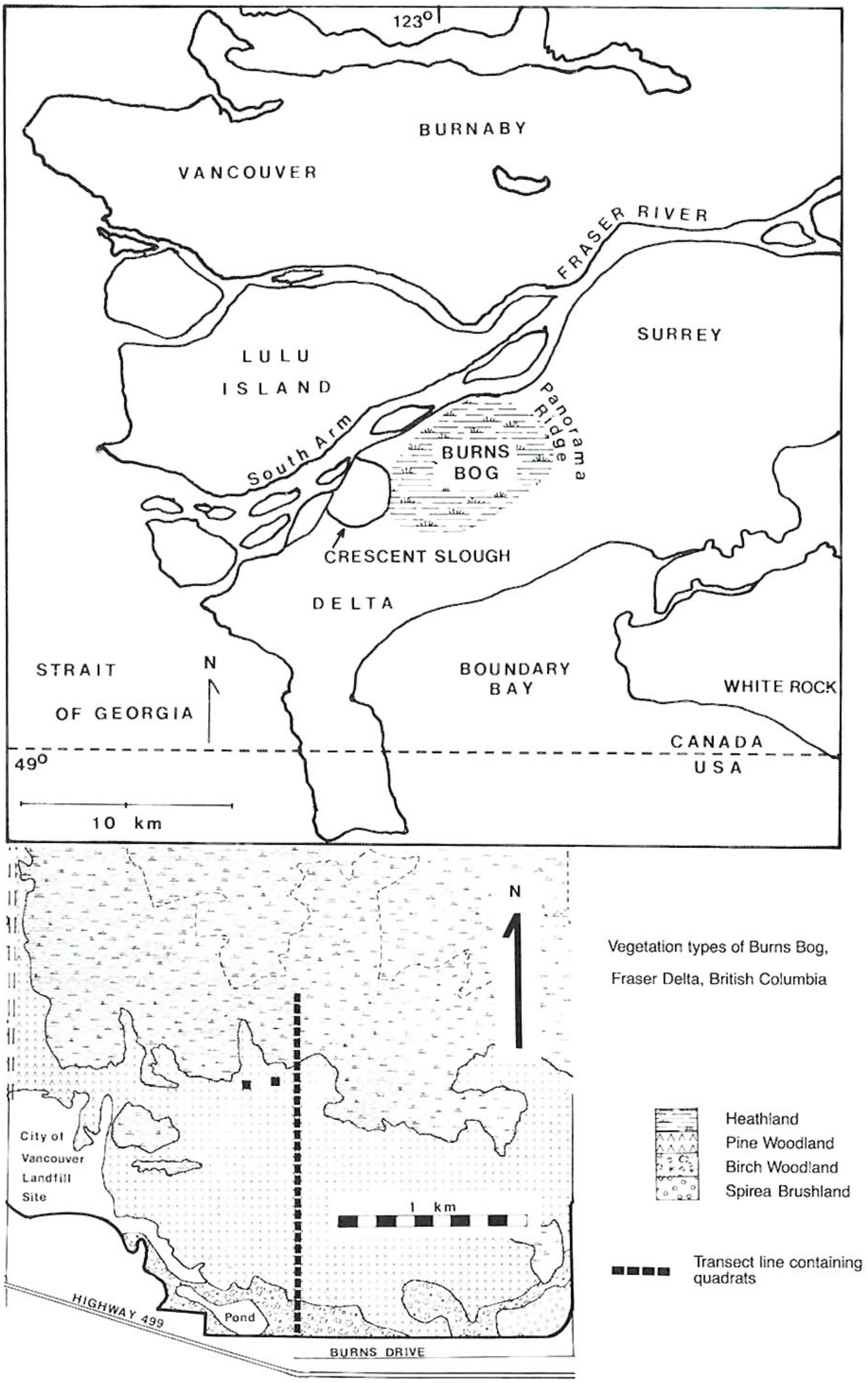

FIGURE 1 — Map of selected vegetation types of Burns Bog, with inset map showing the location of Burns Bog. Adapted from Hebda and Biggs (1981, Figs. 1 and 4).

TABLE I

Frequency values for the lichens of selected vegetation types in Burns Bog, Delta, British Columbia.

Frequency Value	Scale of Abundance Term	Characterization
1	**Very rare**	Observed only once or twice
2	**Rare**	Present in fewer than 20% of hypothetical 10 m^2 plots
3	**Scattered**	Present in 20% to 70% of hypothetical plots
4	**Frequent**	Present in more than 70% of hypothetical plots
5	**Very frequent**	Substratum-dominant or landscape-dominant

Species	Wet Heathland	Dry Heathland	Pine Woodland (Evergreen)	Pine Woodland (Deciduous)	Birch Woodland	Spiraea Brushland
Bryoria sp.	—	—	1	—	—	—
Buellia punctata	—	—	—	—	—	1
Candelaria concolor	—	—	—	2	—	—
Cavernularia hultenii	—	—	—	1	—	—
Cetraria canadensis	—	—	—	1	—	—
C. chlorophylla	—	—	—	2	2	—
C. orbata	—	—	—	—	2	—
C. sepincola	—	—	—	—	2	—
Cladina pacifica	5	3	2	—	—	—
C. rangiferina	3	—	—	—	—	—
Cladonia asahinae	2	2	1	—	—	—
C. bacillaris	2	1	—	—	—	—
C. bellidiflora	4	3	1	—	—	—
C. carassensis	4	3	1	—	—	—
C. cenotes	4	2	—	—	—	—
C. coniocraea	1	1	2	1	1	—
C. cornuta	3	1	—	—	—	—
C. fimbriata	2	—	—	—	—	—
C. gracilis	1	—	—	—	—	—
C. macilenta	2	1	1	1	1	—
C. squamosa	4	3	2	—	—	—
C. subulata	2	1	—	—	—	—
C. vulcani	1	2	3	4	3	—
Coelocaulon aculeatum	1	—	—	—	—	—
Evernia prunastri	—	1	2	3	2	—
Hypocenomyces scalaris	—	—	1	—	—	—
Hypogymnia enteromorpha	—	—	1	2	2	—
H. imshaugii	—	1	—	—	—	—
H. physodes	2	3	3	4	2	1
H. tubulosa	1	2	2	2	—	
Lecanora conizaeoides	—	—	—	—	1	1
L. pacifica	—	—	—	1	3	—
Lecidea uliginosa	2	1	—	—	—	—
Lecidella elaeochroma	—	—	—	—	—	1
Lepraria cfr. *incana*	—	—	2	3	1	—

TABLE I—*Continued*

Frequency values for the lichens of selected vegetation types in Burns Bog, Delta, British Columbia.

SPECIES	WET HEATHLAND	DRY HEATHLAND	PINE WOODLAND (Evergreen)	PINE WOODLAND (Deciduous)	BIRCH WOODLAND	SPIRAEA BRUSHLAND
Melanelia subaurifera	—	1	—	1	2	—
Micarea sp.	—	—	1	2	—	—
Parmelia hydrophila	—	—	—	1	—	—
P. sulcata	2	3	4	4	3	1
Parmeliopsis aleurites	5	4	4	3	2	—
P. ambigua	1	2	2	3	2	1
P, hyperopta	—	—	—	2	1	—
Parmotrema arnoldii	—	1	—	1	—	—
Pertusaria amara	1	2	4	3	—	—
Platismatia glauca	1	2	3	4	2	—
P, herrei	—	—	—	1	—	—
P. norvegica	—	—	—	1	—	—
Scoliciosporum chlorococcum	1	2	4	4	4	1
Usnea sp.	1	2	3	4	2	—
Xanthoria polycarpa	—	2	3	2	3	—

LICHENS

Bryoria sp.

Although a *Bryoria* species somewhat resembling *B. trichodes* (Michx.) Brodo & D. Hawksw. subsp. *trichodes* was collected twice from the branches of exposed *Pinus* snags, accurate identification of the fragmentary specimens has proved impossible. Another earlier report of "*Alectoria jubata*" comes from nearby Richmond Nature Park; owing to the confusion surrounding that name, however, the basionym upon which it is based is currently being discarded. Regrettably, no collection was made, and the species has since disappeared from its former habitat (Taylor, pers. comm.). Very rare. Specimens: 82-315; 83-526.

Buellia punctata (Hoffm.) Mass.

Over fence post in open site, and corticolous over *Sorbus aucuparia* at the periphery of the bog. Rare (or possibly overlooked).

Candelaria concolor (Dicks.) B. Stein

Locally restricted to dead twigs of *Pinus* in open sites, primarily near the bog periphery. Rare to scattered. According to Noble (1982), this species is "frequent in urban areas" on Vancouver Island, but "rare in nonurban environments".

Cavernularia hultenii Degel.

Collected once from the interlaced branches of *Ledum* approximately 15 cm above ground, and once from the lower branches of *Pinus*, both times in the Pine Woodland. Evidently very rare: the present specimens are a first record for the immediate Vancouver area. *Cavernularia* is generally restricted in its distribution to strongly oceanic, and especially very humid, climates (Ahti and Henssen 1965); locally it is restricted to sheltered microhabitats. Specimen: 82-252.

Cetraria canadensis (Räs.) Räs.

Collected from *Pinus* branches in the open Pine Woodland. Very rare. Also recorded from exposed sites on Vancouver Island (Noble 1982), and from similar habitats in Richmond Nature Park as late as 1972, though these latter populations have since disappeared (T. Taylor, pers. comm.). Specimen: 82-313.

Cetraria chlorophylla (Willd.) Vain.

Mostly restricted in the study area to *Betula*, which it colonizes in open, well-lit sites. Scattered. Also rare, however, over *Pinus* near the bog periphery.

Cetraria orbata (Nyl.) Fink

Over *Betula* in well-lit situations near the bog periphery. Scattered.

Cetraria sepincola (Ehrh.) Ach.

Over *Betula* near the bog periphery. Requires open conditions. Scattered.

In view of *C. sepincola*'s decided local affinity for *Betula* species, it is interesting that Noble (1982) did not mention this species as occurring in adjacent parts of Vancouver Island (where *Betula papyrifera* is lacking as a native tree species). On the other hand, according to

Barkman (1958), this species is restricted in the southern part of its range to bog habitats.

[*Cladina mitis* (Sandst.) Hale & Culb.]

Reported from Burns Bog by Hebden (1975), but not observed in the present study, and not expected. Some forms of *C. portentosa*, however, very closely resemble this species.

Cladina portentosa (Duf.) Follm.

(Synonym: *Cladonia pacifica* Ahti; *Cladonia portentosa* subsp. *pacifica* (Ahti) Ahti; *Cladina impexa* (Harm.) B. de Lesd.)

Notwithstanding a considerable morphological variability in the material, it appears that all usnic acid-bearing populations of *Cladina* in Burns Bog should be referred to this species. The several specimens examined combine a negative PD and K reaction with a predominantly trichotomous branching and a UV + bluish white florescence.

Terricolous in well-lit situations. Very frequent in the wet Heathland, where it may achieve a high cover value. Scattered in the Pine Woodland.

T. Ahti (1978) considered the B.C. coastal populations as representative of an as yet unpublished subspecies of *C. portentosa*.

Cladina rangiferina (L.) Nyl.

(Synonym: *Cladonia rangiferina* (L.) Wigg.)

Less abundant than *C. portentosa*, and apparently locally restricted to the wet Heathland. Terricolous in open situations, especially in wettish depressions. Scattered.

Cladonia asahinae Thoms.

(Synonym: *Cladonia chlorophaea* (Floerke ex Somm.) Spreng. s. lat.)

Terricolous over decaying humus on *Sphagnum* hummocks, especially in open sites. Scattered.

Although the present material has been traditionally referred to *C. chlorophaea* (see Taylor 1977 and Hebden 1975), it seems to belong more exactly to *C. asahinae*, a recent segretate of the older aggregate species. *C. asahinae* shows a rather distinctive morphology, the podetium being typically tall, slender, somewhat darkened, and closely covered with tiny, papilla-like 'soredia' which, however, are somewhat hard-corticate throughout, and which grade downwards into protuberant areolae and/or thin, crenulate squamules. The spot tests are K −, C −, KC − and PD + orange.

Cladonia bacillaris Nyl.

Over decaying humus in open hummock situations. Evidently rare, but easily confused with *C. macilenta* in the absence of the appropriate spot tests (see Thomson 1968).

Cladonia bellidiflora (Ach.) Schaer.

Over decaying hummocks, but more abundant in wet, but well-lit, depressions. Often in company with *C. carassensis*. Frequently in the wet and dry Heathland.

Cladonia carassensis Vain.

Most common in wet, seasonally inundated depressions, where it often forms rather extensive colonies. During the wet season, *C. carassensis* apparently sometimes becomes detached from its mucky substratum and floats in shallow puddles of water. Lignum and dry hummocks are also occasionally colonized by this species. Frequent in wet and dry Heathland, but nearly absent elsewhere.

Cladonia cenotea (Ach.) Schaer.

Over decaying humus and moist depressions in open situations. Apparently restricted to the Heathland community. Frequent.

**Cladonia cervicornis* (Ach). Flot. subsp. *verticillata* (Hoffm.) Ahti

Synonym: *C. verticillata* (Hoffm.) Schaer. var. *verticillata*)

Included on the basis of a single well developed specimen collected by T. Taylor in nearby Richmond Nature Park: apparently from decaying raw humus in open heath. Very rare.

[*Cladonia chlorophaea* (Floerke ex Somm.) Spreng. s. lat.]

Though reported by both Taylor and Hebden, most west coast material of the *C. chlorophaea* group apparently should be assigned to *C. asahinae*.

Cladonia coniocraea auct.

Restricted to the branches of *Betula* and especially *Pinus* in rather shady sites. Rare to scattered.

Cladonia cornuta (L.) Hoffm.

Over disturbed humus, mostly in intermediate positions between hummock and depression. Scattered to rare. Also reported by Osvald (1933).

Cladonia fimbriata (L.) Fr.

Collected from disturbed sites in wet Heathland. Also reported from Richmond Nature Park by Taylor (1977). Rare.

[*Cladonia furcata* (Huds.) Schrad.]

Reported from Richmond Nature Park by Taylor (1977). Since this species is presently not recognized from British Columbia (Noble 1982), the report probably should be referred to *C. herrei*.

Cladonia gracilis (L.) Willd. subsp. *turbinata* (Ach.) Ahti

Collected from disturbed humus in open sites, especially over *Sphagnum* hummocks. Rare. Specimen: 82-244.

Cladonia herrei Fink ex Hedr.

Not observed in the field, though two specimens collected from Burns Bog in 1975 by C. Hebden proved to belong to this species. Probably locally very rare, though Noble (1982) reported it as "frequent" from adjacent Vancouver Island.

The proper status of this taxon remains uncertain, particularly as the west coast material would appear to combine the characters of *C. multiformis*, *C. furcata* and, to some extent, *C. scabriuscula*. Until further taxonomic studies have been undertaken, however, it is perhaps advisable to maintain *C. herrei* as a distinct species.

Cladonia macilenta Hoffm.

C. macilenta was collected both from decaying humus and lignum in open situations and, more rarely, from the bark of *Pinus* and *Betula* in somewhat shaded sites. Although it occurs in all of the community types visited, *C. macilenta* is at most rare or scattered.

This species must be carefully distinguished from *C. vulcani*, q.v.

Cladonia metacorallifera Asah. var. *metacorallifera*

Collected once from a decaying *Sphagnum* hummock in the dry Heathland. Very rare. A first record for B.C. of this predominantly northern species. Confirmed by T. Ahti.

Specimen: 82-243.

Cladonia ochrochlora Floerke

Open Heathland hummock situations over decaying humus. Rare.

Specimens: 82-226; 82-240.

Cladonia squamosa (Scop.) Hoffm. var. *squamosa*

A rather widespread lichen in open Heathland situations: over decaying humus on hummocks and in seasonally inundated depressions; also over lignum. Frequent. Also recorded by Osvald (1933). Noble (1982) collected the present (PD −) variety exclusively from the more humid parts of her study area on Vancouver Island.

Cladonia transcendens (Vain.) Vain.

Included here on the basis of a single specimen collected by C. Hebden in 1975. Though also reported from "decomposing heath detritus" in the dry Heathland (Hebda and Biggs 1981), the more usual habitat for this species is on rotten logs and at the bases of conifers (Thomson 1968). *C. bellidiflora* is readily confused with *C. transcendens*, particularly if the chemistry is not checked and the latter's soredia overlooked. Evidently very rare.

Cladonia vulcani Sav.

Observed over the branches of *Pinus* and *Betula* in somewhat shady forest types. Frequent.

C. vulcani is very close in morphology to the locally more widespread (but considerably less frequent) *C. macilenta*—from which it differs in its greener colouration (i.e. usnic acid is present). Ahti (1974) has already noted that the North American populations of this species may not be conspecific with the type (Asian) populations.

Specimens: 82-228; 83-542.

Coelocaulon aculeatum (Schreb.) Link

(Synonym: *Cornicularia aculeata* (Schreb.) Ach.)

Collected from a hummock in an open wet Heathland situation. Observed only once, although also reported by Hebden. Very rare.

Specimen: 83-321.

Evernia prunastri (L.) Ach.

Over branches of *Betula* and *Pinus* in open situations. Populations occurring within 0.5 km of Highway 499 are in poor condition, apparently on account of high levels of atmospheric sulphur dioxide. Scattered, except very rare in the open Heathland.

Hypocenomyce scalaris (Ach.) Choisy

(Synonym: *Psora scalaris* (Ach.) Hook.)

Lignicolous over decaying, fire-charred *Pinus* stumps in open *Ledum* heaths. Owing to the sparse occurrence of its substratum, the present species is apparently locally rare.

Hypogymnia enteromorpha (Ach.) Nyl. s. str.

Although collected from *Betula* and *Pinus*, the present species makes its best local development over the interlaced twigs of low *Ledum* thickets in well-lit, but invariably humid, situations. Rare.

Traditionally, esorediate specimens of *Hypogymnia* growing in the Pacific Northwest have, with few exceptions, been referred to H. *enteromorpha* s. lat. Recent research (see Hale 1979) has revealed, however, that the material might more properly be assigned to as many as five or six segregate species, including *H. enteromorpha* s. str. (Pike and Hale, 1982). Most collections from lower elevations in the Vancouver area belong to either the present species or to *H. imshaugii*.

The local population appears invariably to give a PD + orange-red medullary reaction.

Hypogymnia imshaugii Krog

Observed only once, over *Ledum* in a dry heath. Reported as "extremely rare" from Richmond Nature Park by Taylor (1977).

Hypogymnia physodes (L.) Nyl.

Over twigs and branches of most species of trees and shrubs, including the low-growing ericads. Ranges from open to somewhat shady situations. *H. physodes* is the most widespread member of its genus in the study area. Frequent.

Hypogymnia tubulosa (Schaer.) Hav.

Collected from branches of *Betula* and *Pinus* in well-lit situations. Scattered, except rare in the Heathland.

Lecanora conizaeoides Nyl. ex Cromb.

Scattered over decaying fence post near Highway 499 and over the trunk of a dead *Betula* in a shady site. This toxitolerant lichen was observed only at the margins of the bog.

Lecanora pacifica Tuck.

Most common over the bark of *Betula*, which it colonizes under both open and rather shady conditions. *Pinus* is also rarely colonized. Scattered.

Lecidea uliquinosa (Schrad.) Ach.

Over decaying lignum on *Spagnum* hummocks in open Heathland. Scattered to frequent.

Lecidella elaeochroma (Ach.) Choisy

Observed over *Sorbus aucuparia* branches and over an old fence post in open situations at the bog periphery near Highway 499. Apparently very rare.

Lepraria cfr. *incana* (L.) Ach.

Most common over the sheltered, often shaded undersides of large branches and leaning trunks of *Pinus* and *Betula*. Rare to scattered.

Lepraria, an as yet unmonographed genus, is poorly understood in North America. The present material, however, appears to represent a single taxon. It is pale glaucous green in colour, lacks marginal lobing, and gives a negative reaction with K, C and PD. More typically this species is K+ yellow (atranorin).

Specimen: 82-308.

Melanelia subaurifera (Nyl.) Essl.

(Synonym: *Parmelia subaurifera* Nyl.)

Apparently most frequent over the twigs and branches of *Betula* in somewhat open situations where, with *Parmelia sulcata*, it may occasionally dominate. It occurs also on well-lit *Pinus* branches. Frequent.

Micarea sp.

Growing in association with *Scoliciosporum chlorococcum* over the shaded trunk of *Pinus*. Apparently rare.

**Omphilina* sp.

Taylor (1977) reported *Omphalina umbellifera* from Richmond Nature Park under the superfluous name *Botrydina vulgaris*. Though several populations of an *Omphalina* species were observed during early May in Burns Bog, a cursory search turned up no associated lichen crust. Either rare or overlooked.

Parmelia hygrophila Goward & Ahti

Observed only once: over *Pinus* twigs in the open Pine Woodland with a mixture of *Ledum* and *Pteridium* in the understory. Very rare. Specimen: 83-517.

The present species has been included until recently with *P. saxatilis* from which it differs, however, in producing pale-tipped, often nearly ecorticate "soredio-isidia". The isidia of *P. saxatilis*, in contrast, are dark-tipped and hard-corticate. Further distinguishing characters will be found in Goward and Ahti (1983).

[*Parmelia saxatilis* (L.) Ach.]

Though reported from *Pinus* in nearby Richmond Nature Park (Taylor, 1977), *P. saxatilis* is extremely rare as an epiphyte in the Lower Mainland. It seems probable that these specimens should be referred to *P. hygrophila*.

Parmelia sulcata Tayl.

Found over most woody substrata in both open and somewhat shady habitats. Frequent, except scattered in the Heathland communities.

Parmeliopsis aleurites (Ach.) Nyl.

This species colonizes most woody substrata, including the ericads, but is particularly common over *Pinus* in the drier Pine Woodland and Heathland communities. Here it is very frequent. Given its prominence in Burns Bog, it is intriguing that *P. aleurites* was not encountered by Noble (1982) from adjacent parts of Vancouver Island.

Parmeliopsis ambigua (Wulf.) Nyl.

Over most woody substrata, although seldom abundant. Tolerates considerable shade, but also colonizes well-lit localities. Scattered.

Parmeliopsis hyperopta (Ach.) Arn.

Less common than its frequent associate, *P. ambiqua*; however, present over both *Betula* and *Pinus* in open situations. Rare.

Parmotrema arnoldii (Du Rietz) Hale

(Synonym: *Parmelia arnoldii* Du Rietz)

Observed twice as a minor admixture with *Cladonia macilenta* over *Endocronartium* burls on *Pinus* in rather shaded sites. Very rare.

Specimen: 82-316.

[*Peltigera canina* (L.) Willd.]

Reported by Taylor (1977) from Richmond Nature Park, though not observed in Burns Bog, and not expected. See discussion under *P. membranacea*.

**Peltigera membranacea* (Ach.) Nyl.

Not seen from Burns Bog, though a single healthy specimen collected over moss in an open *Betula* woodland in nearby Richmond Nature park was examined. Apparently very rare.

Although belonging to the *P. canina* group, *P. membranacea* may be distinguished from that species by its discrete, elongate rhizinae and narrow, raised veins, both of which are covered in fine, erect tomentum. The rhizinae of *P. canina*, in contrast, are generally rather flocculent. Neither they nor the veins typically bear tomentum. *P. canina* is predominantly an inland species.

Pertusaria amara (Ach.) Nyl.

Over twigs of *Pinus* and, less commonly, *Ledum* in rather shaded sites. Scattered to frequent, except rare in the Heathland community.

Platismatia glauca (L.) Culb. & C. Culb.

Present over most woody substrata, although locally rather depauperate in all but the most humid situations, especially near the ground over interlaced *Ledum* branches. In the highly xeric Heathland community this species is largely absent altogether, while at the bog periphery, near Highway 499, it is badly deformed. Scattered to frequent.

Platismatia herrei (Imsh.) Culb. & C. Culb.

Observed exclusively over *Pinus* twigs in the open Pine Woodland, particularly in localities having a strong *Pteridium* component in the understory. Rare. Specimen: 83-520.

Platismatia norvegica (Lynge) Culb. & C. Culb.

P. norvegica was noted twice—both times over *Pinus* twigs in the company of the more widespread *P. herrei*. Very rare. Specimen: 83-521.

According to Noble (1982), this species is restricted to the more humid parts of her study area on Vancouver Island.

Scoliciosporum chlorococcum (Stenh.) Vezda

(Synonym: *Bacidia chlorococca* (Stenh.) Lett.)

Widespread over most kinds of bark and lignum, especially in somewhat shaded localities. Very frequent, but less well developed, perhaps, toward the bog centre.

Usnea

The western North American species of the difficult genus *Usnea* are currently undergoing a thorough taxonomic revision by I. Tavares, Berkeley. Accordingly, listed below are only those species whose broad identities have been reasonably well established. It should be noted that at least four additional taxa are known from Burns Bog, some of which may prove to be undescribed (Tavares, pers. comm.).

For a preliminary treatment of the local *Usnea* species, Noble (1982) should also be consulted.

Usnea filipendula Stirt s. lat. Specimen: 82-216 p.p.

Over *Pinus* in open Pine Woodland. Rare.

As already suggested by Noble (1982), the local material may not belong to *U. filipendula* in the strict sense; Tavares (pers. comm.) would consider the Burns Bog collections to represent a "short new subspecies" of *U. filipendula*. The specimens are of a pendent habit, have small, long, narrow papillae and open tubercles with "nests of isidia", and give the following medullary reactions: K+ yellow becoming orange; KC−; C−; and PD+ yellow becoming orange. Also diagnostic are the arched branching and inflated primaries.

Usnea glabrata (Ach.) Vain.

Collected over *Pinus* in open sites in the Pine Woodland. Scattered. Specimens: 82-320; 83-541.

According to Tavares (pers. comm.) this species is common on the west coast of North America, extending as far south as northern California. In addition to its orbicular soralia, it is characterized by a caespitose habit, an extremely lax medulla, a medium to medium-narrow central cord that tends to be yellow, a red-spotted cortex. The medulla reacts K+ pale yellow, KC−, C− and PD− in the local material.

Usnea kujalae Räs. s. lat.

Apparently best developed in humid localities, for example close to the ground over the interlaced branches of *Ledum*. Also collected, however, over *Betula* and *Pinus*. Specimens: 82-200; 82-254.

The present species superficially resembles *U. glabrata*, particularly in its caespitose habit and abundant soredia. *U. kujalae* differs, however, in its slightly denser medulla, uniformly white central cord, lack of red cortical spots, and different medullary reactions: K+ pale yellow; KC−, C−, PD+ yellow becoming orange-red in the local material. According to Räsänen (1933), however, the medulla should give a K− reaction.

Noble (1982) has evidently treated *U. kujalae* within *U. glabrata*.

Usena subfloridana Stirt group

The present taxon occurs over most woody substrata, including *Pinus*, *Betula* and *Ledum*. *U. subfloridana* is probably the most widespread local taxon, being scattered to frequent throughout, except rarer in the Heathland community. Specimens: 82-201; 82-317.

The medullary reactions are K−, KC−, C− and PD− or PD+ yellow. As noted by Noble (1982) a PD− reaction is more common in the local material.

Usnea sylvatica Mot. s. lat.

Over *Pinus* in open Pine Woodland. Rare to scattered. Specimens: 82-216 pp.; 83-539.

U. sylvatica may be distinguished from other local Usneae by its pendulous habit, abundant isidia-like spinules, and large protruding tubercles (these last often occurring only over the primary branches). The medulla, moreover, is thin and dense and gives the following reactions: K+ yellow becoming orange; KC−; C−; and PD+ yellow becoming orange. Tavares (pers. comm. 1982) points out the resemblance of this species to *U. rugulosa*. The papillae in the latter species, however, are smaller and less protruberant.

[*Xanthoria candelaria* (L.) Th. Fr.]

Reported from *Pinus* in nearby Richmond Nature Park by Taylor (1977), but not observed during the present study. The record may actually be based on *Candelaria concolor*, a morphologically quite similar species.

Xanthoria polycarpa (Hoffm.) Rieber s. lat.

Over twigs of *Betula* in open situations. Also reported from Richmond Nature Park from *Pinus*. Scattered.

The material is apparently not conspecific with the European or eastern North American populations of *X. polycarpa*, differing primarily in its looser habit and often partly terete lobes. In *X. polycarpa* s. str., by contrast, the thallus is more or less closely appressed and the lobes dorsiventral. It is possible that the correct name for the local taxon is *X. ramulosa* (Tuck.) Herre; further studies, however, are pending.

MOSSES

Antitrichia curtipendula (Hedw.) Brid.

Extremely rare on an old birch tree in *Betula* woodland. Hebda and Biggs (1981) noted it also from Mixed Coniferous Woodland, Salmonberry Woodland and Alder Woodland, where it tends to be frequent in the Lower Mainland.

Aulacomnium androgynum (Hedw.) Schwaegr.

Noted by Hebda and Biggs from most vegetation types. It occurs most commonly on organic substrata and is frequent in forested sites.

Aulacomnium palustre (Hedw.) Schwaegr.

Widely scattered on wetter organic substrata, thus on peat in the Birch and Pine Woodlands and in the Heathland.

Brachythecum albicans (Hedw.) B.S.G.

Rare in the drier Heath, usually on better drained hummocks.

Brachythecium frigidum (C. Muell.) Besch.

On organic substrata in the Birch Woodland and Spiraea Bushland.

Calliergon stramineum (Brid.) Kindb.

Rare on *Sphagnum* hummock in open Heathland.

Ceratodon purpureus (Hedw.) Brid.

Extremely rare; noted once in a well drained hummock in the Heathland.

Claopodium crispifolium (Hook.) Ren. & Card.

Noted once at the base of a *Betula* tree in the Birch Woodland, but noted by Hebda and Biggs from mixed Coniferous Forest, Salmonberry Bushland and Alder Woodland.

Dicranella cerviculata (Hedw.) Schimp.

Extremely rare on cut peat banks in Heathland.

Dicranodontium denudatum (Brid.) Britt. *ex*. Williams

Locally abundant on exposed peat of trail margin through peatland and apparently confined to this disturbed habitat.

Dicranoweisia cirrata (Hedv.) Lindb. *ex* Milde

Rare on trunks of birches in Birch Woodland, and on *Endocronartium* burls on pines in Pine Woodland.

Dicranum fuscescens Turn.

Noted by us as extremely rare on old birch in Birch Woodland and in pine in Pine Woodland but noted by Hebda and Biggs (1981) on a wider range of habitat types.

Dicranum scoparium Hedw.

In most habitat types; predominantly terrestrial.

Dicranum tauricum Sapeh.

Extremely rare on rotten log in Birch Woodland.

Drepanocladus uncinatus (Hedw.) Warnst.

Noted by Hebda and Biggs (1981) from Birch Woodland and Salmonberry Bushland.

Fontinalis sp.

Noted by Hebda and Biggs from Salmonberry Bushland. The probable species is *F. antipyretica* Hedw.

Funaria hygrometrica Hedw.

Noted once in a hummock in Heathland.

Herzogiella striatella (Brid.) Iwats.

A single population noted at the base of a birch tree in the Birch Woodland. It is the only locality for this species in the Lower Mainland. Specimen: 77726.

Homalothecium fulgescens (Mitt. *ex* C. Muell.) Lawt.

Rare on birch in Birch Woodland; noted by Hebda and Biggs (1981) in Alder Woodland.

Hylocomium splendens (Hedw.) B.S.G.

From a wide diversity of habitat types.

Hypnum circinale Hook.

Rare on birch trees and rotten logs in Birch Woodland.

Hypnum subimponens Lesq.

Rare on boulder in Birch Woodland.

Isopterygium elegans (Brid.) Lindb.

Reported by Hebda and Biggs (1981) from Birch Woodland and Alder Woodland.

Isothecium stoloniferum Brid.

Noted by Hebda and Biggs from all habitat types, but we noted none in the Heathland.

Kindbergia oregana (Sull.) Ochrya

= *Stokesiella* in Hebda and Biggs and noted by them in all habitat types. We found it to be frequent in the woodland types.

Kinderbergia praelonga (Hedw.) Ochrya

= *Stokesiella* in Hebda and Biggs who noted it from forest vegetation types. It was frequent also in the Spirea Bushland.

Leucolepis menziesii (Hook.) Steere. *ex* L. Koch.

Reported by Hebda and Biggs from Mixed Coniferous Woodland, Alder Woodland.

Metaneckera menziesii (Hook. & Drumm.) Steere

Noted by Hebda and Biggs from Mixed Coniferous Woodland.

Mnium spinulosum B.S.G.

From Mixed Coniferous Woodland, Salmonberry Bushland and Alder Woodland, Hebda and Biggs.

Orthotrichum consimile Mitt.

Reported by Hebda and Biggs from Mixed Coniferous and Alder Woodland as well as Salmonberry Bushland. We found it to be extremely rare in the Pine Woodland.

Orthotrichum lyellii Hook. & Tayl.

Noted by Hebda and Biggs from Salmonberry Bushland and Alder Woodland. We found it to be rare in the Birch and Pine Woodlands.

Plagiothecium laetum B.S.G.

Frequent at bases of trees in the Birch Woodland and at bases of shrubs in Spiraea Bushland.

Plagiothecium undulatum (Hedw.) B.S.G.

We found it only on the floor and over logs in the Birch Woodland, and Salmonberry Bushland. Hebda and Biggs (1981) noted it also in the Mixed Coniferous and Alder Woodlands and the Salmonberry Bushland.

Pleurozium schreberi (Brid.) Mitt.

Hebda and Biggs reported this from all vegetation types; we found it to be most common in the drier Heath and Pine Forest.

Pohlia nutans (Hedw.) Lindb.

Abundant in the Birch Woodland, especially on peat, and also intermixed in *Sphagnum* hummocks in the drier Heathland.

Polytrichum commune Hedw.

Although Hebda and Biggs reported this from most vegetation types, we found it to be rare and present only in the Birch Woodland.

Polytrichum juniperinum Hedw.

Hebda and Biggs reported this species from Heathland, Pine Woodland and Spirea Brushland. It is probable that much of their material was actually *P. strictum* Brid., a species often included within *P. juniperinum*. We found *P. juniperinum* to be present in the Birch and Pine Woodlands, but absent in the Heathland.

Polytrichum longisetum Brid.

This was locally abundant on peat banks of a drainage ditch in the Birch Woodland.

Specimen 77708.

Polytrichum strictum Brid.

Abundant in both the wet and dry Heathland, where it grows intermixed in *Sphagnum* hummocks in the wetter Heathland, but in pure clones in the drier. It was present also in the Pine and Birch Woodlands.

Ptilium crista-castrensis Hedw. Ne Not.

This was very rare in the dry Heathland and Pine Woodland. It is the only locality for this species in the Lower Mainland. Specimen: 77719.

Rhacomitrium varium (Mitt.) Jaeg. & Sauerb.

Rare on a single stone in the Birch Woodland.

Rhizomnium glabrescens (Kindb.) Kop.

= *Mnium* in Hebda and Biggs (1981), where they reported it from most woodland habitats. It occurs on both peat and rotten logs.

Rhytidiadilphus loreus (Hedw.) Warnst.

This was reported from all vegetation types by Hebda and Biggs, but we found it to be common only in the Birch Woodland.

Rhytidiadelphus triquetrus (Hedw.) Warnst.

This showed a similar distributional pattern to *R. loreus*.

Sphagnum angustifolium C. Jens.

Frequent, especially in wet depressions in the heathland.

Sphagnum capillifolium (Ehrh.) Hedw.

This species was abundant only in the drier Heathland, where it formed rounded hummocks, from which stems of *Ledum* often emerged.

Sphagnum fallax (Klinggr.) Klinggr.

Frequent, especially in wet depression in heathland.

Sphagnum fuscum (Schimp.) Klinggr.

Common in the wetter Heathland.

Sphagnum henryense Warnst.

Frequent in wet area of bog, especially in heathland.

Sphagnum imbricatum Hornsch. *ex* Russ.

Infrequent in the drier portions of the Heathland. Specimen: 77526.

Sphagnum magellanicum Brid.

Rare in the drier portions of the Heathland.

Sphagnum palustre L.

Very rare in the Heathland and locally abundant near a drainage ditch in the Birch Woodland.

This showed a similar distributional pattern to *Rhytidiadelphus loreus*.

Sphagnum papillosum Lindb.

Common in the wetter Heathland.

Sphagnum rubellum Wils.

Common in the wetter Heathland.

Sphagnum tenellum Ehrh. *ex* Hoffm.

Locally abundant in open areas, especially near pools in the Heathland.

Tetraphis pellucida Hedw.

Abundant only in the Birch Woodland, where it occurred on peat and rotten logs, but noted by Hebda and Biggs (1981) also in the Pine Woodland and Mixed Coniferous Woodland.

Tetraplodon mnioides (Hedw.) B.S.G.

On dung in dry Heathland, very rare. This is the only locality for this species in the Lower Mainland. Specimen: 77529.

Ulota obtusiuscula C. Mull. & Kindb. *ex* Macoun & Kindb.

Very rare on birch and pine trees.

HEPATICS

Calypogeia fissa (L.) Raddi
On moist peat in Heathland.

Calypogeia muelleriana (Schiffn.) K. Muell.
On peat bank in Birch Woodland.

Cephalozia bicuspidata (L.) Dum.
Rotten log in Birch Woodland.

Cephalozia connivens (Dicks.) Lindb.
Moist shaded peat in Heathland. This is the only locality for this species in the Lower Mainland.

Cephaloziella divaricata (Sm.) Schiffn.
Damp humus hummock in Heathland.

Cladopodiella fluitans (Nees) Joerg.
Rare in shallow pool in Heathland.

Frullania tamarisci (L.) Dum., ssp. *nisquallensis* (Sull.) Hatt.
Reported by Hebda and Biggs from Mixed Coniferous Woodland and Salmonberry Bushland.

Gymnocolea inflata (Huds.) Dum.
On shaded peat hummocks in Heathland.

Kurzia makinoana (Steph.) Grolle
Rare on shaded peat hummocks in Heathland.

Lophocolea cuspidata (Nees) Limpr.
On rotten logs and birch trees in Birch Woodland.

Marchantia polymorpha L.
Reported by Hebda and Biggs (1981) from Pine Woodland. This is an unusal habitat for this species; we did not see it.

Mylia anomala (Hook.) S. Gray
On disturbed peat and in *Sphagnum* hummocks in the Heathland.

Pellia neesiana (Gott.) Limpr.
Noted by Hebda and Biggs from Mixed Coniferous Woodland and Salmonberry Bushland.

Porella sp.
Noted by Hebda and Biggs from Mixed Coniferous Woodland, Salmonberry Bushland and Alder Woodland. The probable species is *P. navicularis* (Lehm. & Lindenb.) Lindb., since J. Godfrey (1978) noted that species from the general area.

Ptilidium californicum (Aust.) Underw.
On birch trunk and log in Birch Woodland.

Radula sp.
Reported from Alder Woodland by Hebda and Biggs. The probable species is *R. complanata* (L.) Dum., although *R. bolanderi* Gott. is also possible.

Riccardia latifrons Lindb.
Wet peaty hole in Heathland.

Scapania bolanderi Aust.
From Mixed Coniferous Woodland, Salmonberry Bushland and Alder Woodland, Hebda and Biggs (1981).

Discussion

In broad outline, the distributional patterns assumed by the bryophytes and lichens of Burns Bog correspond well with the vegetation types proposed by Hebda and Biggs (1981). Although such a correspondance may in part be accounted for by differences in substratum availability among these communities, a much more important influence would appear to be that of microclimatic expression. Microclimate is well known to exert a major control over the details of local cryptogamic distribution (e.g. Barkman 1958). In the context of Burns Bog, it is clear that microclimate varies considerably from community to community, and is itself controlled by vegetation physiognomy and structure.

Vegetation "physiognomy", as used here, refers to the most obvious features of a given community type, particularly the size and spacing of its dominant vascular species. In Burns Bog the tendency is for rather closed communities of tall plants to occur near the bog periphery, and open communities of dwarfed plants in the central area. As a result, illumination of the shrub and herb layers increases in the direction of the bog centre, while ambient humidity might be expected to decrease.

Vegetation "structure", in turn, refers to the dominant life form of a community type, that is, whether sclerophyllous (evergreen) or mesophyllous (deciduous). As noted by Barkman (1958), evapotranspiration in sclerophyllous communities is normally minimal, and humidity comparatively low. In mesophyllous communities, by contrast, a more heavily transpiring vegetation tends to create a highly ambient atmospheric humidity. In Burns Bog, the peripheral community types are predominantly deciduous in structure, while the central types, and in particular the Heathland, are comprised increasingly of evergreen species. The major effect of vegetation structure on microclimate would therefore be to accentuate the gradient from humid bog margin to relatively arid bog centre, noted above.

Illumination as a factor controlling cryptogamic distribution

In the case of the Birch Woodland, a comparatively closed canopy tends to reduce incident solar radiation, apparently often to levels prohibiting the establishment of most lichen species. Especially the ground layer is affected. The terricolous lichens, for instance, account for only about five per cent of the total community lichen flora. Although the ground-dwelling bryophytes fare considerably better (several species thrive here, for instance *Dicranum scoparium* and *Kindbergia oregana*), some species are largely excluded from the Birch Woodland by the smothering effect of an annual leaf fall. In more open situations, a riotous growth of *Pteridium* and *Spiraea* deters the establishment of nearly all bryophyte species, except, for example, *Kindbergia praelonga*.

The arboreal cryptogams are slightly better represented here, though it is only in the most open situations that foliose and fruticose lichens are encountered. Elsewhere in the Birch Woodland, and even in relatively well lit situations, trunks and branches are colonized almost solely by the toxitolerant crustose *Scoliciosporum chlorococcum*. In this connection it may be noted that similar birch forests in thermally more continental parts of British Columbia often support a considerably richer lichen flora. Why this should be is not clear. While it may be argued that the prevailing high atmospheric humidity of the local Birch Woodland community is detrimental to the establishment of most lichen species, the possibility should not be overlooked that macrolichens may also be excluded through competition with the here favoured *Scoliciosporum* crusts.

In the more broadly open Pine Woodland, by contrast, illumination is seldom limiting to even the most light-demanding of the arboreal cryptogams. Thus, the widespread occurrence of various *Usnea* species, as well as the occasional appearance of *Cetraria canadensis*, would seem to indicate that a considerable fraction of the incident solar radiation penetrates the forest canopy, particularly in more open stands. A luxuriant shrub layer, on the other hand, largely blocks the establishment of most terrestrial cryptogams, though occasional openings do occur. In these the bryophyte *Pleurozium schreberi* forms often impressive carpets.

Finally, in the Heathland a sparse and dwarfed tree layer combines with a similarly sparse and dwarfed shrub layer to ensure a high degree of illumination even at ground level. Hebda and Biggs (1981) have already commented on the striking representation of terrestrial cryptogams in the Wet Heathland, notably members of the largely acidophilous genus *Cladonia*. While some *Cladonia* species, including *C. asahinae*, *C. macilenta* and *C. squamosa*, are of rather widespread occurrence in the bog (see Table I), others appear to be locally restricted to this community type, for instance *C. cornuta*, *C. cenotea*, *C. gracilis*, *C. metacorallifera* and *C. fimbriata*. Also remarkable is *Cladina portentosa* which, in favourable sites over *Sphagnum* hummocks, competes with *Ledum groenlandicum* for visual dominance.

No fewer than 18 species of *Cladonia* (s. lat.) are presently known to occur in the Heathland community. It is expected that future collecting may bring the total closer to 20 species: doubtless one of the richest assemblages of this genus in the lower mainland of British Columbia. Especially *C. carneola*, *C. cervicornis* ssp. *verticillata*, *C. phyllophora* and *C. pyxidata* should be sought.

Humidity as a factor controlling cryptogamic distribution

In addition to their effect on illumination, the structure and physiognomy of a given community type also control cryptogamic distribution by modifying the local details of atmospheric humidity. Since at least some lichens, including desert species (Friedmann and Galun 1974), can employ atmospheric humidity as an alternate source of water supply, it might be expected that this factor is a criticial one in lichen ecology. The physiology of many, if not most, lichen symbioses apparently requires that the lichen be wetted and dried at more or less frequent intervals (Armstrong 1976; but see also Ahmadjian and Jacobs 1981). Accordingly, habitats having consistently high levels of relative humidity may be generally unsuited to lichen growth. On the other hand, many moss and, in particular, hepatic species will be favoured by just such an environment.

In the Birch Woodland community, a relatively high rate of evapotranspiration from the predominantly mesophyllous understory and canopy layer would tend to maintain a high ambient humidity. The closed nature of the birch stands would likewise serve to retain humidity, both by reducing solar radiation and by largely excluding the drying effects of air circulation (Geiger 1965). It is therefore not surprising that arboreal lichens are here largely restricted to the highly insolated branches of solitary trees. These habitats, it may be noted, provide the only local sites for *Cetraria orbata* and *C. sepincola*. The latter species has not hitherto been reported from coastal British Columbia.

The Pine Woodland community can be divided roughly into two subtypes, depending on whether the dominant shrub layer is mesophyllous, as toward the bog periphery, or sclerophyllous, as toward the bog centre (see Table I). Atmospheric humidity is no doubt generally higher in the mesophyllous subtype than in the sclerophyllous subtype, as already discussed. It is therefore not surprising that a number of relatively hygrophytic arboreal cryptogams occur here, including *Cavernularia hultenii, Hypogymnia enteromorpha* and *Platismatia norvegica*. Against this background of high ambient relative humidity, however, the comparative openness of the Pine Woodland would presumably introduce frequent dry intervals. These, in turn, could be expected to favour the establishment of an extensive arboreal lichen flora. Apparently reflecting this, the mesophyllous subtype of the Pine Woodland supports a greater number of arboreal lichen species than any other local community type. Several species occur locally nowhere else: e.g. *Cavernularia hultenii, Cetraria canadensis, Parmelia hygrophila, Platismatia herrei*.

An unusual microhabitat is associated with the branches of *Pinus contorta* where, in response to infection by the rust fungus *Endocronartium harknesii* (J. P. Moore) Y. Hiratsuka, knot-like burls are frequently produced. These outgrowths favour populations of *Cladonia macilenta, C. asahinae, C. coniocraea* and, especially, *C. vulcani*. Occasionally admixed with these, moreover, are the foliose species *Hypogymnia physodes, Parmelia sulcata* and *Parmotrema arnoldii* — the last a locally rare taxon which in Burns Bog appears to be more or less faithful to this habitat. Among the bryophytes, *Dicranoweisia cirrata* and *Isothecium stoloniferum* are particularly favoured. The burls often support thriving cryptogam populations even when the adjacent branch surface is uncolonized. Presumably a greater moisture-retaining capacity on the part of the burl is the dominant controlling factor here.

For many arboreal cryptogams the sclerophyllous subtype of the Pine Woodland is considerably less suited to colonization. While many species show distinct signs of environmental stress (for example, *Platismatia glauca* frequently occurs here in a stunted and blackened form), others display a less-than-optimum cover value (*Hypogymnia physodes*, for example, has a 5% cover here, as compared with a cover often more than 30% in the mesophyllous Pine Woodland), or disappear altogether (as in the case of *Cetraria chlorophylla* and *Melanelia subaurifera*, among others). At the same time *Parmeliopsis aleurites*, a xerophyte that seldom attains a cover value of more than 5% in the mesophyllous Pine Woodland, here becomes a strikingly abundant species, with a cover value often exceeding 30%.

Alternating with the Sphagnum hummocks in the wet Heathland community are shallow, flat-bottomed depressions. During much of the winter half-year, these are partly inundated with standing water, and even in summer, according to Hebda and Biggs (1981), the water table seldom lies at more than a few cm below the surface. The peculiar hydrological conditions associated with these depressions favour the development of extensive *Cladonia* mats (particularly *C. bellidiflora, C. squamosa* and *C. carassensis*), perhaps through the exclusion of the otherwise competitive vascular plant species. Of these mat-producing species, *C. carassensis* would seem to be best adapted to this habitat: during the winter months that species occasionally floats in loose rafts over the surface of the inundated depressions, often coming to rest the following spring in the open central portions. It should be noted, however, that *C. carassensis* is by no means restricted to these mucky depressions, but colonizes also the more xeric *Sphagnum* hummocks.

On the other hand, a low atmospheric humidity at the level of the tree layer in the Heathland community clearly limits the establishment of most arboreal bryophytes and lichens. The bryophytes in particular avoid arboreal habitats nearly altogether, while among the lichens, the genera *Platismatia* and *Usnea*, for example, are restricted either to the shrub layer or, in more sheltered sites, to the basal branches of the Pines. It is interesting that in shaded sites a fairly extensive *Scoliciosporum* crust still develops. Elsewhere, however, up to 90% of the cryptogamic cover is accounted for by three foliose lichens, namely *Hypogymnia physodes, Parmelia sulcata* and *Parmeliopsis aleurites*. In total, less than 15% of the cryptogamic flora of the Heathland community is accounted for by arboreal species.

Parmeliopsis aleurites

On the basis of its distribution in other parts of North America and Europe, *P. aleurites* appears to favour rather continental climates. Noble (1982), for example, did not report it from her study area on Vancouver Island, nor have other authors recorded it from coastal British Columbia. In contrast, this species is quite common from inland areas

(Goward, unpubl.), as well as from interior and eastern North America (Ahti 1964, Bird 1972, Brodo 1968). In Scandinavia, Dahl and Krog (1973) described its ecology and distribution in the following terms: "Usually on pine . . . in continental, boreal areas, widespread". The high cover value of *P. aleurites* in the Heathland community of Burns Bog may therefore indicate a locally unusual degree of climatic continentality. This interpretation is consistent with the findings of various climatologists, including Rigg (1947) and Williams (1966) who noted that, owing to the poor thermal conductivity of *Sphagnum*, as well as to other factors, the diurnal temperature spread in bogs is conspicuously wider than in adjacent areas. Although apparently no data are available on daily fluctuations in the relative humidity of bogs, it can be postulated that the values would tend to be correspondingly exaggerated.

Pollution

Atmospheric pollution does not yet appear to pose a serious threat to the arboreal lichen flora of Burns Bog. Although it might be argued that the local absence of such highly SO_2-sensitive genera as *Lobaria* and *Sticta* already points to some degree of atmospheric deterioration, it is equally possible that considerations of microclimate or substratum may of themselves exclude these lichen genera. At any rate, to judge from the "healthy" appearance of the next most sensitive genera, namely *Evernia* and *Usnea* (see Gilbert 1974), SO_2 concentrations cannot yet be very high in the bog. The only important exception occurs at the bog perimeter, where the proximity of Highway 499 appears to affect lichen growth for distances of up to half a km. Within this narrow peripheral zone, even such comparatively pollution-resistant genera as *Platismatia* and *Hypogymnia* show definite signs of pollution stress, while the toxiphilous *Lecanora conizaeoides* makes its only known local appearance.

On the other hand, it is probably significant that the crustose lichen *Scoliciosporum chloroccum* occurs over trees throughout Burns Bog: in coastal British Columbia, at least, this highly toxitolerant species (Ahti and Vitikainen 1974) appears to be rather closely associated with human settlement, becoming scarce or absent in uninhabited areas. The fact that even the central portions of Burns Bog now support this lichen may suggest that air quality has already somewhat deteriorated over the area as a whole.

Conclusions

Substratum diversity in Burns Bog is rather low, especially when compared with that of most other local ecosystems. Owing, for example, to a general absence of boulders and rock outcrops, no obligate saxicoles are represented in the flora. Calcicolous species are also excluded by reason of the total predominance of acidic substrata. The fact, moreover, that essentially only four phorophyte species (*Betula papyrifera, Ledum groenlandicum, Pinus contorta* and *Sphagnum* spp.) occur in Burns Bog must further reduce floristic diversity through the exclusion of crustose lichens adapted to unrepresented bark types (see Brodo 1974).

On the other hand, as a result of the rather distinct patterns of vegetation zonation adopted by Burns Bog's vascular plants, microclimatic expression here is extremely varied. One of the major effects of this is to promote correspondingly distinct patterns of cryptogamic distribution. Thus, while some vascular communities, for example the Pine Woodland, support a well developed arboreal flora, others favour a rich assemblage of terrestrial species, especially in the genera *Cladonia* and *Sphagnum*. It is perhaps not surprising, therefore, that Burns Bog, with a combined lichen and bryophyte flora of some 130 species, probably contains a richer cryptogamic component than any other local area of equal size. Also noteworthy is the fact that included among Burns Bog's lichens and bryophytes are several species not yet recorded elsewhere in the lower mainland of British Columbia: *Cavernularia hultenii; Cephalozia connivens; Cetraria sepincola; Herzogiella striatella; Parmeliopsis aleurites; Ptilium crista-castrensis* and *Tetraplodon mnioides*. *Cladonia metacorallifera*, moreover, is a new record for the province.

Hebda and Biggs (1981) have noted the modifying influence of human activity upon Burns Bog's vegetation assemblages. It is significant, for instance, that the Birch Woodland and Pine Woodland communities apparently owe their existence to local hydrological changes associated with the peat mining industry. These communities today provide critical habitats for many arboreal species; accordingly, it is possible to view man's impact upon the cryptogamic component of Burns Bog as primarily a positive one. Not even the pollution factor appears as yet to have adversely affected the cryptogamic flora. On the contrary, at least some species, for example the toxiphilous *Lecanora conizaeoides* and

Scoliciosporum chlorococcum, actually may have been introduced by reason of a slight deterioration in atmospheric quality.

At the same time it must be emphasized that any further deterioration in local air quality could substantially reduce Burns Bog's cryptogamic component. Since arboreal species are generally more adversely affected by atmospheric pollution than are terricolous species (Gilbert 1974), it is especially critical that those communities supporting the richest arboreal floras are located near the bog periphery. Here a pollution effect is apparently already visible in the reduced vigour of many lichen species. On a local scale, the potential severity of the pollution effect is exemplified in nearby Richmond Nature Park, where a formerly diverse arboreal flora has been much reduced during the past decade (T. Taylor, pers. comm.). Indeed, among the macrolichens, only such relatively toxitolerant species as *Hypogymnia physodes* and *Parmelia sulcata* today persist in any numbers.

It is hoped that the present paper, by outlining the current status of lichens and bryophytes in Burns Bog, will both signal a greater concern for the maintenance of its considerable floristic diversity, and provide a baseline against which to evaluate future shifts in local atmospheric quality.

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Grateful acknowledgement is extended to several people for their contributions to this paper: to Dr. W. J. Noble for her generous assistance in identifying the crustose species; to Dr. T. Ahti for his comments on the local Cladoniae; to Dr. I. Tavares for her assistance with the genus *Usnea*; to Mr. T. Taylor for providing useful information on the lichens of Richmond Nature Park; to Ms. K. Bell, Mr. T. McIntosh and Mr. J. Spence for directly and indirectly augmenting our knowledge of the local cryptogamic flora; and, finally, to Drs. T. Ahti and I. M. Brodo and Mr. T. McIntosh for kindly examining the manuscript and providing valuable suggestions.

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