

Mires of Vancouver Island, British Columbia:
Vegetation Classification
and
Differences Between Disturbed and Undisturbed Mires

by

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We accept this dissertation as conforming to the required standard.

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ABSTRACT

My research focuses on three key aspects of mire ecology: 1) delineation of mire regions using floristic criteria; 2) classification of mire plant communities on Vancouver Island, British Columbia; and 3) determining whether floristic, hydrological, and chemical differences exist between disturbed and undisturbed mires. Mires are generally uncommon in southwestern B.C., and have high conservation significance owing to their rarity and uniqueness. Many mires have been affected by human disturbance, particularly drainage.

I identified four floristically and geographically distinct groups of mires based on ordination and classification of floristic data. I also confirmed that mires occurring at low elevations on northern and western Vancouver Island are floristically similar to those in the Prince Rupert area of northwestern B.C., and that mires found at low elevations on eastern Vancouver Island are similar to those on the adjacent Mainland.

At the community scale, I identified 20 plant associations. I grouped the associations into six orders. The *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order consists of 10 associations characterizing hummock, lawn, and heath communities found in bogs and poor fens. The *Triantha glutinosa* order includes six associations typifying lawn communities in moderate-rich and rich fens. The remaining four orders (i.e., the *Eriophorum angustifolium* order, the *Juncus supiniformis* order, the *Rhynchospora alba* - *Scheuchzeria palustris* order, and the *Nuphar lutea* ssp. *polysepala* order) each consist of single associations characterizing communities occurring in wet microhabitats.

I used statistical analyses to confirm the existence of significant differences in seasonal water table fluctuations and chemical composition of soil water between disturbed and undisturbed mires on eastern Vancouver Island. Seasonal water table fluctuations are typically greater in disturbed mires, as are specific conductivity values and most major cation concentrations. Conversely, pH values in disturbed mires are relatively low.

Vegetation structure and community composition also differs between disturbed and undisturbed mires. Central areas of disturbed mires are characterized by dense, species-poor tree and shrub communities, and an absence of communities associated with wet microhabitats. While plant species richness at the site scale is relatively low in disturbed mires, at the plot scale it is not significantly lower than in undisturbed mires.

Examiners:

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CHAPTER 1

GENERAL INTRODUCTION

Mires¹ are peat-accumulating wetlands characterized by an abundance of hydrophilic bryophytes, a water table that remains at or near the ground surface throughout the year, and low nutrient availability (Gore 1983, Zoltai and Vitt 1995). Mires typically occur in regions having abundant precipitation and relatively limited moisture losses to evapotranspiration. In somewhat drier areas they are confined to permanently moist sites with little water movement, usually at the margins of small lakes (Damman and French 1987).

Mires are commonly divided into bogs and fens using hydrological criteria. Bogs receive water and nutrient inputs solely from direct precipitation as a result of the mire surface being situated above the surrounding landscape. Fens receive additional nutrient inputs from water that has flowed through mineral soil. They are less acidic than bogs, and typically have greater cation concentrations (Sjörs 1950, 1952, Malmer 1962, Vitt 1994, 2000, Rydin et al. 1999).

My research focuses on three key aspects of mire ecology: 1) delineation of mire regions using floristic criteria; 2) classification of mire plant communities; and 3) determining whether floristic, hydrological, and chemical differences exist between disturbed and undisturbed mires. All three areas of investigation are critical to mire conservation.

Classification establishes the range of mire types and mire plant communities present within a geographical region, providing a means to assess whether individual mire types and mire plant communities are adequately represented in conservation strategies (Moen

¹The terms *peatland* and *mire* have often been used synonymously (e.g., Vasander 1996, Vitt 2000).

However, most European ecologists use *peatland* to refer to areas having an accumulation of peat but not necessarily intact vegetation, whereas *mire* denotes functioning wetlands with intact, potentially peat-forming vegetation (e.g., Moen 1995, 2003, Maltby 1997, Rydin et al. 1999, Joosten and Clarke 2002).

1985, 2003, Rydin et al. 1999). It is also useful for identifying ecological relationships between vegetation and environmental variables. Such knowledge is useful for many aspects of mire conservation, including management and restoration (Gorham 1990).

Determining whether disturbed and undisturbed mires differ floristically, hydrologically, and chemically is also important for conservation. Disturbance, particularly drainage, alters vegetation structure, plant community composition, water storage capacity, hydroperiod, and nutrient availability (Laine and Vanha-Majamaa 1992, Verry 1997, Bollens et al. 2001). Results of studies comparing disturbed and undisturbed mires are useful for setting meaningful targets for restoring environmental conditions such as water levels and helping identify which species of functional importance are missing from disturbed mires and thus need to be restored.

Such studies are particularly important for conserving plant species and community biodiversity. Although comprehensive analyses are not needed to detect basic differences in vegetation structure and composition between disturbed mires and undisturbed mires, in-depth studies help reveal which plant species and communities are at risk of becoming extirpated from regional species and community pools following disturbance.

I chose Vancouver Island as my study area for several reasons:

1. All three wetland regions identified in coastal British Columbia occur on Vancouver Island (NWWG 1986, Banner et al. 1988). Prior to my research, the locations of regional boundaries had not been assessed using a comprehensive floristic dataset.
2. A regional-scale classification of mire plant communities had not yet been developed for Vancouver Island, despite the existence of several classifications based on limited geographical areas (e.g., Wade 1965, Peden 1967, Ceska 1978, Hebda et al. 1997, Brett et al. 2001);
3. The wide variety of mire ecosystems present on Vancouver Island suggested that a classification developed for Vancouver Island could be used as a starting point

for a more geographically extensive classification of Pacific coast mire plant communities;

4. Human disturbance to wetlands throughout many parts of Vancouver Island made regional-scale characterization of the mire flora and classification of mire plant communities seem critical and timely; and
5. Despite the existence of much research on the vegetation and environmental characteristics of mires located elsewhere, practical application of data from other mire regions is limited by substantial ecological differences related to local environmental conditions, particularly climate.

In the following chapter I describe the environmental setting in which I conducted my research. Chapter 3 focuses on regional differences in the floristic composition of Vancouver Island mires and classification of Vancouver Island mire plant communities. In Chapter 4 I identify floristic and environmental differences between disturbed and undisturbed mires on eastern Vancouver Island. I summarize my conclusions in the final chapter.

CHAPTER 2

STUDY AREA

INTRODUCTION

Most of my study sites are located on Vancouver Island in southwestern British Columbia (Figure 2.1). Vancouver Island is the largest island on the west coast of North America, with a total land area of approximately 32,000 km². It extends almost 450 km in length and reaches 125 km in width at its widest point. Most of the estimated population of 750,000 people is concentrated on the east coast, where low relief, fertile soils, and mild climate favoured settlement.

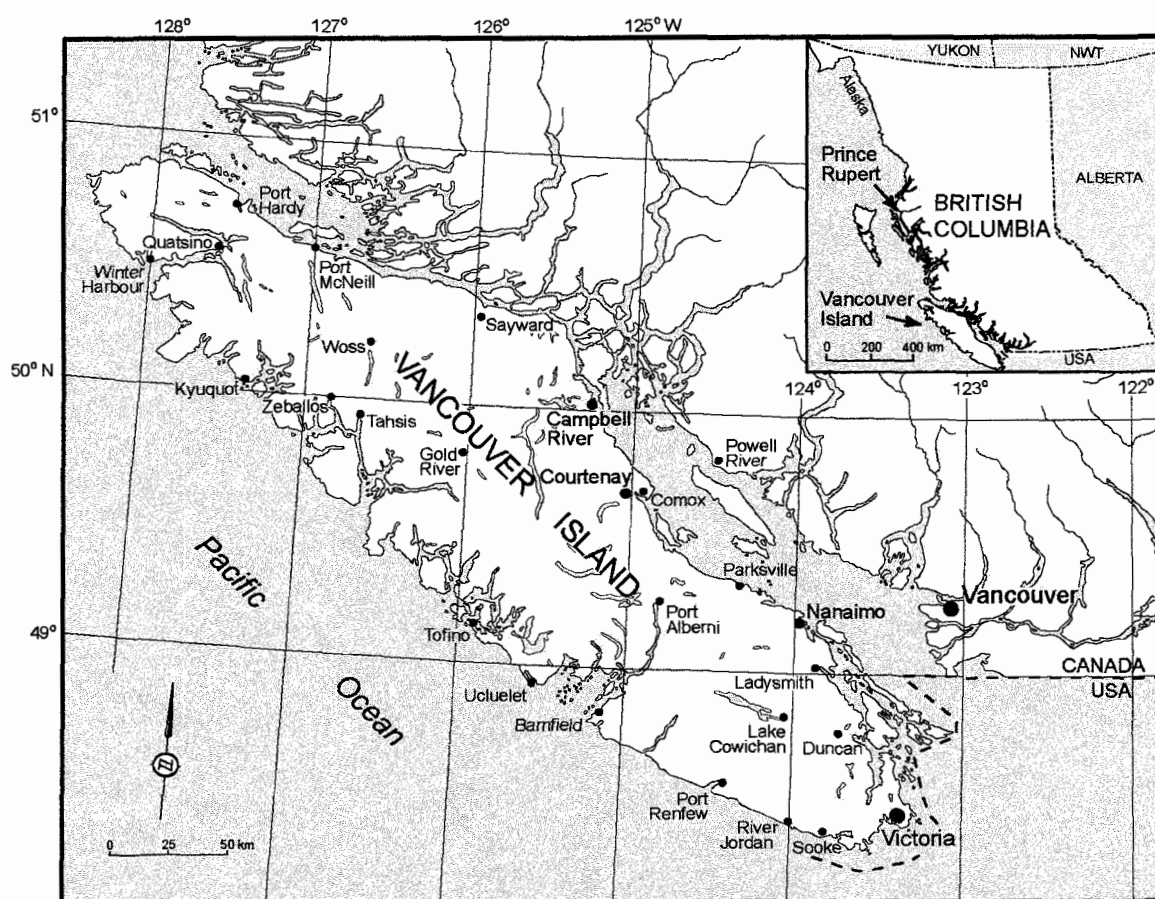


Figure 2.1. Map of Vancouver Island.

Physiography

The coastline of Vancouver Island is irregular and consists of a complex network of islands, inlets, estuaries, and bays. Surface relief is highly variable, ranging from low-lying coastal areas to a mountainous interior characterized by steep slopes, deep valleys, and high plateaux. Maximum elevation is reached at 2,200 m above sea level (asl) (Yorath and Nasmith 1995).

Vancouver Island is situated within Holland's (1976) Coastal Mountains and Islands physiographic region. The region is subdivided into five smaller units: 1) Vancouver Island Ranges; 2) Alberni Basin; 3) Estevan Coastal Plain; 4) Nahwitti Lowland; and 5) Nanaimo Lowland (Figure 2.2).

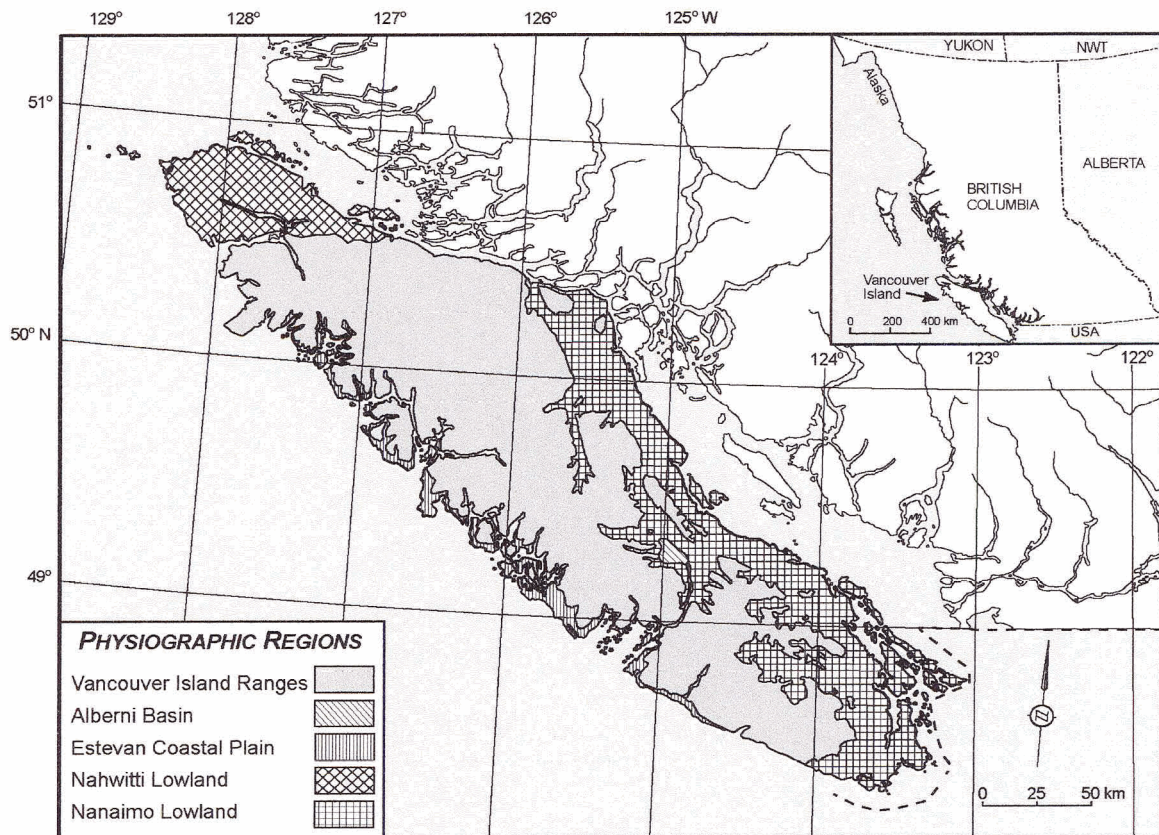


Figure 2.2 Physiographic regions of Vancouver Island (after Holland 1976).

Vancouver Island Ranges

Mountainous areas throughout Vancouver Island are encompassed by the Vancouver Island Ranges (Holland 1976). The central interior of the region consists of several mountain ranges separated by deeply eroded valleys. Many mountain peaks reach 1300 m asl and have sharp ridges sculpted by alpine glaciers rising above 1000 m asl (Clayoquot Sound Scientific Panel 1995). Several of the highest mountains have persistent winter snowpack and some have ice fields. Gentle slopes are restricted to valley bottoms (Clayoquot Sound Scientific Panel 1995).

On western Vancouver Island the mountains are somewhat lower than those of the interior, with ridges seldom exceeding 500 m asl (Clayoquot Sound Scientific Panel 1995). Steep-sided coastal inlets typically extend far into the mountains (Yorath and Nasmith 1995). Mountains on southern Vancouver Island are similarly low (Yorath and Nasmith 1995). They are characterized by fault-line scarps and fault-controlled valleys (Holland 1976).

Large wetlands are relatively uncommon in mountainous areas of Vancouver Island owing to the steep topography. Small wetlands are confined to the margins of lakes and ponds, valley bottoms, and other flat areas having impeded drainage (Brett et al. 2001). Small slope fens are also relatively common in subalpine areas where glacial processes have created undulating topography.

Alberni Basin

The Alberni Basin is the smallest physiographic region on Vancouver Island. It extends from Port Alberni in a northwest direction for approximately 40 km, varying in width from 8 to 13 km. The region has low relief which does not exceed 200 m in elevation (Holland 1976). Wetlands are relatively common; shore mires occupy the margins of several medium-sized lakes (see Ceska 1978).

Estevan Coastal Plain

The Estevan Coastal Plain is a long, narrow strip of lowland following much of the west coast of Vancouver Island. It rarely extends inland beyond 3 km, although at one point it exceeds 12 km in width. The land surface of the Estevan Coastal Plain is almost featureless; it seldom exceeds 50 m in elevation although in some places it is interrupted by irregular, low-lying hills and knolls reaching up to 75 m in elevation (Yorath and Nasmith 1995). Wetlands are common throughout the region.

Nahwitti Lowland

The Nahwitti Lowland encompasses the broad coastal plain located on the northern tip of Vancouver Island. Surface relief in the region is characteristically low but a few isolated summits exceed 600 m in elevation. The eastern side of the Nahwitti Lowland features gently rolling terrain and rounded hills, whereas the western side consists of broad lowlands and valleys. Wetlands are relatively common in the Nahwitti Lowland.

Nanaimo Lowland

The Nanaimo Lowland includes all areas less than 600 m in elevation on eastern Vancouver Island. Denman and Hornby Islands, Gabriola Island, and the southern Gulf Islands are included in the region, whereas Quadra and Texada Islands are not. Terrain in the Nanaimo Lowland is characterized by gently sloping but abruptly terminated ridges separated by narrow valleys (Holland 1976). Small wetlands are relatively common. Mires typically occupy small basins lined with glaciomarine material (Rigg 1925, Rigg and Richardson 1938, Zirul 1967).

Climate

The climate of Vancouver Island is generally described as temperate maritime, but it varies widely along a steep west–east gradient. The moderating effect of the Pacific Ocean together with prevailing westerly winds dominates climate. Three other factors influencing regional climate are: 1) pressure patterns affecting air circulation, 2) the barrier effect of the Coast Mountains, and 3) the rainshadow effect of the Vancouver

Island Ranges and the Olympic Mountains. In winter, the Aleutian Low pressure system delivers a series of storms, dense cloud and strong southwesterly winds. In summer, the North Pacific High pressure system is relatively stable over the northwestern Pacific, leading to substantially higher temperatures, lower humidity, and generally clear conditions. The Coast Mountains form a barrier against the inflow of warm, dry air from the interior of the province in summer and of cold Arctic air from the Yukon and northern British Columbia in winter.

Temperatures at low elevations on western and northern Vancouver Island are moderated by the Pacific Ocean and are generally stable throughout the year (Figure 2.3 A, B). The warm waters of the Kuroshio Current moderate air temperature in winter, as does the upwelling of cold water offshore in summer. Incoming solar radiation is limited throughout the year by clouds and fog. Freezing temperatures and snowfall are rare. Precipitation is heavy, especially in the lowlands of northern and western Vancouver Island and on windward slopes of mountains. Climate is similar on northeast Vancouver Island, although mean annual precipitation is substantially lower (Figure 2.3 C).

At low elevations on eastern Vancouver Island, the Vancouver Island Ranges and the Olympic Mountains create a pronounced rainshadow, resulting in slightly warmer and much drier conditions than occur elsewhere on Vancouver Island. Roughly three-quarters of the annual precipitation falls between late September and March (Figures 2.3 D, E, F). On southern Vancouver Island, periods without measurable rain sometimes extend beyond 50 days in July, August and September. Very little precipitation falls as snow; it typically melts within one week (Nuszdorfer et al. 1991). The growing season is long, with pronounced water deficits typically occurring on zonal and dry sites (Green and Klinka 1994).

Climate at high elevations is characterized by long, cold, wet winters and short, cool, moist summers (Pojar et al. 1991b). Frequent cloud cover throughout the year has a moderating effect on temperature, although snow and freezing temperatures can occur in any month. Most snow falls between November and May. Abundant precipitation

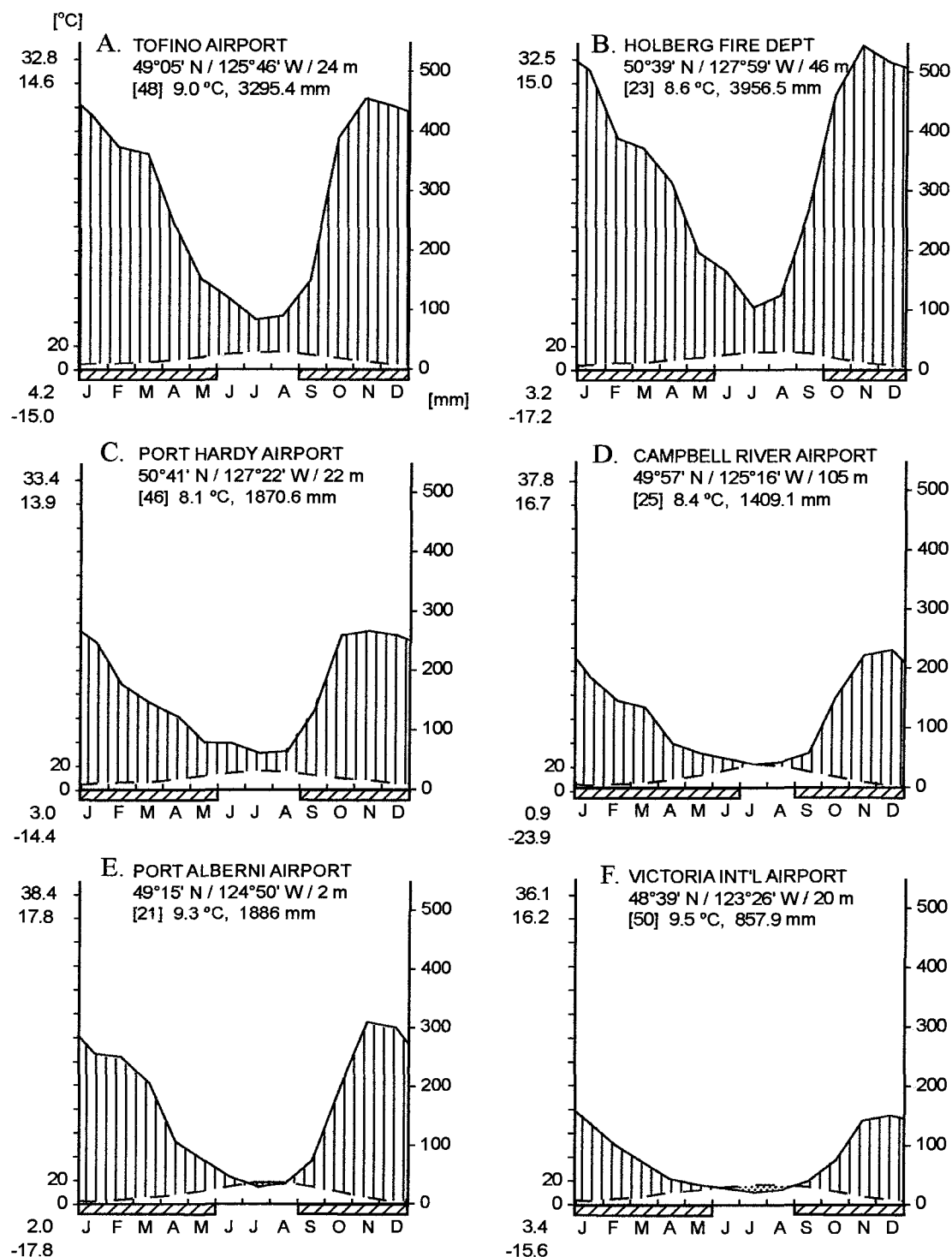


Figure 2.3 Representative climate diagrams for Vancouver Island. Centre, top: length of observation period, mean annual temperature, mean annual precipitation. Left axis: absolute maximum (°C), mean daily maximum of the hottest month (°C), mean daily minimum of the coldest month (°C), absolute minimum (°C). Centre: monthly mean precipitation (mm), monthly mean temperature (°C), humid period (lined), arid period (dotted). Bottom: months with an absolute minimum temperature below 0°C (diagonal lines).

combined with relatively low temperatures results in deep accumulations of snow. Above 900–1000 m asl the snow can persist from October to July in areas protected from direct sunlight (Pojar and Stewart 1991, Brett et al. 2001). The insulating effect of snowpack usually prevents the ground from freezing (Green and Klinka 1994), but it also limits the length of the growing season. Moisture deficits are typically short in duration and occur only on exposed ridge tops.

Vegetation and Soils

Coastal British Columbia has been divided into four biogeoclimatic zones based on the composition of late successional plant communities occurring on sites having intermediate soil moisture and nutrient regimes (Meidinger and Pojar 1991). The climax vegetation of such “zonal sites” reflects the influence of regional climate better than vegetation occurring on sites strongly influenced by local microtopography or physical and chemical properties of soil parent materials.

The four Biogeoclimatic Ecosystem Classification (BEC) zones identified by Krajina (1959) are: Coastal Douglas-fir (CDF); Coastal Western Hemlock (CWH); Mountain Hemlock (MH); and Alpine Tundra (AT). All are represented on Vancouver Island. They correspond with Holland’s (1976) physiographic regions as follows: 1) the AT and MH occur in upper parts of the Vancouver Island Ranges; 2) the CDF is confined to elevations below 150 m in southeastern parts of the Nanaimo Lowland; and 3) the CWH occupies the Estevan Coastal Plain, the Nahwitti Lowland, the Alberni Basin, upper and northern parts of the Nanaimo Lowland, and all of the Vancouver Island Ranges below 800–900 m in elevation.

Coastal Douglas-fir

The Coastal Douglas-fir zone is restricted to elevations below 150 m asl on southeastern Vancouver Island, the Gulf Islands, and western parts of the Lower Mainland. It consists of a single subzone, the Coastal Douglas-fir moist maritime (CDFmm). Forests on zonal

sites in the CDF are dominated by *Pseudotsuga menziesii*¹. Old-growth Douglas-fir forests are rare in the CDF because most were logged at the turn of the century (MacKinnon and Vold 1998). Forest composition depends on soil moisture and nutrient availability. The zonal site association characterizing the CDFmm has a tree layer dominated by *Pseudotsuga menziesii*, which is usually mixed with *Abies grandis* or *Thuja plicata*. Well-developed shrub layers typically consist mainly of *Gaultheria shallon*, *Mahonia nervosa*, *Vaccinium parvifolium*, and *Rosa gymnocarpa*. Common herbaceous plants include *Pteridium aquilinum*, *Rubus ursinus*, and *Symphoricarpos albus*. Common species in the bryophyte layer include *Kindbergia oregana*, *Hylocomium splendens*, and *Rhytidiadelphus triquetrus*.

Quercus garryana communities present in the CDF are endangered in B.C. (Government of B.C. 2004). While closely related to the oak-dominated ecosystems of Oregon and California, Garry oak communities in B.C. support many species occurring nowhere else in the province (Straley et al. 1985). Such communities are characterized by a species-rich ground layer that includes many species of wildflowers including *Camassia quamash*, *C. leichtlinii*, *Zigadenens venenosus*, *Dodecatheon hendersonii*, *Plectritis congesta*, and *Collinsia parviflora*. Species composition of the tree layer varies; in addition to *Quercus garryana* it may include *Arbutus menziesii* and *Pseudotsuga menziesii*. Shrub thickets are a common component of many Garry oak communities. They may include *Rosa nutkana*, *Symphoricarpos albus*, *Mahonia nervosa*, and *Holodiscus discolor*, depending on soil moisture availability. Introduced shrub species such as *Cytisus scoparius* and *Daphne laureola* are common. The native grass *Melica subulata* is sometimes present. However, most grasses are non-native.

Most soils in the CDF are derived from morrainal, colluvial, or marine deposits. Characteristic soils include dystic, eutric, or melanic Brunisols which grade with increasing precipitation to Humo-Ferric Podzols (Nuszdorfer et al. 1991).

¹ Scientific nomenclature for vascular plants, bryophytes, and lichens is given in Chapter 3.

Coastal Western Hemlock

The Coastal Western Hemlock biogeoclimatic zone (CWH) occurs in valley bottoms and lowlands throughout much of Vancouver Island. It ranges in elevation from sea level to 900 m where it is replaced by the Mountain Hemlock zone (Pojar et al. 1991a).

On Vancouver Island the CWH is divided into four subzones. Three of these are further divided into two variants. The subzones and variants follow gradients of continentality (hypermaritime, maritime) and precipitation (very dry, moist, and very wet). The Southern Very Wet Hypermaritime subzone (CWHvh1) encompasses the outer west and north coasts of Vancouver Island, roughly corresponding to the Estevan Coastal Plain and Nahwitti Lowland physiographic regions. Two variants of the Dry Maritime subzone, the Eastern Very Dry Maritime (CWHxm1) and the Western Very Dry Maritime (CWHxm2) include areas influenced by the rainshadow effect of the Vancouver Island Ranges and the Olympic Mountains. Other variants of the CWH subzones in the study area are two variants of the Moist Maritime subzone (CWHmm1, CWHmm2), located on the leeward side of the Vancouver Island Ranges of eastern Vancouver Island, and two variants of the Very Wet Maritime subzone (CWHvm1, CWHvm2), located primarily on the windward side of the Vancouver Island Ranges.

Floristic characteristics of zonal ecosystems in the CWH include the prominence of *Tsuga heterophylla*, a sparse herb layer, and the predominance of several species of moss including *Hylocomium splendens* and *Rhytidiadelphus loreus*. *Thuja plicata* occurs frequently throughout the CWH on Vancouver Island, whereas *Pseudotsuga menziesii* typically reaches maximum abundance in drier parts of the zone. *Abies amabilis* and *Chamaecyparis nootkatensis* are both common, but only in wetter subzones. *Pinus contorta* is common on both very dry and very wet sites (Pojar et al. 1991a).

Characteristic soils in the CWH are Humo-Ferric Podzols and, with increasing precipitation, Ferro-Humic Podzols. In some areas Folisols develop over rock. Dominant soil-forming processes in the CWH include the accumulation of acidic organic matter, leaching, eluviation, illuviation, and gleying (Pojar et al. 1991a).

Mountain Hemlock

The Mountain Hemlock biogeoclimatic zone (MH) includes all subalpine areas situated above the Coastal Western Hemlock (CWH) zone and below the Alpine Tundra (AT) zone. It typically ranges in elevation from approximately 900 to 1600 m asl in southern B.C. (Brooke et al. 1970), although in hypermaritime areas the lower limit descends to 800 m (Klinka and Chourmouzis 2002). At its lower limit *Tsuga mertensiana* is replaced by *Tsuga heterophylla*. This corresponds with the point where snowfall increases substantially in response to cooler temperatures (Orloci 1965, Brooke et al. 1970). At the upper limit of the MH, severe climate or topography inhibits tree growth. Tree islands are replaced by alpine ecosystems above the climatic tree limit (Klinka and Chourmouzis 2002).

Common tree species in forests in the MH are *Tsuga mertensiana*, *Abies amabilis*, and *Chamaecyparis nootkatensis*. A dense shrub layer composed primarily of shrubs in the family Ericaceae is characteristic of the zone. Typical species include *Vaccinium alaskaense*, *V. deliciosum*, *Menziesia ferruginea*, *Elliotia pyroliflora*, *Rhododendron albiflorum*, *Cassiope mertensiana*, and *Phyllodoce empetriflora*. Herbaceous plants common in subalpine forests include several species in the Liliaceae (e.g., *Streptopus roseus*, *Streptopus amplexifolius*, and *Clintonia uniflora*). A dense carpet of mosses consisting primarily of *Rhytidiopsis robusta* is also common (Pojar et al. 1991b).

At high elevations in the MH the short growing season effectively confines trees to scattered clumps and ridge crests where snow melts earlier than at lower elevations in the zone (Klinka et al. 1996). Dominant tree species of the mid-subalpine include *Tsuga mertensiana*, *Abies amabilis* and *Chamaecyparis nootkatensis*. The same shrub species found within the understory of subalpine forests are present beneath the open canopy of tree islands, but the herb and moss layers are reduced. Tree islands are commonly interspersed with heath, meadow and fen communities. Heath communities often consist of prostrate evergreen shrubs such as *Cassiope mertensiana*, *Phyllodoce empetriflora*, *Empetrum nigrum*, and the evergreen “semi-shrub” *Luetkea pectinata*. Species-rich meadows, on the other hand, are dominated by herbaceous plants. Species typical of

nutrient-rich sites near flowing water and adjacent to streams and seeps include *Valeriana sitchensis*, *Senecio triangularis*, and *Veratrum viride*. Sedge or bryophyte dominated fen communities are common around small, stagnant ponds (Brett et al. 2001).

Despite being relatively young, soils in the MH are usually well-developed (Brooke et al. 1970). They remain moist to saturated throughout much of the year. The cool moist climate retards decomposition, resulting in deep accumulations of organic matter (Pojar et al. 1991b). The most common types of soils in the MH are Humic- and Ferro-Humic Podzols. Folisols develop on forested sites underlain by bedrock (Brooke et al. 1970), whereas Brunisols often underlie graminoid communities (Klinka and Chourmouzis 2002). Mires occurring on subdued terrain in the upper elevational limit of the zone are associated with poorly drained organic soils such as Fibrisols, Mesisols, and Humisols.

Alpine Tundra

The Alpine Tundra biogeoclimatic zone (AT) is restricted to mountain peaks above 1650 m on Vancouver Island. As a result of insufficient data, no subzones have been defined, although three major divisions have been recognized (Pojar and Stewart 1991): 1) the Maritime or Coastal division; 2) the Northern Interior; and the Southern Interior. Vancouver Island is part of the Maritime or Coastal division.

The AT is characterized by non-forested vegetation. Trees such as *Abies lasiocarpa*, *Chamaecyparis nootkatensis*, and *Tsuga mertensiana* survive only as dwarf shrubs (krummholz). Vegetation is sparse and discontinuous. Acidic, exposed rocks typically support communities dominated by bryophytes and lichens. Sites having long-lasting snowpack often contain low stature *Marsipella brevissima* or *Saxifraga tolmiei* communities (Brett et al. 2001). Low shrub and alpine heath communities are common throughout the Maritime AT. They may include *Cassiope* spp., *Phyllodoce* spp., *Luetkea pectinata*, *Arctostaphylos uva-ursi*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, and *Vaccinium uliginosum*. Important species in herbaceous meadows include *Lupinus arcticus*, *Senecio triangularis*, *Erigeron peregrinus*, *Valeriana sitchensis*, *Veratrum*

viride, *Arnica* spp., *Pedicularis* spp., *Antennaria lanata*, and *Caltha leptosepala* (Pojar and Stewart 1991).

Most soils in the Alpine Tundra are underdeveloped and belong to the Regosolic order (Pojar and Stewart 1991, Klinka and Chourmouzis 2002). Soil horizons are often poorly differentiated owing to constant churning. Brunisols are common in dry areas, whereas Humic Gleysols or organic soils prevail in wet areas. Ferro-Humic Podzols typically develop under krummholz and dwarf shrub heath communities. Since most soils in the AT are relatively young, they tend to be less leached and acidified than forest soils and are therefore typically more base-rich (Brett et al. 2001).

CHAPTER 3

DESCRIPTION AND CLASSIFICATION OF VANCOUVER ISLAND MIRE VEGETATION

INTRODUCTION

Mire vegetation is well-adapted to extreme environmental conditions including low nutrient availability, a consistently high water table, and extreme acidity or alkalinity (Gore 1983, Zoltai and Vitt 1995). Previous studies have demonstrated that floristic composition of mire vegetation varies in response to both regional and local scale environmental conditions including climate, topography, nutrient availability, pH, and water table depth (Sjörs 1948, 1950, Pakarinen and Ruuhijärvi 1978, Malmer 1988, Økland 1990, Anderson and Davis 1997, Gerdol and Bragazza 2001). Influences on local environmental conditions include successional stage of mire development, microtopographic surface relief, water flow, and chemical composition of surrounding mineral substrates. The high variability of environmental conditions in mires promotes the development of distinctive and varied plant communities.

Eastern and central North American and European mires have been classified and their ecological characteristics are relatively well-known (e.g., Dierssen 1982, Damman 1977, Pollett 1972, Gauthier and Grandtner 1975, Gauthier 1980, Steiner 1992, Doyle 1997). Coastal western North American mires are, by contrast, floristically and ecologically unique (Sjörs 1985). However, unlike those of Eastern and central North America, Europe, and the former U.S.S.R., they have not been thoroughly studied (Banner et al. 1988, Vitt et al. 1990). The purpose of this chapter is to classify Vancouver Island mire vegetation at both regional and community scales to further expand our understanding of the ecology of coastal western North American mires. Classification is essential to mire research because it provides a conceptual framework for defining relationships among the elements of biodiversity and their environment (Miles 1979, Davis and Anderson 2001). As succinctly stated by Krajina (1960, p. 110): “without classification there is no science of ecosystems and ecology.”

Classification is essential for conservation. It facilitates inventory, assessment, and management of ecosystems (Jennings et al. 2002). Mires are naturally uncommon on Vancouver Island. Those occurring at low elevations in southwestern British Columbia and northwestern Washington are threatened by human disturbance (Ward et al. 1992, 1998, Kulzer et al. 2001). Mires are also rare at high elevations because steep topography limits the extent of areas suitable for mire development. They are more prevalent in the narrow band of low-lying poorly drained land situated between coastline and mountains on western and northern Vancouver Island. Mires in this area represent the southernmost extent of wetlands influenced by hypermaritime climate in British Columbia. Conservation of Vancouver Island mires is urgent, but assessment of rarity, fragility, and typicality is limited by the absence of a regional-scale classification based on floristic composition.

My approach to classifying Vancouver Island mire vegetation involved collection of floristic data from a broad range of mire types. The data were analyzed at regional and community scales using a combination of ordination and classification techniques. The regional-scale analysis used total floristic composition of mires to examine regional patterns in mire vegetation. At the community scale, I classified plant associations using phytosociological techniques combined with ordination. To relate the vegetation units to ecological gradients used in other regions (e.g., Ruuhijärvi 1983, Eurola et al. 1984, Moen and Singsaas 1994, Moen 1995, 2003), I also described the type of mire in which each relevé occurred, its position relative to the mire margin or centre, and its microhabitat.

METHODS

Field sampling

Regional scale analysis

To determine whether regional differences exist in mire vegetation on Vancouver Island, I sampled and analysed vegetation data obtained from 43 mires. The primary criterion for study site selection was the presence of hydrophytic bryophytes (primarily species in the

families Sphagnaceae and Amblystegiaceae) in a substantial portion of each wetland. In order to represent a wide range of ecological conditions and floristic composition, I sampled mires occurring in as many hydrotopographic positions and at as many stages of successional development as possible. Study sites were situated between 10 and 1188 m elevation above sea level (asl). They were located in seven of eight subzones or variants of three biogeoclimatic units (Pojar et al. 1987) and nine of ten physiographic regions on Vancouver Island (Yorath and Nasmith 1995). Although my study focused on undisturbed mires, I included eight disturbed mires on eastern Vancouver Island because few undisturbed mires remain in that area. I used data from secondary sources (Wade 1965, Pojar 1974) from Wade's Bog, located near Tofino on western Vancouver Island, in the regional-scale analysis. Data from other studies were difficult to incorporate as a result of differences in sampling strategies. To place the classification in regional context, I sampled five mires located near Prince Rupert on the northwest coast of British Columbia, and three located near Vancouver, in southwestern B.C. A summary of study site locations, elevations, and contextual information is given in Table 3.1. Vancouver Island study site locations are mapped in Figure 3.1.

I compiled complete lists of plant species from each study site, excluding epiphytes, which were not recorded. Field data were collected between July and September, 1999–2001. I conducted my sampling in middle to late summer to ensure that plants were fully developed. This facilitated identification of grasses and sedges in particular, but meant that *Viola* species could only be determined to genus. Over 1000 voucher specimens were collected to verify field identification. Voucher specimens of vascular plants are deposited at the University of Victoria herbarium (UVIC), and bryophytes and lichens are deposited at the University of British Columbia herbarium (UBC).

Vascular plant nomenclature follows Douglas et al. (1999–2001) with the following exceptions: *Ranunculus reptans* L.; *Vaccinium macrocarpon* Ait.; *Vaccinium oxycoccos* L.; *Trientalis arctica* (Fisch. ex Hook.) Hult.; *Rubus stellatus* (Sm.) Boivin; *Cornus unalaschensis* Ledeb.; *Pinguicula macroceras* (Link) Calder & Taylor; *Petasites frigidus* (L.) Fries; *Petasites nivalis* (Greene) Cronq.; and *Hierchloë odorata* (L.) Beauv.

Table 3.1 Study site locations, elevations, physiographic regions, and biogeoclimatic ecosystem classification (BEC) subzones or variants.

#	Site Name ¹	Site Code	Coordinates N/W	Elev. (m)	Physiographic Region ²	BEC Unit ³
1	Stranby (woodland)	STW	50° 48' / 128° 12'	97	Nahwitti Plateau	CWH vh1
2	Stranby (fen)	STR	50° 47' / 128° 11'	81	Nahwitti Plateau	CWH vh1
3	Ronning Main	RON	50° 39' / 128° 12'	75	Nahwitti Plateau	CWH vh1
4	Port McNeill	PTM	50° 34' / 127° 04'	97	Suquash Basin	CWH vm1
5	Tahsish	HWT	50° 19' / 127° 08'	475	North V.I. Ranges	CWH vm1
6	Schoen Meadows	SME	50° 10' / 126° 11'	536	North V.I. Ranges	CWH ms1
7	Upana Lake	UPA	49° 49' / 126° 13'	530	North V.I. Ranges	CWH vm1
8	Sundew Bog	SUN	49° 53' / 125° 37'	260	Quinsam Plateau	CWH xm2
9	Gilson	GIL	49° 56' / 125° 23'	175	Quinsam Plateau	CWH xm1
10	Miller	MIL	49° 58' / 125° 29'	285	Quinsam Plateau	CWH xm2
11	Mirror	MIR	49° 58' / 125° 23'	235	Quinsam Plateau	CWH xm1
12	S. Dogwood St.	SDS	49° 58' / 125° 14'	65	Nanaimo Lowland	CWH xm1
13	Scheuchzeria	SCH	49° 55' / 125° 20'	170	Quinsam Plateau	CWH xm1
14	Nick's Fen	NIC	49° 50' / 125° 13'	115	Nanaimo Lowland	CWH xm1
15	Paradise Meadows	PAR	49° 44' / 125° 18'	1060	North V.I. Ranges	MH mm1
16	slope fen, Strathcona Park	SFS	49° 41' / 125° 21'	1188	North V.I. Ranges	MH mm1
17	Murray Meadows	MUR	49° 42' / 125° 20'	1180	North V.I. Ranges	MH mm1
18	small lake near Divers Lake	SLD	49° 44' / 125° 22'	930	North V.I. Ranges	MH mm1
19	Grant's	GRB	49° 47' / 125° 07'	85	Nanaimo Lowland	CWH xm1
20	Williams Beach	WIL	49° 48' / 125° 03'	95	Nanaimo Lowland	CWH xm1
21	Famham Rd.	FAR	49° 44' / 125° 06'	114	Nanaimo Lowland	CWH xm1
22	Anderson	AND	49° 44' / 125° 12'	545	North V.I. Ranges	CWH mm2
23	Cumberland	CMB	49° 38' / 125° 01'	155	Nanaimo Lowland	CWH xm2
24	Lunchtime	LTL	49° 33' / 125° 04'	800	North V.I. Ranges	MH mm1
25	Tumblewater	TUM	49° 29' / 124° 57'	796	North V.I. Ranges	CWH mm2
26	Fanny Bay	FAN	49° 29' / 124° 49'	35	Nanaimo Lowland	CWH xm1
27	Vargas Island	VAR	49° 10' / 125° 58'	10	Estevan Lowlands	CWH vh1
28	Windy Fen	WIF	49° 07' / 125° 27'	54	West V.I. Fiordland	CWH vm1
29	Wade's Bog	WAD	49° 00' / 125° 38'	18	Estevan Lowlands	CWH vh1
30	Mother Bog	MOB	48° 48' / 125° 08'	28	Estevan Lowlands	CWH vh1
31	Glengarry Bog	GLE	49° 20' / 124° 26'	70	Nanaimo Lowland	CDF mm
32	Rhododendron Lake	RHO	49° 11' / 124° 17'	478	Nanaimo Lakes Highlands	CWH xm2
33	Barrington Bog	BAR	49° 13' / 123° 59'	70	Nanaimo Lowland	CDF mm
34	Ladysmith Bog	LOL	49° 03' / 123° 48'	38	Nanaimo Lowland	CDF mm
35	Tyee Bog	TYE	49° 50' / 123° 43'	38	Nanaimo Lowland	CDF mm
36	small lake, San Juan Ridge	SML	48° 31' / 124° 08'	1016	South V.I. Ranges	MH mm1
37	Cold Lake, San Juan Ridge	COL	48° 31' / 124° 07'	925	South V.I. Ranges	MH mm1
38	Jordan 1500	JOR	48° 32' / 124° 10'	723	South V.I. Ranges	CWH vm2
39	North Main	NMA	48° 30' / 124° 04'	620	South V.I. Ranges	CWH vm2
40	Gunshot	GUN	48° 29' / 124° 07'	690	South V.I. Ranges	CWH vm2
41	Compactum	COM	48° 28' / 124° 06'	712	South V.I. Ranges	CWH vm2
42	Marijuana Bog	MAB	48° 30' / 124° 04'	659	South V.I. Ranges	CWH vm2
43	Ritthet's Bog	RIT	48° 29' / 123° 22'	30	Nanaimo Lowland	CDF mm
44	Diana L. (upper)	DIU	54° 14' / 130° 10'	91	Hecate Lowland	CWH vh2
45	Diana L. (lower)	DIL	54° 14' / 130° 09'	40	Hecate Lowland	CWH vh2
46	Oliver Lake	OLI	54° 17' / 130° 16'	68	Hecate Lowland	CWH vh2
47	Porcher Island	POR	53° 58' / 130° 17'	46	Hecate Lowland	CWH vh2
48	Smith Island	SMI	54° 11' / 130° 13'	64	Hecate Lowland	CWH vh2
49	Pitt Polder	PIT	49° 19' / 122° 38'	10	Fraser Lowland	CWH vm2
50	Surrey Bend	SUR	49° 12' / 122° 44'	5	Fraser Lowland	CWH dm
51	Blaney Bog	BLA	49° 15' / 122° 35'	35	Fraser Lowland	CWH dm

¹Several study site names were created for the purpose of this study. ²Physiographic regions of sites 45–52 after Holland (1976); all others after Yorath and Nasmith (1995). ³Source of Biogeoclimatic Ecosystem Classification (BEC) units: Del Meidinger and Adrian Walton (B.C. Ministry of Forests Research Branch), pers. comm. 2002.

Nomenclature for *Sphagnum* follows Anderson (1990), with the addition of *Sphagnum rubiginosum* Flatb. (Flatberg 1993) and *Sphagnum alaskense* Andrus & Janssens (Andrus

and Janssens 2004). I used Anderson et al. (1990) to standardize moss nomenclature, with the exception of *Palustriella falcata* (Brid.) Hedenäs. Liverworts and lichens follow Schuster (1966–1992), and Goward (1999), respectively.

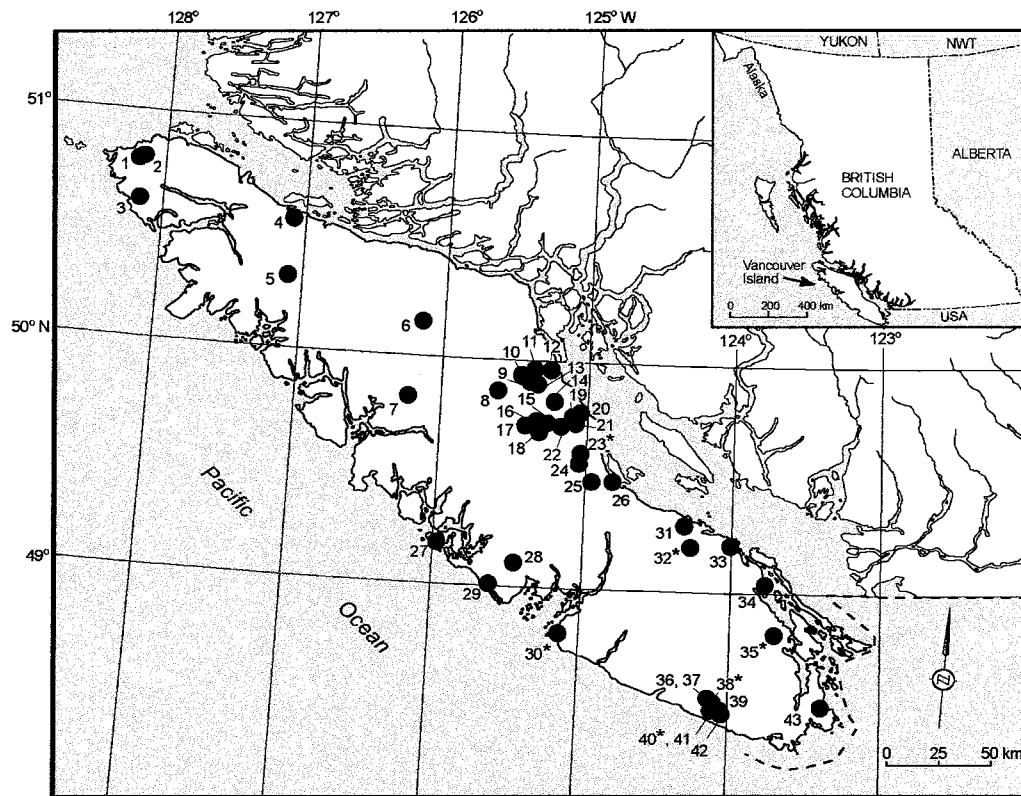


Figure 3.1 Locations of mires sampled on Vancouver Island. Site names are listed in Table 3.1. (*Indicates sites not included in classification of plant communities.)

Community scale analysis

Sample selection

I classified mire plant communities based on data collected from 40 of the 43 Vancouver Island mires sampled for regional-scale analyses. Three mires were not included in the classification of mire plant communities because I was not aware of their existence until after community-scale sampling had been completed. In total, 414 relevés were located subjectively in stands having relatively uniform vegetation composition and structure, as well as consistent microtopographic relief (e.g., hummocks and hollows occurring together in one area were recorded as two separate relevés). Relevé shapes and sizes

varied, but most were square or rectangular and had an area of between 4 and 20 m². The number of relevés per mire varied from two to 27, depending on mire size and vegetation complexity.

Floristic data

For each relevé I compiled complete lists of vascular plant species, bryophytes, and lichens. Epiphytes were not recorded. The abundance of each species was estimated as percent foliar cover following standard methods (e.g., Pakarinen 1984, p. 36).

Microtopography and vegetation physiognomy

To relate mire plant communities to the “hummock–hollow” or water level fluctuation gradient (Sjörs 1948, Malmer 1962, Økland 1989, 1990), I recorded microtopographic habitat type and / or noted the physiognomy of the dominant vegetation for each relevé following the methods of Økland (1990) (see Figure 3.2). Seven habitat types were recognized. “Hummocks” form distinctive mounds reaching between 20–70 cm above the surrounding mire surface. They are well aerated and support vegetation such as ericaceous shrubs that are intolerant of long periods of flooding (Rydin et al. 1999). “Lawns” are lower in height than hummocks, but are firm and relatively level (Sjörs 1948). The ground layer of lawns is dominated by bryophytes, but graminoids such as *Trichophorum cespitosum* and *Eriophorum* spp. are prominent in the herb layer, thus the name “lawn” (Rydin et al. 1999). “Carpets”, by contrast, lack firmness. They are formed by long emergent shoots of *Sphagnum* that follow the movement of the water table as it rises and falls (Rydin et al. 1999). “Hollows” are distinct depressions in the mire surface. They become inundated during wet periods (Weltzin et al. 2001). “Mud bottom hollows” support an abundance of liverworts; in Europe they are rich in micro-algae (Rydin et al. 1999). “Pools” are deep depressions permanently filled with water that can reach up to 2 m in depth. Some fen vegetation lacks distinctive microtopography; for these relevés I recorded the physiognomy of the dominant vegetation (e.g., herbaceous, tall sedges, heath) (see Figure 3.2).

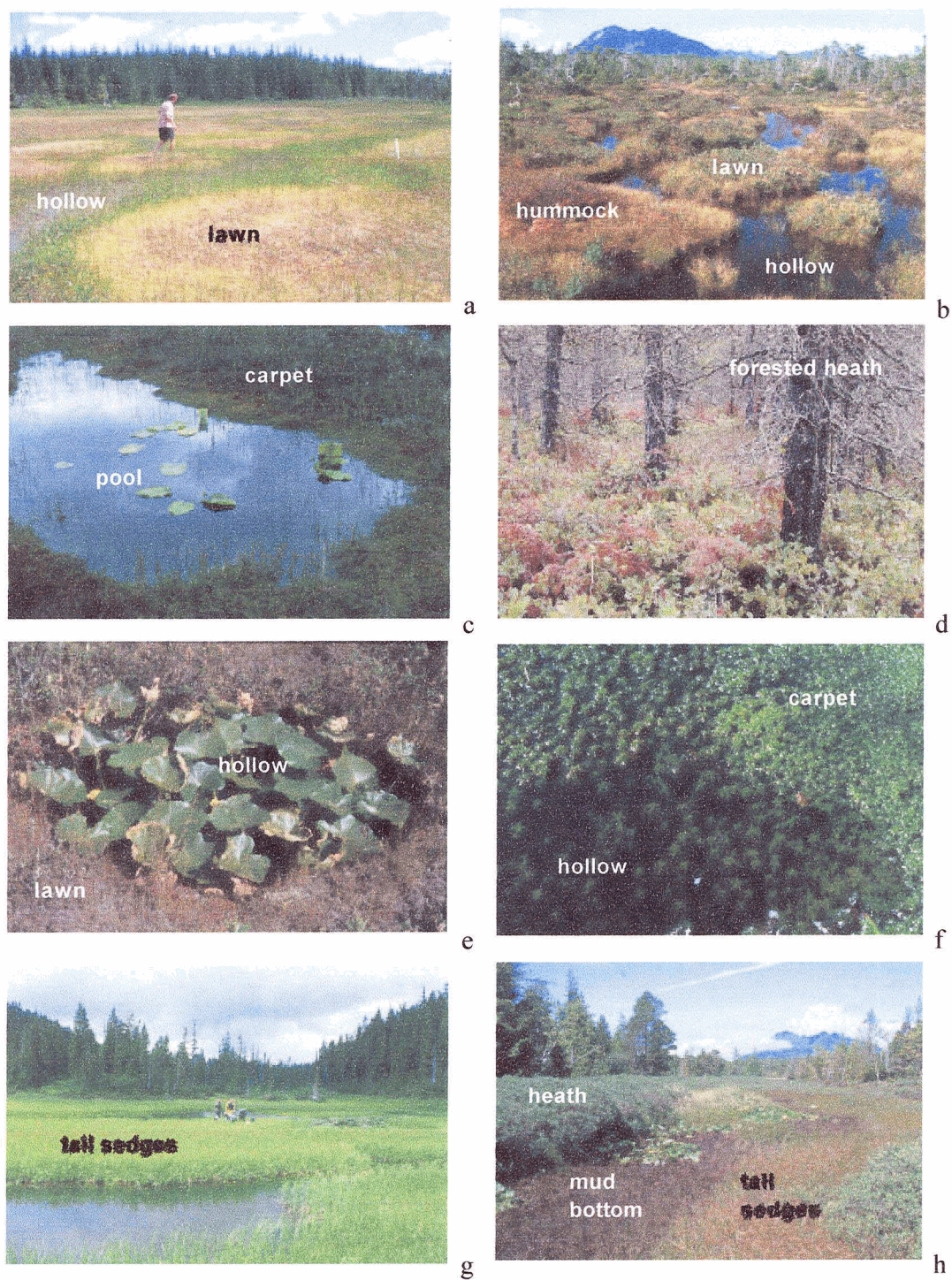


Figure 3.2 Examples of microtopographic surface features or vegetation physiognomy: a. hollow, lawn; b. hummock, lawn, hollow; c. pool, carpet; d. forested heath; e. hollow, lawn; f. hollow, carpet; g. tall sedges; h. heath, mud bottom, tall sedges.

Within-mire location

In order to relate the communities to the “open mire–mire margin” gradient, I noted the general location of relevés within mires: 1) the raised, central open portion of the mire or “mire expanse”; 2) the “lagg” or low-lying area between raised mires and the surrounding landscape; 3) forest margin (Sjörs 1948, 1952, Malmer 1962, Pakarinen and Ruuhijärvi 1978, Økland 1989, Moen and Singsaas 1994); 4) lake shore; 5) floodplain; 6) mid-slope; and 7) top of slope.

Mire types

I evaluated whether mire plant communities were related to mire type by classifying mires according to physiognomy of dominant vegetation and hydrotopography. Hydrotopographical classification was determined through airphoto interpretation and field visits. Mires were subdivided into bog and fen depending on whether a substantial portion of the central part of the mire was higher in elevation than the surrounding land (bog), or not (fen). Examples of the mire types are illustrated in Figure 3.3.

Data analysis

Classification of mire regions

I used two methods to identify regional-scale floristic differences among mires. Both analyses are based on presence-absence floristic data. Mires were classified using cluster analysis, and ordinated using nonmetric multidimensional scaling (NMS) (Kruskal 1964, Mather 1976). NMS has been used in previous studies of mire vegetation in Finland (Starr 1984) and continental western Canada (Beilman 2001).

Agglomerative cluster analysis (Goodall 1973) was performed in PC-ORD for Windows version 4.14 (McCune and Mefford 1999). The data matrix consisted of presence-absence data for 335 plant species in 51 mires. Agglomerative cluster analysis is a “bottom up” technique that proceeds by joining an increasing number of similar elements (in this case, mires) to form larger and larger groups. The technique is “polythetic” because it uses more than one variable (e.g., numerous species) to determine linkages among the sites

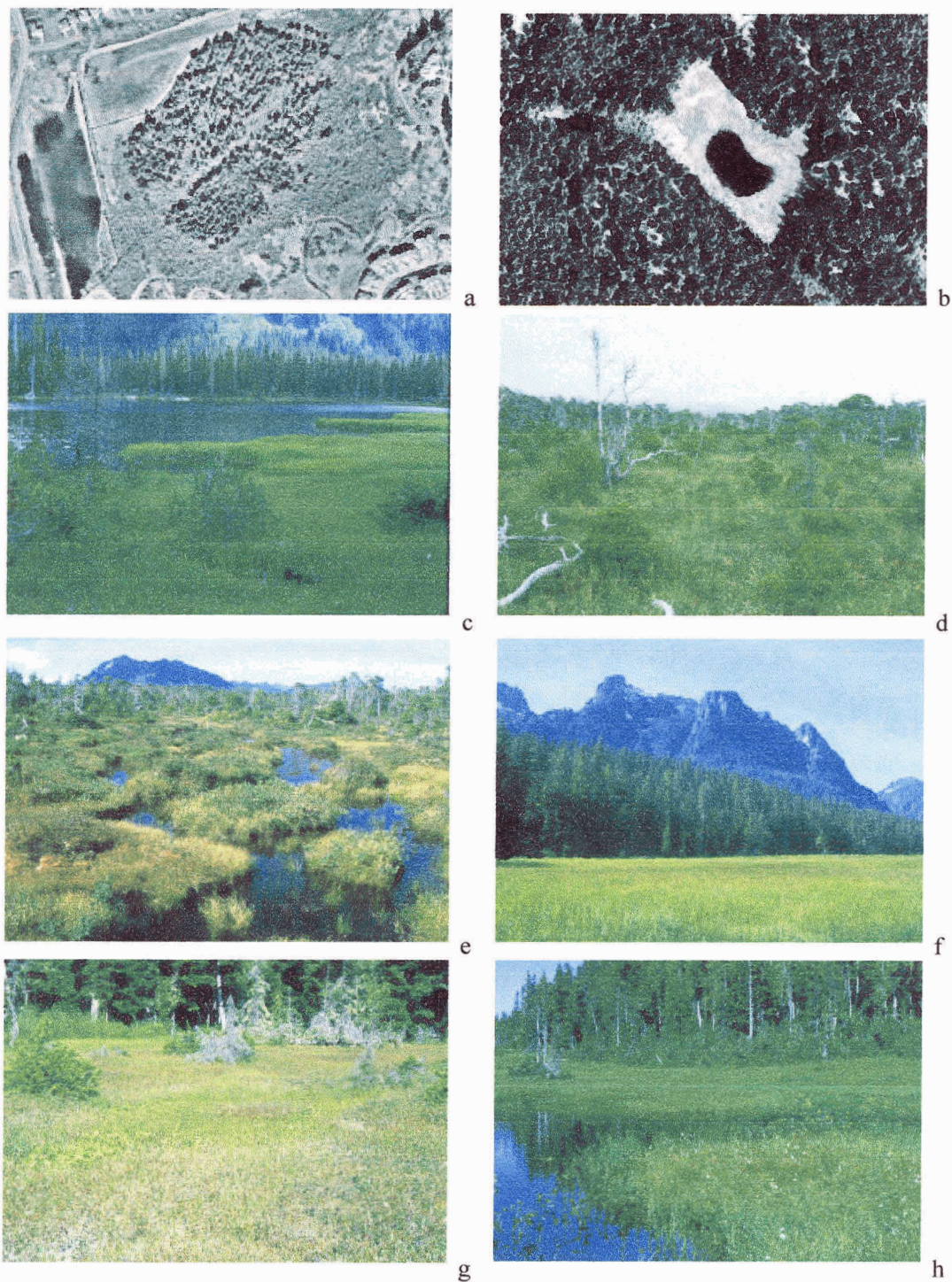


Figure 3.3 Examples of Vancouver Island mire types: a. forested basin bog (disturbed); b. lakeshore bog; c. lakeshore fen; d. flat bog; e. flat bog; f. valley fen; g. flat fen; h. fen complex with sloping fen, flat fen, and shore fen.

(mires) (McCune and Grace 2002).

In the first step in cluster analysis, a distance matrix is calculated between each pair of mires based on floristic differences. Next, similar mires are linked to form groups. When mires (or groups of mires) are linked, the variables of each mire or group of mires (in this case, species) are combined. Merging of groups continues until all clusters are joined. I used Euclidean distance to calculate the distance matrix, and Ward's (1963) method to determine linkage among mires (McCune and Grace 2002). Ward's method uses an analysis of variance (ANOVA) approach to evaluate the distance between elements (and at the next step, between clusters) by attempting to minimize the sums of squares of any two hypothetical clusters that can be formed at each step. Objective procedures for stopping the agglomeration process in cluster analysis depend on arbitrary criteria (McCune and Grace 2002). I selected final clusters that were ecologically interpretable and had long "stems" in the dendrogram. The distance measure on the dendrogram scale is Wishart's (1969) objective function. It indicates how much information was lost at each stage of the agglomeration process.

Mires of Vancouver Island, the Prince Rupert area, and the Lower Mainland were ordinated using non-metric multidimensional scaling (NMS) (Kruskal 1964, Mather 1976) in PC-ORD for Windows version 4.14 (McCune and Mefford 1999). NMS was used as a data-reduction tool to show the relationships among mires based on plant species composition. The technique essentially searches for placement of the mires within a solution with the least difference or stress between mires in the original dissimilarity matrix and a lower dimensional solution. NMS is the ordination method of choice for ecological analyses because it is not constrained by linear relationships or unimodal responses in the data. In this way it avoids many of the distortions of eigenvector techniques (Kenkel and Orlóci 1986, Minchin 1987, Legendre and Legendre 1998, McCune and Grace 2002).

In my analysis, the data matrix consisted of presence-absence data for 337 plant species among 51 mires (sites). I used Sorensen (Bray-Curtis) distance as a measure of ecological

similarity. For each ordination, I used several random starting configurations to ensure that solutions were stable. Dimensionality of the data set was assessed using scree plots. I selected three axes for all ordinations, and specified a maximum of 200 runs to find a solution. To evaluate stability of the ordination I used 100 iterations and a stability criterion of 0.0005. To assess statistical significance and determine whether the axes extracted were stronger than would be expected by chance, I used Monte Carlo tests on the results of each analysis.

Classification of plant associations

I combined four approaches to classify and ordinate Vancouver Island mire plant associations. Following the example of Jeglum (1988), I used TWINSpan (Hill 1979) as a “first cut” to sort relevés into broad groups. Tentative associations were then identified by hand-sorting the relevés within each group using the principles of the Braun-Blanquet approach (Braun-Blanquet 1928, Westhoff and van der Maarel 1973; Mueller-Dombois and Ellenberg 1974, Kent and Coker 1992). Transitional relevés were evaluated for group inclusion using Sørensen’s index of floristic similarity (Magurran 1988). Finally, I ordinated the tentative associations using NMS to visually evaluate differences between similar plant associations (Kruskal 1964, Mather 1976, McCune & Mefford 1999). In the following paragraphs I give a brief overview of each of the three techniques not previously discussed.

Two-way indicator species analysis (TWINSpan) is a polythetic divisive technique that incorporates ordination in a simultaneous classification of sites and species. As summarized by Gauch and Whittaker (1981) and Gauch (1982), the first step in the analysis involves computation of a single-axis reciprocal averaging (RA) ordination. Next, species characterizing the extreme ends of the RA axis are positively or negatively weighted to polarize the samples. Samples are then partitioned into two groups by splitting the axis near the middle. The division of samples between groups is refined by reclassifying the samples using species with maximum affinities for either extreme of the RA axis. The classification is hierarchical, so the entire process is repeated on each new group until the groups are too small for further subdivision. Once the samples have been

classified, the species are classified according to their fidelity to the groups. The final product is a sorted two-way matrix with species in rows and relevés in columns.

TWINSPAN was performed in PC-ORD for Windows version 4.14 (McCune and Mefford 1999). Faults identified in earlier versions of the program are corrected in this version.

For my study, the data matrix consisted of percent cover estimates for 276 species in 416 relevés. Because the data were quantitative, I selected seven user-defined “pseudo-species” cut-levels (Hill 1979): 0.1, 1, 2, 5, 20, 50, 80% plant species cover. Although RA calculations in TWINSPAN are based solely on species presence or absence, quantitative data are incorporated by treating occurrences of the same species at different abundance levels as different species or “pseudo-species”. I obtained the most ecologically interpretable results with the following parameters: maximum six levels of dichotomous divisions; no division of groups having less than five relevés; and maximum 10 indicator species per division. Only the 225 species occurring in more than one relevé were included in the final table.

The Braun-Blanquet or phytosociological approach to floristic classification (Braun-Blanquet 1921, Mueller-Dombois and Ellenberg 1974, Westhoff and van der Maarel 1980) has often been used to classify mire vegetation in Europe and North America (e.g., Wade 1965, Pollett 1972, Gauthier and Grandtner 1975, Damman 1977, Ceska 1978, Gauthier 1980, Wells 1981, 1996, Dierssen 1982, Steiner 1992, Doyle 1997, Klinka et al. 1997, Brett et al. 2001). With this approach, total floristic composition is used to identify vegetation units that are subsequently placed within a defined hierarchy. The basic unit of classification is the *association*, which is defined by Jennings et al. (2002) as “a recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure”. Associations represent closely related plant communities that are easily recognized in the field (Brett et al. 2001). Alliances, classes, and orders are formed by increasingly broader groups of associations, which at a lower level can also be divided into subassociations (Pojar et al. 1987).

I defined associations based on a diagnostic group of species including “character species”, “differential species”, and “companion species”, using criteria defined by Pojar et al. (1987) (Table 3.2). I focused on moss species composition when grouping relevés dominated by bryophytes, because individual moss species occupy distinct ecological niches in mires (Pakarinen 1979, Andrus et al. 1983, Gignac and Vitt 1990, Gignac et al. 1991, Gignac 1992, Anderson et al. 1995, Nicholson and Gignac 1995, Bragazza and Gerdol 1996).

Table 3.2 Diagnostic values of plant species (after Pojar et al. 1987).

Name and symbol	Definition
Character species	
character (ch)	– a species clearly associated with <i>only one unit</i> in a hierarchy – presence class¹ = III, and at least two presence classes greater than other units in the same category
dominant character (dch)	– a species that is not at least two presence classes greater than other units in the same category, but shows clear dominance in only one unit in a hierarchy – presence class = III – species significance class² = 5, and at least two species significance classes greater than other units in the same category
Differential species	
differential (d)	– species that is clearly associated with <i>more than one unit</i> in a hierarchy – presence class = III, and at least two presence classes greater than in other units in the same category and circumscription
dominant differential (dd)	– species that does not meet the presence criteria above, but shows clear dominance in more than one unit in a hierarchy – presence class = III – species significance class = 5, and at least two significance classes greater than other units in the same category and circumscription
Companion species	
constant dominant (cd)	– species presence class V, and mean species significance = 5 in one of the units under comparison
constant (c)	– species presence class V, but species significance class < 5
important companion (ic)	– species that does not meet the criteria for a character, differential, constant dominant, or constant species but shows affinity for a particular unit by its absence from other units under comparison – presence class = II – species significance variable

¹Species presence class as percent frequency: I = 1–20%, II = 21–40%, III = 41–60%, IV = 61–80%, V = 81–100%.

²Species significance class as mean percent cover: + = 0.1–0.3, 1 = 0.4–1.0, 2 = 1.1–2.1, 3 = 2.2–5.0, 4 = 5.1–10.0, 5 = 10.1–20.0, 6 = 20.1–33.0, 7 = 33.1–50.0, 8 = 50.1–70.0, 9 = 70.1–100.

Some relevés appeared to be transitional between associations. To evaluate which association a relevé might belong to, I used Sørensen's index of floristic similarity (Magurran 1988) (Equation 3.1). A minimum floristic similarity index value of 50% was required to assign a relevé to a particular group. Sørensen's index only incorporates presence-absence data; therefore, I also used NMS as a means of evaluating group membership.

Equation 3.1 Sørensen's index of floristic similarity (Magurran 1988).

$$SI = \frac{2c}{(a+b)}$$

where a = the total number of species in the relevé,
 where b = the total number of species in the association, and
 where c = the number of species common to both.

To examine community structure, NMS was performed on the entire data set and on subsets of the data in PC-ORD for Windows version 4.14 (McCune and Mefford 1999). The parameters selected were identical to those used for classifying mire regions. To reduce the polarizing effect of high cover values of dominant species (particularly bryophytes), I standardized the data with logarithmic transformation ($\log_{10}(y+1)$) prior to performing all NMS ordinations.

Nomenclature of vegetation units

Associations were named following the conventions summarized by Jennings et al. (2002). I adopted their approach rather than the traditional methods of the Braun-Blanquet approach or that of Klinka et al. (1996) and Rejmanek (1997), because their conventions have been adopted by government conservation agencies throughout North America including the British Columbia Conservation Data Centre. The nomenclatural rules use both dominant and characteristic species to name a vegetation unit (i.e., association or alliance). Names of associations and alliances incorporate at least one or more species from the dominant strata. Taxa used to name units are separated by a hyphen (-) if they occur in the same stratum, or a slash (/) if they occur in different strata (Jennings et al. 2002).

RESULTS

Regional Classification and Ordination

Results of cluster analysis and nonmetric multidimensional scaling (NMS) demonstrate the existence of four floristically distinct groups of mires on Vancouver Island. The first group occupies low elevation areas along the north and west coasts of Vancouver Island and the Prince Rupert area. The geographical distribution of these mires corresponds with the Pacific Oceanic wetland region (Figures 3.4, 3.5) (NWWG 1986, Banner et al. 1988). The group is clearly subdivided into northern and southern subgroups confirming previous divisions of the Pacific Oceanic wetland region into North Coast and South Coast subregions (NWWG 1986, Banner et al. 1988).

The second group of mires identified by cluster analysis and NMS consists of bogs and poor fens located at low elevations on eastern Vancouver Island and the Lower Mainland. Unlike mires of northern and western Vancouver Island and the Prince Rupert area, floristic composition of mires found at low elevations on either side of the Strait of Georgia is relatively uniform. Results of cluster analysis indicate it is unnecessary to divide the Pacific Temperate wetland region into subregions.

A third group of mires consists entirely of fens located at middle to high elevations (i.e., >450 m asl) throughout Vancouver Island. Both cluster analysis and NMS clearly demonstrate the existence of two subgroups. One is confined to elevations >800 m asl on eastern Vancouver Island. These mires occur in what I have termed the East section of the South Coast subregion of the Coast Mountain wetland region. Mires occurring at middle to high elevations (475–1050 m) elsewhere throughout Vancouver Island occupy what I call the West section of the South Coast subregion of the Coast Mountain wetland region.

In the following paragraphs, I describe and differentiate the mire groups. It is noteworthy that very few plant species occur in all four mire groups. The following species evidently tolerate a wide range of climatic conditions and occupy ecological niches common to most mires surveyed on Vancouver Island:

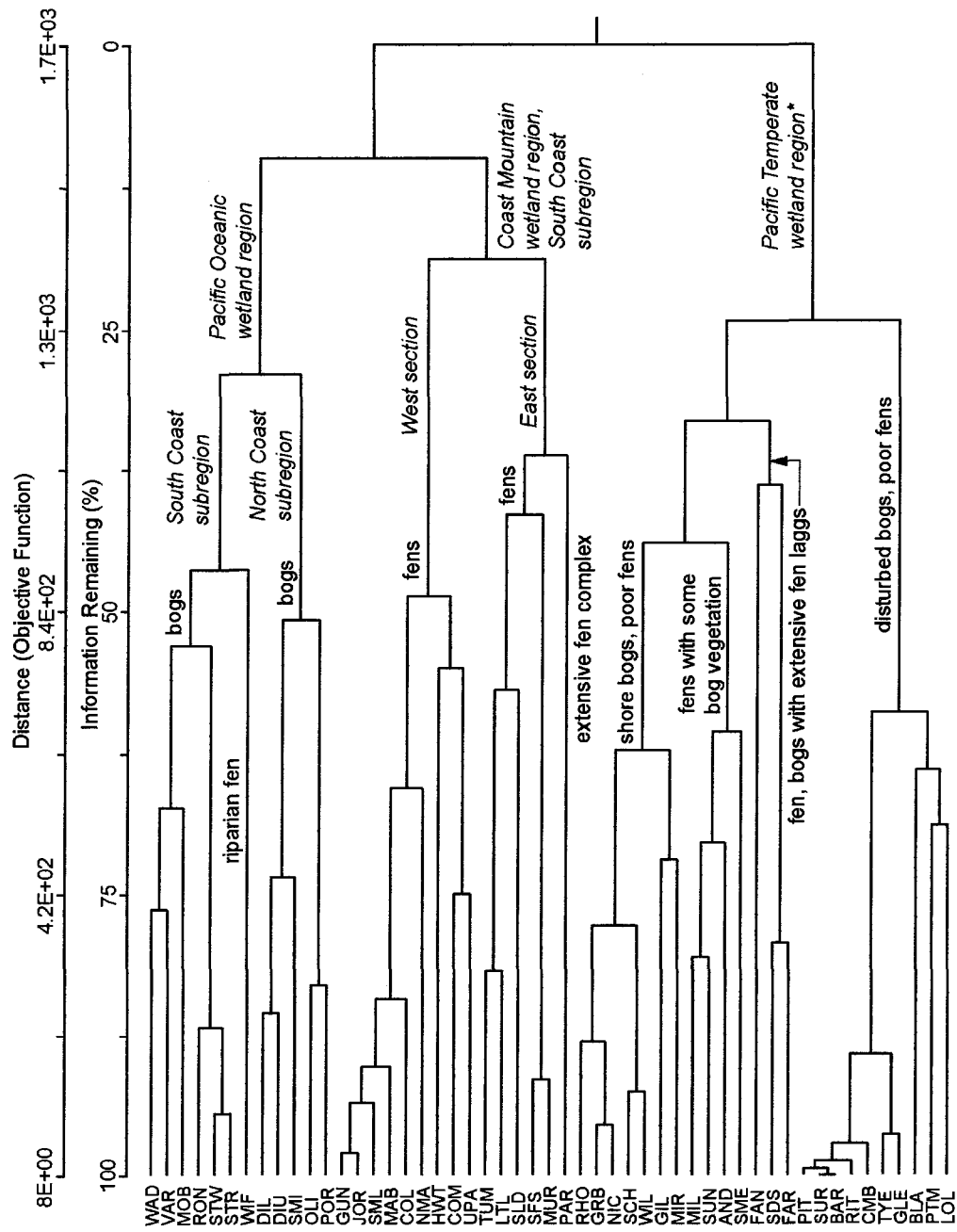


Figure 3.4 Cluster analysis of Vancouver Island mires based on complete species lists. *Minus three misclassified mires: PTM, AND, and SME.

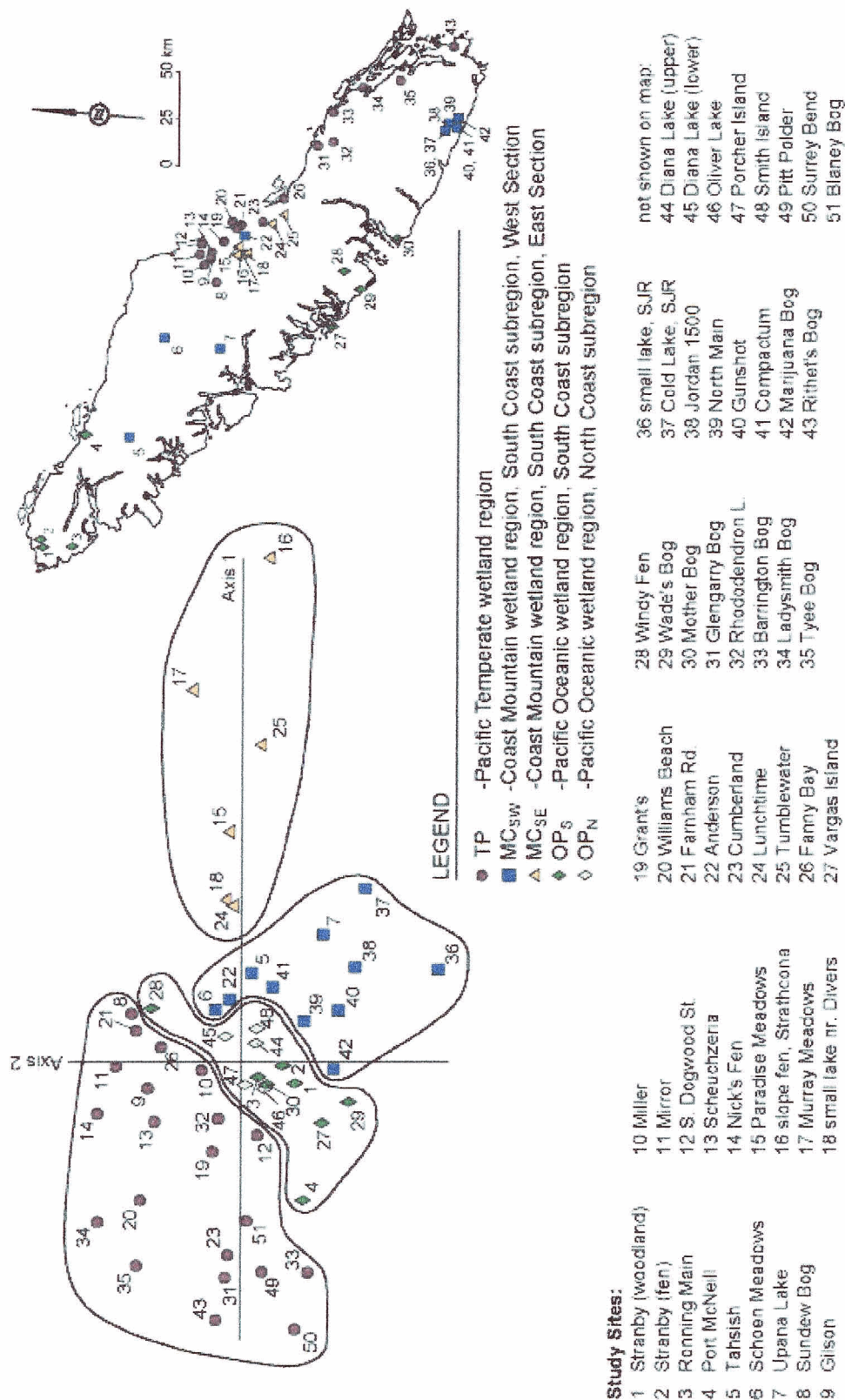


Figure 3.5 NMS ordination of mires based on complete plant species lists. Symbols indicate mire regions.

<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	<i>Cornus unalaschkensis</i>	<i>Drosera rotundifolia</i>
<i>Triantha glutinosa</i>	<i>Trientalis arctica</i>	<i>Carex echinata</i>
<i>Carex pauciflora</i>	<i>Carex utriculata</i>	<i>Aulacomnium palustre</i>

Species such as *Kalmia microphylla* ssp. *occidentalis* and *Drosera rotundifolia* are found in mires on both coasts of Vancouver Island. Other species are geographically widespread but are not abundant. *Aulacomnium palustre*, for example, occurs in bogs, poor fens, moderate-rich fens, and rich fens but is considered to be a poor competitor (Gignac 1992). On Vancouver Island it occurs in fens, in the lagg, and along the banks of shore bogs. Similarly, *Carex utriculata* is typical of fens and often occurs in seasonally flooded areas of the lagg, yet it also persists as a remnant of an earlier successional stage in bryophyte-dominated areas of bogs as a result of “biological inertia” (*sensu* Gorham 1957).

Pacific Oceanic wetland region

Mires are common at low elevations along the west coast of British Columbia. They occupy several hydrotopographic positions. Common mire types include basin bogs, slope bogs, shore bogs, flat bogs, domed bogs, slope fens, stream fens, and shore fens (Banner et al. 1986, 1988). My sampling included all coastal mire types except domed bogs. A large, well-defined group of plant species characterizes coastal mires, including:

<i>Juniperus communis</i>	<i>Vaccinium vitis-idaea</i> ssp. <i>minus</i>	<i>Linnaea borealis</i>
<i>Calamagrostis nutkaensis</i>	<i>Ligusticum calderi</i>	<i>Lycopodium clavatum</i>
<i>Microseris borealis</i>	<i>Racomitrium lanuginosum</i>	<i>Sphagnum alaskense</i>
<i>Sphagnum austinii</i>	<i>Herbertus aduncus</i>	<i>Myrica taylori</i>
<i>Pleurozia purpurea</i>		

Species such as *Sphagnum austinii*, *S. alaskense*, and *Pleurozia purpurea* seldom occur outside mire habitats. Species less commonly recorded from mires in the area but seldom present in mires elsewhere on Vancouver Island include *Blechnum spicant*, *Maianthemum dilatatum*, *Andromeda polifolia*, *Cladina portentosa* ssp. *pacifica*, *Deschampsia cespitosa*, and *Coptis trifolia*.

Mires located in the Pacific Oceanic wetland region on Vancouver Island and in the Prince Rupert area share many plant species. However, floristic differences between mires in the two subregions may reflect differences in climate related to latitude. For example, three species present in Vancouver Island mires but not recorded from mires surveyed in the Prince Rupert area are *Carex obnupta*, *Gentiana sceptrum*, and *Juncus supiniformis* (see also Banner 1983, Vitt et al. 1990). Conversely, species present in the Prince Rupert area but not observed in mires on Vancouver Island include *Malaxis paludosa*, *Juncus stygius*, *Sphagnum quinquefarium*, *Ptilium crista-castrensis*, and *Cetraria aculeata* (see also Wade 1972, Pojar 1974, Banner 1983, Vitt et al. 1990). Both *M. paludosa* and *J. stygius* are provincially rare (Government of B.C. 2004). Provincially rare bryophyte species recorded from Prince Rupert area mires but not from Vancouver Island mires include *Loeskyopnum badium*, *Sphagnum aongstroemii*, and *Sphagnum majus* (Government of B.C. 2004). All have northern or continental affinities (Gignac and Vitt 1990, Douglas et al. 1998–2001). Several species recorded from study sites in the Prince Rupert area were not observed in mires on Vancouver Island but have been previously noted from mires on Brooks Peninsula on western Vancouver Island: *Geum calthifolium*, *Loiseleuria procumbens*, and *Bazzania tricrenata* (Hebda et al. 1997, Schofield 1997).

Several plant species common to Prince Rupert area mires are not present in mires located at low elevations on western and northern Vancouver Island. However, the following taxa do occur in middle to high elevation fens: *Erigeron peregrinus*, *Tsuga mertensiana*, and *Pinguicula macroceras*. Similarly, the lichen *Siphula ceratites* has northern affinities (Brodo et al. 2001), but on Vancouver Island it has been recorded from Brooks Peninsula (Hebda et al. 1997) and I collected it from a fen near Jordan Ridge on southwestern Vancouver Island, where it was observed by Dr. Hans Roemer.

Pacific Temperate Wetland Region

Mires are uncommon in the lowlands of eastern Vancouver Island. Bogs and poor fens typically occupy small basins. Common mire types include basin bogs, shore bogs, and floating bogs (or poor fens). Mires occurring in similar hydrotopographic positions are scattered throughout low-elevation areas of southwestern B.C. and Washington (Banner

et al. 1988, Kulzer et al. 2001). Large raised bogs and poor fens are relatively common in the Fraser River delta. Mires in the Pacific Temperate wetland region are distinguished from mires occurring elsewhere on Vancouver Island by the following group of plant species:

<i>Malus fusca</i>	<i>Rhamnus purshiana</i>	<i>Lycopus uniflorus</i>
<i>Pteridium aquilinum</i>	<i>Carex lasiocarpa</i>	<i>Eriophorum chamissonis</i>
<i>Sphagnum henryense</i>	<i>Sphagnum palustre</i>	

The absence of species such as *Trichophorum cespitosum*, *Eriophorum angustifolium*, and *Chamaecyparis nootkatensis*, which are typically present in mires located elsewhere on Vancouver Island, also sets them apart.

Many mires in the Pacific Temperate region have been disturbed by agricultural development and urbanization. Disturbed mires are forested and floristically depauperate compared to undisturbed mires. Species absent from disturbed mires include:

<i>Myrica gale</i>	<i>Comarum palustre</i>	<i>Drosera anglica</i>
<i>Hypericum anagalloides</i>	<i>Lycopodiella inundata</i>	<i>Lycopus uniflorus</i>
<i>Menyanthes trifoliata</i>	<i>Nuphar lutea</i> ssp. <i>polysepala</i>	<i>Rhynchospora alba</i>
<i>Scheuchzeria palustris</i>	<i>Triantha glutinosa</i>	<i>Viola</i> sp.
<i>Carex echinata</i>	<i>Carex lasiocarpa</i>	<i>Carex sitchensis</i>
<i>Carex utriculata</i>	<i>Sphagnum subsecundum</i>	

All of these species typically occur in wet habitats such as hollows, the lagg, or lake margins. Only three species characterize disturbed mires: *Sphagnum fimbriatum*, *Malus fusca*, and *Lysichiton americanus*. *Malus fusca* and *Lysichiton americanus* are typical of swamps in the region (Banner et al. 1988). *Sphagnum fimbriatum* is sometimes found amongst shrubs such as *Spiraea douglasii* in disturbed marginal areas.

South Coast subregion, Coast Mountain wetland region

All mires occurring at middle to high elevations throughout Vancouver Island are fens; bogs are absent from the South Coast subregion of the Coast Mountain wetland region. The group is floristically characterised by several species including *Sphagnum russowii*,

Vaccinium caespitosum, and *Calamagrostis canadensis*. *Botrychium multifidum* occurs exclusively in this group but is less common. *Myrica gale* is common in the other two wetland regions on Vancouver Island but is absent from fens in the South Coast subregion of the Coast Mountain wetland region. Mires in the South Coast subregion can be divided into two groups based on floristic composition: those occurring at high elevations (795–1190 m asl) on eastern Vancouver Island and those occurring at high elevations elsewhere and at middle elevations throughout Vancouver Island. I have identified these two groups as the “East section” and the “West section”.

East section, South Coast subregion, Coast Mountain wetland region

Fens occurring at high elevations (795–1190 m asl) on the leeward side of the Vancouver Island Ranges occupy several hydrotopographic positions. The most common types of mires are slope fens, shore fens, riparian fens, and valley fens. The short growing season together with heavy, persistent snow cover inhibits bog formation. Fens in the East section are floristically distinguished from mires in other wetland regions on Vancouver Island by the presence of a large group of plant taxa which includes:

<i>Salix barclayi</i>	<i>Leptarrhena pyrolifolia</i>	<i>Mitella pentandra</i>
<i>Parnassia fimbriata</i>	<i>Petasites nivalis</i>	<i>Potentilla drummondii</i> ssp. <i>drummondii</i>
<i>Sanguisorba canadensis</i>	<i>Valeriana sitchensis</i>	<i>Veratrum viride</i>
<i>Carex nigricans</i>	<i>Limprichtia revolvens</i>	<i>Philonotis fontana</i> var. <i>fontana</i>
<i>Rhytidiadelphus squarrosus</i>	<i>Sphagnum teres</i>	

Four of these species, *Leptarrhena pyrolifolia*, *Petasites nivalis*, *Veratrum viride*, and *Valeriana sitchensis* occur primarily in transitional areas between forests and mires. These species are also associated with spring and stream edge habitats. Another plant species typical of mires in the East section is *Carex nigricans*. It also occurs in late snow-melt basins (Brooke et al. 1970, Brett et al. 2001).

Fens comprising the East section of the South Coast subregion of the Coast Mountain wetland region are also distinguished by the absence of a relatively large group of plant species. It includes:

<i>Tsuga heterophylla</i>	<i>Gaultheria shallon</i>	<i>Rubus chamaemorus</i>
<i>Lycopodiella inundata</i>	<i>Rhynchospora alba</i>	<i>Hylocomium splendens</i>
<i>Polytrichum strictum</i>	<i>Sphagnum capillifolium</i>	<i>Cladina rangiferina</i>

West section, South Coast subregion, Coast Mountain wetland region

Mires located at middle to high elevations (475–1120 m asl) on the windward side of the Vancouver Island Ranges include slope fens, flat fens, shore fens, and valley fens. Unlike the West section and other three groups of mires on Vancouver Island, this one is not defined by an exclusive group of plant species. Only one species, *Gaultheria ovatifolia*, is confined to this group of mires. Most of the species defining the group also occur in at least one other region.

Vegetation classification

I identified 20 mire plant associations based on floristic data from 51 Vancouver Island mires. Of the 395 relevés included in the original dataset, I excluded 32 from the classification for the following reasons: 1) some relevés seemed to be transitional between associations, possibly because they were located in an ecotone; 2) the floristic composition of some relevés indicated that the vegetation was transient, likely owing to previous disturbance; and 3) some relevés seemed to represent relatively rare, as-yet undescribed communities that require further sampling.

I grouped the associations into six orders (Table 3.3). The *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order includes ten associations characterizing hummock, lawn, and heath communities occurring in bogs and poor fens. The *Triantha glutinosa* order (syn. *Tofieldia glutinosa* order (O'Connell et al. 1984)) consists of six communities characterizing rich fens. The remaining four orders (i.e., the *Eriophorum angustifolium* order, the *Juncus supiniformis* order, the *Rhynchospora alba* - *Scheuchzeria palustris* order, and the *Nuphar lutea* ssp. *polysepala* order) each consists of single associations (i.e., the *Eriophorum angustifolium* / *Utricularia intermedia* association, the *Juncus supiniformis* association, the *Rhynchospora alba* - *Scheuchzeria*

palustris association, and the *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association). These communities occupy lawn, hollow, pool, and lagg microhabitats.

Diagnostic combinations of species differentiating each association and alliance are given in Tables 3.4 and 3.5. Ordination of the relevés using nonmetric multidimensional scaling demonstrates broad relationships among alliances and associations (Figure 3.6).

Table 3.3 Synopsis of vegetation units in the classification. Plant orders are numbered 1–6.

Vegetation unit number	Order	Alliance	Association
1	<i>Ledum groenlandicum</i> - <i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		
1.1			<i>Gaultheria shallon</i> / <i>Pteridium aquilinum</i>
1.2			<i>Racomitrium lanuginosum</i> / <i>Juniperus communis</i> - <i>Empetrum nigrum</i>
1.3			<i>Sphagnum austinii</i> - <i>Polytrichum strictum</i> / <i>Maianthemum dilatatum</i>
			<i>Sphagnum fuscum</i>
1.4			<i>Sphagnum fuscum</i> - <i>Pleurozium schreberi</i>
1.5			<i>Sphagnum fuscum</i> - <i>Sphagnum angustifolium</i> / <i>Drosera rotundifolia</i>
			<i>Sphagnum papillosum</i>
1.6			<i>Sphagnum papillosum</i> / <i>Triantha glutinosa</i> / <i>Sphagnum rubellum</i>
1.7			<i>Sphagnum papillosum</i> / <i>Deschampsia cespitosa</i>
1.8			<i>Sphagnum papillosum</i> - <i>Sphagnum pacificum</i> / <i>Carex sitchensis</i>
1.9			<i>Aulacomnium palustre</i>
1.10			<i>Carex sitchensis</i> / <i>Spiraea douglasii</i>
2	<i>Triantha glutinosa</i>		
			<i>Caltha leptosepala</i> var. <i>biflora</i>
2.1			<i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Sphagnum pacificum</i> / <i>Kalmia microphylla</i> ssp. <i>occidentalis</i>
2.2			<i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Wamstorfia exannulata</i> / <i>Carex echinata</i>
2.3			<i>Caltha leptosepala</i> var. <i>biflora</i> - <i>Leptarrhena pyrolifolia</i> / <i>Philonotis fontana</i> var. <i>fontana</i>
2.4			<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>
2.5			<i>Juncus acuminatus</i> / <i>Drosera anglica</i> - <i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i>
2.6			<i>Carex lasiocarpa</i> / <i>Lycopus uniflorus</i>
3	<i>Eriophorum angustifolium</i>		
3.1			<i>Eriophorum angustifolium</i> / <i>Utricularia intermedia</i>
4	<i>Juncus supiniiformis</i>		
4.1			<i>Juncus supiniiformis</i>
5	<i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>		
5.1			<i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>
6	<i>Nuphar lutea</i> ssp. <i>polysepala</i>		
6.1			<i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>

Descriptions of each of the 20 associations are contained in the following section. Where an alliance consists of more than one association, I briefly introduce the floristic characteristics of the alliance, followed by a description of each association. I use synoptic tables and ordinations to differentiate between associations occurring in the *Sphagnum fuscum*, *Sphagnum papillosum*, and *Caltha leptosepala* var. *biflora* alliances. Full summary tables for each association are contained in Appendix 1.

Descriptions of vegetation units

***Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* Order**

The *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order encompasses ten associations occurring in bogs and poor fens. Two of the associations represent shrub-dominated heath vegetation. The *Gaultheria shallon* / *Pteridium aquilinum* association occurs primarily near the centre of disturbed mires, whereas the *Carex sitchensis* / *Spiraea douglasii* association typically occupies the lagg surrounding raised bogs or occurs in seasonally inundated parts of poor fens. Neither association has a well-developed bryophyte layer. Both are subject to extreme seasonal water level fluctuations, and high density of the shrub layer and associated leaf litter limits the quantity of light reaching the mire surface.

Four other associations in the *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order characterize hummocks in raised bogs. The *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association and the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association are confined to mires in oceanic regions, whereas both associations in the *Sphagnum fuscum* alliance are widely distributed throughout much of Vancouver Island. Each of the four hummock associations typically has a well-developed bryophyte layer and supports several species of dwarf shrubs.

Another four associations in the *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order encompass low hummocks and lawns in fens. Two associations in the *Sphagnum papillosum* alliance (i.e., the *Sphagnum papillosum* / *Triantha glutinosa* /

Sphagnum rubellum association and the *Sphagnum papillosum* / *Deschampsia cespitosa* association) occur in mires at low elevations on western and northern Vancouver Island in areas where shallow peat overlies undulating ground. The third association in the *Sphagnum papillosum* alliance (i.e., the *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association) is more widespread and is usually found along the margins of bogs and fens. The *Aulacomnium palustre* association seems to be floristically and ecologically transitional between the *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order and the *Triantha glutinosa* order. It typically has both a dwarf shrub layer and a diverse, well-developed herb layer.

Table 3.4 Diagnostic combinations of species for seven associations and alliances in the *Ledum groenlandicum* – *Kalmia microphylla* ssp. *occidentalis* order.

Association / Alliance		1	2	3	4	5	6	7
Number of relevés		13	6	10	125	52	20	15
		Diagnostic value ¹	Presence class ² and mean species significance ³					
Association: <i>Gaultheria shallon</i> / <i>Pteridium aquilinum</i>								
<i>Gaultheria shallon</i>	dd	V 6	V 2	IV 2	II 2	I +	I 2	I +
<i>Pteridium aquilinum</i>	dd	III 5		II 1	I 1			
Association: <i>Racomitrium lanuginosum</i> / <i>Juniperus communis</i> - <i>Empetrum nigrum</i>								
<i>Racomitrium lanuginosum</i>	cd		V 9		I +	I 2		
<i>Juniperus communis</i>	cd		III 5	I 2		I +		
<i>Empetrum nigrum</i>	dd	II 5	V 6	V 3	II 3	II 3	III 3	
Association: <i>Sphagnum austinii</i> - <i>Polytrichum strictum</i> / <i>Maianthemum dilatatum</i>								
<i>Sphagnum austinii</i>	cd		I +	V 9	I +	I 2		
<i>Polytrichum strictum</i>	d			IV 3	I +	I 1	I +	
<i>Maianthemum dilatatum</i>	d		I +	IV 2	I +			
Alliance: <i>Sphagnum fuscum</i>								
<i>Sphagnum fuscum</i>	dd			II 4	III 6	II 3	I +	
Alliance: <i>Sphagnum papillosum</i>								
<i>Sphagnum papillosum</i>	cd				I 3	V 7	III 5	
Association: <i>Aulacomnium palustre</i>								
<i>Aulacomnium palustre</i>	cd	I +		I +	I +	I 1	III 5	I +
Association: <i>Carex sitchensis</i> / <i>Spiraea douglasii</i>								
<i>Carex sitchensis</i>	cd	I +		I 1	I +	I 1	II 1	V 5
<i>Spiraea douglasii</i>	d	II 4			I +		I +	IV 5

¹Diagnostic values: d = differential, dd = dominant differential, cd = constant dominant (Pojar et al. 1987).

²Presence class as percent frequency: I=1-20%, II=21-40%, III=41-60%, IV=61-80%, V=81-100%. ³Species significance class as percent cover range: +=0.1-0.3%, 1=0.4-1%, 2=1.1-2.1%, 3=2.2-5%, 4=5.1-10%, 5=10.1-20%, 6=20.1-33%, 7=33.1-50%, 8=50.1-70%, 9=70.1-100%.

***Gaultheria shallon* / *Pteridium aquilinum* association**

The *Gaultheria shallon* / *Pteridium aquilinum* association typifies shrub heath communities often found in disturbed mires at low to middle elevations (30–660 m asl) on eastern Vancouver Island (Figure 3.7a). *Gaultheria shallon* and *Ledum groenlandicum* are common and usually very abundant in the shrub layer (Table 1, Appendix 1). *Kalmia microphylla* ssp. *occidentalis* is often present but not very abundant. *Empetrum nigrum*, *Spiraea douglasii*, and *Malus fusca*, conversely, occur less frequently but when present are often have high cover values. *Pinus contorta* var. *contorta* usually dominates the canopy layer.

Herbaceous plant species are uncommon in the *Gaultheria shallon* / *Pteridium aquilinum* association. Only *Pteridium aquilinum* was recorded from >40% of relevés. Bryophyte cover is typically low, although a wide variety of species may be present, including *Hylocomium splendens*, *Rhytidiadelphus triquetrus*, *R. loreus*, *Eurhynchium oregonum*, *E. praelongum*, *Pleurozium schreberi*, *Dicranum scoparium*, *Plagiothecium undulatum*, and *Aulacomnium palustre*. Most of these species also occur in forests. Few species of *Sphagnum* species richness and abundance in the *Gaultheria shallon* / *Pteridium aquilinum* association is low. The most common species are *Sphagnum pacificum*, *S. palustre*, *S. capillifolium*, and *S. mendocinum*.

***Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association**

The *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association forms tall hummocks in mires in the Pacific Oceanic wetland region on Vancouver Island (Table 3.1). Species composition is relatively uniform (Table 2, Appendix 1).

Racomitrium lanuginosum dominates the bryophyte layer. Few other species of bryophytes and lichens are prominent. However, *Sphagnum capillifolium* is often present in small quantities. In the mires surveyed, *Dicranum undulatum* occurs exclusively in this association.

The shrub layer of the *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association is typically dominated by *Empetrum nigrum*. Dwarf shrub species

often include *Kalmia microphylla* ssp. *occidentalis*, *Ledum groenlandicum*, and *Gaultheria shallon*. *Myrica gale* and *Juniperus communis* are also common. Stunted individuals of *Pinus contorta* var. *contorta* and *Thuja plicata* are typical of the association and may contribute to hummock formation through the gradual build-up of organic matter around their bases (Wade 1965, p. 33). Three species of herbaceous plants and three species of graminoids are not uncommon in the association: *Sanguisorba officinalis*, *Microseris borealis*, *Triantha glutinosa*, *Eriophorum angustifolium*, *Carex livida*, and *Calamagrostis nutkaensis*. *Platanthera chorisiana*, a regionally rare orchid species, was observed in *Racomitrium* hummocks on Vargas Island in 2000, but was not found during subsequent visits in 2001.

Racomitrium lanuginosum-dominated hummocks range in height from 30–70 cm. Few hummocks exceed 4 m² in extent. The hummocks are often situated adjacent to mud-bottom hollows (Figure 3.7b). Unlike *Sphagnum austinii*-dominated hummocks which remain moist throughout the year, *Racomitrium* hummocks become desiccated during summer dry periods, likely excluding drought-sensitive species such as *Drosera rotundifolia*.

***Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association**

Tall hummocks of the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association are common in bogs throughout the Pacific Oceanic wetland region. They typically occupy slightly raised areas near the centre of low-elevation (5–75 m asl) bogs and are sometimes situated alongside mud-bottom hollows (Figure 3.7). The association is characterized by an abundance of *Sphagnum austinii* with lesser quantities of *Polytrichum strictum* and *Sphagnum capillifolium*. Shrubs and stunted trees are common, but not dense. *Ledum groenlandicum*, *Kalmia microphylla* ssp. *occidentalis*, and *Empetrum nigrum*, for example, are usually present, but none have cover values exceeding 10%. *Gaultheria shallon* is also common, but is very sparse. Common recorded tree species in the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association include *Pinus contorta* var. *contorta*, *Thuja plicata*, and *Tsuga heterophylla*. All three species have stunted growth forms. *Chamaecyparis nootkatensis*

Table 3.5 Diagnostic combinations of species for eight associations and alliances.

Association / Alliance	8	9	10	11	12	13	14	15
Number of relevés	51	35	8	13	6	6	8	27
	Diagnostic value ¹		Presence class ² and mean species significance ³					
Alliance: <i>Caltha leptosepala</i> var. <i>biflora</i>								
<i>Caltha leptosepala</i> var. <i>biflora</i>	d	IV 3	I	1				
Association: <i>Dodecatheon jeffreyi</i>ssp. <i>jeffreyi</i>								
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	d	I	1	IV 3				
Association: <i>Juncus acuminatus</i> / <i>Drosera anglica</i>								
<i>Juncus acuminatus</i>	d			V 3				
<i>Drosera anglica</i>	d	I	+	I	+	V 2	I	3
							II	1
<i>Dichanthelium acuminatum</i>	cd	I	+	IV 5				
var. <i>fasciculatum</i>								
<i>Lycopodiella inundata</i>	d		I	2	IV	+	I	1
							II	2
<i>Schoenoplectus tabernaemontani</i>	d				III	3	I	+
<i>Sphagnum compactum</i>	d	I	+	I	3	III	+	
<i>Triglochin maritima</i>	d				III	+	I	+
<i>Coptis trifolia</i>	d		I	+	III	+		
Association: <i>Carex lasiocarpa</i> / <i>Lycopus uniflorus</i>								
<i>Carex lasiocarpa</i>	cd	I	+	I	+	IV 5	I	+
							II	3
<i>Lycopus uniflorus</i>	d		I	+	I	+	III 3	I
								+
Association: <i>Eriophorum angustifolium</i> / <i>Utricularia intermedia</i>								
<i>Eriophorum angustifolium</i>	dd	III	3	IV	3	I	1	V 5
							II	+
<i>Utricularia intermedia</i>	d							III 4
							I	1
								I
Association: <i>Juncus supiniformis</i>								
<i>Juncus supiniformis</i>	cd	I	+	I	+	I	+	V 5
								I
Association: <i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>								
<i>Rhynchospora alba</i>	dd	I	1	I	1	V	4	IV 5
							II	1
<i>Scheuchzeria palustris</i>	d			I	+	I	+	IV 2
								I
								1
Association: <i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>								
<i>Menyanthes trifoliata</i>	cd	I	1	I	+	II	+	II
								2
<i>Nuphar polysepala</i>	d		I	+		I	+	IV 6
								4
							II	+
								III 4

¹Diagnostic values: d = differential, dd = dominant differential, cd = constant dominant, c = constant (Pojar et al. 1987).

²Presence class as percent frequency: I=1-20%, II=21-40%, III=41-60%, IV=61-80%, V=81-100%. ³Species significance class as percent cover range: +=0.1-0.3%, 1=0.4-1%, 2=1.1-2.1%, 3=2.2-5%, 4=5.1-10%, 5=10.1-20%, 6=20.1-33%, 7=33.1-50%, 8=50.1-70%, 9=70.1-100%.

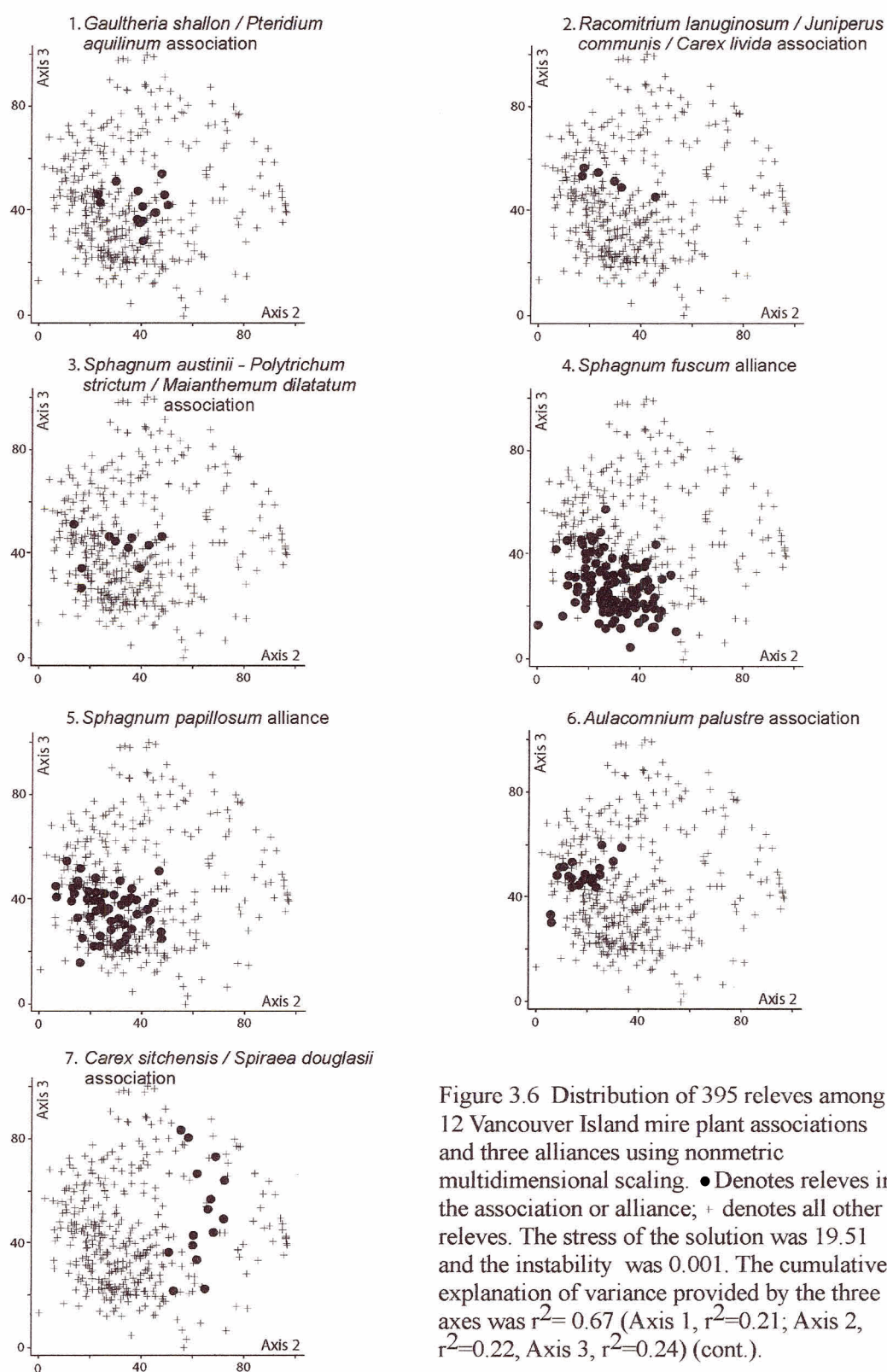


Figure 3.6 Distribution of 395 relevés among 12 Vancouver Island mire plant associations and three alliances using nonmetric multidimensional scaling. ● Denotes relevés in the association or alliance; + denotes all other relevés. The stress of the solution was 19.51 and the instability was 0.001. The cumulative explanation of variance provided by the three axes was $r^2 = 0.67$ (Axis 1, $r^2 = 0.21$; Axis 2, $r^2 = 0.22$, Axis 3, $r^2 = 0.24$) (cont.).

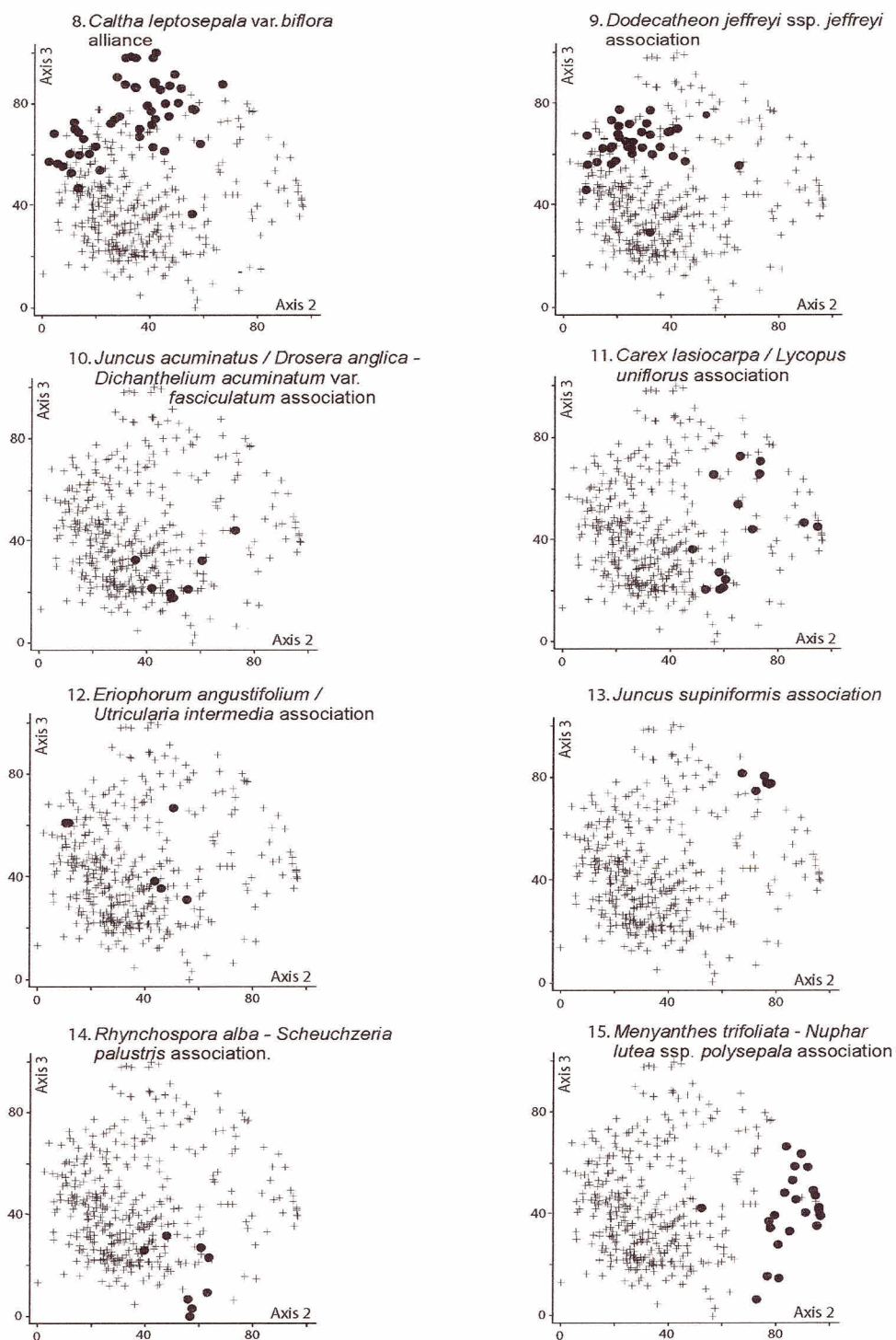


Figure 3.6 (cont.) Distribution of 395 relevés among 12 mire plant associations and three alliances.

and *Pinus monticola* are less typical. The most common herbaceous plants and graminoids in the association are *Drosera rotundifolia*, *Linnaea borealis*, *Maianthemum dilatatum*, and *Calamagrostis nutkaensis*. *Vaccinium oxycoccus* is usually present, whereas lichens and liverworts are absent from the association.

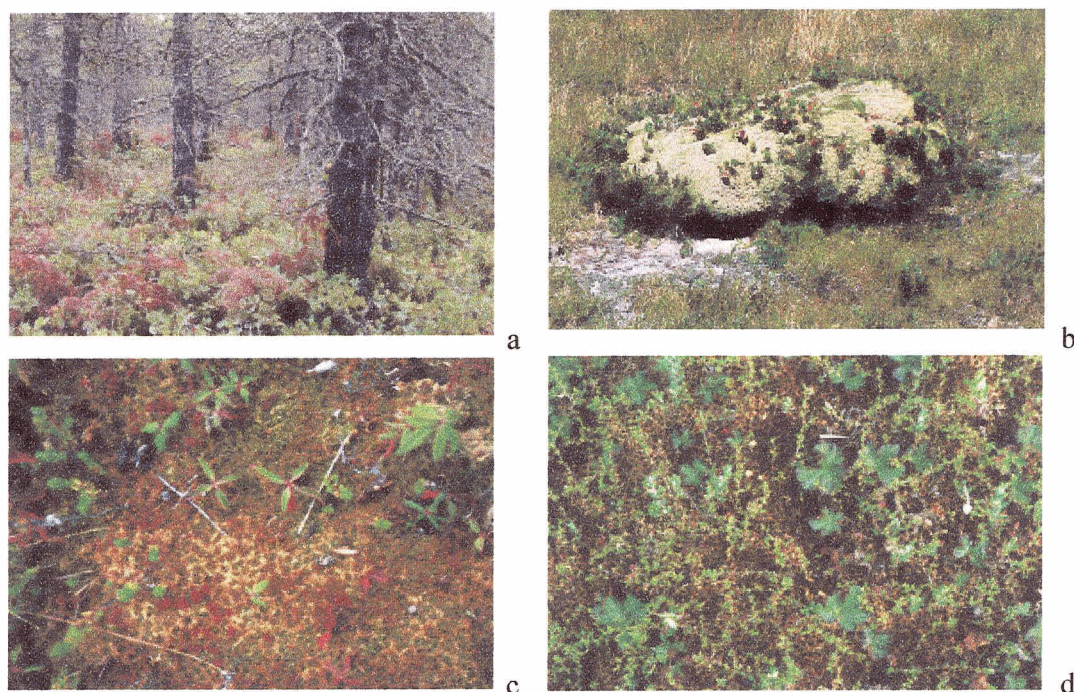


Figure 3.7 Vegetation associations in Vancouver Island mires: a. *Gaultheria shallon* / *Pteridium aquilinum* association; b. *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association; c. *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association; d. *Sphagnum fuscum* - *Pleurozium schreberi* association.

***Sphagnum fuscum* alliance**

Species differentiating the two associations of the *Sphagnum fuscum* alliance are identified in Table 3.6. Ordination of relevé data supports division of the alliance into two associations based on floristic composition. The split between the two groups seems to correspond with differences in moisture and nutrient supplies, although these variables were not measured (Figure 3.8).

Sphagnum fuscum - *Pleurozium schreberi* association

The *Sphagnum fuscum* - *Pleurozium schreberi* association is common in low to middle elevation mires throughout Vancouver Island. It is described from 63 relevés in 20 mires ranging in elevation from 10–710 m asl. The association characterizes hummocks occurring in the driest, most successional advanced parts of bogs (Figure 3.7); it often represents the last remaining bryophyte or lichen dominated association in disturbed mires. *Sphagnum fuscum*, *Sphagnum capillifolium*, or *Pleurozium schreberi* are usually prominent in the bryophyte layer (Table 4, Appendix 1). Lichens species are occasionally abundant, particularly *Cladonia rangiferina*, *Cladonia portentosa* ssp. *pacifica*, *Cladonia bellidiflora*, *Cladonia arbuscula* ssp. *beringiana*, and *Cladonia raii*. The most frequently-occurring vascular plant species in relevés is *Ledum groenlandicum*, followed by *Kalmia microphylla* ssp. *occidentalis* and *Vaccinium oxycoccos*. Other commonly occurring plant taxa include *Pinus contorta* var. *contorta*, *Rubus chamaemorus*, *Eriophorum chamissonis*, *Empetrum nigrum*, and *Vaccinium uliginosum*. Less frequently occurring species include *Drosera rotundifolia*, *Gaultheria shallon*, and *Sphagnum angustifolium*.

Table 3.6 Diagnostic combinations of species for associations of the *Sphagnum fuscum* alliance.

Association number	4.1	4.2
Number of relevés	63	62

Species	Diagnostic value ¹	
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Association 1.4: *Sphagnum fuscum* - *Pleurozium schreberi*

<i>Empetrum nigrum</i>	d	III 4	I	+
<i>Pleurozium schreberi</i>	cd	III 5	I	+
<i>Pinus contorta</i> var. <i>contorta</i>	d	III 3	I	+
<i>Vaccinium uliginosum</i>	d	III 3	I	2

Association 1.5: *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia*

<i>Sphagnum angustifolium</i>	cd	II 2	IV 5
<i>Drosera rotundifolia</i>	d	II +	IV 2
<i>Myrica gale</i>	d	I +	IV 4
<i>Rhynchospora alba</i>	d	I +	III 4

¹Diagnostic values: d = differential, cd = constant dominant (Pojar et al. 1987).

²Presence class as percent frequency: I=1-20%, II=21-40%, III=41-60%, IV=61-80%, V=81-100%. ³Species significance class as percent cover range: +=0.1-0.3%, 1=0.4-1%, 2=1.1-2.1%, 3=2.2-5%, 4=5.1-10%, 5=10.1-20%, 6=20.1-33%, 7=33.1-50%, 8=50.1-70%, 9=70.1-100%.

The *Sphagnum fuscum* - *Pleurozium schreberi* association is differentiated from the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association by

greater presence and abundance of the following species: *Empetrum nigrum*, *Pleurozium schreberi*, *Pinus contorta* var. *contorta*, and *Vaccinium uliginosum* (Table 3.6). The diversity of lichen species in the *Sphagnum fuscum* - *Pleurozium schreberi* association is high compared to the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association. It includes 14 species, whereas only three species were recorded from the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association.

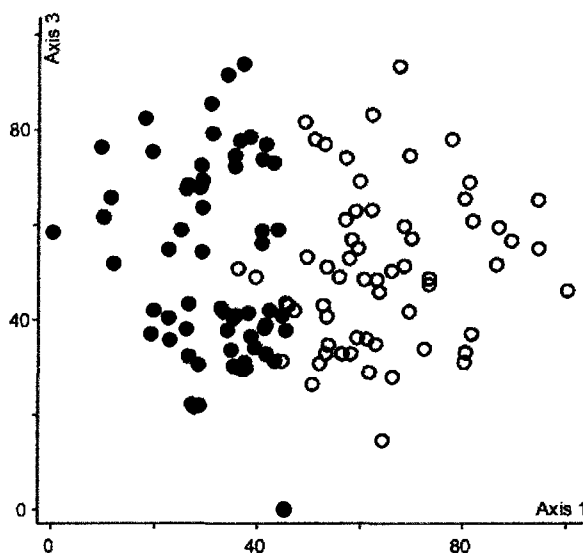


Figure 3.8 Relationships between two *Sphagnum fuscum* associations in Vancouver Island mires using nonmetric multi-dimensional scaling. The two associations are: *Sphagnum fuscum* - *Pleurozium schreberi* (●); and *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* (○). The final stress of the 3D solution was 19.10 and the instability was 0.001. The cumulative explanation of variance provided by the three axes was $r^2 = 0.73$ (Axis 1, $r^2 = 0.31$; Axis 2, $r^2 = 0.19$; Axis 3, $r^2 = 0.21$).

***Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association**

The *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association is floristically and ecologically similar to the *Sphagnum fuscum* - *Pleurozium schreberi* association. Both form hummocks, and both share a large number of species including *Sphagnum fuscum*, *S. capillifolium*, *S. angustifolium*, *Ledum groenlandicum*, *Kalmia microphylla* ssp. *occidentalis*, *Vaccinium oxycoccos*, *Eriophorum chamissonis*, *Drosera rotundifolia*, *Gaultheria shallon*, and *Rubus chamaemorus* (Table 3.7). Key differences in floristic composition of the two associations appear to be related to differences in moisture availability and proximity to relatively mineral-enriched water. The *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association occurs primarily in bogs and poor fens on eastern Vancouver Island, whereas the *Sphagnum fuscum* -

schreberi association also occurs in fens at middle elevations on eastern and southwestern Vancouver Island.

Like the *Sphagnum fuscum* - *Pleurozium schreberi* association, the most common vascular plant species in the hummocks are *Ledum groenlandicum*, *Vaccinium oxycoccos*, and *Kalmia microphylla* ssp. *occidentalis* (Table 5, Appendix 1). *Sphagnum angustifolium* is the most common bryophyte species, followed by *S. fuscum* and *S. capillifolium*. *Sphagnum fuscum* is typically very abundant. *Drosera rotundifolia*, *Myrica gale*, and *Rhynchospora alba* are all relatively common, and occur more frequently and have greater cover than they do in the *Sphagnum fuscum* - *Pleurozium schreberi* association. *Myrica gale* and *Rhynchospora alba*, in particular, reflect wet, nutrient-rich conditions related to the location of relevés alongside lakes, ponds, fens, or the lagg surrounding raised bogs and poor fens (Figure 3.7).

***Sphagnum papillosum* alliance**

Floristic differences between the three associations of the *Sphagnum papillosum* alliance are identified in Table 3.7. The ordination in Figure 3.9 illustrates some overlap between the associations. The *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association, located on the extreme right side of the diagram, contains several species not present in low-elevation mires on eastern Vancouver Island. These include: *Trichophorum cespitosum*, *Ligusticum calderi*, *Sphagnum rubellum*, *Chamaecyparis nootkatensis*, and *Linnaea borealis*. Several of these species are sometimes present but occur much less consistently than they do in the *Sphagnum papillosum* / *Deschampsia cespitosa* association.

***Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association**

The *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association occupies large portions of mires (i.e., >100 m² in area) in the South Coast subregion of the Pacific Oceanic wetland region. It is particularly common in northwestern Vancouver Island mires where it characterizes lawns and cushions that occur below an open canopy

of *Pinus contorta* var. *contorta* and *Chamaecyparis nootkatensis*. The association can be differentiated from other associations in the *Sphagnum papillosum* alliance by a large group of species that includes:

<i>Chamaecyparis nootkatensis</i>	<i>Pinus contorta</i> var. <i>contorta</i>	<i>Cornus unalaschensis</i>
<i>Empetrum nigrum</i>	<i>Linnaea borealis</i>	<i>Ligusticum calderi</i>
<i>Triantha glutinosa</i>	<i>Trientalis arctica</i>	<i>Carex livida</i>
<i>Trichophorum cespitosum</i>	<i>Sphagnum rubellum</i>	<i>Pleurozium schreberi</i>
<i>Sphagnum fuscum</i>	<i>Cladina portentosa</i> ssp. <i>pacifica</i>	

Pinus contorta var. *contorta* and *Ledum groenlandicum* are always present (Table 6, Appendix 1). Two other common shrub species are *Empetrum nigrum* and *Kalmia microphylla* ssp. *occidentalis*.

Table 3.7 Diagnostic combinations of species for associations of the *Sphagnum papillosum* alliance.

Association number	1.6	1.7	1.8
Number of relevés	17	21	14

Species	Diagnostic value ¹						
Association 1.6: <i>Sphagnum papillosum</i> / <i>Triantha glutinosa</i> / <i>Sphagnum rubellum</i>							
<i>Triantha glutinosa</i>	d	V	+	II	+		
<i>Sphagnum rubellum</i>	d	IV	3	I	1		
<i>Cornus unalaschensis</i>	d	IV	2				
<i>Cladina portentosa</i> ssp. <i>pacifica</i>	d	III	4	I	+		
<i>Chamaecyparis nootkatensis</i>	d	III	3	I	+		
<i>Ligusticum calderi</i>	d	II	2	I	+		
<i>Pinus contorta</i> var. <i>contorta</i>	d	V	4	I	+	I	1
<i>Carex livida</i>	d	IV	2	II	2	I	+
<i>Linnaea borealis</i>	d	IV	1	I	+	I	+
<i>Trichophorum cespitosum</i>	d	IV	3	II	3		
<i>Empetrum nigrum</i>	d	IV	4	I	+		
Association 1.7: <i>Sphagnum papillosum</i> / <i>Deschampsia cespitosa</i>							
<i>Deschampsia cespitosa</i>	d	I	+	IV	1	I	+
<i>Rhynchospora alba</i>	d	II	2	IV	4	II	1
<i>Sanguisorba officinalis</i>	d	III	2	V	4	I	1
Association 1.8: <i>Sphagnum papillosum</i> - <i>Sphagnum pacificum</i> / <i>Carex sitchensis</i>							
<i>Sphagnum pacificum</i>	dd	III	3	II	3	IV	7
<i>Carex sitchensis</i>	d	I	+	I	1	III	3

¹Diagnostic values: d = differential, dd = dominant differential, cd = constant dominant, c = constant (Pojar et al. 1987).

²Presence class as percent frequency: I=1–20%, II=21–40%, III=41–60%, IV=61–80%, V=81–100%.

³Species significance class as percent cover range: +=0.1–0.3%, 1=0.4–1%, 2=1.1–2.1%, 3=2.2–5%, 4=5.1–10%; 5=10.1–20%, 6=20.1–33%, 7=33.1–50%, 8=50.1–70%, 9=70.1–100%.

Common and abundant bryophyte species in the *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association include *Sphagnum papillosum*, *S. rubellum*, *S. pacificum*, *S. fuscum*, and *Pleurozium schreberi*. In addition to the three graminoid species listed above, *Carex utriculata*, *Eriophorum angustifolium*, and *Agrostis aequivalvis* are also frequently present. The most common herbaceous species are *Drosera rotundifolia*, *Triantha glutinosa*, *Cornus unalaschensis*, *Linnaea borealis*, *Gentiana douglasiana*, *Trientalis arctica*, *Microseris borealis*, and *Sanguisorba officinalis*. *Vaccinium oxycoccos* is also widespread. The most frequently observed and most abundant lichen species in the association is *Cladina portentosa* ssp. *pacifica*.

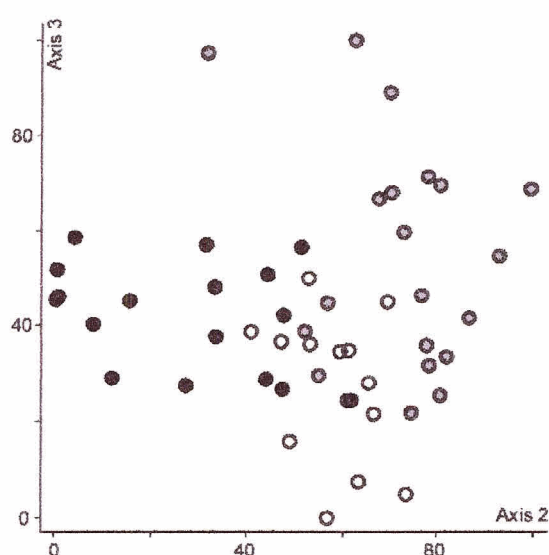


Figure 3.9 Relationships among three associations of the *Sphagnum papillosum* alliance in Vancouver Island mires using nonmetric multidimensional scaling. The three associations are: 1) *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* (●); 2) *Sphagnum papillosum* / *Deschampsia cespitosa* (○); and 3) *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* (●). The final stress of the 3D solution was 14.87 and the instability was 0.001. The cumulative explanation of variance provided by the three axes was $r^2 = 0.83$ (Axis 1: $r^2=0.18$; Axis 2: $r^2=0.38$, Axis 3: $r^2=0.26$).

***Sphagnum papillosum* / *Deschampsia cespitosa* association**

The *Sphagnum papillosum* / *Deschampsia cespitosa* association occurs in mires at low elevations (10–80 m asl) on western and northern Vancouver Island. It forms lawns or occupies hollows, and is dominated by bryophytes and graminoids. Three species distinguish it from other associations in the *Sphagnum papillosum* alliance: *Sanguisorba officinalis*, *Rhynchospora alba*, and *Deschampsia cespitosa* (Table 3.7). None of these species are usually very abundant (Table 7, Appendix 1). Other graminoids and herbaceous plants occurring in the association include *Drosera rotundifolia*, *Trientalis arctica*, *Eriophorum angustifolium*, and *Gentiana douglasiana*.

The most common and abundant bryophyte species occurring in the association is *Sphagnum papillosum*. *Sphagnum pacificum* and *S. mendocinum* are also frequently present, although neither occupies much area. *Sphagnum tenellum* and *S. compactum* are less commonly observed, but where they occur, their abundance is high. Shrub cover in the *Sphagnum papillosum* / *Deschampsia cespitosa* association is generally sparse. The most common shrub species is *Myrica gale*.

***Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association**

The *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association typifies lawn and low hummock communities that are often widespread in fens and also occur along the shores of lakes at low to middle elevations (10–545 m asl) throughout Vancouver Island. The association is dominated by bryophytes and shrubs, and tall sedges are also prominent. The two most common bryophyte species are *Sphagnum papillosum* and *Sphagnum pacificum* (Table 8, Appendix 1). The most common shrub taxa are *Kalmia microphylla* ssp. *occidentalis*, *Ledum groenlandicum*, and *Myrica gale*. *Myrica gale* occurs less frequently than the other two species, but it is usually more abundant. Two species of tall sedges often present in the *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association are *Carex utriculata* and *Carex sitchensis*. *Carex sitchensis* and *Sphagnum pacificum* differentiate the association from the other two associations in the *Sphagnum papillosum* alliance (Table 3.7). Both species are often present in the other two associations, but have much higher abundance in this association.

***Aulacomnium palustre* association**

The *Aulacomnium palustre* association encompasses relatively dry lawn habitats in fens ranging in elevation from 535 to 930 m asl. The association is floristically and ecologically transitional between herbaceous and hummock associations (Table 3.4). Herbaceous plants, sedges, shrubs, and bryophytes are all well represented. In 20 relevés, mean species richness was relatively high (16.6, n=20). The most conspicuous and common herbaceous species is *Sanguisorba officinalis* (Table 9, Appendix 1). *Vaccinium*

oxycoccus, *Triantha glutinosa*, and *Gentiana douglasiana* are also common, but none are very plentiful.

An abundance of sedges contributes a “grassy” aspect to lawn communities (Figure 3.10 a). Of twelve species of graminoids occurring in the association, the three most common species are *Eriophorum angustifolium*, *Carex utriculata*, and *Trichophorum cespitosum*. *Eriophorum angustifolium* is almost always present. Both *Carex utriculata* and *Trichophorum cespitosum* are relatively common and abundant. Species occurring less frequently but also considered to be characteristic of fen lawn associations are *Trientalis arctica*, *Gentiana sceptrum*, and *Plantago macrocarpa*.

The *Aulacomnium palustre* association includes several shrub species, although shrub cover is typically low. The most frequently observed is *Kalmia microphylla* ssp. *occidentalis*, followed by *Ledum groenlandicum* and *Vaccinium uliginosum*, and *Empetrum nigrum*. Mean abundance per relevé of all four taxa was low (< 6%). Bryophyte cover and species richness is relatively high in the association. Five species often present include: *Sphagnum angustifolium*, *S. capillifolium*, *Aulacomnium palustre*, *S. papillosum*, and *S. pacificum*. *Sphagnum* cover is relatively low compared to some other associations.

***Carex sitchensis* / *Spiraea douglasii* association**

The *Carex sitchensis* / *Spiraea douglasii* association occurs in fens and in the lagg surrounding bogs and poor fens on eastern Vancouver Island (Figure 3.10 b). During the growing season the water table fluctuates very little; it remains close to the ground surface even during the driest months (Klinka et al. 1997). Shrubs and tall sedges dominate the association, particularly *Myrica gale*, *Carex sitchensis*, and *Spiraea douglasii* (Table 3.4) (Table 10, Appendix 1). *Ledum groenlandicum* is relatively common, whereas *Carex utriculata* and *C. lasiocarpa* occur somewhat less frequently.

Herbaceous species such as *Comarum palustre* and *Veronica scutellata* are occasionally found in wet areas. Bryophyte cover is typically low. The two most common moss

species are *Sphagnum mendocinum* and *S. subsecundum*. Both persist in shaded conditions amongst shrubs and tall sedges, and tolerate water level fluctuations typical of the lagg.

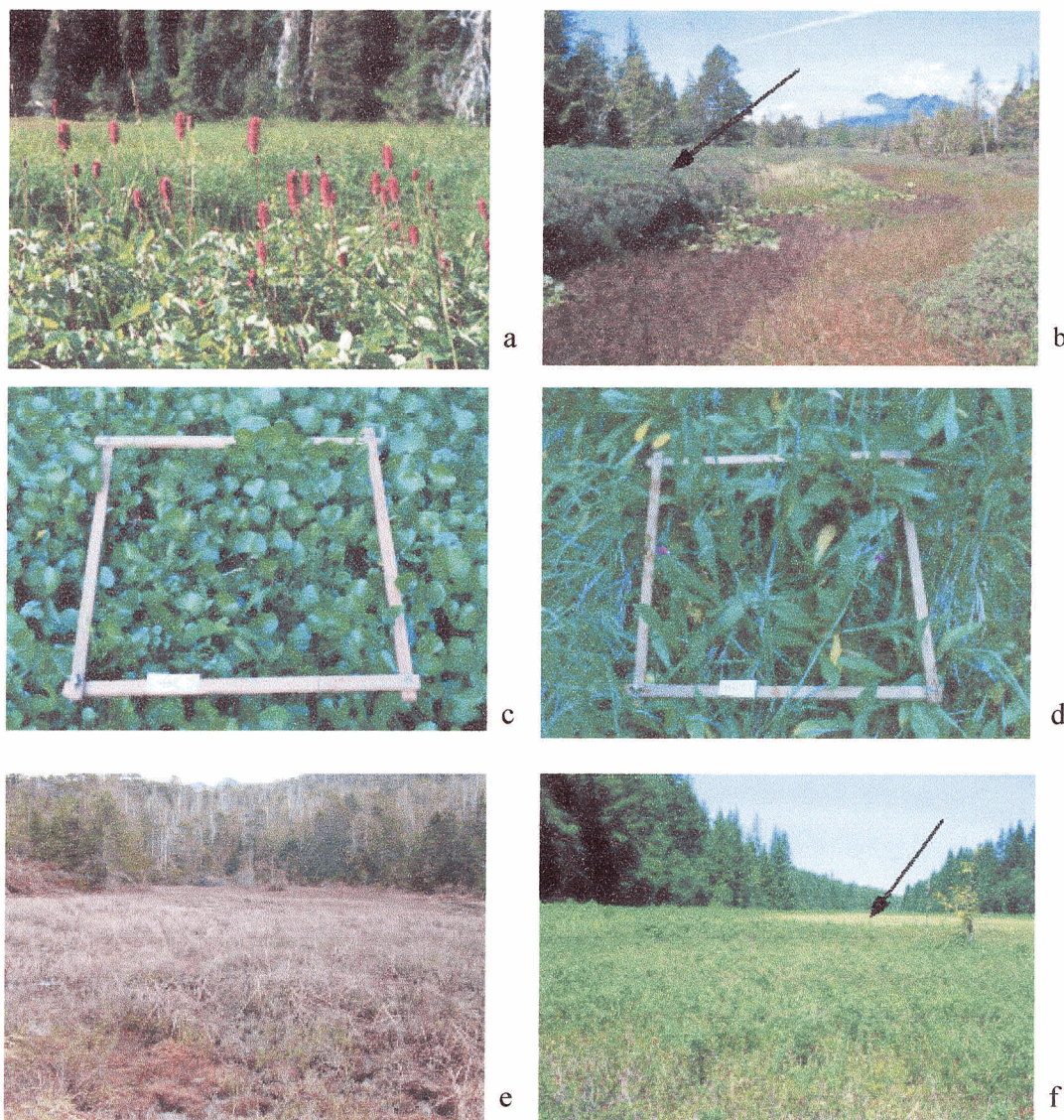


Figure 3.10 Vegetation associations in Vancouver Island mires: a. *Aulacomnium palustre* association; b. *Carex sitchensis* / *Spiraea douglasii* association; c. *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association; d. *Dodecatheon jeffreyi* ssp. *jeffreyi* association; e. *Juncus acuminatus* - *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association; and f. *Carex lasiocarpa* / *Lycopus uniflorus* association.

***Triantha glutinosa* order**

The *Triantha glutinosa* order is represented by four alliances on Vancouver Island. The *Caltha leptosepala* var. *biflora* alliance is composed of three associations, whereas the

Dodecatheon jeffreyi ssp. *jeffreyi* alliance, the *Juncus acuminatus* - *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* alliance, and the *Carex lasiocarpa* / *Lycopus uniflorus* alliance are each based on single associations.

Table 3.8 Diagnostic combinations of species for associations of the *Caltha leptosepala* var. *biflora* alliance.

Association number	2.1	2.2	2.3
Number of relevés	18	20	13

Species		Diagnostic value ¹					
Association 2.1: <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Sphagnum pacificum</i> / <i>Kalmia microphylla</i> ssp. <i>occidentalis</i>							
<i>Sphagnum pacificum</i>	cd	V ²	7 ³	I	+		
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	d	V	3	II	1	I	+
<i>Vaccinium uliginosum</i>	d	IV	4	I	1		
<i>Carex pluriflora</i>	d	III	4	I	1	I	2
<i>Platanthera dilatata</i>	d	III	1	I	+		
Association 2.2: <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Warnstorfia exannulata</i> / <i>Carex echinata</i>							
<i>Warnstorfia exannulata</i>	d			III	3	I	2
<i>Carex echinata</i>	d	II	+	III	3		
<i>Comarum palustre</i>	d	I	+	III	3	I	3
<i>Trientalis arctica</i>	d	I	+	III	1	I	+
Association 2.3: <i>Caltha leptosepala</i> var. <i>biflora</i> - <i>Leptarrhena pyrolifolia</i> / <i>Philonotis fontana</i> var. <i>fontana</i>							
<i>Leptarrhena pyrolifolia</i>	d			II	1	V	3
<i>Sanguisorba canadensis</i>	d					V	3
<i>Philonotis fontana</i> var. <i>fontana</i>	d			II	3	IV	4
<i>Parnassia fimbriata</i>	d			II	1	IV	1
<i>Salix barclayi</i>	d					III	3
<i>Rhytidiadelphus squarrosus</i>	d	I	+	I	3	III	2
<i>Arnica mollis</i>	d					III	1
<i>Mitella pentandra</i>	d			I	+	III	1
<i>Veratrum viride</i>	d	I	+			III	1
<i>Platanthera stricta</i>	d	I	+	I	+	III	1

¹Diagnostic values: d = differential, dd = dominant differential, cd = constant dominant, c = constant (Pojar et al. 1987).

²Presence class as percent frequency: I=1–20%, II=21–40%, III=41–60%, IV=61–80%, V=81–100%.

³Species significance class as percent cover range: +=0.1–0.3%, 1=0.4–1%, 2=1.1–2.1%, 3=2.2–5%, 4=5.1–10%; 5=10.1–20%, 6=20.1–33%, 7=33.1–50%, 8=50.1–70%, 9=70.1–100%.

***Caltha leptosepala* var. *biflora* alliance**

The three associations comprising the *Caltha leptosepala* var. *biflora* alliance occur primarily in middle to high elevation sloping fens. They share many species, including *Caltha leptosepala* var. *biflora*, *Triantha glutinosa*, *Eriophorum angustifolium*, and *Carex sitchensis* (Table 3.8). *Sanguisorba officinalis*, which has high constancy in both the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association and the *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association, is replaced by *Sanguisorba canadensis* in the *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* association. Broad relationships between the associations are illustrated in the ordination in Figure 3.11.

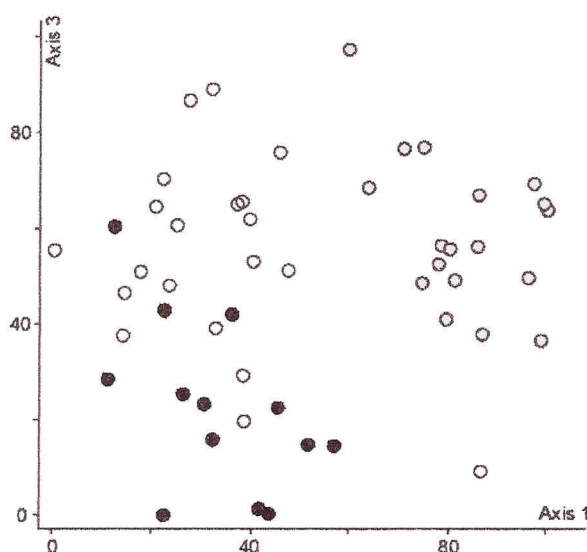


Figure 3.11 Relationships among three associations of the *Caltha leptosepala* var. *biflora* alliance in Vancouver Island mires using nonmetric multidimensional scaling. The three associations are: 1) *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* (○); 2) *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* (○); and 3) *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* (●). The final stress of the 3D solution was 16.85, and the instability was 0.001. The cumulative explanation of variance provided by the three axes was $r^2 = 0.70$ (Axis 1: $r^2 = 0.32$; Axis 2: $r^2 = 0.15$, Axis 3: $r^2 = 0.23$).

***Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association**

The *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association encompasses lawn communities occurring in flat areas in slope fen complexes located at middle to high elevations (475–1060 m asl) throughout Vancouver Island. Similar to the other two associations in the *Caltha leptosepala* var.

biflora alliance, it includes many species of herbaceous plants, graminoids, and bryophytes (Figure 3.10 c) (Table 3.10). Shrubs are more common and abundant in the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association than they are in the other two associations in the alliance, although their stature is typically low. The most frequently observed species are *Kalmia microphylla* ssp. *occidentalis* and *Vaccinium uliginosum* (Table 11, Appendix 1).

Presence and abundance of *Sphagnum* species is relatively high. The bryophyte layer is typically dominated by *Sphagnum pacificum*. *Sphagnum russowii* and *S. papillosum* are sometimes present but have lower cover values. Two species of *Sphagnum* occurring in the association are rare in southwestern B.C.: *Sphagnum riparium* and *S. centrale*.

Carex pluriflora and *Platanthera dilatata* are more common in the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association than they are in the other two associations in the *Caltha leptosepala* var. *biflora* alliance. Among herbaceous plant species, *Sanguisorba officinalis* is particularly common and abundant. Other frequently present herbaceous plant species in the association include *Eriophorum angustifolium*, *Fauria crista-galli*, *C. leptosepala* var. *biflora*, and *Triantha glutinosa*. *Rubus stellatus* occurs in the association and is rare on Vancouver Island.

***Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association**

The *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association characterizes lawns in relatively wet microhabitats in high elevation sloping fens (800–1060 m asl) throughout Vancouver Island. Like the other two associations in the *Caltha leptosepala* var. *biflora* alliance, it includes many species of graminoids, herbaceous plants, and bryophytes. Species floristically distinguishing this association from the other two associations in the *Caltha leptosepala* var. *biflora* alliance include *Sphagnum teres*, *Carex echinata*, *Comarum palustre*, *Carex anthoxanthea*, *Scapania paludosa*, *Sphagnum subsecundum*, *Trientalis arctica*, and *Warnstorfia exannulata* (Table 3.10). *Sanguisorba officinalis* and *Eriophorum angustifolium* are less abundant than they are in the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis*

association (Table 12, Appendix 1). As in both other associations in the alliance, *Caltha leptosepala* var. *biflora* and *Triantha glutinosa* are also very common. Three species of *Sphagnum* that are rare on Vancouver Island occur infrequently in the association: *Sphagnum riparium*, *S. centrale*, and *S. warnstorffii*.

***Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* association**

The *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* association occupies the upper margins of high elevation slope fens (1060–1190 m asl) on eastern Vancouver Island. The sites have a short growing season as a result of persistent snowpack, and are subject to continuous seepage throughout the growing season. The association is rich in herbaceous plant species, graminoids, and bryophytes. It is characterized by a large group of diagnostic plant species (Table 3.10) and can be distinguished from other associations in the *Caltha leptosepala* var. *biflora* alliance by the presence of the following species (Table 13, Appendix 1):

<i>Salix barclayi</i>	<i>Arnica mollis</i>	<i>Equisetum arvense</i>
<i>Fauria crista-galli</i>	<i>Leptarrhena pyrolifolia</i>	<i>Mitella pentandra</i>
<i>Parnassia fimbriata</i>	<i>Platanthera stricta</i>	<i>Sanguisorba canadensis</i>
<i>Veratrum viride</i>	<i>Philonotis fontana</i> var. <i>fontana</i>	<i>Rhytidiadelphus squarrosus</i>

Caltha leptosepala var. *biflora* is always present. *Triantha glutinosa*, *Carex sitchensis*, and *Sphagnum teres* occur somewhat less frequently. Unlike the other two associations in the alliance, *Eriophorum angustifolium* and *Kalmia microphylla* ssp. *occidentalis* are not common. *Sanguisorba officinalis* is replaced by *S. canadensis*.

A wide range of bryophyte species typical of rich fens occurs in the association (e.g., *Campylium stellatum*, *Sphagnum warnstorffii*, *Limprichtia revolvens*, and *Calliergon cordifolium*) (Malmer 1985, Gignac 1992, Gorham and Janssens 1992).

***Dodecatheon jeffreyi* ssp. *jeffreyi* association**

The *Dodecatheon jeffreyi* ssp. *jeffreyi* association occurs in middle to high elevation (475–1060 m asl) fens located throughout Vancouver Island. It is floristically similar to

the *Aulacomnium palustre* association (Table 3.4), but occupies a different ecological niche. Both associations characterize lawn communities, and both have abundant bryophyte cover. However, the *Dodecatheon jeffreyi* ssp. *jeffreyi* association receives abundant seepage during the growing season or occurs along the margins of lakes and is wetter.

Herbaceous plants, bryophytes, and sedges are particularly rich in the *Dodecatheon jeffreyi* ssp. *jeffreyi* association (Figure 3.10 d) (Table 14, Appendix 1). *Sanguisorba officinalis* is common and relatively abundant. *Triantha glutinosa*, *Dodecatheon jeffreyi* ssp. *jeffreyi*, *Gentiana sceptrum*, and *Drosera rotundifolia* are also common. Sedge species occurring in both the *Dodecatheon jeffreyi* ssp. *jeffreyi* association and the *Aulacomnium palustre* association include *Eriophorum angustifolium*, *Trichophorum cespitosum*, and *Carex utriculata*. The shrub layer is not well developed. However, *Kalmia microphylla* ssp. *occidentalis* is not uncommon. Composition of the bryophyte varies; *Sphagnum subsecundum* is the most frequently observed species in the bryophyte layer, although other species such as *Aulacomnium palustre*, *Sphagnum tenellum*, and *S. compactum* may have high cover values in individual sites.

***Juncus acuminatus* - *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association**

The *Juncus acuminatus* - *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* (syn. *Panicum occidentale* Scribn.) association is described from a single moderate-rich fen (“Windy Fen”) located near the northeast end of Kennedy Lake on western Vancouver Island. Ecological conditions are unique: the association occupies the floodplain of a small stream. The mire surface remains moist throughout the growing season. It is not known whether the association is unique to this particular wetland because it was the only low-elevation moderate-rich fen sampled on western Vancouver Island.

The *Juncus acuminatus* - *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association is a lawn community dominated by herbaceous plants (Figure 3.10 e) (Table

15, Appendix 1). It is characterized by a large group of plant species consisting of *Juncus acuminatus*, *Drosera anglica*, *Dichanthelium acuminatum* var. *fasciculatum*, *Lycopodiella inundata*, *Schoenoplectus tabernaemontani*, *Sphagnum compactum*, *Triglochin maritima*, and *Coptis trifolia* (Table 3.5). Other plant species occurring in the association include *Vaccinium oxycoccos*, *Triantha glutinosa*, *Rhynchospora alba*, *Gentiana sceptrum*, *Hypericum anagalloides*, *Viola* sp., *Carex livida*, *Carex utriculata*, and *Myrica gale*. The shrub layer is not well-developed and bryophyte cover is variable.

***Carex lasiocarpa* / *Lycopus uniflorus* association**

The *Carex lasiocarpa* / *Lycopus uniflorus* association occurs in fens and in the lagg surrounding bogs and poor fens at low to middle elevations (35–540 m asl) on eastern Vancouver Island (Figure 3.10 f). The community is usually flooded during winter, but the ground surface is relatively dry during summer. *Carex lasiocarpa* is usually the most conspicuous species, although occasionally *Rhynchospora alba* or *Myrica gale* are dominant (Table 3.5) (Table 16, Appendix 1). *Lycopus uniflorus* and *Triantha glutinosa* are relatively common but seldom abundant. Bryophyte cover is typically low; *Sphagnum subsecundum* is the most common species.

***Eriophorum angustifolium* order**

Eriophorum angustifolium has a wide ecological niche as demonstrated by its presence in many mire plant communities. The *Eriophorum angustifolium* order (Brett et al. 2001) is distinguished from others by the high constancy and abundance of *E. angustifolium*, and a poorly developed bryophyte layer. The *Eriophorum angustifolium* order encompasses several associations occurring in hollows that have standing water throughout much of the growing season.

***Eriophorum angustifolium* association**

The *Eriophorum angustifolium* association occupies hollows in fens ranging in elevation from 80–930 m asl throughout Vancouver Island, except in the eastern lowlands, where it does not occur (Figure 3.12 a). The association is not confined to mire ecosystems; it also

occurs in other types of wetlands such as shallow ponds in subalpine areas (Brett et al. 2001). Composition of the community varies by wetland region. At low elevations on western and northern Vancouver Island *Eriophorum angustifolium* is often accompanied by *Carex livida*, *Utricularia intermedia*, and *Myrica gale* (Table 17, Appendix 1).

***Juncus supiniformis* order**

The *Juncus supiniformis* order consists of a single alliance and association. The species-poor vegetation occurs in hollows and shallow pools, and lacks a well-developed bryophyte layer.

***Juncus supiniformis* association**

The *Juncus supiniformis* association occurs primarily in hollows in fens ranging in elevation from 30 to 930 m asl. The association is characterized by a single species, *Juncus supiniformis* (Table 3.5). The only other frequently-occurring plant species is *Carex utriculata* (Table 18, Appendix 1). Other species of sedges, rushes, aquatic plants, and bryophytes are less common.

***Rhynchospora alba* - *Scheuchzeria palustris* order**

The *Rhynchospora alba* - *Scheuchzeria palustris* order consists of a single alliance and association. The two species that characterize the order do not occur in mires at high elevations. Similar microhabitats in these areas are occupied by the *Juncus supiniformis* association.

***Rhynchospora alba* - *Scheuchzeria palustris* association**

The *Rhynchospora alba* - *Scheuchzeria palustris* association occurs in hollows with little or no standing water in summer (Figure 3.12 b). Similar to other mire plant associations occurring at extreme ends of the moisture gradient, species richness is low. Only *Rhynchospora alba* and *Scheuchzeria palustris* are present with any consistency (Table 3.5) (Table 19, Appendix 1). Several sedge, aquatic, and bryophyte species are less common. In most cases, vascular plant cover is sparse, although species such as

Eriophorum chamissonis, *Lycopodiella inundata*, *Myrica gale*, *Carex limosa*, and *C. livida* are sometimes locally abundant. The bryophyte layer is poorly developed.

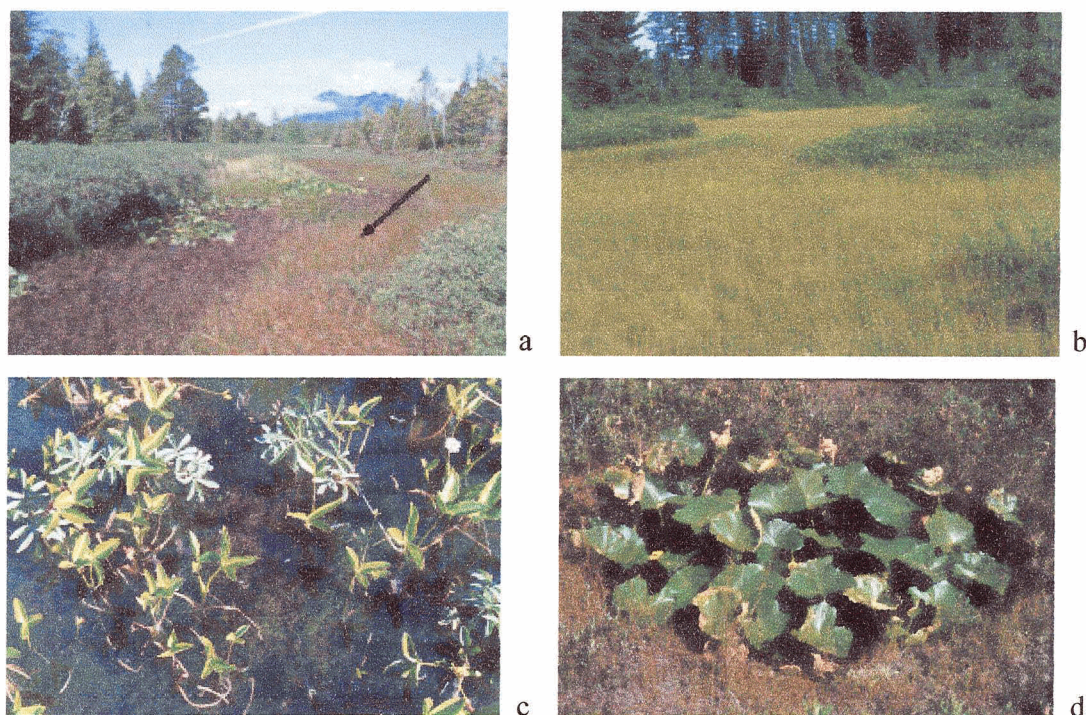


Figure 3.12 Vegetation associations in Vancouver Island mires: a. *Eriophorum angustifolium* - *Utricularia intermedia*; b. *Rhynchospora alba* - *Scheuchzeria palustris*; c, d. *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala*.

***Nuphar lutea* ssp. *polysepala* order**

The *Nuphar lutea* ssp. *polysepala* order (syn. *Nuphar polysepala* order, Klinka et al. 1997) encompasses floating aquatic plant communities occurring in shallow water (20–70 cm) in oligotrophic lakes and as remnants in mires (Klinka et al. 1997). Only one association is recognized in Vancouver Island mires. It is typically dominated either by *Menyanthes trifoliata* or *Nuphar lutea* ssp. *polysepala*.

***Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association**

The *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association is floristically and ecologically well-defined (Table 3.5). It is dominated by aquatic plants, and typically occupies hollows in bogs and poor fens (Figure 3.12 c, d). *Menyanthes trifoliata*, *Nuphar*

lutea ssp. *polysepala*, or both species are always present (Table 20, Appendix 1). Three other plant species occur in the association much less frequently: *Carex lasiocarpa*, *C. sitchensis*, and *Rhynchospora alba*.

Occasionally, the *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association occupies the deepest part of the lagg surrounding bogs and poor fens in the lowlands of eastern Vancouver Island. It also occurs in shallow seasonal channels in fens. The association is relatively common in mires throughout Vancouver Island ranging in elevation from 20 to 1100 m asl.

DISCUSSION

Regional-scale analysis

Comparison with previously delineated wetland regions and subregions

The geographic distribution of four floristically-defined groups of mires identified in my study generally corresponds with three previously delineated wetland regions on Vancouver Island (NWWG 1986, Banner et al. 1988). Mires occurring in the lowlands of northern and western Vancouver Island are encompassed by the South Coast subregion of the Pacific Oceanic wetland region (OP_s), whereas bogs and poor fens confined to low elevations on eastern Vancouver Island belong to the Pacific Temperate wetland region (TP). Two floristically distinct but closely related groups of mires are confined to elevations >450 m asl. Both groups of mires are located within the South Coast subregion of the Coast Mountain wetland region (MC_s). When comparing locations of the mires sampled to regional and subregional boundaries delineated in Banner et al. (1988, p. 308), it becomes apparent that some boundaries should be adjusted (Figure 3.13), and some areas require further sampling, as described in the following paragraphs.

South Coast subregion, Pacific Oceanic wetland region

Mires are relatively widespread and occupy a diverse range of hydrotopographic positions in parts of western and northern Vancouver Island encompassed by the South Coast

subregion of the Pacific Oceanic wetland region (OP_s). Bogs and poor fens are common in broad flat areas where drainage is impeded by cemented soil layers or bedrock at shallow depths (Jungen and Lewis 1978). Moderate rich fens are uncommon in the region but occasionally occur in flat areas alongside streams and lakeshores. As illustrated in Banner et al. (1988), the boundaries of the South Coast subregion mirror the Southern Very Wet Hypermaritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWH vh1). Physiographic regions (*sensu* Holland 1976) encompassed by the South Coast subregion of the Pacific Oceanic wetland region include the entire Estevan Lowland, limited parts of the Vancouver Island Ranges (e.g., Brooks Peninsula), and most of the Nahwitti Lowland. The Suquash Basin (the small, triangular-shaped lowland situated between Port McNeill, Quatsino and Port Hardy) is excluded from the South Coast subregion and is rather shown as the northern extent of the Pacific Temperate wetland region (NWWG 1986, Banner et al. 1988, p. 308).

Mires located in the Suquash Basin are floristically very similar to those of the South Coast subregion of the Pacific Oceanic wetland region. The Port McNeill bog is the only wetland sampled in the Suquash Basin, and it shares many species with low elevation bogs on northern and western Vancouver Island, including *Vaccinium vitis-idaea*, *Sphagnum austinii*, *S. lindbergii*, and *Racomitrium lanuginosum*. Its vegetation physiognomy and composition is similar to disturbed mires located in the Long Beach area of western Vancouver Island (see Wade 1965, p. 46). However, species composition likely reflects previous fire disturbance, causing the Port McNeill bog to be classified with disturbed mires in the Pacific Temperate wetland region (Figure 3.4). Despite the results of cluster analysis, and pending further sampling, the South Coast subregion of the Pacific Oceanic wetland region should be expanded to include mires located in the Suquash Basin.

The findings of my research also suggest that the inland margin of the South Coast subregion of the Pacific Oceanic wetland region should be expanded to incorporate all coastal lowland areas on western and northern Vancouver Island (Figure 3.13). For example, in the current configuration, “Windy Fen”, located at the northeast end of

Kennedy Lake, is excluded from the South Coast subregion of the Pacific Oceanic wetland region. It is a rich fen and is therefore floristically distinct from more typical bogs and poor fens in the area. However, cluster analysis clearly groups it with mires located within the Pacific Oceanic wetland region (Figure 3.4). By contrast, rich fen communities on Brooks Peninsula (described as Herbaceous Bog and Alpine Meadow Vegetation (Hebda et al. 1997)) should be excluded from the South Coast subregion of the Pacific Oceanic wetland region. Floristic composition of fens on Brooks Peninsula indicates they are more closely aligned with middle to high elevation fens encompassed by the West section of the South Coast subregion of the Coast Mountain wetland region.

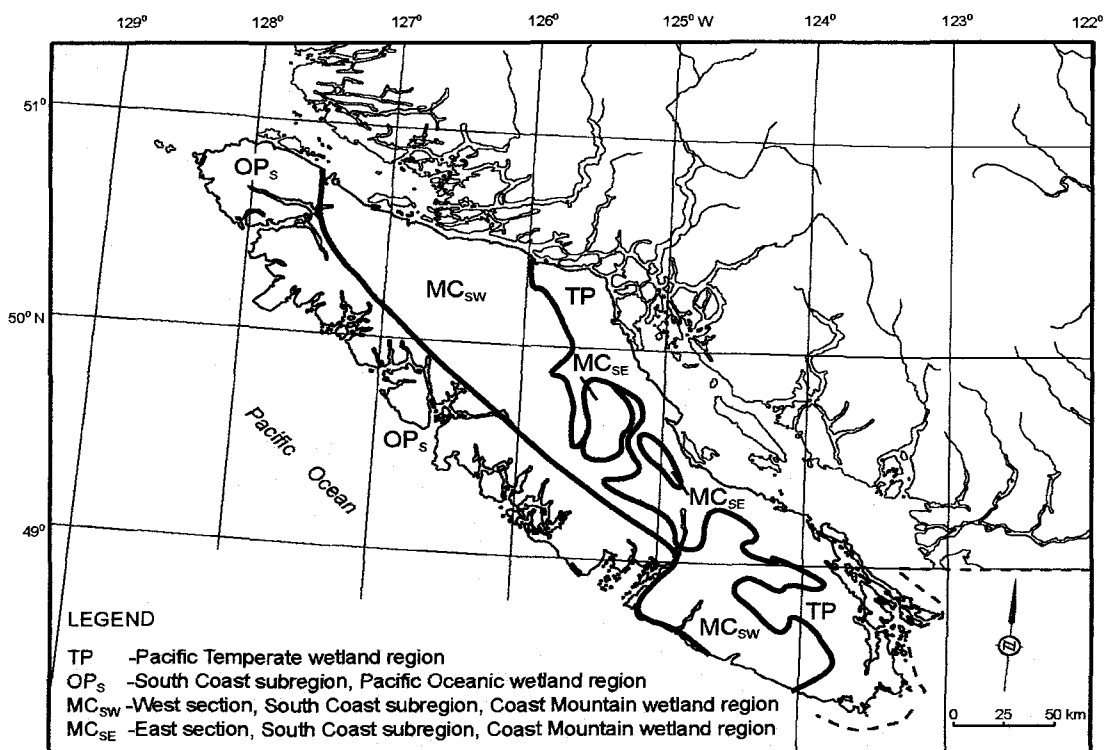


Figure 3.13 Proposed boundaries of wetland regions, subregions, and sections on Vancouver Island based on ordination and classification of total mire floristic composition.

Pacific Temperate wetland region

On eastern Vancouver Island, the Pacific Temperate wetland region is characterized by bogs and poor fens occurring in basins and surrounding lakes (Banner et al. 1988).

Although climatic conditions are generally cool and moist, there is little precipitation during summer and early fall when evapotranspiration rates are concurrently high (Jungen and Lewis 1978). Under such climatic conditions, wetlands are restricted to hydrotopographic positions where accumulated water compensates for the absence of precipitation during the growing season (Damman 1979). Seasonal drought makes these mires particularly sensitive to anthropogenic disturbance and most bogs in the Pacific Temperate region on Vancouver Island have been drained or partially filled. Disturbed bogs on eastern Vancouver Island have a well-developed tree layer of *Pinus contorta* var. *contorta*, an understory dominated by *Ledum groenlandicum* and *Gaultheria shallon*, and limited *Sphagnum* cover (Rigg 1922). Vegetation structure and composition in these bogs reflects the loss of self-regulating functions of the bryophyte layer.

Based on descriptions of mires characteristic of the Pacific Temperate wetland region (Banner et al. 1988), I suggest the regional boundaries be contracted to include only mires located in the seasonally dry lowlands on the east coast of Vancouver Island (Figure 3.13). Mountainous areas of southwestern Vancouver Island and the Suquamish Basin should be excluded. The western and northern boundaries of the region should be adjusted to follow the inland margin of the Very Dry Maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWH xm2).

The classification and ordination of two poor fens located at the interface of the Pacific Temperate wetland region and the South Coast subregion of the Coast Mountain wetland region (described below) (i.e., “Schoen Meadows” and “Anderson”) is unclear and requires further investigation. Although ordination placed the fens among middle to high elevation fens occurring in the West section of the South Coast subregion of the Coast Mountain wetland region (MC_{sw}), cluster analysis grouped them with mires of the Pacific Temperate region. The two fens are floristically distinct from wetlands in adjacent low elevation areas, and contain plant species seldom observed in the Pacific Temperate region including *Sphagnum russowii*, *Geocaulon lividum*, *Gentiana sceptrum*, and *Deschampsia cespitosa*. They also support plant species absent from geographically adjacent slope fens of the East section of the South Coast subregion of the Coast

Mountain wetland region (e.g., *Lycopus uniflorus*, *Rhynchospora alba*, *Sphagnum capillifolium*), described below. Climatic conditions affecting the two fens, which are situated at elevations of 540 and 545 m asl, similarly differ from nearby areas. They are covered with snow for 3–4 months per year, and unlike wetlands in the Pacific Temperate wetland region, are not affected by seasonal drought. Currently, I have placed the fens within the West section of the South Coast subregion of the Coast Mountain wetland region (MC_{sw}). However, further sampling may reveal that they simply form part of a continuum reflecting incremental differences in climate related to altitude.

South Coast subregion, Coast Mountain wetland region

Sloping fens, flat fens, and shore fens located along the margins of small lakes and ponds typify wetlands in the South Coast subregion of the Coast Mountain wetland region. Bogs are absent, although in some sites small areas of bog vegetation exist within the fen matrix. The wetlands are situated at elevations >450 m asl in the mountainous interior of central Vancouver Island. They are relatively uncommon, because wetland development is limited by steep topography and well-drained soils. In keeping with suggested modifications to the boundaries of the other two wetland regions on Vancouver Island, the South Coast subregion should be defined by the boundaries of the Vancouver Island Ranges physiographic region (*sensu* Holland 1976), which encompasses all mountainous areas on Vancouver Island.

Within the South Coast subregion I recognized two floristically distinct groups of middle to high elevation fens (see Figures 3.4, 3.5). One group is confined to elevations >800 m asl on eastern Vancouver Island in areas having persistent snowpack for at least seven months per year (B.C. Environment Historical Snow Survey Data, 2001). I have defined this unit as the East section (MC_{se}). The other group of fens is distributed throughout more temperate middle to high elevation areas (475–1050 m) where snowpack usually lasts for less than four months per year. I have called this unit the West section (MC_{sw}).

Although climate differs between the sections, it is difficult to attribute floristic differences to this factor alone. Snowpack duration affects the length of the growing

season and therefore peat accumulation and decomposition rates (Jungen and Lewis 1978). Additionally, heavy snowpack insulates vegetation from desiccation caused by low winter temperatures. However, local-scale factors such as physiography, chemical composition, and structure of surrounding soils, and the presence or absence of springs affect water flow and temperature, pH, and nutrient availability. Until these factors are quantified and their impacts analyzed, it is impossible to determine whether climate or local factors have a greater influence on floristic differences between the two mire groups.

Regional context

To place Vancouver Island mires in regional context I sampled five mires located near Prince Rupert on the north coast of British Columbia and three mires located in the Fraser Lowland near Vancouver. The results of cluster analysis and NMS ordination (Figures 3.4, 3.5) support grouping mires occurring at low elevations on western and northern Vancouver Island with mires in the Prince Rupert area. This group of mires corresponds with the Pacific Oceanic wetland region (NWWG 1986, Banner et al. 1988). Dividing the region into North Coast and South Coast subregions (Banner et al. 1988) is also supported by cluster analysis and NMS (Banner et al. 1988).

Cluster analysis and NMS (Figures 3.4, 3.5) also confirm that mires located in the Fraser Lowland are floristically very similar to mires occurring at low elevations on eastern Vancouver Island, despite differences in mire development and hydrotopographic position between the two groups. However, if I had included large, heavily disturbed mires such as Burns Bog, Lulu Island Bog, and Langley Bog in the study, a floristically distinct subgroup would likely have emerged owing to the presence of numerous exotic plant species including *Calluna vulgaris*, *Vaccinium corymbosum*, *V. macrocarpon*, and *Betula pendula*.

Regional-scale gradients

The primary regional-scale influence on mire development and vegetation is climate (Damman 1979, Wells 1996). Its influence on plant growth and decay strongly affects

peat formation and accumulation (Boelter and Verry 1977). Regional patterns of mire zonation follow oceanicity–continentality, latitudinal, and altitudinal climatic gradients which affect precipitation, evapotranspiration, decomposition rates, and length of the growing season. The oceanicity–continentality gradient is prevalent in coastal areas of the British Isles, northwestern Europe, and eastern North America (e.g., Damman 1979). The latitudinal gradient is particularly strong in parts of Europe and North America having continental climate (e.g., Ruuhijärvi 1970, Moore and Bellamy 1974, Eurola and Vorren 1980, Eurola et al. 1984, NWWG 1986, Zoltai 1988, Steiner 1997). The altitudinal gradient is best demonstrated in mountainous areas located far from the coast, such as the Alps (Eurola et al. 1984). In coastal regions it can be difficult to separate the effects of altitude from the influence of oceanicity (Moen 1999, Eurola et al. 1984).

Oceanicity–Continentality gradient

Bogs located in cool, oceanic regions of eastern and western North America, the British Isles, and Europe are floristically distinct from those located farther inland. Although mire structure differs among the regions (Damman 1995), and despite the great distances separating them, there are striking similarities in the vegetation of oceanic bogs. Particularly conspicuous are two species of mosses dominating the bryophyte layer in hummock communities. *Sphagnum austinii* and *Racomitrium lanuginosum* are common in bogs occurring at low elevations on the outer west and north coasts of British Columbia and southeast Alaska (Neiland 1971, Sjörs 1985). *Racomitrium lanuginosum*, in particular, is absent from inland mires because it requires a consistent supply of moisture throughout the year (Ellis and Tallis 2003), owing to its susceptibility to desiccation (Tallis 1964). *Sphagnum austinii* is similarly confined to oceanic regions, although in southwestern British Columbia two small (<20 m²) peripheral populations exist in the Fraser Lowland (Golinski 2000).

Other plant species considered to be characteristic of oceanic bogs include *Juniperus communis* and *Pleurozia purpurea*. *Juniperus communis* occurs in upland sites across North America, but in mires it is confined to oceanic regions. *Pleurozia purpurea* is found in hollows in oceanic mires in western North America, northwestern Europe, the

British Isles, and Japan (Dierssen 1982, Furuki and Mizutani 1994), but not in inland mires.

Some plant species considered to be indicators of mineral-enriched water (e.g., *Myrica gale* and *Sphagnum papillosum*) in inland mires occur in bogs in oceanic regions of British Columbia and Newfoundland (Wells 1976). The occurrence of such species in bogs has been attributed to high atmospheric nutrient deposition associated with sea spray (Osvald 1949, Tansley 1953, Damman 1978, 1995b, Wells 1996).

Locally, the floristic composition of bogs on western and northern Vancouver Island reflects relatively low summer temperatures and limited evapotranspiration associated with fog. This favours the presence of such species as *Vaccinium vitis-idaea* and *Sphagnum alaskense*, which in coastal mires reach far south beyond their contiguous range in continental areas. Limited temperature fluctuation and relatively constant precipitation throughout the growing season also favours the presence of herbaceous species like *Plantago macrocarpa* that are absent from inland regions.

Further inland along the oceanicity–continentality gradient, mires in the lowlands of eastern Vancouver Island are floristically transitional between wetlands of the Pacific Oceanic wetland region and those occurring in the Boreal wetland region located east of the Coast Mountains. Seasonal drought and low humidity during the growing season excludes many species typical of oceanic bogs and fens from the Pacific Temperate wetland region. Yet many plant taxa present in low elevation mires on eastern Vancouver Island have coastal distribution patterns and are absent from continental mires. These include: *Agrostis aequivallis*, *Carex sitchensis*, *Cornus unalaschkensis*, *Maianthemum dilatatum*, *Sanguisorba officinalis*, *Gaultheria shallon*, *Empetrum nigrum*, *Sphagnum palustre*, *S. henryense*, *S. pacificum*, and *Cladina portentosa* ssp. *pacifica*. This trend in floristic distribution is particularly evident when comparing the composition of the tree layer in coastal mires to those located in continental areas (Vitt et al. 1990) (Table 3.9). There is no overlap of tree taxa between bogs of the two Pacific coast wetland regions and the Boreal wetland region.

Table 3.9 Regional distribution of tree taxa in British Columbia bogs.

Taxon	Region*
1 <i>Chamaecyparis nootkatensis</i>	OP
2 <i>Tsuga mertensiana</i>	OP
3 <i>Pinus contorta</i> var. <i>contorta</i>	OP, TP
4 <i>Thuja plicata</i>	OP, TP
5 <i>Tsuga heterophylla</i>	OP, TP
6 <i>Picea mariana</i>	B
7 <i>Larix laricina</i>	B

* OP= Pacific Oceanic wetland region; TP= Pacific Temperate wetland region; B= Boreal wetland region.

The distribution of several mire plant associations on Vancouver Island also follows an oceanicity–continentality gradient (Table 3.10). Six associations described in this chapter occur exclusively in mires of the Pacific Oceanic wetland region (i.e., the *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association; the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association; the *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association; the *Sphagnum papillosum* / *Deschampsia cespitosa* association; the *Juncus acuminatus* / *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association; and the *Eriophorum angustifolium* / *Utricularia intermedia* association). At middle to high elevations one association is confined to mires of the East section of the South Coast subregion of the Coast Mountain wetland region (i.e., the *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* association), while another is present only in the West section of the South Coast subregion of the Coast Mountain wetland region (i.e., the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association).

Latitudinal gradient

There is little evidence that the floristic composition of mires on northern and southern Vancouver Island differ as a result of a latitudinal. However, the gradient is readily observed when comparing mires of the North Coast and South Coast subregions of the Pacific Oceanic wetland region. As previously described, species having northern tendencies occurring in mires in the Prince Rupert area include *Sphagnum aongstroemii*, *S. majus*, *S. quinquefarium*, *Juncus stygius*, *Geum calthifolium*, *Loiseleuria procumbens*,

Bazzania tricenata, and *Siphula ceratites* (Gignac and Vitt 1990, Douglas et al. 1998–2001, Brodo et al. 2001). These species are generally absent from Vancouver Island mires or occur only as outliers in only one or two localities (e.g., *Geum calthifolium*, *Ledum procumbens*, *Siphula ceratites* on Brooks Peninsula).

Table 3.10 Regional distribution of mire plant associations. Associations present in the two “transitional” fens but not occurring in other mires the West section of the South Coast subregion of the Coast Mountain wetland region are marked with an asterisk.

Association	Region
1 <i>Gaultheria shallon</i> / <i>Pteridium aquilinum</i>	TP, MC _{SW}
2 <i>Racomitrium lanuginosum</i> / <i>Juniperus communis</i> - <i>Empetrum nigrum</i>	OP _s
3 <i>Sphagnum austinii</i> - <i>Polytrichum strictum</i> / <i>Maianthemum dilatatum</i>	OP _s
4 <i>Sphagnum fuscum</i> - <i>Pleurozium schreberi</i>	OP _s , TP, MC _{SW}
5 <i>Sphagnum fuscum</i> - <i>Sphagnum angustifolium</i> / <i>Drosera rotundifolia</i>	OP _s , TP, MC _{SW} *
6 <i>Sphagnum papillosum</i> / <i>Triantha glutinosa</i> / <i>Sphagnum rubellum</i>	OP _s
7 <i>Sphagnum papillosum</i> / <i>Deschampsia cespitosa</i>	OP _s
8 <i>Sphagnum papillosum</i> - <i>Sphagnum pacificum</i> / <i>Carex sitchensis</i>	OP _s , TP, MC _{SW} *
9 <i>Aulacomnium palustre</i>	MC _{SW} , MC _{SE}
10 <i>Carex sitchensis</i> / <i>Spiraea douglasii</i>	TP, MC _{SW} *
11 <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Sphagnum pacificum</i> / <i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	MC _{SW}
12 <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Wurmstorfia exannulata</i> / <i>Carex echinata</i>	TP, MC _{SW} , MC _{SE}
13 <i>Caltha leptosepala</i> var. <i>biflora</i> - <i>Leptarrhena pyrolifolia</i> / <i>Philonotis fontana</i> var. <i>fontana</i>	MC _{SE}
14 <i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	MC _{SW} , MC _{SE}
15 <i>Juncus acuminatus</i> / <i>Drosera anglica</i> - <i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i>	OP _s
16 <i>Carex lasiocarpa</i> / <i>Lycopus uniflorus</i>	TP, MC _{SW} *
17 <i>Eriophorum angustifolium</i> / <i>Utricularia intermedia</i>	OP _s
18 <i>Juncus supiniformis</i>	OP _s , MC _{SW} , MC _{SE}
19 <i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>	OP _s , TP, MC _{SW} *
20 <i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>	OP _s , TP, MC _{SW} , MC _{SE}

OP_s= South Coast subregion, Pacific Oceanic wetland region; TP= Pacific Temperate wetland region; MC_{SW}= West section, South Coast subregion, Coast Mountain wetland region; MC_{SE}= East section, South Coast subregion, Coast Mountain wetland region.

Altitudinal gradient

As previously noted, in coastal areas it is difficult to attribute differences in floristic composition between mires occurring at low elevations and those found at high elevations solely to differences in climate. Bogs are absent from high elevation areas on Vancouver Island; because they receive nutrients solely from precipitation, their floristic composition is not influenced by local-scale environmental factors such as chemical composition of groundwater. In this way, bogs parallel the “zonal site” in Krajina’s (1965) biogeoclimatic classification system.

Regardless, clear differences exist between the vegetation of mires occurring at middle to high elevations and mires found at low elevations on Vancouver Island. Many plant species recorded from mires at high elevations do not occur in mires of the Pacific Temperate and Pacific Oceanic wetland regions. Similarly, several plant species found in mires at low elevations, particularly on eastern Vancouver Island, do not occur in mires at high elevations. Among plant species not found in mires at high elevations on Vancouver Island are many species of *Sphagnum* including: *Sphagnum alaskense*, *S. austinii*, *S. henryense*, *S. palustre*, and *S. subnitens*. Plant communities follow similar trends as identified in Table 3.10.

Mire plant communities

Most mire plant associations on Vancouver Island occupy distinct niches along hummock–hollow and mire margin–mire centre gradients (Table 3.11).

Table 3.11 Positions of mire plant associations along the hummock-hollow gradient.

Association	Microhabitat
1 <i>Gaultheria shallon</i> / <i>Pteridium aquilinum</i>	heath
2 <i>Racomitrium lanuginosum</i> / <i>Juniperus communis</i> - <i>Empetrum nigrum</i>	hummock
3 <i>Sphagnum austinii</i> - <i>Polytrichum strictum</i> / <i>Maianthemum dilatatum</i>	hummock
4 <i>Sphagnum fuscum</i> - <i>Pleurozium schreberi</i>	hummock
5 <i>Sphagnum fuscum</i> - <i>Sphagnum angustifolium</i> / <i>Drosera rotundifolia</i>	hummock
6 <i>Sphagnum papillosum</i> / <i>Triantha glutinosa</i> / <i>Sphagnum rubellum</i>	lawn
7 <i>Sphagnum papillosum</i> / <i>Deschampsia cespitosa</i>	lawn
8 <i>Sphagnum papillosum</i> - <i>Sphagnum pacificum</i> / <i>Carex sitchensis</i>	lawn
9 <i>Aulacomnium palustre</i>	lawn
10 <i>Carex sitchensis</i> / <i>Spiraea douglasii</i>	heath / tall sedge
11 <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Sphagnum pacificum</i> / <i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	lawn
12 <i>Caltha leptosepala</i> var. <i>biflora</i> / <i>Wamstorfia exannulata</i> / <i>Carex echinata</i>	carpet
13 <i>Caltha leptosepala</i> var. <i>biflora</i> - <i>Leptarrhena pyrolifolia</i> / <i>Philonotis fontana</i> var. <i>fontana</i>	lawn
14 <i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	lawn
15 <i>Juncus acuminatus</i> / <i>Drosera anglica</i> - <i>Dichantherium acuminatum</i> var. <i>fasciculatum</i>	hollow
16 <i>Carex lasiocarpa</i> / <i>Lycopus uniflorus</i>	lawn / tall sedge
17 <i>Eriophorum angustifolium</i> / <i>Utricularia intermedia</i>	hollow
18 <i>Juncus supiniformis</i>	hollow
19 <i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>	hollow
20 <i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>	hollow / pool

Within-mire gradients

Hummock-hollow gradient

Four associations characterize hummock communities. The two most prominent associations on western and northern Vancouver Island are the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association and the *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association. *Sphagnum austinii* hummock communities are usually located inland from the margin in raised bogs, as are *R. lanuginosum* hummock communities. Both associations usually occupy central areas in raised bogs, and both are occasionally situated alongside mud-bottom hollows. Two *Sphagnum fuscum* associations also form hummocks. The *Sphagnum fuscum* - *Pleurozium schreberi* association reflects somewhat drier conditions near the centre of raised bogs, whereas the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* occurs alongside relatively mineral-rich water sources such as lakes or pond edges, or the lagg.

Four associations occurring in low elevation mires are described as lawn communities. The *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association is typical of wet areas in fens throughout Vancouver Island. Its typical “grassy” appearance results from an abundance of graminoids including *Rhynchospora alba*, *Carex utriculata*, and *C. sitchensis*. The *Carex lasiocarpa* / *Lycopus uniflorus* association occurs in similar microhabitats. The other two associations occur in bogs and poor fens on northern and western Vancouver Island. The *Sphagnum papillosum* / *Deschampsia cespitosa* association is characterized by several graminoid species including *Eriophorum angustifolium*, *Rhynchospora alba*, *Deschampsia cespitosa*, and *Agrostis aequivalvis*. The *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association is more ecologically diverse, and contains many species of sedges and grasses including *Eriophorum angustifolium*, *Carex utriculata*, *Trichophorum caespitosum*, and *Agrostis aequivalvis*.

Lawn communities dominate middle to high elevation fens. The *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association occurs

in central areas of gently sloping fens. Common graminoid species in the association include *Eriophorum angustifolium* and *Carex pluriflora*. The *Dodecatheon jeffreyi* ssp. *jeffreyi* association is present in similar but slightly wetter habitats. Dominant species in the Cyperaceae include *Eriophorum angustifolium*, *Carex utriculata*, and *Trichophorum caespitosum*. Within middle to high elevation fens, the *Aulacomnium palustre* association represents the driest lawn community. Although several graminoids are present, including *Eriophorum angustifolium*, *Carex utriculata*, and *Trichophorum caespitosum*, an abundance of shrub species such as *Ledum groenlandicum*, *Kalmia microphylla* ssp. *occidentalis* and *Empetrum nigrum* indicates relatively dry conditions.

Two high elevation fen communities do not relate well to the hummock–hollow gradient. The *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* occurs at the upper margins of slope fens and is dominated by herbaceous plant species. The ground on which it occurs is not wet enough to be considered “carpet”, yet the community contains few sedges or grasses and therefore lacks the “grassy” appearance typical of lawn communities. I consider the *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association to be transitional between “lawn”, as indicated by the presence of graminoids such as *Eriophorum angustifolium*, *Carex sitchensis*, and *Carex anthoxanthea*, and “carpet” as evidenced by such species as *Comarum palustre*, *Scapania paludosa*, *Calliergonella cuspidata*, and *Warnstorfia exannulata*.

Several plant communities are confined to hollows and shallow pools. The *Rhynchospora alba* - *Scheuchzeria palustris* association occurs in hollows in fens on eastern Vancouver Island, usually in central areas having little water flow. The *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association occurs in relatively deep hollows and pools near the centre of bogs and fens, and in the lagg. It is widely distributed in wetland regions throughout Vancouver Island and is found in all mire types except moderate-rich fens (i.e., “Windy Fen”) on western Vancouver Island. Two other associations typically occupying hollows having standing water throughout much of the growing season are the *Juncus supiniformis* association and the *Eriophorum angustifolium* association. The

Juncus supiniformis association occupies hollows and shallow pools in fens, whereas the *Eriophorum angustifolium* association occurs in similar habitats but is also found in small ponds not associated with mires. The *Juncus acuminatus* / *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association occurs in hollows within the floodplain of a small stream.

The *Gaultheria shallon* / *Pteridium aquilinum* association, which typifies shrub heath vegetation occurring near the centre of disturbed bogs does not occupy a discrete position along the hummock–hollow gradient. It occurs under relatively dry conditions, but little microtopographic variation is evident because the upper peat layers decompose following anthropogenic disturbance. Another association occurring in bogs and poor fens at low elevations on eastern Vancouver Island that similarly does not occupy a discrete position along the hummock–hollow gradient is the *Carex sitchensis* / *Spiraea douglasii* association. It typically occurs in the outer margins of poor fens and in the lagg surrounding raised bogs.

Mire margin–mire centre gradient

The mire margin–mire centre gradient is much less prominent in mires of coastal British Columbia than it is in other parts of North America and Europe. However, some plant communities occupy discrete positions along this gradient.

The outer margins of poor fens and the lagg surrounding raised bogs often support two prominent mire plant communities: the *Carex sitchensis* / *Spiraea douglasii* association and the *Carex lasiocarpa* / *Lycopus uniflorus* association. *Sphagnum* species tolerant of relatively mineral-rich water and seasonal drought conditions such as *Sphagnum mendocinum* and *S. subsecundum* dominate the sparse bryophyte layer of the *Carex sitchensis* / *Spiraea douglasii* association. The *Carex lasiocarpa* / *Lycopus uniflorus* association occurs in similar habitats. Little, if any, standing water persists in these sites during summer.

The *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var.

fontana association also occupies the mire margin. It occurs alongside the forest edge in high elevation fens on eastern Vancouver Island.

Plant communities typically occupying central areas in mires include the *Gaultheria shallon* / *Pteridium aquilinum* association, the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association, the *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association, and both associations in the *Sphagnum fuscum* alliance.

Relationships to previous classifications

Fourteen of 20 mire plant associations identified in my study resemble communities previously described from mires in southwestern British Columbia (Table 3.12). Six associations are new.

Six of the associations defined in this dissertation are similar to communities described from mires at low elevations on eastern Vancouver Island by Ceska (1978). The *Sphagnum fuscum* - *Pleurozium schreberi* association encompasses two variants of the “*Sphagno-Ledetum groenlandici*”, including a “typical variant” and a “*Myrica* variant”, whereas the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association is similar to another variant of the “*Sphagno-Ledetum groenlandici*” (i.e., the “*Carex pauciflora*”). In a recent classification of wetland vegetation by MacKenzie and Moran (2004), both the *Sphagnum fuscum* – *Pleurozium schreberi* association and the *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association appear to be encompassed by a broadly defined “*Ledum groenlandicum* - *Kalmia microphylla* - *Sphagnum* site association” (“Wb50”). However, direct comparison of the two classifications is hindered by differences in methods and data presentation (e.g., use of large relevés; cover estimates for individual species of *Sphagnum* combined within four groups; summary tables not presented).

Most mire plant communities typical of fens and the lagg surrounding raised bogs in the Pacific Temperate wetland region have been described by Ceska (1978). The *Carex*

sitchensis / *Spiraea douglasii* association identified in my study encompasses two associations recognized by Ceska (1978): the “*Carici-Myricetum gale* association” and the “*Carici-Spiraeetum douglasii* association”. The *Carex sitchensis* / *Spiraea douglasii* association may include two site associations described by MacKenzie and Moran (2004): the “*Myrica gale* - *Carex sitchensis* site association” (“Wf52”) and the “*Myrica gale* - *Spiraea douglasii* - *Carex lasiocarpa* site association”, although *C. lasiocarpa* is neither common nor abundant in my *Carex sitchensis* / *Spiraea douglasii* association. The *Carex lasiocarpa* / *Lycopus uniflorus* association described in my study is analogous to Ceska’s (1978) “*Rhynchosporo-Caricetum lasiocarpae*, typical variant” and MacKenzie and Moran’s (2004) “*Carex lasiocarpa* - *Rhynchospora alba* site association” (“Wf53”). Another association occurring in fens on eastern Vancouver Island, the *Rhynchospora alba* - *Scheuchzeria palustris* association, is similar to Ceska’s (1978) “*Scheuchzeria-Eriophoretum chamissonis* association”.

The *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association encompasses two variants of a “*Rhynchosporo-Caricetum lasiocarpae* association” and Ceska’s (1978) “*Menyantho-Dulichietum arundinacei* association”. I chose to define the *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association broadly because vegetation dominated by *Menyanthes trifoliata* and *Nuphar lutea* ssp. *polysepala* intergrades continuously along a water depth gradient.

Shrub heath communities typical of drained bogs on eastern Vancouver Island which I characterized as the *Gaultheria shallon* / *Pteridium aquilinum* association are analogous to the “*Pinus contorta* var. *contorta* - *Ledum groenlandicum* - *Gaultheria shallon* site association” described by MacKenzie and Moran (2004).

Two associations defining hummock vegetation and two associations characterizing poor fen vegetation in mires located in the Pacific Oceanic wetland region on northern and western Vancouver Island have been described in previous publications. Hummock communities of the *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association are included in the “*Pinus contorta* var. *contorta* - *Empetrum nigrum* -

Table 3.12 Comparison of mire plant associations defined in this study with communities described in previous classifications.

Association	Community
<i>Gaultheria shallon</i> / <i>Ptendum aquilinum</i>	? <i>Pinus contorta</i> var. <i>contorta</i> - <i>Ledum groenlandicum</i> - <i>Gaultheria shallon</i> (MacKenzie and Moran 2004)
<i>Sphagnum austinii</i> - <i>Polytrichum strictum</i> / <i>Maianthemum dilatatum</i>	? <i>Pinus contorta</i> var. <i>contorta</i> - <i>Empetrum nigrum</i> - <i>Sphagnum austinii</i> "Wb51" (MacKenzie and Moran 2004)
<i>Racomitrium lanuginosum</i> / <i>Juniperus communis</i> / <i>Carex livida</i>	? <i>Juniperus communis</i> - <i>Trichophorum cespitosum</i> - <i>Racomitrium lanuginosum</i> "Wb52" (MacKenzie and Moran 2004)
<i>Sphagnum fuscum</i> - <i>Pleurozium schreberi</i>	? <i>Sphagno-Ledetum groenlandici</i> , typical variant (Ceska 1978) ? <i>Sphagno-Ledetum groenlandici</i> , <i>Myrica</i> variant (Ceska 1978) ? <i>Ledum groenlandicum</i> - <i>Kalmia microphylla</i> - <i>Sphagnum</i> "Wb50" (MacKenzie and Moran 2004)
<i>Sphagnum fuscum</i> - <i>Sphagnum angustifolium</i> / <i>Drosera rotundifolia</i>	? <i>Sphagno-Ledetum groenlandici</i> , <i>Carex pauciflora</i> variant (Ceska 1978)
<i>Sphagnum papillosum</i> / <i>Triantha glutinosa</i> / <i>Sphagnum rubellum</i>	? <i>Scirpus caespitosus</i> - <i>Sphagnum mendocinum</i> association (Wade 1965) ? Ericaceous shrub - <i>Trichophorum caespitosum</i> - <i>Sphagnum</i> spp. - <i>Cladonia</i> spp. - <i>Siphula ceratites</i> open bog (Banner 1983) ? Deep Bog (Hebda et al. 1997) ? <i>Pinus contorta</i> - <i>Chamaecyparis nootkatensis</i> - <i>Trichophorum cespitosum</i> "Wb53" (MacKenzie and Moran 2004)
<i>Sphagnum papillosum</i> / <i>Deschampsia cespitosa</i>	? <i>Scirpus caespitosus</i> - <i>Sphagnum mendocinum</i> association (Wade 1965) ? <i>Oxycoccus quadripetalus</i> - <i>Sphagnum papillosum</i> association (Wade 1965) ? <i>Ledum groenlandicum</i> - <i>Sphagnum capillaceum</i> association (Wade 1965) ? <i>Pinus contorta</i> - <i>Sphagnum capillaceum</i> association (Wade 1965)
<i>Carex sitchensis</i> / <i>Spiraea douglasii</i>	? <i>Carici-Myricetum gale</i> association (Ceska 1978) ? <i>Carici-Spiraeetum douglasii</i> association (Ceska 1978) ? <i>Myrica gale</i> - <i>Carex sitchensis</i> "Wf52" (MacKenzie and Moran 2004) ? <i>Myrica gale</i> - <i>Spiraea douglasii</i> - <i>Carex lasiocarpa</i> (MacKenzie and Moran 2004)
<i>Caltha leptosepala</i> var. <i>biflora</i> - <i>Leptarrhena pyrolifolia</i> / <i>Philonotis fontana</i> var. <i>fontana</i>	? <i>Caltha leptosepala</i> - <i>Leptarrhena pyrolifolia</i> association (Brooke et al. 1970, Brett et al. 2001)
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	? Bog Shrub / Shallow Bog (Hebda et al. 1997)
<i>Carex lasiocarpa</i> / <i>Lycopus uniflorus</i>	? <i>Rhynchosporo-Caricetum lasiocarpae</i> , typical variant (Ceska 1978) ? <i>Carex lasiocarpa</i> - <i>Rhynchospora alba</i> "Wf53" (MacKenzie and Moran 2004)
<i>Eriophorum angustifolium</i> / <i>Utricularia intermedia</i>	? <i>Wamstorfia exannulata</i> - <i>Eriophorum angustifolium</i> association (Brett et al. 2001)
<i>Rhynchospora alba</i> - <i>Scheuchzeria palustris</i>	? <i>Scheuchzeria-Eriophoretum chamissonis</i> association (Ceska 1978)
<i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>	? <i>Nuphar polysepala</i> : <i>Carex lasiocarpa</i> subassociation (Klinka et al. 1997) ? <i>Rhynchosporo-Caricetum lasiocarpae</i> , <i>Nuphar</i> variant (Ceska 1978) ? <i>Rhynchosporo-Caricetum lasiocarpae</i> , <i>Dulichium</i> variant (Ceska 1978) ? <i>Menyantho-Dulichietum arundinacei</i> association (Ceska 1978)

Sphagnum austinii site association” (“Wb51”) defined by MacKenzie and Moran (2004), whereas the *Racomitrium lanuginosum* / *Juniperus communis* / *Carex livida* association is encompassed by the “*Juniper communis* - *Trichophorum cespitosum* - *Racomitrium lanuginosum* site association” (“Wb52”) (MacKenzie and Moran 2004).

Lawn communities characterized by the *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association closely resemble the “*Scirpus caespitosus* - *Sphagnum mendocinum* association” occurring in Pacific Rim National Park on western Vancouver Island (Wade 1965), “Deep Bog” on Brooks Peninsula (Hebda et al. 1997), and “Ericaceous shrub - *Trichophorum caespitosum* - *Sphagnum* spp. - *Cladonia* spp. - *Siphula ceratites* open bog” in the Prince Rupert area (Banner 1983). The community is classified as the “*Pinus contorta* - *Chamaecyparis nootkatensis* - *Trichophorum cespitosum* site association” (“Wb53”) by MacKenzie and Moran (2004).

Another association in the *Sphagnum papillosum* alliance characterizing poor fen vegetation on northern and western Vancouver Island is the *Sphagnum papillosum* / *Deschampsia cespitosa* association. It encompasses four floristically similar associations described by Wade (1965), including: 1) the “*Scirpus caespitosus* - *Sphagnum mendocinum* association”; 2) the “*Oxycoccus quadripetalus* - *Sphagnum papillosum* association”; 3) the “*Ledum groenlandicum* - *Sphagnum capillaceum* association”; and 4) the “*Pinus contorta* - *Sphagnum capillaceum* association”.

The *Eriophorum angustifolium* – *Utricularia intermedia* association occurs in hollows. It is related to the “*Warnstorfia exannulata* - *Eriophorum angustifolium* association” described by Brett et al. (2001).

Only two rich fen communities identified from Vancouver Island mires have been previously described. The *Dodecatheon jeffreyi* ssp. *jeffreyi* association is largely confined to fens occurring on the windward side of the Vancouver Island Ranges. It is similar to “Bog Shrub / Shallow Bog” vegetation described from Brooks Peninsula (Hebda et al. 1997). The *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* /

Philonotis fontana var. *fontana* association occurs in rich fens on the leeward side of the Vancouver Island Ranges. It clearly resembles subalpine wetland vegetation in the Mountain Hemlock zone of southwestern British Columbia described as the “*Caltha leptosepala* - *Leptarrhena pyrolifolia* association” by Brooke et al. (1970) and Brett et al. (2001).

CONCLUSIONS

My research examined regional and community scale patterns in mire vegetation on Vancouver Island. At the regional scale, I identified four floristically distinct groups of mires. Their geographical distribution closely corresponds with previously delineated wetland regions in coastal British Columbia (NWWG 1986, Banner et al. 1988). The results of my work suggest the boundaries between mire regions should be modified as follows: 1) the South Coast subregion of the Pacific Oceanic wetland region should be expanded to include mires located in the Suquamish Basin on northern Vancouver Island; 2) the inland margin of the South Coast subregion of the Pacific Oceanic wetland region should be expanded to incorporate all coastal lowland areas on western and northern Vancouver Island; 3) Brooks Peninsula should be excluded from the Pacific Oceanic wetland region; and 4) the boundaries of the Pacific Temperate wetland region should be contracted to encompass only the seasonally dry lowlands of eastern Vancouver Island. The inland margin of the Pacific Temperate wetland region should follow the edge of the Very Dry Maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWH xm2).

I also recommend further sampling of mires and mire plant communities in the following areas: northern Vancouver Island; Brooks Peninsula; the Mt. Arrowsmith area; moderate-rich fens on western and northern Vancouver Island; and middle to high elevation fens on eastern Vancouver Island. Such sampling would further clarify the position of regional boundaries and could lead to the discovery of relatively rare mire plant communities that could not be described in this paper as a result of an insufficient number of samples.

Regional-scale patterns of mire distribution follow a complex altitudinal / oceanicity–continentality gradient and a less prominent latitudinal gradient, which is most evident when comparing mires of western and northern Vancouver Island to those occurring on the north coast of British Columbia.

I recognized 20 mire plant associations on Vancouver Island. Of these, 14 are similar to previously described communities and six are newly described. Two of the newly described associations are lawn communities occurring in middle to high elevation fens, one is a lawn community described from a single moderate-rich fen on western Vancouver Island, two of the associations occupy hollows in fens, and one association is a lawn community occurring primarily in low to middle elevation fens on eastern Vancouver Island.

At the regional scale, few associations are widespread throughout Vancouver Island; most are confined to one or two wetland regions. Within mires, most associations occupy distinct niches along hummock–hollow and mire margin–mire centre gradients. Not surprisingly, the hummock–hollow gradient is better developed in bogs and poor fens because hummocks are common in those wetland types, whereas they occur very infrequently in moderate rich and rich fens. The mire centre–mire margin gradient in Vancouver Island mires is less distinct than it is in mires elsewhere in North America and in Europe.

CHAPTER 4

FLORISTIC, HYDROLOGICAL, AND CHEMICAL CHARACTERISTICS OF DISTURBED AND UNDISTURBED MIRES ON EASTERN VANCOUVER ISLAND

INTRODUCTION

One of the central objectives of my research was to investigate whether significant floristic and environmental differences exist between disturbed and undisturbed mires at low elevations on eastern Vancouver Island. Mires are particularly uncommon in the region (Ward et al. 1998), and their conservation value is considered to be high (Government of B.C. 2004). However, very little basic ecological research has been undertaken on lowland basin mires in southwestern British Columbia, and their ecological characteristics are poorly known. If mire ecosystems are going to be successfully conserved, it is essential to understand how floristic characteristics and environmental conditions change as a result of human disturbance, in this case, drainage. Similarly, if restoration is being considered, understanding biological and environmental conditions in undisturbed mires is essential for setting restoration goals.

Mire plant species are closely coupled with their environment, making them particularly sensitive to human disturbance, including drainage and nutrient enrichment. Species in the “keystone” genus *Sphagnum* function as “ecosystem engineers” in mires, actively initiating and maintaining conditions allowing them to out-compete other plants for light and other resources (Larsen 1982, van Breemen 1995, Rochefort 2000). Few plant taxa thrive in the cold, nutrient-poor, acidic, and anoxic mire environment created by *Sphagnum* species; mires are typically species-poor (Moore and Bellamy 1974, Larsen 1982, Dierssen 1992, van Breemen 1995). Those taxa that do become established and persist are highly specialized. To survive in wet environments, for example, species such as *Vaccinium oxycoccos* and *Andromeda polifolia* have shallow root systems. Similarly, oxygen is delivered to submersed root systems of some sedges and rushes through aerenchyma tissue in the stems (Dierssen 1992). Strategies for obtaining and conserving nutrients in mire environments include: cation exchange in *Sphagnum* species; symbiotic mycorrhizal relationships promoting the uptake of nitrogen, phosphorous, and potassium

in species of the Ericaceae and Orchidaceae; translocation of nutrients from stems to roots prior to onset of winter dormancy in *Rubus chamaemorus*; carnivory in *Drosera* and *Utricularia* species; and retention of leaves for more than one season in Ericaceous plants (Larsen 1982, Dierssen 1992).

Adaptations allowing plants to survive and compete (e.g., Rydin 1986, 1997a, 1997b) are effective in undisturbed mires. However, disturbance that causes desiccation, increased water table fluctuations, and increased nutrient availability decreases *Sphagnum* cover and diminishes its functional properties. As mires become drier and chemical composition changes, trees and shrubs out-compete specialized plants for light. As a result, diversity of such life forms as bryophytes, graminoids, and herbaceous plants is reduced (Laine and Vanha-Majamaa 1992). Even without detailed studies, general observations of the rapid development of pine forest in lowland mires of southeastern Vancouver Island that have been drained for agriculture attest to the sensitivity of mire vegetation to human disturbance.

There are several possible approaches to studying the effects of disturbance on mires. Historic vegetation can be determined using paleoecological techniques such as macrofossil analysis and related to environmental conditions in contemporary mires having analogous vegetation (e.g., Janssens 1988). Where mires have been intensively studied and mapped, historical and current vegetation and environmental conditions can be directly compared (Sjörs and Gunnarsson 1992). In Sweden, for example, this approach has been applied to mires in areas subject to atmospheric nitrogen deposition (Gunnarsson 2000). In the absence of intensive historical studies, disturbed and undisturbed mires occurring in similar hydrotopographic positions, at similar stages of succession and under similar climatic regimes, can be compared. This is the general approach used in my study.

In this chapter I compare vegetation and hydrological and chemical variables among individual mires and between disturbed and undisturbed mire groups at low elevations on eastern Vancouver Island. The scarcity of mires in the region led to the inclusion of both

raised bogs and poor fens at varying stages of succession. I hypothesized that disturbed mires would exhibit significant differences in vegetation, water table fluctuation, and chemical composition of soil water compared with undisturbed mires in the same region. I predicted that human disturbance, particularly drainage, would reduce vegetation diversity, increase seasonal water table fluctuations, and increase cation concentrations.

METHODS

I collected and analysed plant community and environmental data from ten mires on eastern Vancouver Island: three disturbed mires and seven relatively undisturbed mires. I also compared plant species diversity among these mires and an additional four mires by determining the proportion of the regional mire plant species pool present in each, and utilized the results of mire plant community classification (Chapter 3) to evaluate plant community diversity.

Study sites

The 14 study sites are located between 48° 29' and 49° 58' N, and 123° 22' and 125° 298' W on eastern Vancouver Island at elevations <285 m asl (Figure 4.1, Table 4.1). The study area corresponds with the Nanaimo Lowland physiographic region (Holland 1976). It encompasses two biogeoclimatic (BEC) subzones: the Coastal Douglas-fir Moist Maritime subzone and the Coastal Western Hemlock Very Dry subzone (Krajina 1965, Pojar et al. 1987, Klinka et al. 1991, Meidinger and Pojar 1991). Study sites were selected from a limited group of mires identified in previous studies and through airphoto interpretation (Ward et al. 1998). The study sites represent the regional range of mire types and mire vegetation. All of the study sites are (or were) *Sphagnum*-dominated basin mires, which typically develop through the gradual in-filling of shallow lakes (Rigg and Richardson 1934, 1938). They include flat bogs, raised bogs, shore bogs, and *Sphagnum*-dominated poor fens. Characteristics of each study site including location, elevation, general type, and disturbance history are summarized in Table 4.1.

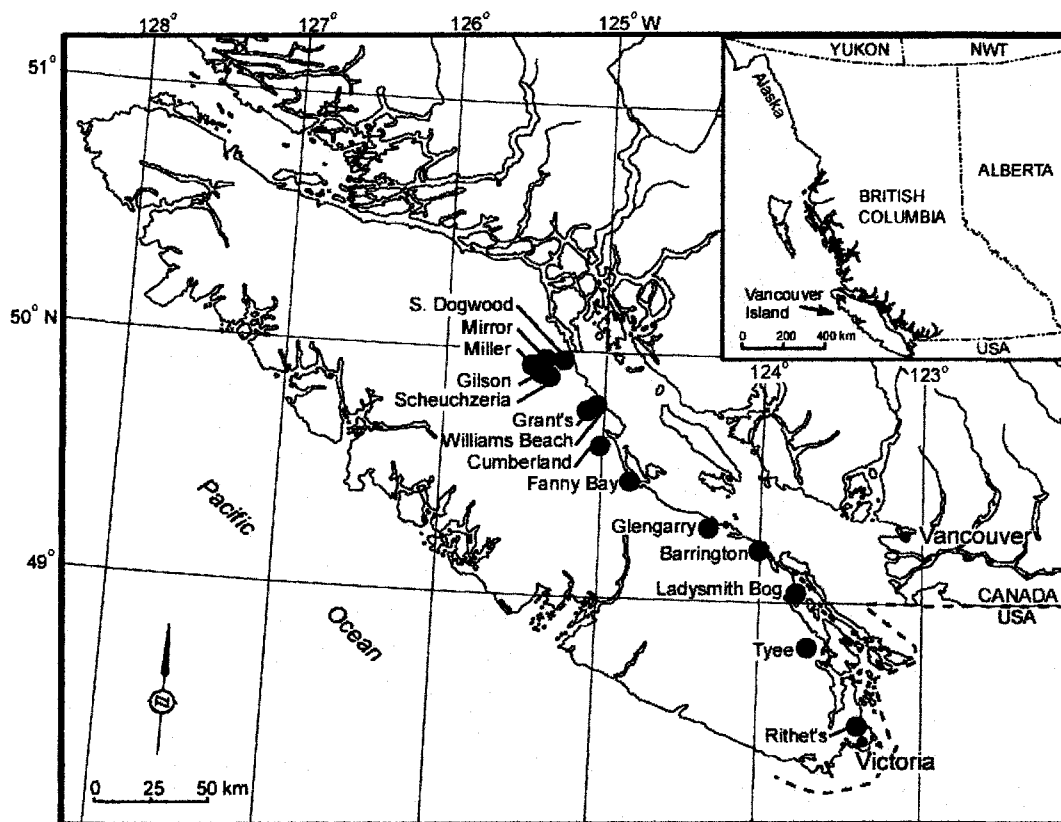


Figure 4.1 Study site locations on eastern Vancouver Island.

Field sampling

Vegetation

I collected two types of vegetation data. The first data set was collected from small plots for use in comparisons of vegetation, water tables, and water chemistry between disturbed and undisturbed mires. The second data set consisted of complete species lists from 14 sites. It was used to identify differences in overall species richness between disturbed and undisturbed mires, and to determine which vegetation types were represented.

To obtain the first data set, I sampled ten mires using 0.25 m^2 plots located subjectively in uniform stands of vegetation. Plots were placed subjectively to maximize the variety of

vegetation sampled, given resource constraints for water chemical analyses, and to exclude transitional plots that would have been included if a random sampling design had been used. The total number of plots was 174, and the number of plots per mire varied from 10 and 41, depending on the variety of species combinations present. I used relatively small plots because mire vegetation is heterogeneous, and species composition and environmental conditions can vary substantially over small distances (e.g., Økland 1990a, 1990b). For each plot I used standard methods to estimate the percent foliar cover of each taxon present (e.g., Mueller-Dombois and Ellensberg 1974, Westhoff and van der Maarel 1980, Pakarinen 1984). Voucher specimens were retained to facilitate positive identification of taxa that could not be reliably identified in the field. Vascular plant specimens are deposited in the University of Victoria herbarium (UVIC), and bryophyte and lichen specimens are deposited in the University of British Columbia herbarium (UBC).

To facilitate interpretation, I noted the microhabitat type of each plot (e.g., hummock, hollow, lawn, carpet) and its general within-mire location (e.g., centre, lake margin, lagg).

To determine the regional mire species pool (i.e., plant taxa present in similar habitats in the region) I compiled lists of all species of vascular plants, bryophytes, and lichens (excluding epiphytes) noted during multiple field visits between 1995 and 2000. The regional species pool consisted of the combined species lists from all 14 mires. I calculated the percentage of the regional species pool present in each mire.

Analysis of mire plant community diversity employs the results of vegetation classification outlined in Chapter 3. Methods used to obtain vegetation data for that study are described on p. 17.

Water table depths

During the year prior to collecting data specifically for this study, I gained a general impression of seasonal patterns of water table fluctuation in five representative mires by

measuring water table depths once per month between September 1997 and September 1998. Water tables were measured in dipwells placed in a variety of microhabitat types along transects extending from the marginal lagg to the centre of each mire. Dipwells consisted of 2 m lengths of 23 mm diameter PVC pipe perforated with lateral openings spaced 1 cm apart starting 15 cm below the apex and extending to the base (Figure 4.2) (Bragazza 1993, Bragazza and Gerdol 1996). The base of each dipwell was capped to prevent sediment from entering the pipe upon insertion into the peat. Each dipwell was inserted into the peat to a depth of 190 cm below the mire surface, leaving 10 cm exposed. A removable cap was placed over the upper opening to prevent debris from falling in.

Table 4.1 Study site names, locations, elevations, mire types, and types of disturbance.

#	Site Name ¹	Location		Elev. (m)	Mire Type	Disturbance
		N	W			
1	Rithet's Bog ¹	48° 29'	123° 22'	30	treed bog	drained (agriculture), urban
2	Barrington Bog ¹	49° 12'	123° 59'	70	treed bog	drained (one end filled, road), urban
3	Fanny Bay	49° 29'	124° 49'	35	treed bog	catchment heavily modified (roads)
4	Williams Beach	49° 48'	125° 03'	95	bog "islands"	undisturbed (beavers)
5	Grant's	49° 47'	125° 07'	85	shore bog	undisturbed
6	Scheuchzeria	49° 55'	125° 20'	170	shore fen	undisturbed (beavers)
7	Tyee Bog ¹	49° 50'	123° 43'	38	basin fen	catchment modified (railway)
8	Miller	49° 57'	125° 29'	285	shore bog	undisturbed
9	Gilson	49° 56'	125° 23'	175	shore fen	undisturbed (beavers)
10	Mirror	49° 58'	125° 23'	235	shore bog	undisturbed
11	S. Dogwood St.	49° 58'	125° 14'	65	treed bog	drainage modified (one end filled, road)
12	Cumberland	49° 37'	125° 01'	155	treed bog	drained (agriculture)
13	Glengarry Bog ¹	49° 20'	124° 49'	70	treed bog	drained (agriculture, golf course)
14	Ladysmith Bog ¹	49° 03'	123° 47'	38	shore bog	undisturbed (beavers)

¹ Previously existing names. Other mires were named for the purpose of this study.

Study sites were visited once per month around mid-day. Depth from the mire surface to the water table was determined by blowing air into a 2.5 m length of flexible plastic tubing while lowering it into the dipwell. When "bubbling" occurred, the tube was

marked with a felt pen adjacent to the top of the dipwell and withdrawn. Water table depth was calculated by measuring the distance between the mark and the bottom end of the flexible tube, minus the distance between the top of the monitoring well and the mire surface (i.e., 10 cm). Where there was standing water (e.g., in hollows during winter months), I used a tape measure to determine the depth of standing water. In this way water table depths were determined relative to the mire surface; when the water table was below ground it was expressed as a negative value. When there was standing water it was expressed as a positive value.

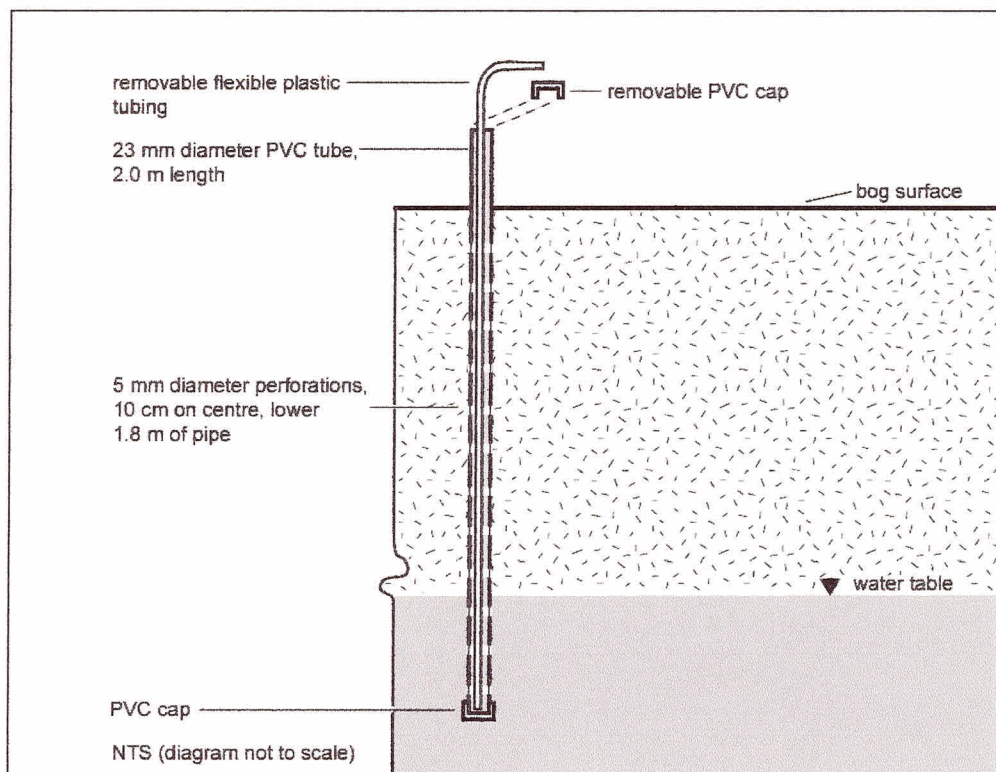


Figure 4.2 Diagram of dipwells used to measure monthly water tables.

Preliminary monitoring indicated that the water table typically rises rapidly in response to heavy rainfall in late September and stays high throughout winter. In April it declines, likely in response to decreased precipitation and increased water uptake by plants. It reaches a seasonal low in September. Based on these observations, I measured seasonal

high water table depths during the week of January 5–13, 1999 in 174 marked plots in the 10 of the 14 study sites using probes constructed of 2.05 m lengths of 23 mm diameter PVC pipe capped at the lower end with a 2 cm long piece of pointed wooden doweling. The lower 10 cm of each probe was perforated with 0.5 mm holes spaced at 1 cm intervals (Figure 4.3). In very wet plots where the water table was located just below the mire surface, the water column reached equilibrium in the PVC probe almost instantly after it was inserted. For drier plots, I waited 20 minutes before taking measurements. To measure depth to the water table I blew air into a 2.5 m piece of flexible plastic tubing while lowering it into the probe. When “bubbling” occurred, I marked the side of the flexible tubing with a marker and removed it. To calculate water table depth I measured the distance from the top of the probe to the mire surface minus the distance between the mark on the flexible tubing and its lower end. In plots having standing water, I measured water depths using a tape measure.

I determined the seasonal low water table for each plot by taking measurements in each of the same 174 plots once per week beginning in late July 1998 and continuing until the water table began to rise with the onset of heavy rain in late September.

Water samples

Water samples for hydrochemical analyses (pH, specific conductivity, Ca^{2+} , Mg^{2+} , Na^+ , K^+) were collected from the surface 5 cm of the water table in all 174 plots between January 5–13, 1999. Sampling in winter minimized variation in chemical concentrations resulting from differences in precipitation and evaporation among mires (Gorham and Janssens 1992). Magnesium concentrations, for example, can increase threefold during dry periods (Gorham 1956) in poorly buffered pools. Similarly, biological demand is low during winter, and chemical concentrations are unlikely to be affected by leaching of bryophyte tissues induced by senescence (Gerdol 1991, Bragazza 1993).

Water samples collected for chemical analyses were obtained from the centre of each of the 174 marked vegetation plots described above. Pore water samples were obtained by pressing the pointed PVC probe described above into the peat surface at the centre of

each plot. Once the water table was reached and enough water had flowed into the probe, samples were extracted using a hand pump attached to a length of flexible plastic tubing. The PVC pipe, tubing, and hand pump were rinsed once with distilled water and twice with part of the sample solution prior to sample collection. The 200 ml plastic collection bottles, purchased specifically for this study, were washed with 5 ml of hydrochloric acid and rinsed with distilled water in the lab prior to fieldwork. In the field, each container was rinsed once with distilled water and twice with part of the sample solution (Proctor 1994).

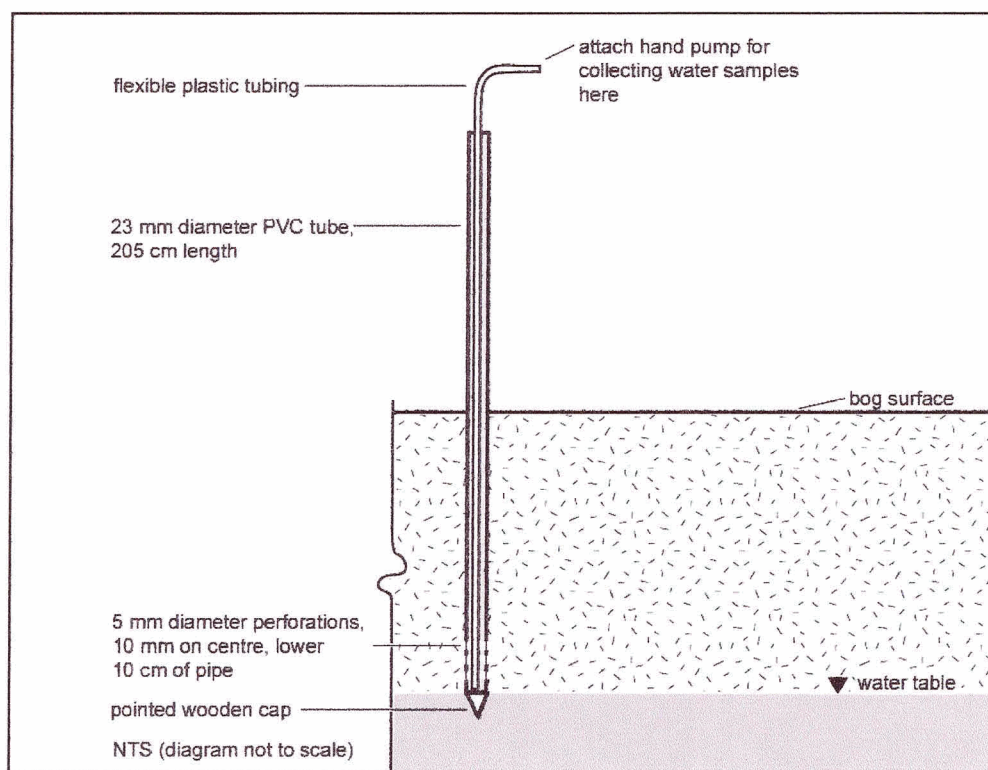


Figure 4.3 Diagram of probes used to measure water table depths and to collect water samples.

In microhabitats having standing water, surface water samples were obtained by dipping a 200 ml Nalgene® collection cup just below the water surface near the centre of each plot. Prior to collection of each sample pair, the collection cup and collection bottles were treated using the same methods employed for collection materials described above.

pH was measured in the field using a Hannah Instruments pHep3 portable meter with Automatic Temperature Compensation (Hannah Instruments, Woonsocket, RI). The meter was calibrated with pH 4.0 and pH 7.0 buffer solutions (VWR Scientific, West Chester, PA) immediately prior to sampling in each mire. The pH probe and sample collection cup were rinsed three times before each reading with distilled water and then twice with part of the sample solution. Readings were taken while gently stirring the probe in 100 ml of sample solution.

Each pair of water samples was placed in a cooler immediately after sampling, then refrigerated following transport (Proctor 1994). Samples were not filtered (Proctor 1994). After standing for approximately six hours the water was generally clear, and water from the top of one of the bottles in each pair was analysed without further treatment. Specific conductivity, a measure of concentrations of total dissolved ions and cations, was determined within 12 hours of sample collection using a Fisher Scientific digital conductivity meter with automatic temperature compensation (to 25 °C) (Cat. No. 09-327-1, Fisher Scientific, Pittsburgh, PA). The meter was calibrated to 101.2 $\mu\text{S}/\text{cm}$ immediately prior to processing samples from each mire using Traceable[®] Conductivity Calibration Standard Cat. No. 4066 (Control Company, Houston, TX). The conductivity probe was rinsed once with distilled water and twice with part of the sample solution prior to each reading. Readings were taken while gently stirring the probe in 100 ml of sample solution.

Samples for analyses of cation concentrations (Ca^{2+} , Mg^{2+} , Na^+ , K^+) were acidified with 5 ml HCl (hydrochloric acid) and kept refrigerated for one week until they were analysed (Vitt and Bayley 1984). Carol Dyck in Dr. Les Lavkulich's lab at the University of British Columbia analysed cations by atomic absorption spectrometry using a PerkinElmer[™] Model #306 spectrometer (PerkinElmer, Wellesley, MA). Several "blanks" (100 ml of deionized water acidified with 5 ml HCl) were included to ensure quality control.

Data analysis

Data collected from small plots were arranged in two matrices. The vegetation data matrix comprised percent cover estimates for 61 species. The corresponding environmental data matrix included chemical variables (pH, specific conductivity, Ca^{2+} , Mg^{2+} , Na^+ , K^+) and high, low, and mean water table measurements. The data matrix for species pool calculations consisted of presence-absence data for mire plant species compiled from 14 mires. Methods for analysing the species pool and for determining plant community diversity are described at the end of this section.

Data analysis consisted of inspection of the data for normality and outliers, univariate analysis, multivariate analysis, and comparisons of species richness and community richness (i.e., the number of communities present in each mire). Data analyses were facilitated by several computer software programs, including Microsoft® EXCEL 97 (Microsoft Corporation 1985–1996), JMP IN version 3.2.6 (SAS Institute Inc. 1999), PC-ORD for Windows 4.0 (McCune and Mefford 1999), and SigmaPlot 2.0 (Jandel Corporation 1994).

Data review

I inspected the environmental data matrix for missing values and rejected entire cases (i.e., plots) if two or more values were missing. If only one value was missing, I inserted the extrapolated mean of that variable from plots occurring in the same microhabitat type within the same mire. I tested all environmental variables for normal distribution using the Shapiro-Wilk W test (Shapiro and Wilk 1965) in JMP IN version 3.2.6 (SAS Institute Inc. 1999). Because none of the environmental variables were normally distributed, I log transformed ($z = \log_{10}(x+1)$) the environmental data to improve normality. Similarly, to reduce the effect of abundant species (e.g., 86% of the vegetation data matrix consisted of zeros), I transformed species cover data ($z = \log_{10}(y+1)$) (Palmer 1993, McCune and Mefford 1999, McCune and Grace 2002). I used the outlier test in PC-ORD 4.0 (McCune and Mefford 1999) and scatterplots of each pair of environmental variables to detect outliers. Two cases were rejected.

Univariate analyses

I used non-parametric analysis of variance (ANOVA) tests to determine whether vegetation and environmental conditions varied significantly among mires (the Kruskal-Wallis test, where $k=10$) or between disturbed and undisturbed mire groups (the Mann-Whitney U test, where $k=2$) (Kruskal and Wallis 1952, JMP IN version 3.2.6, SAS Institute Inc. 1999). The alpha level of 0.05 was used to reject the null hypothesis that there were no significant differences between mires or mire groups.

Multivariate analyses

Nonmetric multi-dimensional scaling (NMS) (Kruskal 1964, Mather 1976) was used to identify relationships between vegetation and environmental conditions (PC-ORD for Windows version 4.14, McCune and Mefford 1999). The vegetation data matrix consisted of percent cover data for 61 plant species, and the environmental data matrix contained 5 variables: pH, specific conductivity, Mg^{2+} , Na^{+} , and mean water table. I used Sorensen (Bray-Curtis) distance as a measure of ecological similarity. For each ordination, I used several random starting configurations to ensure that solutions were stable. Dimensionality of the data set was assessed using scree plots. I selected three axes for all ordinations, and specified a maximum of 200 runs to find a solution. To evaluate stability of the ordination I used 100 iterations and a stability criterion of 0.0005. To assess statistical significance and determine whether the axes extracted were stronger than would be expected by chance, I evaluated the results of each analysis using Monte Carlo tests.

Plant species pool

As a general measure of plant species richness I calculated the percentage of the regional mire plant species pool represented in each mire. To determine the regional species pool, I combined lists of vascular plants, bryophytes, and lichen species from each of the study sites. Heavily disturbed marginal areas were excluded. A “core” species pool was identified based on taxa present in >50% of mires surveyed. I grouped the vegetation by

life form as follows: trees, shrubs, graminoids, herbaceous plants and trailing shrubs, aquatic plants, *Sphagnum* species, other bryophytes, and lichens.

At the plot level, I determined whether vegetation differed significantly between disturbed and undisturbed mires using non-parametric analysis of variance (ANOVA) tests and the Kruskal-Wallis test (JMP IN version 3.2.6, SAS Institute Inc. 1999). The alpha level of 0.05 was used to reject the null hypothesis that vegetation did not differ.

Plant community richness

To evaluate mire plant community richness (i.e., the number of mire plant associations present in each mire), I used the results of vegetation classification (described in Chapter 3) to identify which associations were present in each mire.

RESULTS

Undisturbed mires and those affected by human disturbance differ greatly in vegetation structure, floristic composition, and environmental conditions. Variation in environmental conditions both within and between mires is shown in Table 4.2.

Univariate analyses of environmental variables

Univariate analyses demonstrate consistent significant differences among mires and between disturbed and undisturbed mire groups for means of all five environmental variables. Calcium and potassium were not included in univariate or multivariate analyses because they were highly correlated with magnesium and sodium ($\text{Ca}^{2+} / \text{Mg}^{2+} = 0.611$; $\text{Na}^+ / \text{K}^+ = 0.856$). A summary of test statistics (Kruskal-Wallis chi-squared values) between mires and including Tukey tests identifying statistically significant differences between mire pairs is given in Table 4.3. Table 4.4 summarizes similar statistics between disturbed and undisturbed mire groups (Mann-Whitney U values).

Table 4.2 Summary of mean, standard deviation, and range of values for hydrological and water chemistry variables.

Mire	Water table fluctuation (cm)	pH	SC	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺
Rithet's	57.5 (7.7)	4.0 (0.2)	108.7 (21.1)	2.85 (0.99)	2.22 (0.52)	1.98 (0.57)	12.10 (1.43)
range:	49.0-67.0	3.8-4.3	90.4-148.0	1.80-4.30	1.51-2.80	1.50-3.00	11.30-15.00
Barrington	92.5 (14.7)	3.7 (0.2)	64.0 (15.6)	0.96 (0.55)	0.22 (0.15)	0.47 (0.23)	2.31 (0.56)
range:	69.0-115.5	3.8-4.4	37.3-81.1	0.31-2.08	0.09-0.60	0.15-0.82	1.42-3.30
Fanny Bay	61.9 (21.8)	3.8 (0.3)	42.8 (8.3)	0.89 (0.68)	0.31 (0.26)	0.13 (0.06)	0.91 (0.30)
range:	16.0-91.5	3.8-4.7	21.5-53.0	0.10-2.45	0.10-0.97	0.07-0.27	0.57-1.75
Williams	17.7 (10.5)	4.3 (0.5)	30.5 (7.3)	0.44 (0.46)	0.25 (0.22)	0.29 (0.19)	2.07 (0.34)
range:	6.0-32.0	3.8-5.8	11.1-40.8	0.07-1.63	0.04-0.89	0.09-0.82	1.31-2.96
Grant's	35.0 (20.3)	4.2 (0.5)	24.0 (13.0)	0.25 (0.26)	0.18 (0.17)	0.18 (0.13)	1.16 (0.30)
range:	6.5-81.5	3.6-5.7	10.3-64.9	0.04-1.06	0.04-0.69	0.02-0.65	0.83-1.96
Scheuchzeria	35.0 (24.0)	4.0 (0.4)	28.6 (10.1)	0.61 (0.70)	0.21 (0.17)	0.18 (0.12)	0.63 (0.19)
range:	13.5-91.0	3.6-5.3	12.2-46.6	0.10-2.69	0.06-0.75	0.03-0.51	0.36-1.25
Tyee	23.5 (6.8)	4.0 (0.3)	23.2 (13.9)	0.52 (0.32)	0.18 (0.15)	0.24 (0.27)	0.65 (0.10)
range:	11.5-40.5	3.5-4.5	9.7-64.9	0.08-1.10	0.04-0.56	0.07-1.20	0.46-0.82
Miller	43.2 (23.2)	4.5 (0.8)	26.0 (11.4)	1.12 (1.08)	0.37 (0.25)	0.17 (0.16)	0.77 (0.38)
range:	22.5-89.0	3.6-6.0	12.9-48.2	0.27-4.66	0.08-0.85	0.06-0.60	0.29-1.31
Gilson	13.7 (3.8)	4.3 (0.6)	24.5 (9.6)	1.59 (1.25)	0.38 (0.26)	0.12 (0.06)	0.92 (0.33)
range:	5.5-20.0	3.7-5.3	11.0-43.1	0.09-4.16	0.09-1.05	0.05-0.31	0.48-1.51
Mirror	23.8 (4.7)	4.5 (0.7)	27.7 (9.5)	2.76 (1.95)	0.43 (0.27)	0.12 (0.05)	0.91 (0.21)
range:	18.0-33.5	3.7-5.6	14.4-46.3	0.46-13.70	0.09-1.51	0.05-0.23	0.50-1.28

[†] All water chemistry measurements in mg/l except specific conductivity ($\mu\text{S}/\text{cm}$) and pH ($-\log [\text{H}^+]$)

Table 4.3 Summary of ANOVA results between mires. Significant differences between mires based on Tukey tests between all pairs are denoted by the number of individual mires (e.g., pH in Williams is significantly different from Scheuchzeria (6), Fanny Bay (3), and Barrington (2)).

Statistic:	Water Table Fluctuation	Water Chemistry Variables			
Mire:		pH	Conductivity	Mg ²⁺	Na ⁺
1. Rithet's	2,10,7,4,9	10	2,3,4,6,10,8,9,5,7	10,9,8,3,4,2,6,7,5	2,4,7,6,5,8,3,9,10
2. Barrington	3,1,8,5,6,10,7,4,9	5,4,9,8,10	3,4,6,10,8,9,1,5,7	1	7,6,5,8,3,9,10,1
3. Fanny Bay	2,5,6,10,7,4,9	5,4,9,8,10	4,6,10,8,9,2,5,7,1	1	1
4. Williams	6,5,8,1,3,2	6,3,2	3,2,1	1	2,1
5. Grant's	4,9,3,2	10,3,2	3,2,1	1	2,1
6. Scheuchzeria	4,9,3,2	4,9,8,10	3,2,1	1	2,1
7. Tyee	1,3,2	8,10	3,2,1	1	2,1
8. Miller	10,7,4,9,2	6,3,2	3,2,1	1	2,1
9. Gilson	6,5,8,1,3,2	6,3,2	3,2,1	1	2,1
10. Mirror	8,1,3,2	5,7,1,6,3,2	3,2,1	1,10	2,1
X ² (DF=9)	90.50	41.96	74.13	46.06	56.42
Prob>X ²	<0.0001	<0.0001	<0.0001	<0.0001	0.0001

Table 4.4 Summary of ANOVA results between disturbed and undisturbed mire groups. U values and significance values are presented in the lower two rows.

Statistic:	Water Table Fluctuation	Water Chemistry Variables			
		pH	SC	Mg ²⁺	Na ⁺
U (DF=1)	55.08	23.38	60.22	6.47	7.82
Prob>U	<0.0001	<0.0001	<0.0001	0.0109	0.0052

Results of analysis of variance (ANOVA) on key environmental variables are presented in Figures 4.4 to 4.8 (note: most values were log₁₀ transformed prior to testing). *Post-hoc* Student's t tests included in each figure indicate significant differences between mires (i.e., overlapping circles indicate no significant difference exists).

Water table fluctuation

Mean seasonal water table fluctuations were significantly greater in disturbed mires than they were in all but one undisturbed mire (Figure 4.4). Water table fluctuations were relatively uniform throughout disturbed mires in contrast with undisturbed mires, where water tables fluctuated widely. Water table fluctuations in Barrington Bog, for example, ranged from 69.0–115.5 cm (mean: 92.5 cm), whereas in an undisturbed shore mire with an extensive lagg (*Scheuchzeria*) they only varied from 13.5–91.0 cm (mean 35.0 cm). Mean seasonal water table fluctuations were least variable in narrow shore mires lacking a lagg. At Gilson, for example, mean seasonal water table fluctuations ranged from 5.5–20 cm (mean 13.7 cm) during the study period.

Soil water pH

Mean pH values varied widely between disturbed and undisturbed mires (Figure 4.5). However, disturbed mires generally had low mean pH values compared to undisturbed mires, and the highest mean values were recorded from shore fens. Mires having low mean pH values also had the greatest mean seasonal water table fluctuations. For example, Barrington Bog, Fanny Bay Bog, and Rithet's Bog had mean water table fluctuations of 92.5 cm, 61.9 cm, and 57.5 cm, and mean pH values of 3.7, 3.8, and 4.0, respectively. By contrast, Miller, Mirror, and Gilson had mean seasonal water table

fluctuations of 43.2 cm, 23.8 cm, and 13.7 cm, and mean pH values of 4.5, 4.5, and 4.3, respectively.

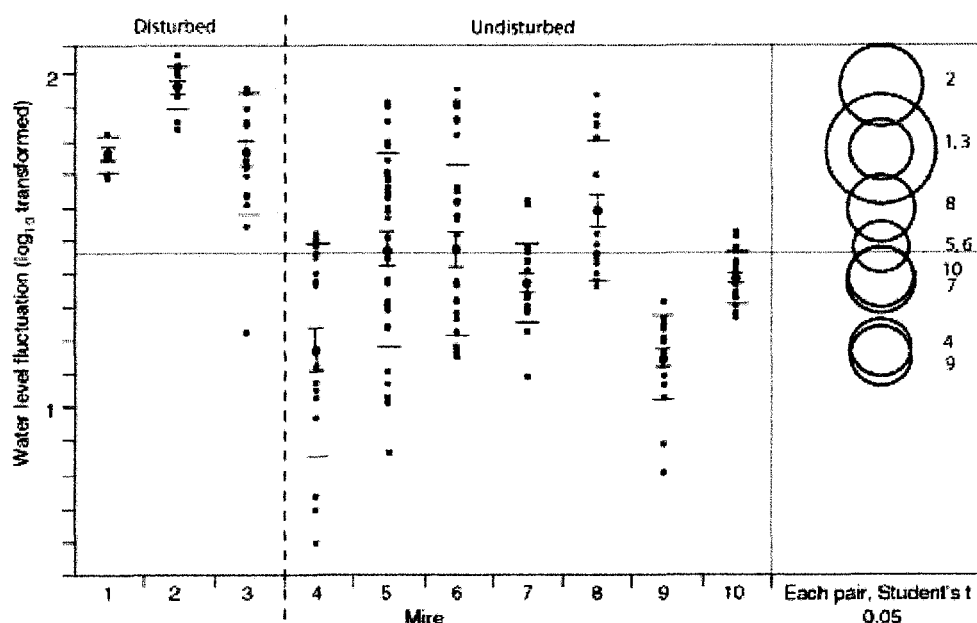


Figure 4.4 Mean, standard error, and standard deviation of $\log_{10}$ transformed water table fluctuation data. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

Specific conductivity

Statistically significant differences in mean specific conductivity values between disturbed and undisturbed mires are well-illustrated by ANOVA and student's t-test results in Figure 4.6. Mean specific conductivity values in the three disturbed mires were 108.7 $\mu\text{S}/\text{cm}$ at Rithet's Bog, 64.0 $\mu\text{S}/\text{cm}$ at Barrington Bog and 42.8 $\mu\text{S}/\text{cm}$ at Fanny Bay Bog. Conversely, the lowest mean value measured from relatively undisturbed mires was 23.2 $\mu\text{S}/\text{cm}$ at Tyee Bog. Specific conductivity values in undisturbed mires never exceeded 30.5 $\mu\text{S}/\text{cm}$. They follow a trend similar to pH and water table fluctuations: mires having the greatest water table fluctuations and the lowest pH values also have the highest specific conductivity values.

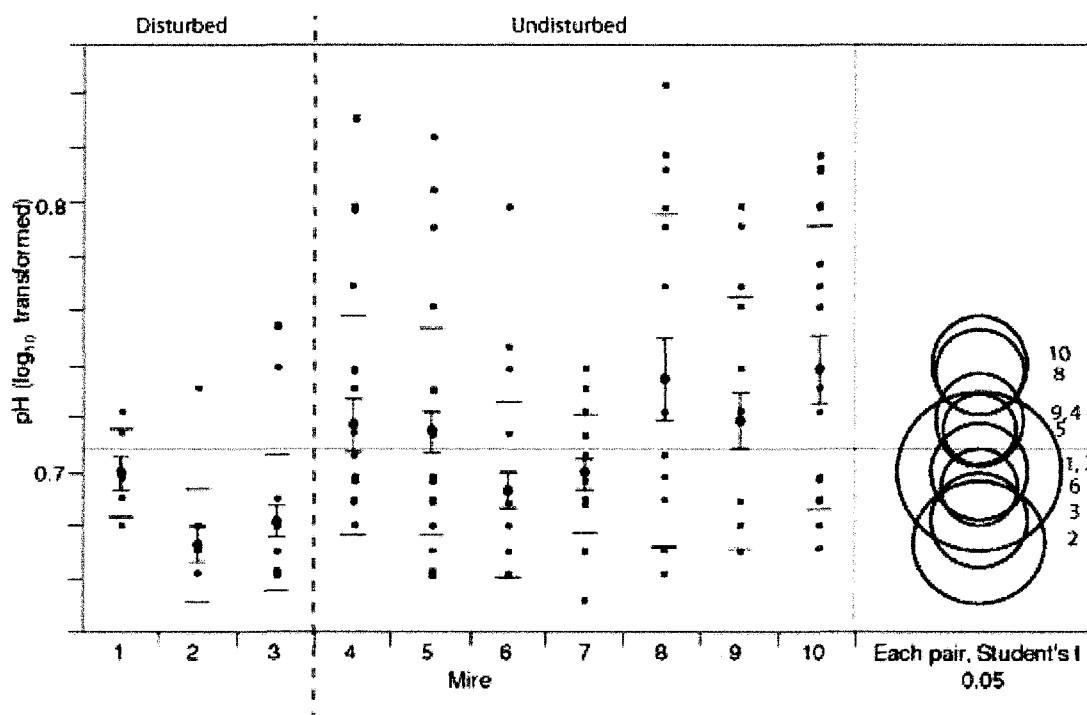


Figure 4.5 Mean, standard error, and standard deviation of $\log_{10}$ pH data. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

Sodium

Sodium concentrations were similarly significantly higher in disturbed mires than they were in undisturbed mires, although no significant differences existed between the disturbed mires (Figure 4.7). The highest mean value was recorded from Rithet's Bog (1.98 mg/l), whereas the lowest mean values were measured at Gilson and Mirror (0.12 mg/l).

Magnesium

Magnesium concentrations were significantly higher at Rithet's Bog than they were in any other mires, including Barrington Bog and Fanny Bay Bog (Figure 4.8). Mean magnesium concentrations at Rithet's Bog were 2.22 mg/l, whereas mean concentrations in all other mires ranged from 0.18 mg/l (Tyee Bog, Grant's) to 0.43 mg/l (Mirror).

Multivariate analysis

Non-metric multidimensional scaling (NMS) demonstrates a clear division between heavily disturbed and undisturbed mires based on vegetation composition and cover, although some overlap between groups is evident (Figure 4.9). Fanny Bay Bog is identified as “transitional” in the diagram to illustrate this overlap. The joint biplot of environmental factors overlying the ordination indicates that water table fluctuations, specific conductivity, and sodium concentrations are generally greater in disturbed mires than in undisturbed mires. Potassium concentrations (not shown) are also greater. As a group, undisturbed mires have higher pH values than heavily disturbed mires.

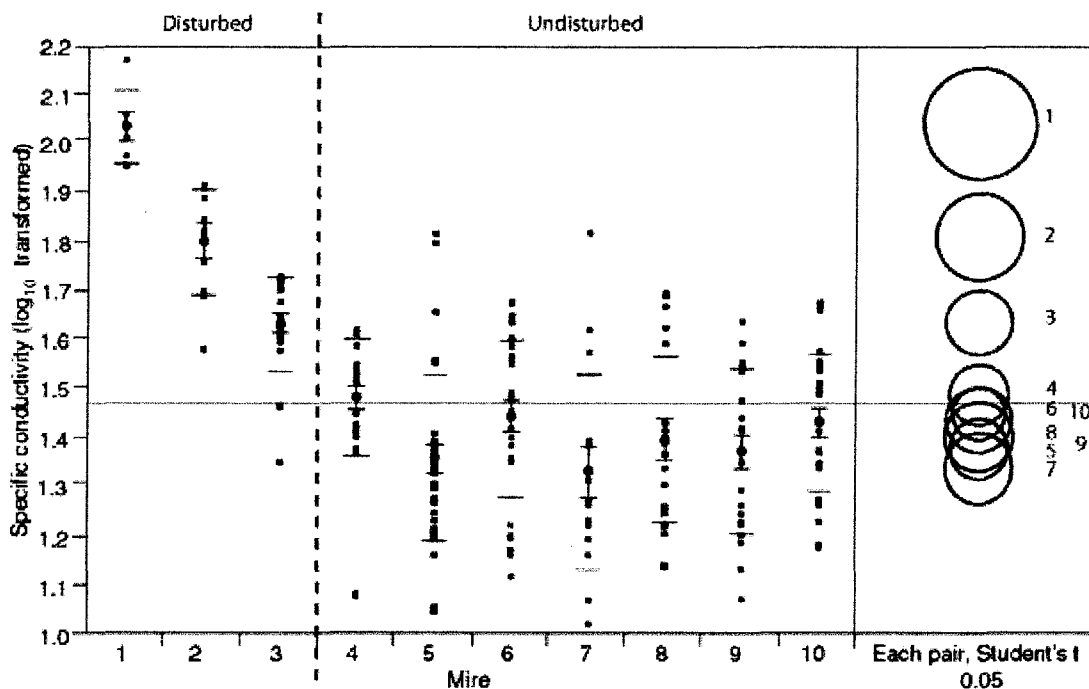


Figure 4.6 Mean, standard error, and standard deviation of $\log_{10}$ transformed specific conductivity data. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

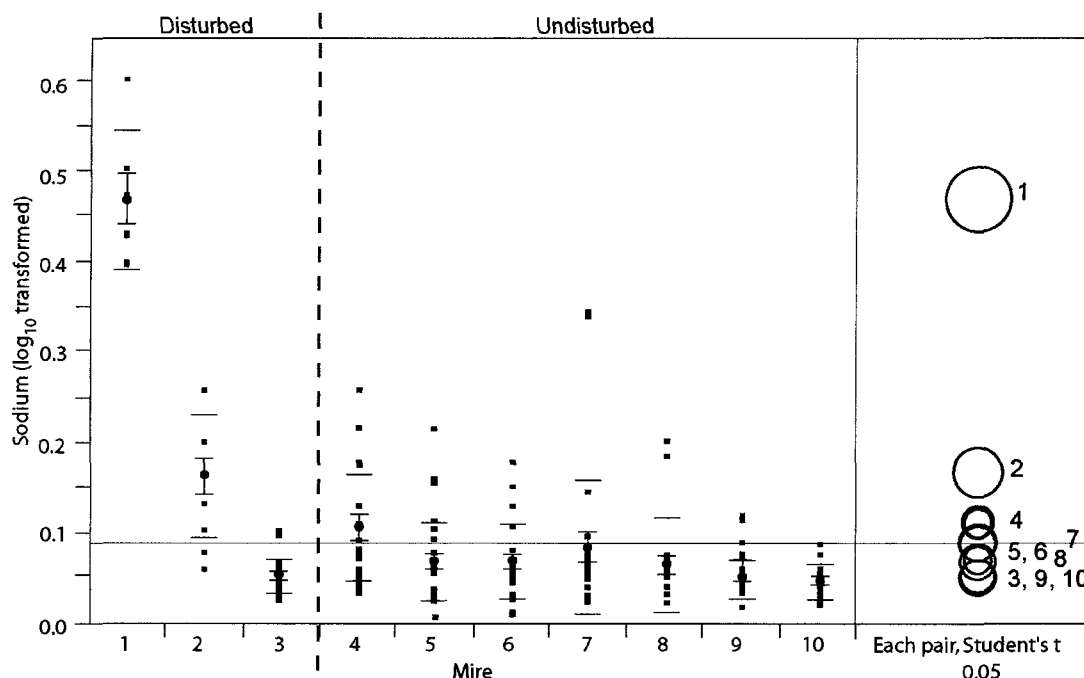


Figure 4.7 Mean, standard error, and standard deviation of $\log_{10}$ transformed sodium concentration data. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

Plant species pool

The species pool for bogs and poor fens at low elevations on eastern Vancouver Island consists of 146 taxa. Half of these taxa (i.e., 73) are uncommon. They include 45 taxa recorded from single sites and 28 recorded from only two sites. Most taxa have their centre of distribution outside mires and are considered "accidental" in bogs and poor fens. Others are considered typical of acidic mires but are regionally rare (see Gignac and Vitt 1990, Gignac et al. 1991, Gignac 1992, 1994) (Table 4.5). Thirty-eight taxa form the core of the species pool (Table 4.6). They were observed in more than half of the undisturbed mires surveyed. Most taxa are herbaceous plants (24%) and graminoids (21%) (Table 4.7). Bryophytes are also common, with *Sphagnum* species comprising 16% of the core group and other bryophytes accounting for 8% of the total. The entire species pool of 146 taxa is similarly distributed among life form groups: herbaceous plants comprise 23% of the pool, followed by graminoids (18%) and bryophytes

excluding *Sphagnum* (18%). Together, *Sphagnum* and other bryophytes account for almost 30% of the pool.

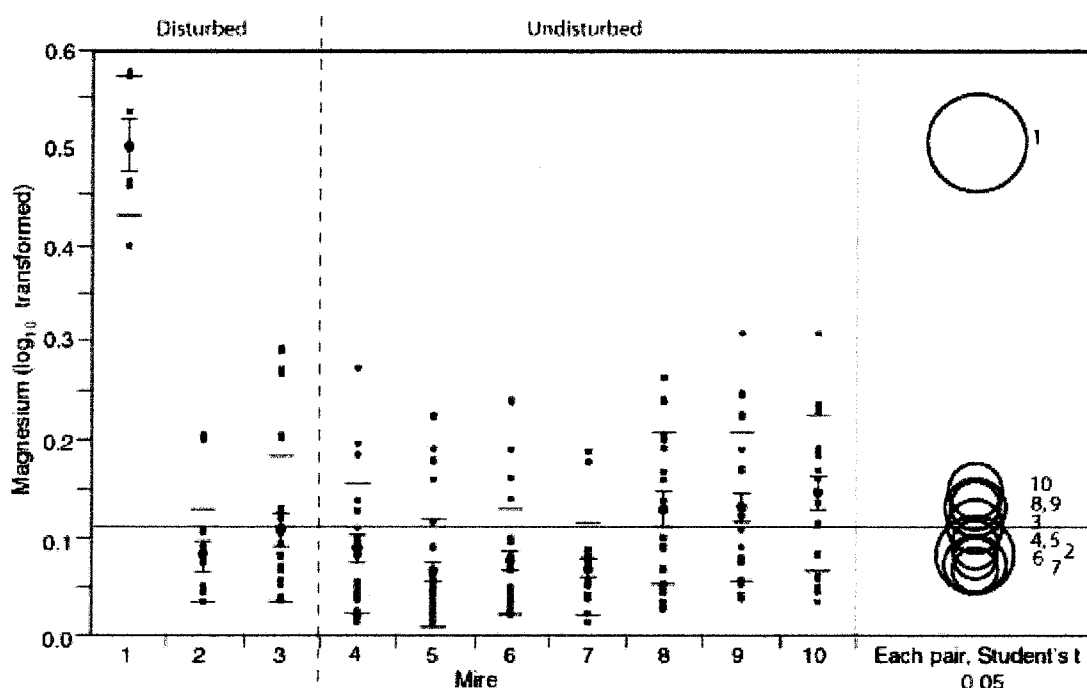


Figure 4.8 Mean, standard error, and standard deviation of $\log_{10}$ transformed magnesium concentration data. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

Disturbed mires at low elevations on eastern Vancouver Island generally have lower total species richness than undisturbed mires although ANOVA results demonstrate high variability among mires (Table 4.8). This trend is particularly evident in raised bogs lacking a well-developed fen lagg or having a highly modified lagg that was excluded from sampling (e.g., Rithet's Bog, Cumberland Bog). Conversely, bogs located within disturbed catchments but still retaining an extensive intact fen lagg (e.g., Fanny Bay, South Dogwood) contain a diverse range of shrub, graminoid, and herbaceous plant species, which increases species richness. Graminoids and herbaceous plants are otherwise poorly represented in the disturbed mires surveyed. Plant species found in many undisturbed mires in the region but absent from or having very low cover in

disturbed mires include *Kalmia microphylla* ssp. *occidentalis*, *Eriophorum chamissonis*, *Drosera rotundifolia*, *Vaccinium oxycoccos*, *Sphagnum fuscum*, and *Sphagnum capillifolium*. Several of these taxa were formerly more abundant at Rithet's Bog (Peden 1967).

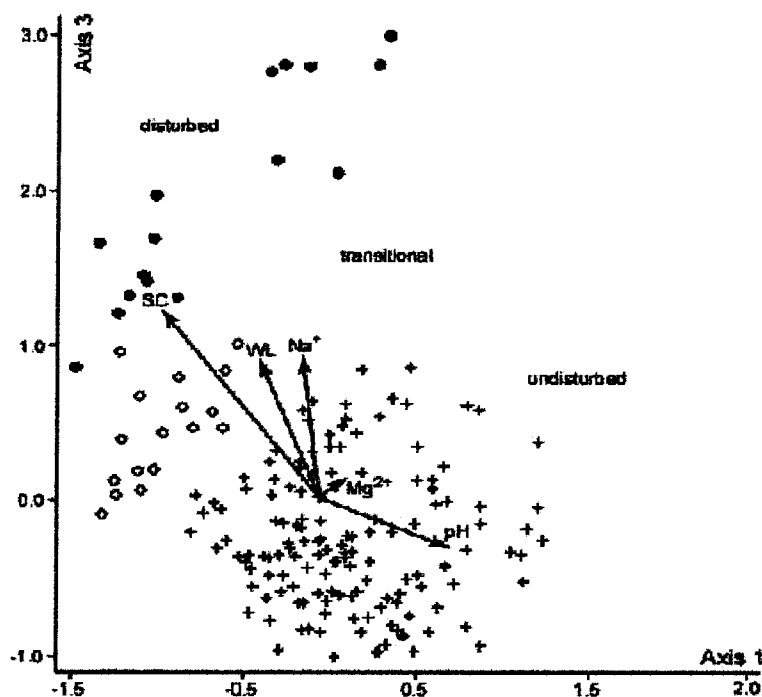


Figure 4.9 Ordination (NMS) of 174 plots in species space demonstrating the division of eastern Vancouver Island mires into disturbed and undisturbed mire groups. Environmental conditions associated with anthropogenic disturbance include relatively high specific conductivity (SC), sodium (Na⁺), potassium (K⁺, not shown), and seasonal water table fluctuation (WL). pH is relatively low compared to undisturbed mires. The stress of the NMS solution was 16.258 and the instability was 0.00048. The cumulative explanation of variance provided by the three axes was $r^2 = 0.872$ (Axis 1, $r^2 = 0.199$; Axis 2, $r^2 = 0.096$; Axis 3, $r^2 = 0.536$).

Mires having high total species richness typically have communities influenced by relatively mineral-enriched water in the lagg or alongside lakes. These communities support herbaceous plant, graminoid, and bryophyte taxa absent from the central portion of raised bogs.

Table 4.5 Plant taxa typical of mires located elsewhere in coastal B.C. but observed in few bogs and poor fens on eastern Vancouver Island. The number of mires (out of 14) from which each taxon was recorded is indicated in parentheses.

Shrubs	Herbaceous plants (cont.)
<i>Vaccinium uliginosum</i> (3)	<i>Platanthera dilatata</i> (2)
<i>Andromeda polifolia</i> (2)	<i>Platanthera stricta</i> (2)
Graminoids	<i>Gentiana sceptrum</i> (1)
<i>Carex viridula</i> ssp. <i>viridula</i> (4)	Sphagnum species
<i>Agrostis oregonensis</i> (3)	<i>Sphagnum pacificum</i> (9)
<i>Carex livida</i> (2)	<i>Sphagnum magellanicum</i> (5)
<i>Juncus supiniformis</i> (1)	<i>Sphagnum papillosum</i> (4)
Aquatic plants	<i>Sphagnum subsecundum</i> (4)
<i>Menyanthes trifoliata</i> (5)	<i>Sphagnum tenellum</i> (1)
<i>Utricularia minor</i> (2)	Other bryophytes
Herbaceous plants	<i>Polytrichum strictum</i> (4)
<i>Lycopus uniflorus</i> (5)	Lichens
<i>Lycopodiella inundata</i> (3)	<i>Cladina portentosa</i> ssp. <i>pacifica</i> (4)
<i>Sanguisorba officinalis</i> (2)	

At the plot level, three fens had significantly higher mean species richness per plot than was recorded from plots in disturbed mires (Figure 4.10). Mean numbers of plant taxa per 0.25 m² plot in Gilson, Miller and Scheuchzeria were 10.4, 10.0, and 8.8, respectively. Rithet's Bog and Barrington Bog had 5.0 and 5.2 taxa per plot, whereas plant species richness in the remaining mires ranged from 5.6 to 7.2.

Plant community richness

The number of plant associations present in study sites varies from one to six (Table 4.9). Heavily disturbed mires (i.e., Rithet's Bog, Barrington Bog) are characterized by a single association consisting of heath vegetation. The *Gaultheria shallon* – *Pteridium aquilinum* association represents the dry end of the moisture gradient. It contains few graminoids, herbaceous plants, or bryophytes, and has little *Sphagnum* cover. Conversely, the mire with the greatest community diversity (Mirror) is a medium-sized (5 ha) shore mire containing six of the seven vegetation associations occurring in mires at low elevations

on eastern Vancouver Island. The only association not present was the *Gaultheria shallon* – *Pteridium aquilinum* association.

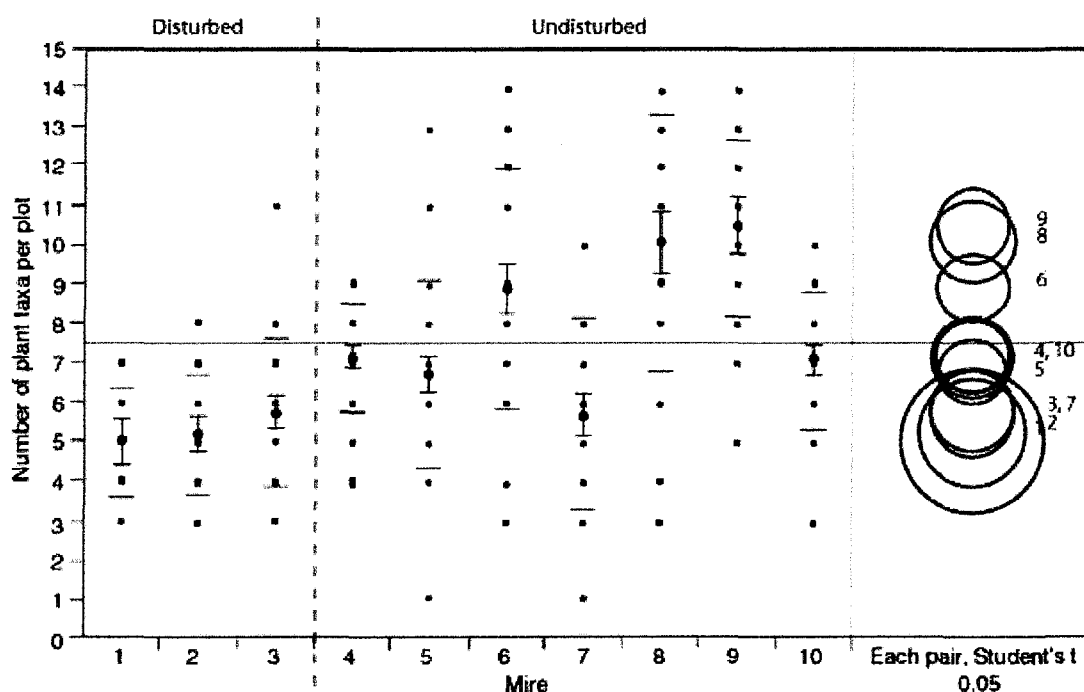


Figure 4.10 Mean, standard error, and standard deviation of $\log_{10}$ transformed data of number of plant taxa per plot. The mires are: 1. Rithet's Bog, 2. Barrington Bog, 3. Fanny Bay, 4. Williams Beach, 5. Grant's, 6. Scheuchzeria, 7. Tyee Bog, 8. Miller, 9. Gilson, and 10. Mirror. Note: overlapping circles indicate no significant differences between mires.

Most undisturbed mires are characterized by two to four associations. They typically span the hummock–hollow moisture gradient. The only exception (Gilson) is a narrow shore mire lacking hollows and a well-developed fen lagg. It contains only two hummock associations corresponding to wet and dry conditions (the *Sphagnum fuscum* – *Sphagnum angustifolium* / *Drosera rotundifolia* association, and the *Sphagnum fuscum* – *Pleurozium schreberi* association, respectively).

Table 4.6 Plant taxa observed in >50% of the 14 undisturbed bogs and poor fens surveyed on eastern Vancouver Island. The number of occurrences is indicated in parentheses.

Trees	Herbaceous plants and trailing shrubs
<i>Tsuga heterophylla</i> (7)	<i>Drosera rotundifolia</i> (9)
<i>Pinus monticola</i> (6)	<i>Vaccinium oxycoccos</i> (9)
<i>Pinus contorta</i> var. <i>contorta</i> (5)	<i>Drosera anglica</i> (6)
<i>Thuja plicata</i> (5)	<i>Viola</i> sp. (6)
Shrubs	
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i> (9)	<i>Cornus unalaschensis</i> (5)
<i>Ledum groenlandicum</i> (9)	<i>Rubus chamaemorus</i> (5)
<i>Gaultheria shallon</i> (8)	<i>Triantha glutinosa</i> (5)
<i>Myrica gale</i> (8)	<i>Trientalis arctica</i> (5)
	Sphagnum species
<i>Empetrum nigrum</i> (5)	<i>Sphagnum fuscum</i> (9)
Graminoids	<i>Sphagnum angustifolium</i> (8)
<i>Eriophorum chamissonis</i> (9)	<i>Sphagnum capillifolium</i> (8)
<i>Rhynchospora alba</i> (9)	<i>Sphagnum henryense</i> (5)
<i>Carex lasiocarpa</i> (7)	<i>Sphagnum mendocinum</i> (5)
<i>Carex pauciflora</i> (6)	<i>Sphagnum palustre</i> (5)
<i>Carex sitchensis</i> (6)	Other bryophytes
<i>Carex echinata</i> (5)	<i>Pleurozium schreberi</i> (8)
<i>Carex limosa</i> (5)	<i>Mylia anomala</i> (7)
<i>Carex utriculata</i> (5)	<i>Aulacomnium palustre</i> (5)
<i>Dulichium arundinaceum</i> (5)	Lichens
Aquatic plants	<i>Cladina rangiferina</i> (5)
<i>Comarum palustre</i> (6)	
<i>Nuphar lutea</i> ssp. <i>polysepala</i> (6)	

Table 4.7 Number of taxa per life form group occurring in bogs and poor fens in mires at low elevations on eastern Vancouver Island.

Life form group	Core taxa	All taxa
trees	4	5
shrubs	5	22
graminoids	9	27
herbaceous plants and trailing shrubs	8	33
aquatics	2	7
<i>Sphagnum</i> mosses	6	16
bryophytes excluding <i>Sphagnum</i>	3	27
lichens	1	9
Total:	38	146

Table 4.8 Total plant species richness in low elevation eastern Vancouver Island bogs and poor fens.

Life form group	Rithet's Bog	Barrington Bog	Tyee Bog	Glengarry Bog	Cumberland	Williams Beach	Ladysmith Bog	Grant's	S. Dogwood	Scheuchzeria	Gilson	Mirror	Miller	Fanny Bay
trees	3	1	1	2	2	3	2	2	2	2	4	2	4	5
shrubs	7	7	3	4	7	6	5	9	9	8	5	4	7	10
graminoids	1	1	2	2	0	7	6	10	9	8	13	12	17	19
herbaceous plants and trailing shrubs	3	4	3	3	7	5	5	6	8	9	17	12	17	20
aquatics	0	0	2	0	1	2	3	1	1	2	0	6	2	3
<i>Sphagnum</i> species	2	5	3	5	7	6	5	8	4	7	9	9	8	7
bryophytes excluding <i>Sphagnum</i>	3	2	3	7	3	4	7	4	8	8	4	8	6	13
lichens	0	0	3	3	1	0	4	0	4	3	1	3	1	4
Total number of taxa	19	20	20	26	28	33	37	40	45	47	53	56	62	81

Table 4.9 Mire plant community richness in bogs and poor fens in mires at low elevations on eastern Vancouver Island.

Association	Rithet's Bog	Barrington Bog	Ladysmith Bog	Gilson	Fanny Bay	Glengarry Bog	Grant's	S. Dogwood	Tyee Bog	Williams Beach	Miller	Scheuchzeria	Mirror
<i>Gaultheria shallon</i> / <i>Pteridium aquilinum</i>	1	1				1		1			1		
<i>Sphagnum fuscum</i> - <i>Pleurozium schreberi</i>				1		1	1		1		1	1	1
<i>Sphagnum fuscum</i> - <i>S. angustifolium</i> / <i>Drosera rotundifolia</i>			1	1	1	1	1		1	1	1	1	1
<i>Carex sitchensis</i> / <i>Spiraea douglasii</i>							1	1			1	1	1
<i>Carex lasiocarpa</i>					1								1
<i>Rhynchospora alba</i>										1		1	1
<i>Menyanthes trifoliata</i> - <i>Nuphar lutea</i> ssp. <i>polysepala</i>					1			1	1	1			1
Number of associations	1	1	1	2	3	3	3	3	3	3	4	4	6

DISCUSSION

Ideally, studies investigating floristic and environmental differences between disturbed and undisturbed mires should compare sites varying little beyond the actual effects of disturbance. However, all heavily disturbed mires on southeastern Vancouver Island are raised bogs, and no nearby undisturbed bogs (e.g., Turner's Bog; see Ceska 1978) remain to draw comparisons from. Therefore, in this study, bogs and poor fens representing a continuum of successional stages from poor fen to bog were selected for comparison with disturbed mires.

In suggesting that differences in the vegetation and environmental conditions between disturbed and undisturbed mires are related to disturbance, I acknowledge that bogs and poor fens differ ecologically. For example, poor fens typically have higher species richness, higher pH, greater cation concentrations, and greater specific conductivity values than bogs (Glaser 1992, Gorham and Janssens 1992, Malmer et al. 1992, Vitt 1994, van Breemen 1995, Zoltai and Vitt 1995). Even when these differences are accounted for, however, study results indicate that dissimilarities between mires are linked to disturbance. Unavoidable shortcomings in the methodology do not detract from the conclusion that eastern Vancouver Island mires are sensitive to, and have been affected by, human disturbance.

Vegetation structure

Vegetation clearly differs between disturbed and undisturbed mires at low elevations on eastern Vancouver Island. Disturbed mires are characterized by well-developed stands of *Pinus contorta* var. *contorta* in the tree layer and a dense understory dominated by *Ledum groenlandicum* and *Gaultheria shallon*. Drained bogs in the Fraser Lowland and western Washington are similar, although *Tsuga heterophylla* sometimes replaces *P. contorta* in the tree layer (Rigg 1917, 1922, Pearson 1983). Although it has been suggested that over time mires naturally become forests (e.g., Rigg 1917), there is no evidence to suggest that in the absence of disturbance or shifts in climate, productivity shifts from lower vegetation layers to tree and tall shrub layers, and *Sphagnum* cover diminishes (van Breemen 1995). Raised bogs in northern Europe, for example, are typically open in character, and even forested mires have well-developed microtopography and understory layers.

Plant species richness

As expected, plant species richness is relatively low in disturbed mires on eastern Vancouver Island. At the plot scale, however, it is not significantly lower than it is in most undisturbed mires, because most undisturbed study sites have wet microhabitats that typically support species-poor vegetation such as the *Carex lasiocarpa* association, the *Rhynchospora alba* association, and the *Menyanthes trifoliata* association.

In general, bryophyte and field layers of undisturbed mires contain numerous species of dwarf shrubs, graminoids, herbaceous plants, and bryophytes that are absent from undisturbed mires or are not abundant. These species typically have narrow ecological amplitudes (Dierssen 1992), making them vulnerable to extirpation from mires affected by desiccation and eutrophication. Taxa extirpated from Rithet's Bog since it was drained in the early 1900s, for example, include *Sphagnum capillifolium*, (voucher specimen at Royal B.C. Museum), *Eriophorum chamissonis* (noted by Szczawinski and Harrison 1972), and *Drosera rotundifolia* (noted by Rigg 1922, Stirling 1965, Peden 1967, Szczawinski and Harrison 1972). Similarly, very few individual plants (i.e., <5) of *Kalmia microphylla* ssp. *occidentalis* and *Vaccinium oxycoccos* remain. Because plant

species found in mire environments seldom occur in other habitats, their extirpation negatively impacts regional biodiversity.

Community richness

Community richness is low in disturbed bogs as a result of drainage. Drainage reduces the mean summer water table and eliminates wet microhabitats such as hollows and lawns (Verry 1997). Shrub heath vegetation is uniform and extensive, whereas communities containing a diverse range of herbaceous plants, graminoids, and bryophytes occupy a limited area. Dense trees and shrubs grow well in dry conditions caused by drainage, but in turn they cause “biological drainage”, whereby maturing vegetation suppresses the water table during the growing season and increases moisture losses to evapotranspiration (Heikurainen and Päivänen, 1970). *Sphagnum* cannot effectively compete for light beneath dense shrub cover, and the process of peat formation and accumulation ceases. Accelerated decomposition further reduces microtopographic surface relief through subsidence (Maltby 1997, Verry 1997).

Exotic plant species

One major characteristic distinguishing disturbed mires on eastern Vancouver Island from those located in the Fraser Lowland is the low abundance of exotic plant species. Individual plants of *Ilex aquifolium* and *Rubus laciniatus* are present in the centre of Rithet’s Bog, for example, and *Solanum dulcamara* is abundant in a drainage ditch. However, none of these species threatens local biodiversity. By contrast, many plant species native to mires of eastern North America are prominent in disturbed mires throughout the Fraser Lowland and occupy niches otherwise inhabited by native taxa, including *Eriophorum virginicum*, *Vaccinium macrocarpon*, *V. corymbosum*, and *Sphagnum cuspidatum*, conversely. Colonization of eastern Vancouver Island mires by these species is likely limited by dispersal.

Disturbance and succession

It has been hypothesized that mires eventually become forests, and that tree and shrub vegetation in disturbed mires resembles that expected to be typical of advanced successional stages of mires had they more time to develop (Rigg 1917). However, there is no evidence to suggest, that in the absence of a shift in climate toward drier climatic conditions that *Sphagnum* cover would become diminished and vegetation become dominated by trees and shrubs (van Breemen 1995). Advanced successional stages of forested mires in northern and central Europe, for example, are characterized by well-developed microtopography, and understory vegetation typically includes such species as *Sphagnum capillifolium*, *Vaccinium vitis-idaea*, *V. oxycoccus*, and *Ledum palustre*. On eastern Vancouver Island, by contrast, large portions of disturbed mires are dominated by *Ledum groenlandicum* and *Gaultheria shallon*, and very few species of dwarf shrubs, graminoids, herbaceous plants, and bryophytes are present in the understory.

Water chemistry

Water chemistry differs widely between disturbed and undisturbed mires on eastern Vancouver Island. Specific conductivity values and most major cation concentrations are significantly higher in disturbed mires than they are in undisturbed mires, whereas pH values are relatively low. In undisturbed mires, specific conductivity and cation concentrations would typically be lower than they would be in poor fens, as would pH. This strongly suggests a strong link between disturbance and water chemistry change.

The high specific conductivity and cation concentrations measured in the disturbed mires are likely related to drainage from surrounding urban land use and decomposition of organic materials within the mire. Specific conductivity provides a general indicator of nutrient enrichment, and mean values of 108.7 $\mu\text{S/cm}$ at Rithet's Bog, 64.0 $\mu\text{S/cm}$ at Barrington Bog, and 42.8 $\mu\text{S/cm}$ at Fanny Bay are significantly higher than mean values from undisturbed mires which range from 23.2 $\mu\text{S/cm}$ at Tyee to 30.5 $\mu\text{S/cm}$ at Williams Beach. For perspective, specific conductivity exceeding 100 $\mu\text{S/cm}$ was used as the

threshold to indicate moderate to high urbanization effects in Puget Sound wetlands (Horner *et al.* 2001).

The low pH measured in the disturbed mires may be related to drainage, which through increased aeration and decomposition of surface peat releases organic acids (Clymo 1963). Mean pH of water samples was less variable than values obtained for other chemical parameters. It ranged from approximately 3.7 to 4.5, indicating some degree of groundwater influence in several mires.

CONCLUSIONS

Disturbed mires are dominated by trees and shrubs and the bryophyte layer is sparse. Few herbaceous plant species and graminoids occur in disturbed mires, and many species typical of undisturbed mires are either absent or occur only in very limited quantities (e.g., *Kalmia microphylla* ssp. *occidentalis*, *Vaccinium oxycoccos*, *Drosera rotundifolia*, *Eriophorum chamissonis*, *Sphagnum capillifolium* and *Sphagnum fuscum*). Disturbed mires support very few plant communities; the most common and abundant is the *Gaultheria shallon* – *Pteridium aquilinum* association.

Environmental characteristics also differ significantly between disturbed and undisturbed mires. Mean seasonal water table fluctuations are significantly greater in disturbed mires than they are in undisturbed mires, as are specific conductivity values and sodium concentrations. Magnesium concentrations follow a similar trend but the differences between disturbed and undisturbed mires is not statistically significant.

CHAPTER 5

SUMMARY AND CONCLUSIONS

My research focused on three aspects of mire ecology: delineation of mire regions based on floristic data, classification of mire plant communities, and identification of floristic, hydrological, and chemical differences between disturbed and undisturbed mires on eastern Vancouver Island. The results are directly applicable to mire conservation and are particularly relevant in southwestern B.C. given on-going threats to mire ecosystems from various forms of development, including agricultural use, road development, urbanization, and forestry.

Regional-scale classifications provide a useful framework for assessing mire conservation priorities (Jennings et al. 2002). Without classification it is difficult to distinguish between and compare among the wide variety of mires occurring within a relatively large geographical area. It is also difficult to identify relationships between vegetation and its environment.

To determine whether statistical analyses of floristic data supported previously described wetland regions (i.e., NWWG 1986, Banner et al. 1988), I analysed floristic data collected from 43 mires located throughout Vancouver Island. I incorporated data from five mires located near Prince Rupert and three in the Lower Mainland for context. Results of the analyses are largely consistent with previous descriptive work (NWWG 1986, Banner et al. 1988). Vancouver Island is divided into three wetland regions: the Pacific Oceanic wetland region, the Coast Mountain wetland region, and the Pacific Temperate wetland region.

Although mires of western and northern Vancouver Island and mires of the Prince Rupert area are floristically very similar, they form distinct groups because the distributions of several plant species do not overlap. Results of NMS and cluster analysis support subdividing the Pacific Oceanic wetland region into North Coast and South Coast subregions. Conversely, mires occurring in the lowlands of eastern Vancouver Island and

mires sampled in the Lower Mainland area are floristically very similar despite substantial differences in development history and hydrotopographic position. The results of my work are in agreement with that of Banner et al. (1988): there is no need to subdivide the Pacific Temperate wetland region into subregions.

Mires found at middle to high elevations on Vancouver Island are encompassed by the South Coast subregion of the Coast Mountains wetland region. My analyses suggest the subregion should be divided into East and West sections.

Plant community classification is equally important for conservation. In British Columbia, the BC Conservation Data Centre uses vegetation classification at the association level to assess conservation significance of individual sites. My study encompasses areas not previously sampled, particularly in mountainous areas, and increases the number of low-elevation study sites in areas examined in previous studies (e.g., Wade 1965, Peden 1967, Ceska 1978, Hebda et al. 1997, Brett et al. 2001).

At the community scale, I identified 20 plant associations from a broad range of Vancouver Island mires using traditional phytosociological techniques and ordination. I grouped the associations into six orders. One order (the *Ledum groenlandicum* - *Kalmia microphylla* ssp. *occidentalis* order) consists of ten associations from hummocks, lawns, and heath in bogs and poor fens. Two hummock associations characterized by *Sphagnum fuscum* are united in the *Sphagnum fuscum* alliance, and three associations characterized by *Sphagnum papillosum* are grouped into the *Sphagnum papillosum* alliance. Three associations were not grouped into alliances, including the *Gaultheria shallon* / *Pteridium aquilinum* association, the *Racomitrium lanuginosum* / *Juniperus communis* - *Empetrum nigrum* association, and the *Sphagnum austinii* – *Polytrichum strictum* / *Maianthemum dilatatum* association.

The remaining five orders are composed of communities occurring in hollows, pools, and the lagg surrounding raised bogs. Several of the associations describe moderate-rich and rich fen vegetation. Rich fen communities are represented by the *Triantha glutinosa*

order. On Vancouver Island it encompasses six associations, including three forming the *Caltha leptosepala* var. *biflora* alliance. The other four orders (i.e., the *Eriophorum angustifolium* order, the *Juncus supiniformis* order, the *Rhynchospora alba* – *Scheuchzeria palustris* order, and the *Nuphar lutea* ssp. *polysepala* orders) each consist of single associations (i.e., the *Eriophorum angustifolium* association, the *Juncus supiniformis* association, the *Rhynchospora alba* – *Scheuchzeria palustris* association, and the *Nuphar lutea* ssp. *polysepala* association).

Fourteen of the 20 mire plant associations identified in my study resemble communities previously described from mires in southwestern British Columbia. Six associations are new. Three of the newly described associations are lawn communities occurring in middle to high elevation fens (i.e., the *Aulacomnium palustre* association, the *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association, and the *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association); one is a lawn community described from a single moderate-rich fen on western Vancouver Island (i.e., *Juncus acuminatus* / *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association), one of the associations occupies hollows in fens (i.e., the *Juncus supiniformis* association), and one association is a lawn community occurring primarily in low to middle elevation fens on eastern Vancouver Island (i.e., the *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association). None of these associations are particularly common, and their conservation status is likely high.

In general, Vancouver Island mires and their plant communities are globally unique. Similar to mires elsewhere, the vegetation is dominated by bryophytes, dwarf shrubs, and graminoids, and it contains many species that are widely distributed in mires throughout the northern hemisphere. However, much of the Vancouver Island mire flora is endemic to western North America or the Pacific Rim, and marked climatic differences between coastal and continental areas mean its composition changes substantially over very short distances. In addition, mire ecosystems are relatively uncommon in southwestern British Columbia. For these reasons, mire ecosystems should be conserved.

Mires are particularly rare at low elevations on eastern Vancouver Island (Ward et al. 1998). The most common types of mires present in the region are basin bogs and poor fens. They range in successional stage of development from narrow shore fens to slightly domed raised bogs (Banner et al. 1988), few of which are intact. Much of the region is settled and many mires were damaged or destroyed as a result of drainage for agricultural or urban land use. Mires remaining on eastern Vancouver Island have high conservation value as a result of their scarcity and because they are near the southern margin of the range of mire distribution in coastal western North America.

To conserve remaining mires on eastern Vancouver Island it is essential to understand how vegetation structure, plant community composition, and environmental conditions differ between disturbed and undisturbed mires. The results of the study comparing disturbed and undisturbed mires at low elevations on eastern Vancouver Island can be directly applied to local mire restoration. The data clearly demonstrate substantial differences in vegetation structure, floristic composition, hydrological conditions, and chemical concentrations between the two mire groups, and knowledge of these differences is essential for evaluating restoration potential and setting goals.

Despite overlap in some parameters, disturbed and undisturbed mires on eastern Vancouver Island differ greatly. Vegetation in undisturbed mires is open in character and has a nearly continuous bryophyte layer dominated by several species of *Sphagnum* and other wetland mosses. Herbaceous and graminoid taxa are diverse, particularly in areas influenced by minerogenous water such as the lagg. The dwarf shrub layer is typically well developed but seldom dense, although the lagg often contains thickets of *Myrica gale* and *Spiraea douglasii*. Tree cover in undisturbed mires is sparse. However, *Pinus contorta* var. *contorta* sometimes occurs in dwarf form, and some individuals of *P. contorta* and *P. monticola* exceed 10 m in height.

Disturbed mires, by contrast, are dominated by trees and shrubs. The bryophyte layer is discontinuous beneath a canopy typically composed of *Pinus contorta* var. *contorta* or *Tsuga heterophylla* and dense understory of *Gaultheria shallon* and *Ledum*

groenlandicum. Herbaceous plants and graminoids are neither diverse nor abundant. Plant species that are typical of undisturbed mires in the region but which are usually absent from or not abundant in disturbed mires include *Kalmia microphylla* ssp. *occidentalis*, *Vaccinium oxycoccos*, *Drosera rotundifolia*, *Eriophorum chamissonis*, *Sphagnum capillifolium* and *Sphagnum fuscum*.

Disturbed and undisturbed mires also differ in plant community richness. The number of distinct plant communities is typically higher in undisturbed mires than in disturbed ones. Up to six distinct plant communities were present in some of the undisturbed study sites, whereas sites that had been drained or partially filled typically had only one plant community. The *Gaultheria shallon* – *Pteridium aquilinum* association characterizes heath vegetation and occurs at the dry end of the moisture gradient. It contains few graminoids, herbaceous plants, or *Sphagnum* species. *Sphagnum* cover is usually low. The *Gaultheria shallon* – *Pteridium aquilinum* association is the dominant plant community in disturbed mires. Hummock communities are typically common in undisturbed mires, but they are usually absent from disturbed mires. They are encompassed by two associations. The *Sphagnum fuscum* – *Pleurozium schreberi* association occurs in sites having greater water level fluctuations and lower pH than in habitats occupied by the *Sphagnum fuscum* – *Sphagnum angustifolium* / *Drosera rotundifolia* association.

Drainage reduces the mean summer water table and eliminates wet microhabitats such as hollows and lawns (Verry 1997). Although no hollows remain in disturbed mires on eastern Vancouver Island, the *Menyanthes trifoliata* – *Nuphar polysepalum* association, which often occurs in relatively deep hollows and parts of the lagg having little water flow, is present in the lagg of two disturbed mires. The *Carex lasiocarpa* association occurs in areas of the lagg having some water movement, whereas the *Rhynchospora alba* association occupies hollows having shallow standing water throughout much of the year. Neither are present in disturbed mires. The *Spiraea douglasii* / *Carex sitchensis* / *Myrica gale* association is found at one disturbed site. It is confined to the outer margin of the lagg where seasonal water level fluctuations are moderate.

Moisture and nutrient conditions vary widely along hummock–hollow and mire margin–mire centre gradients in undisturbed mires on eastern Vancouver Island. Heterogeneity of environmental conditions is reflected in plant community composition, with each association occupying a particular niche depending on water level fluctuations, pH, and ionic concentrations. Environmental variables in disturbed bogs, by contrast, are relatively uniform as is vegetation composition and structure.

I found mean water table fluctuations were significantly greater in disturbed mires than they were in most undisturbed sites. Disturbed mires typically lack extensive *Sphagnum* cover which functions to moderate seasonal water table fluctuations (van Breeman 1994). Disturbed mires are also characterized by extensive tree and shrub cover, which effectively lowers the water table during the growing season through “biological drainage”. Extreme seasonal water table fluctuations in disturbed mires are associated with mean specific conductivity values and sodium concentrations that are significantly higher than were recorded from undisturbed mires.

Specific conductivity provides a general indicator of water quality. High specific conductivity values and high cation concentrations in disturbed mires may result from aeration and decomposition of organic matter, or they may be linked to surrounding urban land use. High acidity in undisturbed mires results from decomposition, which causes the release of organic acids (Clymo, 1963). Regardless of the cause, the combination of high specific conductivity coupled with high acidity is challenging because few key functional plant species are able to persist under such conditions.

The results of my research demonstrate the breadth of mire communities present on Vancouver Island. The classification of plant communities provides a means for assessing the conservation significance of mire plant communities in southwestern B.C. The addition of mires located at middle to high elevations increases our knowledge of such ecosystems, which were previously not well known. Identifying differences between disturbed and undisturbed mires on eastern Vancouver Island is also useful for conservation because it demonstrates the likely effects of drainage and provides data that can be used for setting targets for restoration.

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APPENDIX 1

VEGETATION CLASSIFICATION TABLES

Table 1 *Gaultheria shallon* / *Pteridium aquilinum* association

Site	SD	RB	RB	RB	RB	RB	RB	ML	MA	B	B	B	ML		
Plot Number	10	1	2	3	8	9	10	7	3	2	3	4	6		
Vascular Spp./ Relevé	8	4	5	3	6	7	6	11	10	6	8	7	10		
Bryophyte Spp./ Relevé	7	3	1	2	0	3	0	4	1	4	4	5	2		
Lichen Spp./ Relevé	0	0	0	0	0	0	0	0	2	0	0	0	0		
Vascular Plant Cover (%)	50	60	90	80	100	100	100	90	90	90	80	60	100		
Bryophyte Cover (%)	35	25	15	35	0	10	0	10	5	20	10	40	2		
Lichen Cover (%)	0	0	0	0	0	0	0	0	10	0	0	0	0		
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	SP'	SS'
Character Species:															
<i>Gaultheria shallon</i>	45	35	10	10	30	70	5	2	4	45	45	35	2	V	6
<i>Pteridium aquilinum</i>	30				80				15	8	20	15	3	III	5
Companion Species:															
<i>Ledum groenlandicum</i>	5	10	5	45	20	15	50	20	12	45	55	30	10	V	6
Other Species:															
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		15						3	4	15	1	8	5	III	3
<i>Pinus contorta</i> var. <i>contorta</i>	35			25	50	50	30				10			III	5
<i>Hylocomium splendens</i>	15							2		15	5	10	1	III	3
<i>Spiraea douglasii</i>			2			10	70			0.1		0.5		II	4
<i>Rhytidiadelphus triquetris</i>		15		5						5	1	2		II	3
<i>Cornus unalaschensis</i>	5							0.2		2	2	1		II	1
<i>Sphagnum pacificum</i>	10		15	30		1								II	3
<i>Sphagnum palustre</i>						1				1	2	15		II	2
<i>Empetrum nigrum</i>								85	80				95	II	5
<i>Malus fusca</i>			50			5	15							II	4
<i>Rubus chamaemorus</i>								20	5				8	II	3
<i>Vaccinium uliginosum</i>	2							15	8					II	2
<i>Sphagnum capillifolium</i>	10									1		10		II	2
<i>Pleurozium schreberi</i>	1							5	5					II	1
<i>Vaccinium oxycoccus</i>		2									0.1	1		II	+
<i>Tsuga heterophylla</i>	1				1			1						II	+

Minor Species: *Eurhynchium oregonum* 2(5)*, 6(10), *Sphagnum mendocinum* 11(1), 12(5), *Dicranum scoparium* 1(0.1), 2(5); *Rhytidiadelphus loreus* 8(2), 13(1), *Sorbus sitchensis* 6(2), 7(1), *Carex sitchensis* 8(0.1), 13(0.5), *Cornus stolonifera* 3(25), *Myrica gale* 13(20), *Cladina rangiferina* 9(10), *Triantha glutinosa* 9(3), *Betula pumila* var. *glandulifera* 5(2), *Lonicera involucrata* 6(2), *Pinus monticola* 8(2), *Sanguisorba officinalis* 13(2), *Tsuga mertensiana* 9(2), *Cladonia squamosa* 9(1), *Eriophorum chamissonis* 13(1), *Eurhynchium praelongum* 1(1), *Plagiothecium undulatum* 8(1), *Pseudotsuga menziesii* 11(1), *Vaccinium caespitosum* 9(1), *Vaccinium parvifolium* 1(1), *Thuja plicata* 8(0.2), *Aulacomnium palustre* 1(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

¹ Species presence class as percent frequency: I = 1–20%, II = 21–40%, III = 41–60%, IV = 61–80%, V = 81–100%.

² Species significance class as mean percent cover: 0.1 = 0.1–0.3, 1 = 0.4–1.0, 2 = 1.1–2.1, 3 = 2.2–5.0,

4 = 5.1–10.0, 5 = 10.1–20.0, 6 = 20.1–33.0, 7 = 33.1–50.0, 8 = 50.1–70.0, 9 = 70.1–100.

Table 2 *Racomitrium lanuginosum* / *Juniperus communis* / *Carex livida* association

Site	V	V	V	V	V	RM		
Plot Number	17	20	22	23	25	14		
Vascular Spp./ Relevé	9	16	16	13	13	11		
Bryophyte Spp./ Relevé	1	2	4	2	4	1		
Lichen Spp./ Relevé	0	1	0	0	0	1		
Vascular Plant Cover (%)	20	45	40	35	60	20		
Bryophyte Cover (%)	100	100	100	100	90	95		
Lichen Cover (%)	0	0.1	0	0	0	5		
Running Number	1	2	3	4	5	6	SP	SS
Character Species:								
<i>Racomitrium lanuginosum</i>	100	98	95	95	80	95	V	9
<i>Juniperus communis</i>		35	2		30		III	5
Differential Species:								
<i>Empetrum nigrum</i>	5	10	30	25	45	8	V	6
Companion Species:								
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	8	5	3	1	3	4	V	3
<i>Ledum groenlandicum</i>	5	5	8	2	1	2	V	3
<i>Gaultheria shallon</i>	2	2	2	1	3	2	V	2
<i>Pinus contorta</i> var. <i>contorta</i>		25	2	5	6	1	V	4
<i>Eriophorum angustifolium</i>	0.1	1	1	2		3	V	2
<i>Sanguisorba officinalis</i>	1	2	1	1	1		V	1
Other Species:								
<i>Calamagrostis nutkaensis</i>	5	3	5	2			III	3
<i>Thuja plicata</i>			2	5	2	5	III	3
<i>Microseris borealis</i>		1	3	1	0.1		III	1
<i>Carex livida</i>	1	1			2	1	III	1
<i>Myrica gale</i>			5	0.1	15		III	3
<i>Sphagnum capillifolium</i>			1	5	2		III	2
<i>Trientalis arctica</i>	1	2	0.1				III	1
<i>Dicranum undulatum</i>			2		5		II	2
<i>Vaccinium uliginosum</i>			1	0.5			II	+
<i>Triantha glutinosa</i>			1		0.1		II	+
<i>Comus unalaschensis</i>		0.1				0.5	II	+
<i>Deschampsia cespitosa</i>		0.1	0.1				II	+
Minor Species: <i>Cladonia uncialis</i> 6(5)*, <i>Trichophorum cespitosum</i> 6(5), <i>Hylocomium splendens</i> 5(3), <i>Polytrichum commune</i> 2(2), <i>Sphagnum austinii</i> 3(2), <i>Vaccinium caespitosum</i> 6(2), <i>Andromeda polifolia</i> 4(0.5), <i>Blechnum spicant</i> 2(0.1), <i>Cladina rangiferina</i> 2(0.1), <i>Coptis trifolia</i> 5(0.1), <i>Maianthemum dilatatum</i> 2(0.1).								

* First number refers to running number, second number (in parentheses) is percent cover.

Table 3 *Sphagnum austinii* - *Polytrichum strictum* / *Maianthemum dilatatum* association

Site	V	V	V	V	RM	MB	MB	MB	MB	MB		
Plot Number	2	19	12	13	5	8	10	1	5	7		
Vascular Spp./ Relevé	13	14	13	16	18	15	16	20	14	10		
Bryophyte Spp./ Relevé	2	2	2	3	2	4	2	5	5	5		
Lichen Spp./ Relevé	0	0	0	0	0	0	0	0	0	0		
Vascular Plant Cover (%)	15	15	35	20	35	10	10	15	15	20		
Bryophyte Cover (%)	100	100	100	100	85	100	100	99	100	100		
Lichen Cover (%)	0	0	0	0	0	0	0	0	0	0		
Running Number	1	2	3	4	5	6	7	8	9	10	SP	SS
Character Species:												
<i>Sphagnum austinii</i>	98	98	100	95	80	90	95	95	65	40	V	9
<i>Polytrichum strictum</i>		2		1		5	5	3	2	5	IV	3
<i>Maianthemum dilatatum</i>	0.1		3	0.1			2	3	3	5	IV	2
Companion Species:												
<i>Ledum groenlandicum</i>	2	2	4	5	2	5	5	10	10	10	V	4
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	4	10	5	10	6	3	1	0.1	1	2	V	3
<i>Empetrum nigrum</i>	2	2	10	1	4	2	1	0.1	1	1	V	3
<i>Drosera rotundifolia</i>	1	4	2	2	0.1	1	1	1	0.1	1	V	2
Other Species:												
<i>Linnaea borealis</i>			3	0.1	0.1	2	1	2	1	0.1	IV	1
<i>Pinus contorta</i> var. <i>contorta</i>	10		5	5	15		15	5	1		IV	4
<i>Gaultheria shallon</i>	1	2	1	0.2	0.1	2		8			IV	2
<i>Sphagnum capillifolium</i>	2			3	2	3		1	0.1	2	IV	2
<i>Calamagrostis nutkaensis</i>		1	0.2	0.2		1		2	2	2	IV	1
<i>Vaccinium oxycoccus</i>		0.1		0.1		1	1	1	2		III	1
<i>Thuja plicata</i>		5	25	5			15	2			III	4
<i>Tsuga heterophylla</i>	0.1			0.1	0.1	1	1				III	+
<i>Microseris borealis</i>	0.1	0.2		5			2				II	1
<i>Cornus unalaschensis</i>		1	0.5		2			2			II	1
<i>Pteridium aquilinum</i>		2	0.1			1				1	II	1
<i>Sphagnum fuscum</i>						2			25	50	II	4
<i>Sphagnum magellanicum</i>								2	10	2	II	2
<i>Vaccinium uliginosum</i>				0.2					8	0.1	II	1
<i>Myrica gale</i>				1		5	2				II	1
<i>Sanguisorba officinalis</i>	0.1					5	0.1				II	1
<i>Triantha glutinosa</i>					0.1	2	1				II	+
<i>Blechnum spicant</i>	0.1				0.1			2			II	+
<i>Trientalis arctica</i>		1	0.2	1							II	+
Minor Species: <i>Juniperus communis</i> 4(1)*, 5(15), <i>Chamaecyparis nootkatensis</i> 1(5), 5(10), <i>Carex sitchensis</i> 6(2), 7(4), <i>Carex pluriflora</i> 6(2), 10(3), <i>Lysichiton americanus</i> 8(2), 9(2), <i>Menziesia ferruginea</i> 8(3), 9(1), <i>Andromeda polifolia</i> 5(1), 6(1), <i>Vaccinium ovatum</i> 8(0.1), 9(0.1), <i>Trichophorum cespitosum</i> 5(6), <i>Carex echinata</i> 7(2), <i>Carex obnupta</i> 6(2), <i>Eriophorum angustifolium</i> 5(2), <i>Sphagnum rubellum</i> 3(2), <i>Ligusticum calderi</i> 5(1), <i>Vaccinium ovatum</i> 8(1), <i>Aulacomnium palustre</i> 7(0.1), <i>Carex livida</i> 2(0.1), <i>Carex pauciflora</i> 5(0.1), <i>Coptis trifolia</i> 1(0.1), <i>Pinus monticola</i> 7(0.1), <i>Vaccinium parvifolium</i> 8(0.1).												

* First number refers to running number, second number (in parentheses) is percent cover.

Table 4 *Sphagnum fuscum* - *Pleurozium schreberi* association (continued, p. 137)

Site	ML	ML	GR	GR	NM	GG	MA	MA	FB	FB	A	SU	GI	GI	SZ	WB
Plot Number	4	10	7	8	16	5	2	9	3	9	3	7	4	5	5	1
Vascular Spp./ Relevé	10	8	9	11	10	5	14	18	6	5	5	8	9	7	8	10
Bryophyte Spp./ Relevé	3	3	3	3	5	4	3	5	5	6	3	3	2	2	4	3
Lichen Spp./ Relevé	2	2	0	0	3	0	1	0	0	2	0	1	0	0	0	0
Vascular Plant Cover (%)	30	30	50	40	60	30	70	60	25	30	15	45	15	20	10	30
Bryophyte Cover (%)	70	70	100	75	100	95	70	100	100	95	100	80	100	100	100	100
Lichen Cover (%)	30	30	0	0	3	5	20	0	0	5	0	20	0	0	0	0
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Pleurozium schreberi</i>	70	35	95	40	45	80	65	20	55	70	2					
Companion Species:																
<i>Ledum groenlandicum</i>	20	10	25	40	15	40	15	25	25	2		20	5	12	4	15
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	5	8	5	3	5	2	5			20	6	10	5	6	5	5
<i>Vaccinium oxycoccus</i>	0.1		1			3		2	1	5	5	5	3	5	4	10
Other Species:																
<i>Sphagnum capillifolium</i>					20	15	5				5		2	2	2	2
<i>Sphagnum fuscum</i>		35	1					3		2	95	80	100	100	100	95
<i>Rubus chamaemorus</i>	6	2	15	6			15	1				5	13	15	8	25
<i>Pinus contorta</i> var. <i>contorta</i>	1		1	35		30			20	5						0.5
<i>Empetrum nigrum</i>				0.2	40		25	4								
<i>Eriophorum chamissonis</i>	2		1	0.2						2					0.5	0.1
<i>Vaccinium uliginosum</i>		20	30	1	8		8	10								
<i>Drosera rotundifolia</i>											0.1	0.1	1	1		2
<i>Gaultheria shallon</i>	2		1	5	10		3	15	20				6	1		0.5
<i>Sphagnum angustifolium</i>		0.5	5	10					5	0.1						
<i>Cladina rangiferina</i>	2	2			1		20			2		20				
<i>Comus unalaschensis</i>	4		5	2	1			10								
<i>Carex pauciflora</i>		2									6		2	1		
<i>Myliia anomala</i>											1				0.1	3
<i>Tsuga heterophylla</i>		1		1		1			25			5	1			1
<i>Eriophorum angustifolium</i>											2					
Minor Species: <i>Cladina portentosa</i> ssp. <i>pacifica</i> 6(5)*, 10(2), 20(0.1), 21(1), 23(90), 26(30), 28(32), 30(15), 31(50), 33(30), 60(2), 63(5), <i>Pinus monticola</i> 2(0.1), 5(15), 12(2), 15(1), 16(0.5), 23(2), 26(5), 39(3), 40(5), 43(1), 56(0.1), <i>Aulacomnium palustre</i> 8(10), 12(1), 23(0.1), 26(2), 29(1), 34(1), 35(1), 37(10), 39(15), 40(0.1), <i>Sphagnum papillosum</i> 37(15), 39(20), 40(2), 44(1), 46(2), 51(2), 53(1), 61(1), <i>Pteridium aquilinum</i> 1(8), 4(2), 7(15), 8(6), 13(5), 29(0.1), 34(4), 55(3), <i>Triantha glutinosa</i> 7(0.1), 8(2), 34(0.1), 35(0.1), 39(1), 40(1), 44(0.1), 54(0.1), <i>Hylocomium splendens</i> 4(25), 5(10), 8(60), 35(5), 56(2), 58(5), 63(2), <i>Sanguisorba officinalis</i> 8(2), 34(3), 36(3), 38(1), 39(30), 40(10), 44(3), <i>Thuja plicata</i> 1(2), 2(2), 38(6), 44(8), 46(2), 55(10), 56(1), <i>Vaccinium caespitosum</i> 5(5), 7(2), 8(3), 40(1), 41(1), 42(2), 43(5), <i>Sphagnum pacificum</i> 35(2), 37(2), 39(2), 58(20), 59(1), 61(10), <i>Rhynchospora alba</i> 15(0.5), 18(2), 23(0.5), 24(0.5), 25(0.1), 27(5), <i>Dicranum scoparium</i> 9(2), 28(1), 31(2), 34(1), 62(0.5), 63(1), <i>Cladonia raii</i> 1(30), 2(30), 27(35), 48(5), 52(5), <i>Chamaecyparis nootkatensis</i> 5(25), 7(15), 8(5), 35(6), 39(0.1), <i>Tsuga mertensiana</i> 7(5), 8(4), 35(10), 41(1), 42(10), <i>Carex utriculata</i> 7(3), 8(10), 34(1), 35(0.5), 42(3), <i>Rhytidadelphus triquetris</i> 5(10), 6(1), 9(5), 58(1), 63(0.15), <i>Andromeda polifolia</i> 24(5), 25(3), 38(1), 50(0.2), <i>Fauria crista-galli</i> 7(2), 8(0.1), 39(0.1), 42(1), <i>Carex sitchensis</i> 39(0.1), 49(1), 52(1), 56(0.2), <i>Coptis trifolia</i> 29(1), 34(1), 35(0.1), 36(0.1), <i>Cladonia bellidiflora</i> 30(45), 32(1), 62(0.5), <i>Gaultheria ovalifolia</i> 5(2), 7(4), 8(1), <i>Vaccinium vitis-idaea</i> ssp. <i>minus</i> 20(3), 28(1), 37(1), <i>Vaccinium parvifolium</i> 9(2), 58(1), 63(1), <i>Cladonia gracilis</i> ssp. <i>vulnerata</i> 5(1), 28(1), 35(0.1), <i>Cephalozia lunulifolia</i> 15(0.1), 23(0.1), 26(0.1), <i>Sphagnum rubellum</i> 36(100), 44(5), <i>Sphagnum austinii</i> 37(0.1), 38(152), <i>Sphagnum mendocinum</i> 29(2), 34(2), <i>Myrica gale</i> 19(0.1), 27(3), <i>Cladonia squamosa</i> 28(1), 32(1), <i>Linnaea borealis</i> 35(1), 36(1), <i>Cladonia</i> sp. 20(1), 26(0.1), <i>Lysichiton americanus</i> 35(0.5), 40(1), <i>Trichophorum cespitosum</i> 34(1), 39(0.1), <i>Carex pluriflora</i> 42(0.1), 47(0.5), <i>Ceratodon purpureus</i> 20(0.1), 37(0.1), <i>Agrostis aequivalvis</i> 35(0.1), 39(0.1), <i>Cladina arbuscula</i> ssp. <i>beringiana</i> 24(90), <i>Eurhynchium oreganum</i> 9(35), <i>Cladonia gracilis</i> ssp. <i>turbinata</i> 30(25), <i>Racomitrium lanuginosum</i> 28(25), <i>Sphagnum palustre</i> 10(25), <i>Polytrichum commune</i> 38(20), <i>Coptis asplenifolia</i> 8(15), <i>Rhytidadelphus loreus</i> 5(15), <i>Sphagnum russowii</i> 8(10), <i>Carex livida</i> 40(5), <i>Cladonia ecmocyna</i> 30(5) (continued, p. 137)																

*First number refers to running number, second number (in parentheses) is percent cover.

Table 4 *Sphagnum fuscum* - *Pleurozium schreberi* association
(continued from p. 136; continued, p. 138)

Site	GR	GR	MR	PT	FB	GG	LB	SZ	SZ	LB	MR	PT	SM	GG	GG	MA	FB
Plot Number	6	9	10	4	12	9	2	7	10	7	14	5	5	7	4	11	11
Vascular Spp./ Relevé	9	9	5	10	7	7	9	8	7	10	7	10	9	3	6	6	6
Bryophyte Spp./ Relevé	2	2	2	4	4	3	5	0	0	7	1	3	5	0	4	1	3
Lichen Spp./ Relevé	0	0	0	4	2	0	1	2	1	5	2	5	2	5	2	3	3
Vascular Plant Cover (%)	30	20	15	45	15	35	29	10	20	65	20	45	25	5	40	60	20
Bryophyte Cover (%)	100	100	100	25	100	100	10	0	0	40	0.1	31	65	0	22	50	15
Lichen Cover (%)	0	0	0	2	2	0	90	100	100	30	95	43	35	100	60	40	75
Running Number	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Character Species:																	
<i>Pleurozium schreberi</i>																	
Companion Species:																	
<i>Ledum groenlandicum</i>	5	1	20	30	2	8	20	4	10	20	3	25	15	0.5	30	20	2
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	3	10	5	2	8	6	5	5	5	15	5	1	15	3	10	1	15
<i>Vaccinium oxycoccos</i>	4	6	1	1	3	5	1	0.2	1	8	5		1		1		1
Other Species:																	
<i>Sphagnum capillifolium</i>	10	10			2	1				0.1	0.1		25		15		10
<i>Sphagnum fuscum</i>	90	90	100	15	95	100	10			20							
<i>Rubus chamaemorus</i>	10	15	5	5		20		3	5		1	2				10	
<i>Pinus contorta</i> var. <i>contorta</i>		2		0.1	2	6	1			1		8			15		5
<i>Empetrum nigrum</i>	30	1		2								30				15	
<i>Eriophorum chamissonis</i>	1	1		1	2		0.1	0.5	1			0.1		2	0.2		2
<i>Vaccinium uliginosum</i>	5			5								20	8			2	
<i>Drosera rotundifolia</i>	0.5	2		0.1	1	3	0.1			1	0.1		0.1				0.5
<i>Gaultheria shallon</i>										0.1		2					
<i>Sphagnum angustifolium</i>					3		0.1			1			2		2		3
<i>Cladonia rangiferina</i>					1			10	100	0.1	50	8	35	10	10	40	45
<i>Cornus unalaschkensis</i>												2					
<i>Carex pauciflora</i>					1		0.1			0.1			1				
<i>Myrica anomala</i>			2	5	3	5	0.1			2							
<i>Tsuga heterophylla</i>						4				15					0.2		
<i>Eriophorum angustifolium</i>	0.1												5			2	

Minor species (continued from p. 136): *Plantago macrocarpa* 39(5)*, *Menziesia ferruginea* 63(2), *Calamagrostis nutkaensis* 38(2), *Trientalis arctica* 34(2), *Blechnum spicant* 37(1), *Carex limosa* 54(1), *Cladonia furcata* 5(1), *Cladonia singularis* 20(1), *Cladonia uncialis* 28(1), *Geocaulon lividum* 12(1), *Gymnocolia inflata* 37(1), *Microseris borealis* 44(1), *Spiraea douglasii* 34(1), *Scheuchzeria palustris* 15(0.5), *Carex echinata* 40(0.1), *Carex stylosa* 39(0.1), *Cladonia chlorophaea* 29(0.1), *Cladonia scabruscula* 20(0.1), *Gentiana douglasiana* 8(0.1), *Gentiana sceptrum* 34(0.1), *Nuphar lutea* ssp. *polysepala* 26(0.1), *Plagiothecium undulatum* 63(0.1), *Platanthera dilatata* 39(0.1), *Rhamnus purshiana* 24(0.1), *Sphagnum henryense* 49(0.1), *Spiranthes romanzoffiana* 39(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 4 *Sphagnum fuscum* - *Pleurozium schreberi* association
(continued from p. 137; continued, p. 139)

Site	SM	TA	TA	PT	V	NM	CF	MA	MA	MA	V	A	RM	RM	ML	GR	GR
Plot Number	4	5	8	2	24	3	9	12	10	1	11	6	15	16	14	2	3
Vascular Spp./ Relevé	15	16	9	13	11	19	16	9	13	11	12	5	6	6	4	9	12
Bryophyte Spp./ Relevé	7	9	1	9	3	5	5	3	1	3	3	3	3	1	1	5	2
Lichen Spp./ Relevé	0	2	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Vascular Plant Cover (%)	30	60	40	40	60	25	60	25	60	70	35	20	12	30	40	50	55
Bryophyte Cover (%)	100	86	100	85	100	100	100	100	90	100	100	100	100	100	95	95	95
Lichen Cover (%)	0	5	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0
Running Number	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Character Species:																	
<i>Pleurozium schreberi</i>	40	2						2		20							
Companion Species:																	
<i>Ledum groenlandicum</i>	20			25	15	3	10	20	25	15	10	6	5	5	5	10	5
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	10	15	15	3	1	5		1	2	8	3	1		3	2	5	5
<i>Vaccinium oxycoccos</i>	1	2	5	2		1	2	1	1	2	2	1	0.5	0.1		15	10
Other Species:																	
<i>Sphagnum capillifolium</i>	50	55		50	65	50	3					0.5	5			2	
<i>Sphagnum fuscum</i>	5			2			95	95	100	60	95	100	95	100	100	90	90
<i>Rubus chamaemorus</i>				2				10	10	8					4	15	20
<i>Pinus contorta</i> var. <i>contorta</i>				8	2						1		2			1	2
<i>Empetrum nigrum</i>		20	12	2	40	8	10	2	12	35	5		7	20			30
<i>Eriophorum chamissonis</i>				2												1	2
<i>Vaccinium uliginosum</i>	15			1	3	4	5	1	10	5	1	15			30	20	30
<i>Drosera rotundifolia</i>	1	0.1		0.1			1	1			0.1					0.2	0.2
<i>Gaultheria shallon</i>		2		5	1		1		5	5							
<i>Sphagnum angustifolium</i>	2	1				15	2					2				1	5
<i>Cladina rangiferina</i>		5								5							
<i>Cornus unalaschkensis</i>		1	5	3	2	0.1	3		3	3				10			
<i>Carex pauciflora</i>		2					5					2					1
<i>Myrica anomala</i>	1	20		0.1				5		10							
<i>Tsuga heterophylla</i>																	
<i>Eriophorum angustifolium</i>	2	20	10			2	1			10	6		6				0.5

Table 5 *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association (continued, p. 141)

	Site	SZ	SZ	GI	GI	MR	MR	MR	MR	MB	MB	GI	SZ	WB	WB	GR	MR
Plot Number		1	15	8	9	11	19	20	21	2	4	7	11	7	8	10	6
Vascular Spp./ Relevé		8	4	11	11	5	7	6	8	15	13	10	7	6	9	9	8
Bryophyte Spp./ Relevé		3	2	4	3	3	2	2	1	7	2	3	3	3	2	3	3
Lichen Spp./ Relevé		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vascular Plant Cover (%)		25	60	20	25	25	20	30	35	20	30	25	10	20	25	20	25
Bryophyte Cover (%)		100	90	100	100	100	100	100	100	100	100	100	100	100	100	100	95
Lichen Cover (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Running Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																	
<i>Sphagnum angustifolium</i>		5	25	20	2	2						20				1	
<i>Drosera rotundifolia</i>		0.1		2	0.5		2	10	5	1		2		1	2	1	1
<i>Myrica gale</i>		7		8	20	5	5	10		2	10	7			10		
<i>Rhynchospora alba</i>				15	1		5		25			20	0.5	20	4	15	25
Companion Species:																	
<i>Ledum groenlandicum</i>		10	40	5	5	15	2	1	2	15	25	2	1	1	5	0.5	0.5
<i>Vaccinium oxycoccos</i>		2	10	4	8	2	20	15	15		2	1	5	10	10	5	5
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		5	30	7	6	10		2	1	2	2	3	3	1	5	5	2
Other Species:																	
<i>Sphagnum fuscum</i>		2		10		2						30		3	15	30	2
<i>Sphagnum capillifolium</i>							10	1		2		50	100	95	85	70	80
<i>Rubus chamaemorus</i>		3	10		2										5	0.1	0.5
<i>Gaultheria shallon</i>		0.5		2	1					2	2	2					
<i>Carex lasiocarpa</i>				5		2	1	5	2								
<i>Eriophorum chamissonis</i>												0.5	1	2			
<i>Sphagnum magellanicum</i>		95	65	70	80	95	90	99	100	70	95						
Minor Species: <i>Sphagnum papillosum</i> 9(10)*, 12(0.1), 13(2), 28(20), 30(3), 45(0.1), 49(20), 50(95), 51(75), 53(95), 54(45), 55(90), <i>Carex pauciflora</i> 26(5), 31(1), 37(1), 38(2), 39(10), 40(15), 41(2), 47(10), 49(4), 55(3), 60(10), 61(3), <i>Sphagnum henryense</i> 4(20), 37(20), 38(80), 39(85), 40(100), 41(100), 42(85), 43(70), 44(90), 61(95), 62(100), <i>Sphagnum palustre</i> 19(70), 20(97), 21(95), 22(100), 23(90), 24(100), 25(65), 26(80), 31(1), 33(1), 37(20), <i>Sanguisorba officinalis</i> 3(3), 10(0.1), 39(5), 40(5), 42(10), 44(2), 57(3), 58(1), 59(1), <i>Vaccinium uliginosum</i> 10(5), 18(7), 23(10), 24(15), 25(10), 40(15), 47(20), 49(7), <i>Carex utriculata</i> 9(8), 21(0.5), 39(10), 40(1), 47(2), 51(1), 62(5), <i>Lycopodiella inundata</i> 3(7), 11(5), 26(2), 27(1), 40(1), 57(6), 58(5), <i>Myrica anomala</i> 16(2), 29(10), 31(2), 33(1), 34(10), 35(1), 56(1), <i>Lycopus uniflorus</i> 20(1), 35(1), 36(10), 42(1), 43(2), 44(1), 59(5), <i>Carex sitchensis</i> 9(4), 23(3), 43(20), 46(1), 58(15), 60(0.5), <i>Pteridium aquilinum</i> 3(1), 4(2), 39(10), 42(10), 60(2), 61(2), <i>Viola</i> sp. 7(1), 8(2), 27(1), 36(1), 58(2), 59(2), <i>Triantha glutinosa</i> 11(1), 27(1), 38(0.5), 44(1), 49(2), 57(2), <i>Sphagnum mendocinum</i> 12(0.1), 23(5), 45(15), 47(60), 50(5), <i>Calliergonella cuspidata</i> 35(1), 36(2), 57(35), 58(5), 59(5), <i>Thuja plicata</i> 4(2), 10(1), 27(1), 44(5), <i>Sphagnum pacificum</i> 9(0.1), 10(5), 52(2), 60(15), 61(20), <i>Eriophorum angustifolium</i> 15(5), 18(4), 47(2), 49(0.5), 54(6), <i>Trientalis arctica</i> 19(2), 26(2), 58(3), 59(2), <i>Aulacomnium palustre</i> 31(1), 34(2), 47(1), 49(1), <i>Comarum palustre</i> 20(1), 52(2), 56(0.2), <i>Lysichiton americanus</i> 9(0.1), 32(0.1), 37(1), 38(3), <i>Scheuchzeria palustris</i> 16(0.5), 45(0.1), 10(2), 42(25), <i>Cornus unalaschensis</i> 10(2), 39(10), 44(0.2), <i>Menyanthes trifoliata</i> 26(5), 37(1), 38(5), <i>Tsuga heterophylla</i> 4(1), 41(2), 61(2), <i>Hypericum anagalloides</i> 20(1), 43(2), 58(1), <i>Drosera anglica</i> 16(2), 53(5), <i>Carex echinata</i> 8(5), 9(1), <i>Pellia</i> sp. 35(1), 36(5), <i>Maianthemum dilatatum</i> 9(2), 10(3), <i>Pinus contorta</i> var. <i>contorta</i> 9(0.1), 15(4), <i>Andromeda polifolia</i> 12(3), 27(1), <i>Linnaea borealis</i> 9(2), 10(2), <i>Calamagrostis nutkaensis</i> 9(1), 10(2), <i>Agrostis scabra</i> 11(0.5), 47(2), <i>Rhamnus purshiana</i> 21(1), 27(1), <i>Cladina rangiferina</i> 47(1), 56(0.5), <i>Cladonia squamosa</i> 34(0.5), 56(1), <i>Empetrum nigrum</i> 14(0.1), 15(1), <i>Cephalozia lunulifolia</i> 31(0.1), 33(0.1), <i>Sphagnum tenellum</i> 56(30), <i>Dulichium arundinaceum</i> 22(15), <i>Sphagnum austini</i> 9(15), <i>Sphagnum subsecundum</i> 57(15), <i>Typha latifolia</i> 33(10), <i>Calamagrostis canadensis</i> 59(3), <i>Straminergon stramineum</i> 3(2), <i>Carex cusickii</i> 20(2), <i>Lycopodium annotinum</i> 9(2), <i>Polytrichum strictum</i> 9(2), <i>Agrostis</i> sp. 21(1), <i>Bidens cernua</i> 20(1), <i>Juncus effusus</i> 20(1), <i>Leptodictyum riparium</i> 35(1), <i>Malus fusca</i> 27(1), <i>Pinus monticola</i> 1(1), <i>Pleurozium schreberi</i> 47(1), <i>Pohlia nutans</i> 46(1), <i>Spiranthes romanzoffiana</i> 40(1), <i>Utricularia gibba</i> 20(1), <i>Cicuta douglasii</i> 58(0.5), <i>Cladonia raii</i> 56(0.5), <i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i> 59(0.5), <i>Agrostis oregonensis</i> 27(0.2), <i>Calicium</i> sp. 45(0.1), <i>Carex limosa</i> 52(0.1), <i>Carex livida</i> 37(0.1), <i>Nuphar lutea</i> ssp. <i>polysepala</i> 20(0.1), <i>Rhytidiadelphus loreus</i> 9(0.1) (continued, p. 141)																	

* First number refers to running number, second number (in parentheses) is percent cover.

Table 5 *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia*
association (continued from p. 140; continued, p. 142)

Site	MR	ML	LB	LB	WB	WB	GR	GR	GR	FB	SZ	NF	NF	NF	LB	LB	LB
Plot Number:	12	13	8	4	2	10	11	15	16	18	14	6	5	7	1	3	6
Vascular Spp./ Relevé:	6	7	7	14	9	6	7	5	6	9	15	6	6	6	7	7	7
Bryophyte Spp./ Relevé:	3	1	2	3	3	1	3	1	2	2	3	2	3	3	7	1	5
Lichen Spp./ Relevé:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vascular Plant Cover (%):	15	25	60	48	40	45	25	70	45	40	30	35	25	35	25	15	60
Bryophyte Cover (%):	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Lichen Cover (%):	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Running Number:	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Character Species:																	
<i>Sphagnum angustifolium</i>	5			1	5				35	20	0.1	1		1	1		1
<i>Drosera rotundifolia</i>	1	2	2	2	1	10	1		2	2	1	1	0.1	1	1	2	0.1
<i>Myrica gale</i>	5	10	10	20	25	10	1	40			10	3	5	15		0.1	20
<i>Rhynchospora alba</i>	3	1	2	5	1	10					2			5	1	4	
Companion Species:																	
<i>Ledum groenlandicum</i>	2	2	30	2	20		10	35	20	10	4	5	10	5	20	5	25
<i>Vaccinium oxycoccos</i>	5		25	1	20	10	10		35	20	3	6	20	10	1	3	20
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	5	2	20	10	25		5	2	15	3	20	8	10	5	15	10	
Other Species:																	
<i>Sphagnum fuscum</i>	5		30	2							90	80	90	95	95	100	100
<i>Sphagnum capillifolium</i>	90	100			0.5		5				10				0.1		1
<i>Rubus chamaemorus</i>											1						
<i>Gaultheria shallon</i>								5									
<i>Carex lasiocarpa</i>						10						1					
<i>Eriophorum chamissonis</i>									2	2			20		0.1		
<i>Sphagnum magellanicum</i>																	

Minor Species (continued from p. 140): *Vaccinium ovalifolium* 9(0.1)*.

* First number refers to running number, second number (in parentheses) is percent cover.

Table 5 *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia*
association (continued from p. 141; continued, p. 143)

Site	MR	MR	MR	FB	FB	ML	ML	GI	GI	GI	ML	SZ	SZ	SM	A	A	SZ
Plot Number	4	8	15	13	8	19	20	6	10	11	5	4	8	6	7	21	12
Vascular Spp./ Relevé	6	9	9	10	9	10	13	7	10	9	14	8	6	7	4	8	5
Bryophyte Spp./ Relevé	5	6	5	4	3	2	1	2	3	2	2	4	3	6	2	5	2
Lichen Spp./ Relevé	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Vascular Plant Cover (%)	25	25	20	25	30	30	40	20	45	60	30	20	40	30	40	40	20
Bryophyte Cover (%)	95	100	100	100	100	95	100	100	95	100	100	100	98	100	100	100	100
Lichen Cover (%)	5.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Running Number	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Character Species:																	
<i>Sphagnum angustifolium</i>	10	2	15	5	15			2	5	30		85	100	60	100	45	
<i>Drosera rotundifolia</i>	0.5	1	1	0.5	2	2	1		2		1						
<i>Myrica gale</i>	1	10	15			5	2		15	50	10						
<i>Rhynchospora alba</i>		5	8			2	10		30		2	1					5
Companion Species:																	
<i>Ledum groenlandicum</i>	10	4	2	10	10	2	2	10	1	5	5	10	10	5	25	5	1
<i>Vaccinium oxycoccos</i>	2	3	5	3	5		10	1	2	5	5	2	5	3	0.5	3	10
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	20	10	15	10	5	10	5	1		2	4	5	20	8	2	3	5
Other Species:																	
<i>Sphagnum fuscum</i>	70	95	60	60	5	15					10	1		35	2	30	
<i>Sphagnum capillifolium</i>	5		20											5		5	
<i>Rubus chamaemorus</i>	2	2						20			4	10	5		30	20	1
<i>Gaultheria shallon</i>				2				3	5	30	3						
<i>Carex lasiocarpa</i>		1	8				5			5							
<i>Eriophorum chamissonis</i>				1	2						1	0.1	1				
<i>Sphagnum magellanicum</i>									5				2				

Table 5 *Sphagnum fuscum* - *Sphagnum angustifolium* / *Drosera rotundifolia* association (continued from p. 142)

Site	NF	GR	A	A	A	MR	GI	GI	ML	ML	GI	NF		
Plot Number	8	4	2	9	13	7	1	3	9	2	2	9		
Vascular Spp./ Relevé	7	8	4	4	4	6	10	10	13	8	10	7		
Bryophyte Spp./ Relevé	4	3	3	2	2	9	4	2	3	3	2	2		
Lichen Spp./ Relevé	0	0	0	0	0	2	0	0	0	0	0	0		
Vascular Plant Cover (%)	15	12	10	10	10	60	25	30	35	30	30	35		
Bryophyte Cover (%)	100	100	100	100	100	60	100	100	100	100	100	100		
Lichen Cover (%)	0	0	0	0	0	1	0	0	0	0	0	0		
Running Number	51	52	53	54	55	56	57	58	59	60	61	62	SP	SS
Character Species:														
<i>Sphagnum angustifolium</i>	20	95	3	55	10		50	75	65	40	5	1	IV	5
<i>Drosera rotundifolia</i>	1	2	1				1	2	2		0	1	IV	2
<i>Myrica gale</i>	5						5	5	20	0.5	25	15	IV	4
<i>Rhynchospora alba</i>	15	10	3			60	15	20	5		1	0	III	4
Companion Species:														
<i>Ledum groenlandicum</i>	4	1				0.1	0.2	5	1	30	12	15	V	4
<i>Vaccinium oxycoccos</i>	15	1	2	3	10	1	2	5	5	1	4	4	V	4
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	8	2		1	0.2	1	2	10	10	2	0	20	V	4
Other Species:														
<i>Sphagnum fuscum</i>	20							30	30				III	6
<i>Sphagnum capillifolium</i>	5	5	2			1		2		45			III	5
<i>Rubus chamaemorus</i>					0.5	0.1					4		II	2
<i>Gaultheria shallon</i>										3	15		II	2
<i>Carex lasiocarpa</i>							6	15	2				II	2
<i>Eriophorum chamissonis</i>		1		2									II	1
<i>Sphagnum magellanicum</i>							2						II	5

Table 6 *Sphagnum papillosum* / *Triantha glutinosa* / *Sphagnum rubellum* association
(continued from p. 144)

Minor Species: *Myliia anomala* 14(5)*, 15(2), 16(10), *Cladina rangiferina* 8(1), 11(5), 16(1), *Sphagnum lindbergii* 5(0.1), 6(5), 7(1), *Deschampsia cespitosa* 1(3), 7(0.1), 13(0.1), *Blechnum spicant* 3(0.1), 9(1), 11(1), *Cladonia gracilis* ssp. *vulnerata* 5(0.1), 14(0.1), 16(1), *Vaccinium vitis-idaea* ssp. *minus* 9(0.1), 10(0.1), 17(1), *Juniperus communis* 4(8), 16(2), *Dicranum scoparium* 9(5), 11(1), *Rhytidiadelphus loreus* 10(5), (1), *Pleurozia purpurea* 8(3), 11(1), *Carex sitchensis* 2(3), 9(0.1), *Carex obnupta* 3(1), 10(2), *Herbertus aduncus* 10(2), 11(0.1), *Sphagnum compactum* 8(1), 11(0.1), *Coptis trifolia* 8(0.1), 11(0.1), *Platanthera dilatata* 5(0.1), 12(0.1), *Gymnocolia inflata* 6(1), *Myliia taylori* 10(1), *Pellia* sp. 11(1), *Sphagnum mendocinum* 12(1), *Gentiana sceptrum* 3(0.5), *Bryum pseudotriquetrum* 3(0.1), *Carex leptalea* 9(0.1), *Cephalozia connivens* 3(0.1), *Cladina arbuscula* ssp. *beringiana* 16(0.1), *Fauria crista-galli* 11(0.1), *Ichmadophila ericetorum* 10(0.1), *Juncus ensifolius* 12(0.1), *Lycopodium annotinum* 9(0.1), *Plantago macrocarpa* 3(0.1), *Selaginella selaginoides* 6(0.1), *Sphagnum alaskense* 7(0.1), *Vaccinium uliginosum* 4(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 7 *Sphagnum papillosum* / *Deschampsia cespitosa* association (continued, p. 147)

Site	MB	MB	MB	MB	MB	MB	RM	RM	ST	ST	V	V	V	V	V	V
Plot Number	9	12	16	17	18	19	6	13	3	5	1	8	9	14	15	16
Vascular Spp./ Relevé	18	14	10	14	14	12	6	14	12	20	15	13	11	8	14	11
Bryophyte Spp./ Relevé	3	2	1	2	2	0	4	2	5	4	5	4	5	2	4	2
Lichen Spp./ Relevé	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Vascular Plant Cover (%)	30	25	30	40	70	55	30	90	4	30	53	30	25	50	85	60
Bryophyte Cover (%)	100	100	100	100	10	0	85	20	25	100	100	100	100	1	65	5
Lichen Cover (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Deschampsia cespitosa</i>	1	2		2	3	3		1		1				1	2	2
Companion Species:																
<i>Drosera rotundifolia</i>	1	1	1	1	1		2	0.1	1	0.1	1	1	1	0.1	2	1
<i>Sanguisorba officinalis</i>	3		5	3	5	2			2	5	2	8	2	5	35	20
<i>Sphagnum papillosum</i>	85	95	100	90	8				10	65	70	20	90		35	4
<i>Myrica gale</i>	8	8	5	10	15	20			10	25	3			1	5	5
Other Species:																
<i>Rhynchospora alba</i>		15		5	3	3	12		35	2	1		5	30	5	20
<i>Vaccinium oxycoccus</i>	0.1	1	1					3	1	2	10	0.5	2			
<i>Eriophorum angustifolium</i>							15	20	5	15	20			10	25	5
<i>Trientalis arctica</i>	2	2	2	1						1	1	0.1	0.1		1	
<i>Agrostis aequivallis</i>	2	4	2	2	1		1	2		1		0.2	0.1			
<i>Gentiana douglasiana</i>	3	0.1		3	3	1					0.1					
<i>Gentiana sceptrum</i>					2							2		5	2	2
<i>Sphagnum tenellum</i>							5				10	75				1
<i>Sphagnum pacificum</i>	5	5								15	5	2	0.1		15	
<i>Sphagnum mendocinum</i>	10				3						10		5	1	5	
<i>Carex livida</i>	0.1					1		15		8		0.1	0.5			
<i>Plantago macrocarpa</i>	4	2	1	4	4	3										
<i>Carex echinata</i>	3	3			1	3				0.1					5	
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		1						0.1		2	2	1				
<i>Ledum groenlandicum</i>								0.1		1	2	0.5	0.1		1	
<i>Trichophorum cespitosum</i>	2			10	20			3								20
<i>Carex obnupta</i>	2		5	12	5										0.1	
<i>Microseris borealis</i>	1										5	3				
<i>Triantha glutinosa</i>	1								1	0.1			0.1			

Minor Species: *Gymnocolia inflata* 7(70)*, 9(10), 13(5), 21(0.1), *Viola* sp. 2(1), 4(2), 6(1), 15(20), *Lycopodiella inundata* 6(2), 14(2), 16(1), 21(8), *Sphagnum rubellum* 10(10), 11(5), 12(5), *Pellia* sp. 7(5), 9(3), 15(10), *Carex saxatilis* ssp. *laxa* 15(10), 16(1), 18(5), *Menyanthes trifoliata* 5(10), 7(4), 9(2), *Dodecatheon jeffreyi* ssp. *jeffreyi* 1(1), 4(3), 9(2), *Sphagnum compactum* 7(5), 18(95), *Hypericum anagalloides* 8(50), 15(5), *Juncus canadensis* 5(10), 6(15), *Carex stylosa* 12(15), 13(1), *Carex sitchensis* 1(5), 3(10), *Scapania paludosa* 8(10), 9(1), *Drosera anglica* 6(2), 7(3), *Camassia quamash* ssp. *azurea* 1(2), 4(1), *Empetrum nigrum* 11(2), 12(1), *Lysichiton americanus* 8(1), 10(2), *Pinus contorta* var. *contorta* 2(1), 11(2), *Thuja plicata* 2(2), 10(0.1), *Vaccinium uliginosum* 11(1), 12(0.5), *Andromeda polifolia* 9(0.1), 10(1), *Coptis trifolia* 19(15), *Utricularia intermedia* 9(15), *Aulacomnium palustre* 8(10), *Lycopodium clavatum* 20(10), *Sphagnum fuscum* 10(10), *Cladina portentosa* ssp. *pacifica* 14(5), *Juncus supiniiformis* 16(5), *Chamaecyparis nootkatensis* 20(3), *Juniperus communis* 19(3), *Sphagnum capillifolium* 19(2), *Carex* sp. 11(1), *Coptis aspleniifolia* 10(1), *Equisetum arvense* 8(1), *Juncus ensifolius* 8(1), *Ligusticum calderi* 8(1), *Lycopodium annotinum* 10(1), *Mylia anomala* 9(1), *Carex utriculata* 20(0.1), *Linnaea borealis* 10(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 7 *Sphagnum papillosum* / *Deschampsia cespitosa* association (continued from p. 146)

Site	V	V	V	WF	V		
Plot Number	21	26	27	5	18		
Vascular Spp./ Relevé	12	8	13	11	10		
Bryophyte Spp./ Relevé	2	3	3	1	2		
Lichen Spp./ Relevé	0	0	0	0	0		
Vascular Plant Cover (%)	30	40	50	38	40		
Bryophyte Cover (%)	100	100	100	100	75		
Lichen Cover (%)	0	0	0	0	0		
Running Number	17	18	19	20	21	SP	SS
Character Species:							
<i>Deschampsia cespitosa</i>	0.2	0.1	1		0.2	IV	1
Companion Species:							
<i>Drosera rotundifolia</i>		2	1	0.1	1	V	1
<i>Sanguisorba officinalis</i>	10	15	4	15	5	V	4
<i>Sphagnum papillosum</i>	2	5	95	100	5	V	7
<i>Myrica gale</i>	15	2	5	5	5	V	4
Other Species:							
<i>Rhynchospora alba</i>	10		20		20	IV	4
<i>Vaccinium oxycoccos</i>	3	1	2	1		IV	2
<i>Eriophorum angustifolium</i>	5	20	1		1	III	4
<i>Trientalis arctica</i>		1	0.1	1		III	1
<i>Agrostis aequivalvis</i>						III	1
<i>Gentiana douglasiana</i>	3		1		2	III	1
<i>Gentiana sceptrum</i>	2		2		5	II	2
<i>Sphagnum tenellum</i>	98		5		70	II	5
<i>Sphagnum pacificum</i>						II	3
<i>Sphagnum mendocinum</i>		2				II	2
<i>Carex livida</i>	1					II	2
<i>Plantago macrocarpa</i>				0.1		II	1
<i>Carex echinata</i>				2		II	1
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	5		2			II	1
<i>Ledum groenlandicum</i>	0.1					II	+
<i>Trichophorum cespitosum</i>						II	3
<i>Carex obnupta</i>						II	2
<i>Microseris borealis</i>	5				4	II	1
<i>Triantha glutinosa</i>				1		II	+

Table 8 *Sphagnum papillosum* - *Sphagnum pacificum* / *Carex sitchensis* association

Site	NF	WB	SU	A	A	A	WB	ML	GR	GR	MB	MB	V	V		
Plot Number	12	3	8	16	18	20	9	15	1	5	3	6	3	4		
Vascular Spp./ Relevé	9	8	6	7	5	7	9	6	7	8	14	11	9	4		
Bryophyte Spp./ Relevé	6	2	2	4	2	2	6	1	5	4	3	2	2	2		
Vascular Plant Cover (%)	35	20	10	5	25	25	85	35	35	65	70	60	45	55		
Bryophyte Cover (%)	95	100	100	100	100	100	100	100	95	100	100	100	100	100		
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SP	SS
Character Species:																
<i>Sphagnum pacificum</i>	1 10 100 80 100 95 63 45 60 20 10															IV 7
Companion Species:																
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	3 10 2 1 2 3 15 4 4 15 10 5 2 2															V 4
Other Species:																
<i>Sphagnum papillosum</i>	55	98	90	85	90	2	1				40	40	80	90	IV	7
<i>Ledum groenlandicum</i>	8	5	0.1				20	15	25	10	5	5	5	5	IV	4
<i>Vaccinium oxycoccos</i>	15	2	2	1	2	3	15	15	8		2	4			IV	3
<i>Myrica gale</i>	15	10					30	15		15	20	25	5	40	IV	5
<i>Carex sitchensis</i>					0.1	10		10	2		5	5			III	3
<i>Carex utriculata</i>	2	5				2	1	5			5	10			III	2
<i>Carex limosa</i>			2	2	7	5				30					II	3
<i>Rhynchospora alba</i>	2	2		2			2			5					II	1
<i>Drosera rotundifolia</i>		1					0.2			1	0.1	1			II	+
<i>Sphagnum capillifolium</i>		2		2			10			2					II	2
<i>Eriophorum chamissonis</i>	1	1	5						0.5						II	1
<i>Menyanthes trifoliata</i>				1	20	6									II	2
<i>Sphagnum fuscum</i>			10				5		1						II	2
<i>Aulacomnium palustre</i>	1						2		3						II	1

Minor Species: *Polytrichum strictum* 1(35)*, 9(0.5), *Carex obnupta* 13(15), 14(8), *Thuja plicata* 11(0.1), 13(5), *Sanguisorba officinalis* 11(1), 12(4), *Spiraea douglasii* 9(4), 12(1), *Scheuchzeria palustris* 4(2), 10(1), *Sphagnum subsecundum* 1(0.1), 4(2), *Drosera anglica* 3(1), 4(1), *Linnaea borealis* 11(1), 12(0.1), *Sphagnum palustre* 10(35), *Vaccinium uliginosum* 9(25), *Sphagnum magellanicum* 11(15), *Pinus contorta* var. *contorta* 13(10), *Sphagnum mendocinum* 4(10), *Trientalis arctica* 12(6), *Eriophorum angustifolium* 6(5), *Straminergon stramineum* 7(3), *Carex lasiocarpa* 7(2), *Comarum palustre* 10(2), *Lycopodium annotinum* 11(2), *Malus fusca* 13(2), *Myrica anomala* 1(2), *Sphagnum angustifolium* 2(2), *Sphagnum henryense* 9(2), *Carex canescens* 1(2), *Carex echinata* 1(2), *Carex livida* 11(1), *Deschampsia cespitosa* 11(1), *Calamagrostis nutkaensis* 11(1), *Gaultheria shallon* 13(1), *Lysichiton americanus* 11(1), *Gentiana sceptrum* 11(1), *Viola* sp. 7(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 9 *Aulacomnium palustre* association (continued, p. 150)

Site	DL	SM	NM	NM	NM	NM	NM	NM	CF	CF	SM	A	NM	NM	NM	NM
Plot Number	8	2	1	2	4	5	6	13	6	8	3	22	7	10	11	15
Vascular Spp./ Relevé	23	13	15	11	18	13	12	11	10	14	17	12	15	12	13	12
Bryophyte Spp./ Relevé	3	4	4	5	8	8	4	4	6	4	6	6	1	4	2	8
Lichen Spp./ Relevé	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4
Vascular Plant Cover (%)	70	30	55	30	55	30	55	30	55	60	45	50	80	35	25	25
Bryophyte Cover (%)	5	100	100	100	95	85	100	100	100	100	100	100	25	100	100	80
Lichen Cover (%)	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	18
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Aulacomnium palustre</i>	2	0.1	55	20	50	70	10			15	1	5				15
Companion Species:																
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	15	2	5	5	2	2	5	5	3		2	3	4	5	10	2
<i>Sanguisorba officinalis</i>	10	20	10	25	20	5	35	15	8	5	25		15	20	10	15
Other Species:																
<i>Eriophorum angustifolium</i>		15	1	4	1			5	40	1	1	2		8	5	
<i>Ledum groenlandicum</i>	8	2	5		0.1		0.1	8		0.1	10	5	25	20	15	2
<i>Vaccinium uliginosum</i>	5		3		5	5	3	2		1		20	4	3	1	8
<i>Vaccinium oxycoccos</i>		2	1	2			1	1	2	5		1	1	1	3	1
<i>Sphagnum angustifolium</i>		50	25	10	15	5	70	40	5			75		90	95	
<i>Sphagnum capillifolium</i>			15	10	5	5	15	10	5	15		5		2	5	5
<i>Empetrum nigrum</i>			1	8	10		15	10				5	5		3	5
<i>Triantha glutinosa</i>	0.1	2	1	1	2	2	0.1			2	0.1					1
<i>Sphagnum palustre</i>				55	20	5	5	35	25	65						20
<i>Sphagnum pacificum</i>		10	5	5	2			15	55	5				10		
<i>Carex utriculata</i>	2	2				1	15	0.1			15			10	3	
<i>Trichophorum cespitosum</i>			25	1	3	10	1	3		3						15
<i>Gentiana douglasiana</i>						3		1	1	6				0.1	1	1
<i>Sphagnum russowii</i>	2										1	5	25			
<i>Plantago macrocarpa</i>			10	2	10	15	0.1		5	8						
<i>Carex pauciflora</i>		3								10	2	1			2	
<i>Cornus unalaschkensis</i>	1										1	0.5	5	5	3	
<i>Carex sitchensis</i>			0.1		0.1				1	1		2	10			
<i>Gentiana sceptrum</i>	1	1			0.1	5				1	0.1					
<i>Trientalis arctica</i>	1	2	0.1							0.1	2		1			

Minor Species: *Sphagnum mendocinum* 2(50)*, 5(2), 6(2), 11(90), *Chamaecyparis nootkatensis* 1(0.1), 4(2), 5(1), 12(1), *Drosera rotundifolia* 1(0.1), 2(1), 11(1), 20(0.5), *Gaultheria shallon* 13(8), 14(10), 15(2), *Carex pluriflora* 13(1), 14(1), 15(10), *Carex stylosa* 6(0.1), 8(8), 16(2), *Coptis trifolia* 1(0.1), 2(8), 11(2), *Coptis aspleniifolia* 1(5), 12(2), 14(3), *Vaccinium caespitosum* 1(1), 5(0.1), 13(4), *Equisetum arvense* 3(0.1), 5(0.1), 7(3), *Hypericum anagalloides* 1(1), 2(0.1), 11(2), *Spiraea douglasii* 1(0.1), 13(0.1), 16(2), *Agrostis aequivalvis* 5(1), 7(0.1), 13(1), *Platanthera dilatata* 9(1), 11(0.1), 18(0.1), *Rubus chamaemorus* 12(15), 20(8), *Straminergon stramineum* 12(5), 20(5), *Dodecatheon jeffreyi* ssp. *jeffreyi* 1(0.1), 9(6), *Sphagnum subsecundum* 9(5), 11(1), *Pleurozium schreberi* 12(5), 14(0.1), *Pinus monticola* 4(1), 5(3), *Carex livida* 5(1), 6(1), *Erigeron peregrinus* 1(1), 3(1), *Fauria crista-galli* 1(1), 3(1), *Agrostis oregonensis* 1(0.5), 10(1), *Danthonia intermedia* 5(1), 8(0.1), *Geocaulon lividum* 2(0.1), 17(1), *Sphagnum tenellum* 16(40), *Pinus contorta* var. *contorta* 17(15), *Carex anthoxanthea* 1(5), *Cladina portentosa* ssp. *pacifica* 16(5), *Cladina rangiferina* 16(5), *Cladonia uncialis* 16(5), *Sphagnum fuscum* 9(5), *Trollius albiflorus* 11(5), *Carex canescens* 13(3), *Cladonia gracilis* ssp. *turbinata* 16(3), *Lysichiton americanus* 11(2), *Caltha leptosepala* var. *biflora* 1(1), *Campylopus stellatus* 1(1), *Carex leptalea* 11(1), *Sphagnum rubellum* 18(1), *Tsuga mertensiana* 16(1), *Cladonia furcata* 5(0.1), *Galium trifidum* 17(0.1), *Lycopodium annotinum* 1(0.1), *Polytrichum strictum* 5(0.1), *Spiranthes romanzoffiana* 4(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 9 *Aulacomnium palustre* association (continued from p. 149)

Site	DL	NM	A	A		
Plot Number	3	9	8	10		
Vascular Spp./ Relevé	11	9	3	7		
Bryophyte Spp./ Relevé	2	3	2	3		
Lichen Spp./ Relevé	0	0	0	0		
Vascular Plant Cover (%)	65	45	15	20		
Bryophyte Cover (%)	100	100	100	100		
Lichen Cover (%)	0	0	0	0		
Running Number	17	18	19	20	SP	SS
Character Species:						
<i>Aulacomnium palustre</i>					III	5
Companion Species:						
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	2	4	3	2	V	3
<i>Sanguisorba officinalis</i>	3	15			V	5
Other Species:						
<i>Eriophorum angustifolium</i>	15	25	10	10	IV	4
<i>Ledum groenlandicum</i>	3	10			IV	4
<i>Vaccinium uliginosum</i>	15	2		1	IV	3
<i>Vaccinium oxycoccus</i>		4	5	3	IV	2
<i>Sphagnum angustifolium</i>		90	5	10	IV	6
<i>Sphagnum capillifolium</i>					III	4
<i>Empetrum nigrum</i>	20	8			III	3
<i>Triantha glutinosa</i>	1				III	1
<i>Sphagnum palustre</i>	1				III	5
<i>Sphagnum pacificum</i>		10			III	4
<i>Carex utriculata</i>		2			III	3
<i>Trichophorum cespitosum</i>					III	3
<i>Gentiana douglasiana</i>					III	1
<i>Sphagnum russowii</i>	100		95	85	II	5
<i>Plantago macrocarpa</i>					II	3
<i>Carex pauciflora</i>	3			1	II	2
<i>Cornus unalaschensis</i>					II	1
<i>Carex sitchensis</i>					II	1
<i>Gentiana sceptrum</i>					II	1
<i>Trientalis arctica</i>					II	+

Table 10 *Carex sitchensis* / *Spiraea douglasii* association

Site	ML	MR	FR	SZ	NF	NF	FR	GB	GB	ML	NF	SM	SD	SD	GB		
Plot Number	11	17	3	9	1	2	2	14	13	1	3	8	8	12	12		
Vascular Spp./ Relevé	5	8	13	7	8	6	6	7	10	6	5	8	4	6	7		
Bryophyte Spp./ Relevé	0	3	2	1	0	4	5	1	2	1	0	1	4	4	2		
Vascular Plant Cover (%)	50	50	60	80	80	70	70	40	70	80	90	50	60	50	40		
Bryophyte Cover (%)	0	10	30	1	0	1	15	30	25	20	0	2	40	60	80		
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	SP	SS
Character Species:																	
<i>Carex sitchensis</i>	1		10	1	20	5	10	40	50	20	50	35		5	20	V	5
<i>Spiraea douglasii</i>			20	30	50		30	1	10	2	5		10	8	20	IV	5
Other Species:																	
<i>Myrica gale</i>	20	20		70	10	50		1	10	40	3	15			30	IV	5
<i>Ledum groenlandicum</i>		1		2	1	10	2		0.1	30					20	III	3
<i>Sphagnum mendocinum</i>				1			15		5	20			30	60	70	III	5
<i>Sphagnum subsecundum</i>		10	30			0.1	2	30	20			2				III	4
<i>Carex lasiocarpa</i>	25	15	2					1							1	III	3
<i>Carex utriculata</i>			5		10	1	10		1							III	2
<i>Comarum palustre</i>			10	0.5	2					2		1				III	1
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		1		1		8					2					III	1
<i>Veronica scutellata</i>			2					3	2			0.1				III	1

Minor Species: *Carex exsiccata* 3(5)*, 13(50), 14(40), *Salix sitchensis* 5(1), 6(1), 9(2), *Campylyum stellatum* 2(1), 6(0.1), 7(0.1), *Lysichiton americanus* 3(20), 7(1), *Sphagnum pacificum* 13(10), 15(10), *Cicuta douglasii* 8(8), 9(3), *Carex canescens* 2(10), 13(0.1), *Rhynchospora alba* 1(5), 2(2), *Vaccinium oxycoccus* 2(5), 10(0.5), *Menyanthes trifoliata* 11(1), 12(3), *Aulacomnium palustre* 13(1), 14(2), *Wamstorfia fluitans* 3(1), 7(2), *Gaultheria shallon* 4(0.5), 5(2), *Wamstorfia exannulatus* ssp. *procerus* 13(1), 14(1), *Malus fusca* 7(1), 15(1), *Trientalis arctica* 13(0.1), 14(0.1), *Carex echinata* 3(5), *Carex obnupta* 14(5), *Vaccinium uliginosum* 14(5), *Salix geyeriana* 9(3), *Calliergonella cuspidata* 2(2), *Carex livida* 1(2), *Agrostis* sp. 15(1), *Calicium* sp. 7(1), *Deschampsia cespitosa* 12(1), *Hypericum anagalloides* 12(1), *Agrostis oregonensis* 3(0.1), *Galium trifidum* 3(0.1), *Gymnocolia inflata* 14(0.1), *Hylocomium splendens* 6(0.1), *Limprichtia revolvens* 6(0.1), *Lycopus uniflorus* 3(0.1), *Platanthera stricta* 12(0.11), *Ranunculus reptans* 3(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 11 *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association (continued, p. 153)

Site	CL	CL	CF	U	TA	CL	CL	CL	CL	PM	PM	SL	SL	CL	CF	SL
Plot Number	3	5	10	3	1	8	4	7	2	4	3	2	3	6	12	4
Vascular Spp./ Relevé	12	16	9	16	25	12	15	14	9	11	14	4	7	9	9	11
Bryophyte Spp./ Relevé	2	4	3	3	12	6	3	4	3	6	6	2	3	3	2	3
Vascular Plant Cover (%)	20	55	35	50	105	10	25	15	60	10	50	20	65	20	20	40
Bryophyte Cover (%)	100	55	100	30	90	95	100	40	95	100	85	100	40	100	100	100
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Sphagnum pacificum</i>	100	20	55	15	65	55	100	5	90			85	25	5		10
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>		5		3	1	0.1	5	2		2	2	5	5	2	2	15
<i>Vaccinium uliginosum</i>	10			30		4	20	0.1		1	1	8	15	1		30
<i>Carex pluriflora</i>	15				3	1	2	5	35			15				8
Companion Species:																
<i>Sanguisorba officinalis</i>	15	15	5	15	5	3	10	2	10	0.1	8		20	10	10	2
Other Species:																
<i>Eriophorum angustifolium</i>	5	10	30	5				1		0.1	5	5	2	30	8	20
<i>Fauria crista-galli</i>	15	4			3	1		1	2					1		2 3
<i>Caltha leptosepala</i> var. <i>biflora</i>	5	12		4	45			1		1		8			5	
<i>Triantha glutinosa</i>		1		0.1		2	1	1		0.1					3	1
<i>Platanthera dilatata</i>	1	2	1		0.5			1		0.1				1	0.1	0.1
<i>Sphagnum papillosum</i>			30	0.1				1	10	2					5	95
<i>Sphagnum russowii</i>					1					2	60	5		2		55
<i>Gentiana sceptrum</i>	2	5	1				0.1	1	2							
<i>Drosera rotundifolia</i>	0.1			0.1	0.1	1		1	0.1							0.1
<i>Aulacomnium palustre</i>		35				0.1	1			1	0.1					
<i>Carex utriculata</i>		1		10		3	0.1	1							15	
<i>Gymnocolia inflata</i>	1	2				10	0.1	5						15		
<i>Sphagnum capillifolium</i>					1								15			35
<i>Vaccinium caespitosum</i>		0.1			2		0.1				0.1					
<i>Trichophorum cespitosum</i>			1	1		1		5							1	
<i>Carex stylosa</i>				1		1		2					1			2
<i>Cornus unalaschkensis</i>		1			1		2		1							
<i>Empetrum nigrum</i>											1					2
<i>Carex sitchensis</i>			5		3					2	5					
<i>Carex echinata</i>				1		1		1		1						
<i>Agrostis aequivalvis</i>	0.1				0.1		1							2		
<i>Carex pauciflora</i>						0.1				0.1					1	1

Minor Species: *Sphagnum lindbergii* 6(30)*, 8(20), 14(90), *Carex leptalea* 2(15), 5(5), 15(1), *Dodecatheon jeffreyi* ssp. *jeffreyi* 3(5), 4(0.1), 11(1), *Vaccinium oxycoccos* 3(2), 10(2), 14(90), *Trientalis arctica* 1(1), 5(1), 7(1), *Polytrichum commune* 10(0.1), 11(65), *Sphagnum riparium* 10(15), 11(8), *Sphagnum mendocinum* 3(15), 4(0.1), *Blechnum spicant* 2(1), 5(10), *Straminergon stramineum* 10(2), 11(5), *Coptis asplenifolia* 2(4), 5(2), *Pleurozium schreberi* 5(2), 18(2), *Calamagrostis canadensis* 1(1), 18(2), *Tsuga mertensiana* 5(2), 16(1), *Cephalozia bicuspidata* 2(0.1), 5(1), *Sphagnum tenellum* 2(0.1), 5(1), *Gentiana douglasiana* 6(0.1), 8(0.1), *Rubus pedatus* 2(0.1), 7(0.1), *Sphagnum centrale* 10(25), *Gaultheria shallon* 5(20), *Hylocomium splendens* 5(10), *Plantago macrocarpa* 3(10), *Sphagnum palustre* 18(10), *Potentilla drummondii* ssp. *drummondii* 11(5), *Sphagnum angustifolium* 5(5), *Rubus stellatus* 11(3), *Juncus ensifolius* 4(2), *Juncus supiniiformis* 8(2), *Rhizomnium glabrescens* 5(2), *Scapania paludosa* 6(2), *Tsuga heterophylla* 5(2), *Sphagnum squarrosum* 18(2), *Viola* sp. 11(2), *Carex livida* 18(1), *Aster* sp. 4(1), *Calicium* sp. 5(1), *Chamaecyparis nootkatensis* 5(1), *Drosera anglica* 10(1), *Erigeron peregrinus* 5(1), *Hypnum callichroum* 5(1), *Lysichiton americanus* 5(1) (cont., p. 151)

* First number refers to running number, second number (in parentheses) is percent cover.

Table 11 *Caltha leptosepala* var. *biflora* / *Sphagnum pacificum* / *Kalmia microphylla* ssp. *occidentalis* association (continued from p. 152)

	Site			
	SL	U		
Plot Number	5	1		
Vascular Spp./ Relevé	6	12		
Bryophyte Spp./ Relevé	4	6		
Vascular Plant Cover (%)	45	75		
Bryophyte Cover (%)	100	30		
Running Number	17	18	SP	SS
Character Species:				
<i>Sphagnum pacificum</i>	55	15	V	7
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	3	1	V	3
<i>Vaccinium uliginosum</i>	3	35	IV	4
<i>Carex pluriflora</i>	15		III	4
Companion Species:				
<i>Sanguisorba officinalis</i>	5	10	V	4
Other Species:				
<i>Eriophorum angustifolium</i>			IV	4
<i>Fauria crista-galli</i>	2		III	2
<i>Caltha leptosepala</i> var. <i>biflora</i>		2	III	3
<i>Triantha glutinosa</i>			III	1
<i>Platanthera dilatata</i>			III	1
<i>Sphagnum papillosum</i>			II	4
<i>Sphagnum russowii</i>	20		II	4
<i>Gentiana sceptrum</i>		0.1	II	1
<i>Drosera rotundifolia</i>			II	+
<i>Aulacomnium palustre</i>		5	II	3
<i>Carex utriculata</i>			II	2
<i>Gymnocolia inflata</i>			II	2
<i>Sphagnum capillifolium</i>	25		II	3
<i>Vaccinium caespitosum</i>		8	II	1
<i>Trichophorum caespitosum</i>			II	1
<i>Carex stylosa</i>			II	1
<i>Cornus unalaschkensis</i>		1	II	+
<i>Empetrum nigrum</i>	15	1	II	2
<i>Carex sitchensis</i>			II	1
<i>Carex echinata</i>			II	+
<i>Agrostis aequivalvis</i>			II	+
<i>Carex pauciflora</i>			II	+

Minor species (continued from p. 150): *Menyanthes trifoliata* 10(1)*, *Comarum palustre* 11(1), *Rhytidiadelphus loreus* 5(1), *Sphagnum compactum* 18(1), *Spiraea douglasii* 18(1), *Veratrum viride* 5(1), *Platanthera stricta* 5(0.5), *Gaultheria ovalifolia* 2(0.1), *Hieracium odorata* 11(0.1), *Listera cordata* 5(0.1), *Maianthemum dilatatum* 18(0.1), *Rhytidiadelphus squarrosus* 11(0.1), *Selaginella selaginoides* 5(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 12 *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association (continued, p. 155)

Site	PM	TM	LT	LT	LT	LT	TM	TM	TM	TM	TM	PM	PM	CL	LT	LT
Plot Number	18	6	1	2	5	7	1	2	4	5	7	7	17	1	6	8
Vascular Spp./ Relevé	10	15	21	22	14	12	19	10	9	15	12	16	9	11	12	10
Bryophyte Spp./ Relevé	2	3	4	6	5	4	4	7	6	4	5	4	5	4	6	4
Vascular Plant Cover (%)	25	60	55	50	40	75	70	35	30	30	40	45	25	65	55	60
Bryophyte Cover (%)	100	95	85	60	45	15	95	60	50	70	100	85	75	90	40	85
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Carex echinata</i>	15		1	5	2	3	25		10	2	4					
<i>Warnstorfia exannulata</i>	20		0.1			5	15	1	25	1		0.1				
Other Species:																
<i>Carex sitchensis</i>	6		15	15	2	15	2		2	1	5	5		2	30	
<i>Triantha glutinosa</i>		5	1	5	4	8	2	1	1	1	5	2	0.5		5	
<i>Caltha leptosepala</i> var. <i>biflora</i>	4	1	0.1	1	1	0.1	1	1	0.1	0.1	0.1	0.5	1	2	0.1	
<i>Sanguisorba officinalis</i>	0.1		5	1	1	2	10	0.1		2	0.1			0.1		15
<i>Eriophorum angustifolium</i>	3	5	1	20	15	2		5				3	5			
<i>Carex anthoxantha</i>	0.1	3	5	2	2		5			5	2	4	5			2
<i>Comarum palustre</i>		1	10	2	3			1	0.1	1	15					
<i>Sphagnum teres</i>	20		85	5	20	2		1	20		1					
<i>Scapania paludosa</i>		70		5	5	10		15	25	45	1	0.1			2	
<i>Sphagnum subsecundum</i>				40	15		1	25	10	2			40		2	1
<i>Trientalis arctica</i>				0.1	0.1	0.1	1			0.1	2			3	2	0.1
<i>Calliergonella cuspidata</i>			0.1	10		2		2	1					2	5	50
<i>Leptarrhena pyrrolifolia</i>	2	1		0.1		2	4			0.1						2
<i>Drosera rotundifolia</i>				0.1	0.1	2			0.1	1	1				1	
<i>Trichophorum cespitosum</i>				5				1	15	1		1	0.1		25	
<i>Parnassia fimbriata</i>		0.1	0.1	0.1	2	3	2								1	
<i>Lysichiton americanus</i>		30	15					20	20	10	2					
<i>Hypericum anagalloides</i>			0.1	2	2	50						2			30	
<i>Agrostis oregonensis</i>		1			0.1		1				0.1	0.1				
<i>Equisetum arvense</i>		2					2	5	1	1		1				
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>				1								2	0.1		5	
<i>Philonotis fontana</i> var. <i>fontana</i>		5				3		1							5	30
<i>Coptis asplenifolia</i>		1	0.1			1	1				2					

Minor Species: *Fauria crista-galli* 1(1)*, 12(15), 13(4), 14(60), *Vaccinium uliginosum* 4(8), 12(5), 17(5), 19(1), *Erigeron peregrinus* 2(2), 7(2), 8(0.1), 17(0.1), *Platanthera dilatata* 2(0.1), 3(1), 4(1), 14(0.1), *Pinguicula macroceras* 7(0.1), 9(0.1), 10(0.1), 12(1), *Pellia* sp. 5(1), 11(95), 15(0.1), *Campyllum stellatum* 9(1), 15(30), 20(25), *Angelica genuflexa* 2(2), 3(15), 16(10), *Dodecatheon jeffreyi* ssp. *jeffreyi* 1(8), 12(4), 13(4), *Viola* sp. 7(8), 14(3), 20(1), *Carex pluriflora* 4(0.1), 12(0.1), 17(8), *Sphagnum squarrosum* 3(2), 16(5), 17(1), *Platanthera stricta* 3(1), 5(2), 15(0.1), *Juncus ensifolius* 4(1), 9(0.1), 10(0.1), *Straminergon stramineum* 18(90), 19(20), *Sphagnum riparium* 1(8), 19(70), *Sphagnum angustifolium* 5(6), 17(40), *Aster* sp. 4(1), 16(30), *Calamagrostis canadensis* 7(10), 14(4), *Sphagnum pacificum* 11(1), 14(5), *Aulacomnium palustre* 4(0.1), 14(5), *Drosera anglica* 19(1), 20(2), *Valeriana sitchensis* 3(2), 16(1), *Athyrium filix-femina* 3(2), 7(0.1), *Vaccinium oxycoccos* 4(0.1), 15(2), *Luzula parviflora* 3(1), 17(1), *Carex sitchensis* 14(0.1), 18(1), *Carex canescens* 3(0.1), 19(0.1), *Deschampsia cespitosa* 3(0.1), 16(0.1), *Galium trifidum* 3(0.1), 16(0.1), *Lophozia* sp. 1(0.1), 13(0.1), *Mitella pentandra* 3(0.1), 7(0.1), *Limprichtia revolvens* 12(85), *Hypnum dieckii* 14(80), *Rhytidiadelphus squarrosus* 7(80), *Rhynchospora alba* 20(30), *Myrica gale* 20(25), *Menyanthes trifoliata* 19(20), *Sphagnum mendocinum* 13(20), *Scapania irrigua* 13(15), *Scapania uliginosa* 7(10), *Juncus filiformis* 7(6), *Senecio moresbiensis* 20(5), *Carex utriculata* 14(3), *Viola palustris* 1(3), *Carex lasiocarpa* 20(2), *Carex viridula* ssp. *viridula* 20(2), *Carex macloviana* 18(1), *Carex pauciflora* 19(1) (continued, p. 154)

* First number refers to running number, second number (in parentheses) is percent cover.

Table 12 *Caltha leptosepala* var. *biflora* / *Warnstorfia exannulata* / *Carex echinata* association (continued from p. 154)

	Site	LT	PM	PM	SU		
Plot Number	4	6	1	1			
Vascular Spp./ Relevé	15	6	11	12			
Bryophyte Spp./ Relevé	3	2	6	1			
Vascular Plant Cover (%)	30	55	30	80			
Bryophyte Cover (%)	100	95	100	25			
Running Number	17	18	19	20	SP	SS	
Character Species:							
<i>Carex echinata</i>	0.1			5	III	3	
<i>Warnstorfia exannulata</i>			0.1		III	3	
Other Species:							
<i>Carex sitchensis</i>	2	45	2	2	IV	4	
<i>Triantha glutinosa</i>	5		1	5	IV	3	
<i>Caltha leptosepala</i> var. <i>biflora</i>					IV	1	
<i>Sanguisorba officinalis</i>	1	0.1		2	IV	2	
<i>Eriophorum angustifolium</i>	1	10	2		III	3	
<i>Carex anthoxanthea</i>					III	2	
<i>Comarum palustre</i>	15	2	10		III	3	
<i>Sphagnum teres</i>	60	5	10		III	5	
<i>Scapania paludosa</i>					III	4	
<i>Sphagnum subsecundum</i>			1		III	4	
<i>Trientalis arctica</i>			0.1		III	1	
<i>Calliergonella cuspidata</i>					II	3	
<i>Leptarrhena pyrolifolia</i>	1				II	1	
<i>Drosera rotundifolia</i>	0.1				II	+	
<i>Trichophorum cespitosum</i>					II	3	
<i>Parnassia fimbriata</i>					II	1	
<i>Lysichiton americanus</i>					II	3	
<i>Hypericum anagalloides</i>					II	3	
<i>Agrostis oregonensis</i>	0.1				II	+	
<i>Equisetum arvense</i>					II	1	
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	8		2		II	1	
<i>Philonotis fontana</i> var. <i>fontana</i>					II	3	
<i>Coptis aspleniifolia</i>					II	+	

Minor species (continued from p. 153): *Dichanthelium acuminatum* var. *fasciculatum* 20(1)*, *Gentiana sceptrum* 15(1), *Bryum weigeli* 3(0.1), *Calliergon sarmentosum* 12(0.1), *Calicium* sp. 1(0.1), *Carex leptalea* 14(0.1), *Carex saxatilis* ssp. *laxa* 19(0.1), *Gentiana douglasiana* 17(0.1), *Lonicera involucrata* 4(0.1), *Odontoschisma elongatum* 13(0.1), *Rubus stellatus* 1(0.1), *Sphagnum centrale* 19(0.1), *Sphagnum warnstorffii* 12(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 13 *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* / *Philonotis fontana* var. *fontana* association (continued, p. 157)

Site	PM	PM	PM	PM	PM	SF	SF	MM	MM	MM	MM	MM	MM	MM		
Plot Number	8	9	10	15	16	1	2	7	1	2	3	4	5			
Vascular Spp./ Relevé	20	18	11	16	12	19	17	25	14	11	14	7	13			
Bryophyte Spp./ Relevé	10	10	13	8	3	7	2	1	8	4	1	4	2			
Vascular Plant Cover (%)	55	35	15	20	40	20	90	80	40	50	85	65	80			
Bryophyte Cover (%)	85	90	98	95	100	100	20	25	100	10	5	80	10			
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	SP	SS	
Character Species:																
<i>Leptarrhena pyrolifolia</i>	2		4	1	4	2	2	4	0.5	20	5	1		V	3	
<i>Sanguisorba canadensis</i>	1	3		0.5		5	0.1	10	2	10	2	1	2	V	3	
<i>Parnassia fimbriata</i>	0.1	1	0.1			3	2	1		1	1		1	N	1	
<i>Fauria crista-galli</i>	30	10	8	10	25				1	5	2			N	4	
<i>Philonotis fontana</i> var. <i>fontana</i>	30	30	1	5		55	1			0.1	5			N	4	
<i>Triantha glutinosa</i>	0.1	0.5	1			1	1	1	1	1				N	1	
<i>Equisetum arvense</i>	3	0.1		0.1		10	3	2	20					III	3	
<i>Veratrum viride</i>	0.1	5		2	5	0.1		1	0.1					III	1	
<i>Sphagnum teres</i>	1.5	10	10	5					2			50		III	4	
<i>Salix barclayi</i>						0.1	10			0.1	15	30	2	III	3	
<i>Rhytidiadelphus squarrosus</i>	2	15	1	0.1		0.1				0.1				III	2	
<i>Arnica mollis</i>	4	1		1	2	2	0.1							III	1	
<i>Mitella pentandra</i>	0.1	3	0.1	2		0.1		1						III	1	
<i>Platanthera stricta</i>	0.5	1		1	1	0.1	0.1							III	+	
Companion Species:																
<i>Caltha leptosepala</i> var. <i>biflora</i>	5	5	2	0.5	2	4	5	10	20	8	5	1	5	V	4	
Other Species:																
<i>Carex sitchensis</i>							20	1		10	25	30	10	III	4	
<i>Rhizomnium pseudopunctatum</i>	45	25	2	5								0.1		II	4	
<i>Erigeron peregrinus</i>							0.1	3	0.1		5		5	II	1	
<i>Trollius albiflorus</i>	0.1			0.1		0.1	0.1	8						II	1	
<i>Agrostis oregonensis</i>						0.1		2	0.1		2		4	II	1	
<i>Veronica wormskjoldii</i> var. <i>wormskjoldii</i>								0.1	0.1	1	1		0.1	II	+	
<i>Sphagnum squarrosum</i>				45	65				10			20		II	5	
<i>Campylium stellatum</i>						30	20	25	0.1					II	4	
<i>Carex nigricans</i>							15		30	2			5	II	3	
<i>Eriophorum angustifolium</i>			2				10				15		20	II	3	
<i>Scapania paludosa</i>		0.5	4	35		1								II	3	
<i>Leptarrhena pyrolifolia</i>	2		15							10			2	II	3	
<i>Carex anthoxanthea</i>	8	5	3								1			II	2	
<i>Bryum pseudotriquetrum</i>	0.5	5	3	5										II	1	
<i>Streptopus lanceolatus</i> var. <i>curvipes</i>	1.5	2		2	1									II	1	
<i>Petasites frigidus</i>	0.5	0.5				5	0.1							II	1	
<i>Potentilla drummondii</i> ssp. <i>drummondii</i>							0.1	2					20	II	2	
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	10	2	3											II	2	
<i>Straminergon stramineum</i>		5	2	0.5										II	1	
<i>Calamagrostis canadensis</i>								5				0.1	1	II	1	
<i>Sphagnum subsecundum</i>			2						1	1				II	+	
<i>Carex deweyana</i>		0.5		2	1									II	+	
<i>Viola</i> sp.	0.1	2						1						II	+	
<i>Valeriana sitchensis</i>	0.5				0.5			2						II	+	

Minor species listed on p. 156

Table 13 *Caltha leptosepala* var. *biflora* - *Leptarrhena pyrolifolia* /
Philonotis fontana var. *fontana* association (continued from p. 156)

Minor Species: *Scapania undulata* 5(0.1)*, 9(75), *Comarum palustre* 11(15), 12(25), *Wamstorfia exannulata* 3(10), 10(10), *Carex pluriflora* 3(2), 10(15), *Scapania uliginosa* 1(5), 13(8), *Vaccinium ovalifolium* 4(2), 5(10), *Lophozia* sp. 6(0.1), 9(5), *Chamaecyparis nootkatensis* 1(3), 5(1), *Orthilia secunda* 2(2), 4(0.5), *Carex macloviana* 6(0.1), 7(2), *Ledum groenlandicum* 3(0.1), 8(1), *Phleum alpinum* 6(0.1), 8(1), *Pellia* sp. 1(0.1), 2(0.1), *Sphagnum wamstorffii* 3(55), *Sphagnum tenellum* 5(35), *Palustriella falcata* 6(25), *Calliergon cordifolium* 12(10), *Carex sitchensis* 8(7), *Wamstorfia fluitans* 9(5), *Gymnocarpium dryopteris* 4(3), *Carex macrochaeta* 11(2), *Coptis asplenifolia* 1(2), *Sphagnum mendocinum* 3(2), *Sphagnum russowii* 9(2), *Aster occidentalis* 1(1), *Danthonia intermedia* 8(1), *Epilobium* sp. 13(1), *Pinguicula macroceras* 6(1), *Prunella vulgaris* 8(10), *Odontoschisma elongatum* 3(0.5), *Vaccinium caespitosum* 1(0.5), *Calicium* sp. 1(0.2), *Pohlia wahlenbergii* 2(0.2), *Aulacomnium palustre* 3(0.1), *Botrychium multifidum* 8(0.1), *Cephalozia bicuspidata* 5(0.1), *Cornus unalaschkensis* 5(0.1), *Huperzia haleakalea* 9(0.1), *Phyllodoce empetrifolia* 9(0.1), *Romanzoffia sitchensis* 6(0.1), *Senecio triangularis* 6(0.1), *Trientalis arctica* 8(0.1), *Tsuga mertensiana* 9(0.1), *Viola glabella* 4(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 14 *Dodecatheon jeffreyi* ssp. *jeffreyi* association (continued, p. 159)

Site	PM	DL	CF	CF	CF	CF	CF	DL	DL	DL	U	NM	CF	SM	DL	PM
Plot Number	5	2	13	14	3	4	2	5	6	10	5	8	5	1	9	12
Vascular Spp./ Relevé	11	8	15	13	11	12	7	4	9	14	14	9	20	20	19	11
Bryophyte Spp./ Relevé	5	6	4	4	1	3	2	1	2	4	1	3	4	8	6	3
Vascular Plant Cover (%)	25	35	90	95	30	70	40	80	50	90	35	60	95	80	50	30
Bryophyte Cover (%)	100	100	90	45	85	85	95	10	25	50	40	20	35	95	20	90
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Character Species:																
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	1	10	2	10	5	5		1	5	1		15		15	5	
Companion Species:																
<i>Sanguisorba officinalis</i>	7	4	15	15	5	3	5	15		55		10	20	20	15	
Other Species:																
<i>Eriophorum angustifolium</i>	15	2			0.1			10							10	3
<i>Triantha glutinosa</i>	0.1		1	0.1	2	0.1	2	3							3	0.5
<i>Sphagnum subsecundum</i>		10	5	5	85	80	35	10		5				10	1	0.1
<i>Trichophorum cespitosum</i>								30			0.1	2			10	10
<i>Drosera rotundifolia</i>											0.1				1	
<i>Gentiana sceptrum</i>											0.1	2	2	4	1	1
<i>Carex utriculata</i>		25	3	2				80				15				
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	0.5	1		2					2				0.1		2	0.1
<i>Aulacomnium palustre</i>				5		1						1		5	2	
<i>Sphagnum papillosum</i>						5							1	2		
<i>Carex livida</i>					8							4				
<i>Fauria crista-galli</i>			20	20		1										3
<i>Scapania paludosa</i>				20												0.1
<i>Sphagnum tenellum</i>																
<i>Carex sitchensis</i>		1			2							15	8			3
<i>Hypericum anagalloides</i>					2	0.1			2	6				5	15	
<i>Erigeron peregrinus</i>			5					5	5						2	
<i>Vaccinium uliginosum</i>						0.1						1	10			
<i>Sphagnum mendocinum</i>												5		10		
<i>Platanthera dilatata</i>	0.1		2	3			2							1	0.1	
<i>Gentiana douglasiana</i>			0.1	1	1	1										
<i>Agrostis oregonensis</i>			1							0.1			0.1		1	
<i>Trientalis arctica</i>	0.5					0.1			1				1	0.1	1	

Minor Species: *Limprichtia revolvens* 9(20)*, 10(15), 16(75), 17(10), 19(0.1), 23(2), 30(1), *Carex anthoxanthea* 3(25), 10(5), 13(10), 15(2), 26(6), 27(4), 35(1), *Sphagnum angustifolium* 2(20), 7(60), 14(10), 18(10), 27(5), 34(2), *Gymnocolia inflata* 20(10), 27(0.1), 28(5), 31(2), 32(10), 35(65), *Calliergonella cuspidata* 3(20), 4(15), 10(30), 23(5), 26(0.1), 30(0.1), *Plantago macrocarpa* 5(1), 6(15), 12(10), 13(2), 18(1), 24(10), *Caltha leptosepala* var. *biflora* 13(8), 21(0.1), 26(10), 29(1), 33(5), 34(3), *Viola* sp. 10(1), 14(5), 19(0.1), 22(1), 26(1), 30(0.1), *Vaccinium oxycoccus* 6(0.1), 7(3), 19(1), 28(1), 29(0.1), 31(1), *Agrostis aequivalvis* 14(1), 24(1), 27(1), 28(0.1), 30(1), 32(1), *Calamagrostis canadensis* 1(1), 2(1), 8(1), 10(0.1), 13(0.1), 15(0.1), *Wernstorffia fluitans* 11(1), 12(15), 21(1), 24(40), 33(1), *Lycopodiella inundata* 11(10), 20(30), 21(1), 22(3), 25(10), *Lysichiton americanus* 3(10), 4(3), 13(1), 27(2), 29(5), *Comarum palustre* 1(1), 2(3), 8(15), 14(1), 15(1), *Juncus ensifolius* 11(0.1), 21(0.1), 22(2), 26(0.1), 34(15), *Ledum groenlandicum* 3(5), 4(1), 13(5), 17(1), *Campylium stellatum* 9(5), 15(1), 17(1), 29(0.1), 30(1), *Coptis asplenifolia* 4(0.1), 13(1), 26(2), 27(1), 29(0.1), *Pinguicula macroceras* 9(2), 15(1), 17(0.1), 20(1), 28(0.1), 30(0.1), *Coptis trifolia* 17(0.1), 19(0.1), 28(1), 29(0.1), *Selaginella selaginoides* 3(0.1), 13(0.1), 27(0.1), 28(0.1), 30(1), *Sphagnum teres* 1(50), 1(50), 10(0.1), 14(30), *Odontoschisma elongatum* 11(40), 20(5), 21(5), 28(1), *Straminergon stramineum* 1(5), 2(15), 14(10), 35(1), *Sphagnum capillifolium* 27(5), 28(2), 29(1), 30(1), *Aster* sp. 21(1), 26(3), 33(1), 24(2), *Sphagnum pacificum* 26(40), 27(80), 34(5) (continued, p. 158)

*First number refers to running number, second number (in parentheses) is percent cover.

Table 14 *Dodecatheon jeffreyi* ssp. *jeffreyi* association (continued from p. 158; continued, p. 160)

Site	DL	CF	TA	TA	U	U	DL	NM	NM	U	TA	TA	TA	TA	CF	SL
Plot Number	7	1	7	9	4	6	12	14	17	7	3	11	4	6	11	1
Vascular Spp./ Relevé	19	12	14	10	14	15	8	8	8	16	17	19	23	20	13	12
Bryophyte Spp./ Relevé	3	3	3	4	4	0	3	2	4	6	9	6	4	9	4	4
Vascular Plant Cover (%)	85	30	74	67	30	65	30	40	25	50	63	59	81	74	30	30
Bryophyte Cover (%)	10	100	70	46	30	0	20	45	5	90	98	16	37	17	95	95
Running Number	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Character Species:																
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	2	5			2	0.1	15			2					8	
Companion Species:																
<i>Sanguisorba officinalis</i>	15	20	2	5	8	0.1	2		0.1	20	10	20	5	15	15	3
Other Species:																
<i>Eriophorum angustifolium</i>	5	2	15	10	3	15	10	5	2			2	25	5		5
<i>Triantha glutinosa</i>	3	1	0.1	1	1	1	1		0.1	1	0.1	2	1	2	2	2
<i>Sphagnum subsecundum</i>	1	80			10		20				4		1	1		5
<i>Trichophorum cespitosum</i>	25		5	10	20			1	1	2	0.1	15	25		5	12
<i>Drosera rotundifolia</i>	1	0.1	2	1	0.1	0.1	0.1		2		1	1	1	0.1	1	1
<i>Gentiana sceptrum</i>	2		0.1	0.1	0.1	1	1	3			2	5	0.1	4		
<i>Carex utriculata</i>	15		5				10	15	0.1	2	20		5			
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	6				1						1	0.1	0.1	6		1
<i>Aulacomnium palustre</i>		10	70							2	2	1		3		1
<i>Sphagnum papillosum</i>					15			3	30					1	5	
<i>Carex livida</i>		8	12		0.1	20	5		12				1			
<i>Fauria crista-galli</i>	0.1										15	5			3	5
<i>Scapania paludosa</i>			0.1	1						10	0.1	5	35	5		
<i>Sphagnum tenellum</i>				10				1		1	2			1	1	85
<i>Carex sitchensis</i>		1	30	8								1		4		
<i>Hypericum anagalloides</i>	20				1	4										
<i>Erigeron peregrinus</i>	5	3	0.1	1							2	2	0.5	15	10	
<i>Vaccinium uliginosum</i>	1				10							1		3	1	2
<i>Sphagnum mendocinum</i>								5	1	10	1					
<i>Platanthera dilatata</i>											1				1	
<i>Gentiana douglasiana</i>		1			2				1						2	
<i>Agrostis oregonensis</i>	0.1				0.1	2			2						0.1	
<i>Trientalis arctica</i>	0.1											0.1		1	1	

Minor Species (continued from p. 157): *Sphagnum compactum* 20(20)*, 28(1), 31(90), *Carex echinata* 16(2), 22(15), 26(2), *Deschampsia cespitosa* 12(1), 14(1), 24(15), *Drosera anglica* 9(1), 11(2), 16(10), *Caltha leptosepala* var. *leptosepala* 5(2), 7(2), 18(8), *Lycopus uniflorus* 11(2), 14(2), 22(5), *Wamstorfia exannulata* 2(0.1), 15(2), 35(5), *Carex saxitalis* ssp. *laxa* 11(0.1), 22(1), 24(5), *Danthonia intermedia* 10(1), 14(2), 21(0.1), *Carex pluriflora* 27(2), 29(0.1), 32(1), *Parnassia fimbriata* 1(0.1), 9(2), 15(0.1), *Botrychium multifidum* 4(0.1), 10(0.1), 30(0.1), *Sphagnum russowii* 1(45), 2(5), 35(12), *Vaccinium caespitosum* 1(0.5), 13(5), 30(0.1), *Pleurozium schreberi* 13(30), 30(2), *Rhytidiadelphus squarrosus* 14(20), 30(1), *Calliergon sarmentosum* 16(15), 35(1), *Carex leptalea* 14(3), 30(10), *Carex luzulina* 10(10), 15(3), *Menyanthes trifoliata* 19(1), 29(5), *Carex pauciflora* 27(1), 29(3), *Linnaea borealis* 29(0.1), 30(3), *Lycopodium clavatum* 26(0.1), 30(3), *Carex limosa* 27(2), 29(0.1), *Equisetum arvense* 9(0.1), 16(0.5), *Chamaecyparis nootkatensis* 13(1), 30(0.1), *Empetrum nigrum* 29(0.1), 32(0.1), *Romanzoffia sitchensis* 28(0.1), 32(0.1), *Rhynchospora alba* 25(20), *Aster foliaceus* 14(15), *Gaultheria shallon* 13(15), *Carex viridula* ssp. *viridula* 11(10), *Myrica gale* 14(10), *Polytrichum strictum* 14(10), *Carex canescens* 2(5), *Juncus falcatus* 11(5), *Sphagnum squarrosum* 3(5), *Carex nigricans* 35(5), *Hypericum scouleri* ssp. *scouleri* 14(4), *Juncus supiniformis* 11(4), *Pohlia wahlenbergii* 15(3), *Calicium* sp. 15(3), *Rhytidiadelphus loreus* 13(2) (continued, p. 159)

* First number refers to running number, second number (in parentheses) is percent cover.

Table 14 *Dodecatheon jeffreyi* ssp. *jeffreyi* association (continued from p. 159)

Site	U	U	PM		
Plot Number	2	8	11		
Vascular Spp./ Relevé	16	11	9		
Bryophyte Spp./ Relevé	5	4	10		
Vascular Plant Cover (%)	50	60	25		
Bryophyte Cover (%)	30	35	95		
Running Number	33	34	35	SP	SS
Character Species:					
<i>Dodecatheon jeffreyi</i> ssp. <i>jeffreyi</i>	10	5	1	IV	3
Companion Species:					
<i>Sanguisorba officinalis</i>	3	15		V	4
Other Species:					
<i>Eriophorum angustifolium</i>	5	8	4	IV	3
<i>Triantha glutinosa</i>	1	1	1	IV	1
<i>Sphagnum subsecundum</i>	2			III	5
<i>Trichophorum cespitosum</i>	15	1	0.1	III	4
<i>Drosera rotundifolia</i>	0.1			III	+
<i>Gentiana sceptrum</i>				III	1
<i>Carex utriculata</i>	0.1	20		III	4
<i>Kalmia microphylla</i> ssp. <i>occidentalis</i>	2		0.1	III	1
<i>Aulacomnium palustre</i>	2		1	II	3
<i>Sphagnum papillosum</i>	25	20	10	II	3
<i>Carex livida</i>	8			II	3
<i>Fauria crista-galli</i>			15	II	3
<i>Scapania paludosa</i>		10		II	3
<i>Sphagnum tenellum</i>			5	II	3
<i>Carex sitchensis</i>				II	2
<i>Hypericum anagalloides</i>	1			II	2
<i>Erigeron peregrinus</i>				II	2
<i>Vaccinium uliginosum</i>	15	1	3	II	2
<i>Sphagnum mendocinum</i>	1		3	II	1
<i>Platanthera dilatata</i>				II	+
<i>Gentiana douglasiana</i>	0.1			II	+
<i>Agrostis oregonensis</i>	0.1			II	+
<i>Trientalis arctica</i>				II	+
Minor Species (continued from p. 158): <i>Utricularia minor</i> 29(2)*, <i>Dicranum scoparium</i> 13(2), <i>Carex stylosa</i> 4(2), <i>Carex flava</i> 14(2), <i>Polytrichum commune</i> 1(1), <i>Senecio triangularis</i> 3(1), <i>Sphagnum riparium</i> 1(1), <i>Carex buxbaumii</i> 14(1), <i>Cornus unalaschkensis</i> 13(1), <i>Trollius albiflorus</i> 3(1), <i>Veronica beccabunga</i> ssp. <i>americana</i> 14(1), <i>Scapania uliginosa</i> 35(0.5), <i>Cephalozia bicuspidata</i> 35(0.1), <i>Carex lasiocarpa</i> 14(0.1), <i>Galium trifidum</i> 15(0.1), <i>Gaultheria ovalifolia</i> 28(0.1), <i>Juncus effusus</i> 34(0.1), <i>Leptarrhena pyrolifolia</i> 17(0.1), <i>Mitella pentandra</i> 10(0.1), <i>Nuphar lutea</i> ssp. <i>polysepala</i> 29(0.1), <i>Philonotis fontana</i> var. <i>fontana</i> 10(0.1), <i>Platanthera stricta</i> 29(0.1), <i>Spiraea douglasii</i> 11(0.1), <i>Spiranthes romanzoffiana</i> 33(0.1).					

* First number refers to running number, second number (in parentheses) is percent cover.

Table 15 *Juncus acuminatus* / *Drosera anglica* - *Dichanthelium acuminatum* var. *fasciculatum* association

Site	WF	WF	WF	WF	WF	WF	WF	WF	
Plot Number	1	2	3	6	8	10	11	12	
Vascular Spp./ Relevé	17	8	26	14	17	21	11	17	
Bryophyte Spp./ Relevé	5	1	4	3	1	4	1	0	
Lichen Spp./ Relevé	0	0	1	0	0	1	0	0	
Vascular Plant Cover (%)	38	13	63	38	50	32	66	52	
Bryophyte Cover (%)	4	0	1	4	3	2	10	0	
Lichen Cover (%)	0	0	0	0	0	0	0	0	
Running Number	1	2	3	4	5	6	7	8	SP SS
Character Species:									
<i>Drosera anglica</i>	2	3	1	2	2	1	0	1	V 2
<i>Juncus acuminatus</i>	4	1	4	3	1	5	1		V 3
<i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i>	20		40	15	0	10		5	IV 5
<i>Vaccinium oxycoccos</i>	0		2	2		0	1		IV 1
<i>Lycopodiella inundata</i>	1		0	0	1	1			IV +
<i>Schoenoplectus tabernaemontani</i>	0	4			1		15		III 3
<i>Sphagnum compactum</i>	1			1	0	0			III +
<i>Triglochin maritima</i>	0	1					1	0	III +
<i>Coptis trifolia</i>				0	0	0		0	""
Companion Species:									
<i>Triantha glutinosa</i>	0	1	1	1	1	0	0	1	V 1
<i>Rhynchospora alba</i>	5		2	2	40	5	0	1	V 4
<i>Myrica gale</i>	5	2	10	10	1	5	2	15	V 4
Other Species:									
<i>Gentiana sceptrum</i>	0		1	0	0	1		1	IV +
<i>Carex utriculata</i>	0			2	0	0	5		IV 1
<i>Carex livida</i>			1		2		40	0	III 4
<i>Sanguisorba officinalis</i>	1		1			1		6	III 1
<i>Hypericum anagalloides</i>			0	0		0	0		III +
<i>Viola</i> sp.			0	0	0	0			III +
<i>Trichophorum cespitosum</i>			1			0		20	II 3
<i>Pellia</i> sp.				1	5	0			II 1
<i>Plantago macrocarpa</i>			1			1		0	II +
<i>Drosera rotundifolia</i>	0				0	0			II +
<i>Selaginella selaginoides</i>	0		0		0				II +
<i>Sphagnum subsecundum</i>	0	0			0				II +
<i>Odontoschisma elongatum</i>	3			2					II 1
<i>Menyanthes trifoliata</i>					0		2		II +
<i>Prunella vulgaris</i>			0				1		II +
<i>Sphagnum subnitens</i>			0		1				II +
<i>Trientalis arctica</i>			1			0			II +
<i>Agrostis aequivallis</i>	0		0						II +
<i>Blechnum spicant</i>			0			0			II +
<i>Chamaecyparis nootkatensis</i>			0			0			II +
<i>Danthonia spicata</i>			0				0		II +
<i>Deschampsia cespitosa</i>			0			0			""
<i>Gymnocolia inflata</i>	0		0						II +
Minor Species: <i>Limprichtia revolvens</i> 7(10)*, <i>Bryum pseudotriquetrum</i> 6(2), <i>Lycopodium clavatum</i> 2(2), <i>Carex flava</i> 1(1), <i>Dulichium arundinaceum</i> 5(1), <i>Ledum groenlandicum</i> 3(1), <i>Thuja plicata</i> 1(0.5), <i>Cladonia pleurota</i> 3(0.1), <i>Cladina portentosa</i> ssp. <i>pacifica</i> 6(0.1), <i>Kalmia microphylla</i> ssp. <i>occidentalis</i> 3(0.1), <i>Lycopus uniflorus</i> 8(0.1), <i>Pinus contorta</i> var. <i>contorta</i> 3(0.1), <i>Potamogeton</i> sp. 2(0.1), <i>Racomitrium lanuginosum</i> 3(0.1), <i>Scheuchzeria palustris</i> 4(0.1), <i>Sphagnum papillosum</i> 1(0.1).									

* First number refers to running number, second number (in parentheses) is percent cover.

Table 16 *Carex lasiocarpa* / *Lycopus uniflorus* association

Site	MR	MR	FR	FR	SU	SU	SU	SU	SM	FB	FB	FB	FB		
Plot Number	3	9	4	5	2	3	4	5	9	1	14	15	16		
Vascular Spp./ Relevé	10	11	12	11	6	6	9	9	5	12	14	12	19		
Bryophyte Spp./ Relevé	3	2	1	1	1	1	1	1	1	0	4	3	3		
Vascular Plant Cover (%)	50	50	70	65	40	60	60	75	50	70	25	95	90		
Bryophyte Cover (%)	20	40	30	20	2	5	5	100	15	0	100	5	20		
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	SP	SS
Character Species:															
<i>Carex lasiocarpa</i>	1	7	20	20	10	10		1	50	20				IV	5
<i>Lycopus uniflorus</i>			2	1				1		20		5	5	III	3
Other Species:															
<i>Rhynchospora alba</i>	35	1			5	60	30	5				2	3	IV	5
<i>Myrica gale</i>	25	15			15	15	15	50	2					III	5
<i>Triantha glutinosa</i>					0.1	1	1	5				1	2	III	1
<i>Sphagnum subsecundum</i>	5	40	30	20					15					II	4
<i>Carex livida</i>			0.1	3	10		2					80		II	4
<i>Comarum palustre</i>		2	20	5						2	5			II	3
<i>Carex echinata</i>	1	0.1					0.1	5					1	II	1
<i>Viola</i> sp.		0.2	1	0.1				1					0.2	II	+
<i>Lysichiton americanus</i>			15	15								5	4	II	3
<i>Vaccinium oxycoccos</i>		20					5				5		0.2	II	3
<i>Spiraea douglasii</i>			2	3						2	1			II	1
<i>Veronica scutellata</i>			1	0.1						1	0.5			II	+
<i>Carex viridula</i> ssp. <i>viridula</i>							0.1					5	80	II	4
<i>Campylium stellatum</i>					2	5	5							II	1
<i>Angelica genuflexa</i>											5	2	4	II	1
<i>Carex utriculata</i>			2						5		3			II	1
<i>Dulichium arundinaceum</i>										8		1	1	II	1
<i>Hypericum anagalloides</i>				0.1								2	5	II	1
<i>Leptodictyum riparium</i>		1										1	5	II	1
<i>Carex sitchensis</i>	1						1						3	II	1
<i>Carex limosa</i>	1								2				1	II	+
<i>Agrostis oregonensis</i>			0.1								2	1		II	+
<i>Menyanthes trifoliata</i>		0.1								2		0.1		II	+
Minor Species: <i>Sphagnum teres</i> 8(100)*, 11(70), <i>Calliergonella cuspidata</i> 11(25), 13(15), <i>Hypericum scouleri</i> ssp. <i>scouleri</i> 11(10), 13(1), <i>Carex exsiccata</i> 3(10), 10(0.5), <i>Lycopodiella inundata</i> 1(1), 2(8), <i>Calliergon cordifolium</i> 12(6), 13(1), <i>Aulacomnium palustre</i> 1(1), 11(5), <i>Nuphar lutea</i> ssp. <i>polysepala</i> 10(4), 13(0.2), <i>Aster modestus</i> 11(2), 13(0.5), <i>Platanthera dilatata</i> 12(1), 13(1), <i>Drosera anglica</i> 6(0.1), 7(1), <i>Drosera rotundifolia</i> 1(1), (0.1), <i>Galium trifidum</i> 3(0.1), 10(0.1), <i>Sanguisorba officinalis</i> 5(0.1), 6(0.1), <i>Pellia</i> sp. 1(15), <i>Eriophorum angustifolium</i> 7(10), <i>Lonicera involucrata</i> 11(5), <i>Eleocharis palustris</i> 10(3), <i>Agrostis stolonifera</i> 2(2), <i>Carex cusickii</i> 11(2), <i>Carex leptalea</i> 11(2), <i>Ledum groenlandicum</i> 11(2), <i>Scheuchzeria palustris</i> 1(2), <i>Senecio moresbiensis</i> 8(2), <i>Rhizomnium pseudopunctatum</i> 11(1), <i>Riccardia multifida</i> 1(1), <i>Sisyrinchium californicum</i> 13(1), <i>Gentiana sceptrum</i> 4(0.1), <i>Kalmia microphylla</i> ssp. <i>occidentalis</i> 9(0.1), <i>Salix lucida</i> ssp. <i>lasiandra</i> 10(0.1), <i>Trientalis arctica</i> 12(0.1), <i>Veronica beccabunga</i> ssp. <i>americana</i> 4(0.1).															

* First number refers to running number, second number (in parentheses) is percent cover.

Table 17 *Eriophorum angustifolium* / *Utricularia intermedia* association

Site	MA	DL	DL	ES	ES	ST		
Plot Number	6	1	4	1	2	1		
Vascular Spp./ Relevé	1	2	4	6	4	24		
Bryophyte Spp./ Relevé	0	0	0	0	0	11		
Vascular Plant Cover (%)	30	30	35	20	35	45		
Bryophyte Cover (%)	0	0	0	0	0	95		
Running Number	1	2	3	4	5	6	SP	SS
Character Species:								
<i>Eriophorum angustifolium</i>	30	20	15	8	3	8	V	5
<i>Utricularia intermedia</i>				2	20	20	III	4
Other Species:								
<i>Myrica gale</i>				15	10	2	III	3
<i>Carex livida</i>				1	0.1	0.1	III	+
<i>Rhynchospora alba</i>				3		1	II	1

Minor Species: *Drosera anglica* 3(20)*, *Carex luzulina* 2(10), *Carex saxitalis* ssp. *laxa*, 2(10), *Carex sitchensis* 3(10), *Utricularia minor* 3(2), *Menyanthes trifoliata* 4(2), *Lysichiton americanus* 6(1), *Drosera rotundifolia* 6(0.1), *Juncus supiniformis* 6(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 18 *Juncus supiniformis* association

	Site	MB	DL	MA	WF	NM	MA		
Plot Number		14	11	7	9	18	4		
Vascular Spp./ Relevé		3	4	2	6	2	2		
Bryophyte Spp./ Relevé		1	2	0	1	0	0		
Vascular Plant Cover (%)		30	35	20	23	15	12		
Bryophyte Cover (%)		5	5	0	0	0	0		
Running Number		1	2	3	4	5	6	SP	SS
Character Species:									
<i>Juncus supiniformis</i>		15	20	8	8	8	12	V	5
Other Species:									
<i>Carex utriculata</i>			20	12	10			III	4
<i>Eriophorum angustifolium</i>			1			0.1		II	+

Minor Species: *Carex stylosa* 5(10)*, *Sphagnum mendocinum* 1(5), *Wormstorfia exannulata* 2(5), *Carex sitchensis* 1(3), *Juncus canadensis* 1(2), *Pinus contorta* var. *contorta* 1(1), *Schoenoplectus tabernaemontani* 4(1), *Utricularia minor* 4(1), *Triglochin maritima* 4(0.5), *Carex obnupta* 4(0.1), *Sphagnum subsecundum* 2(0.1).

* First number refers to running number, second number (in parentheses) is percent cover.

Table 19 *Rhynchospora alba* - *Scheuchzeria palustris* association

Site	A	A	MR	MR	WB	SZ	SZ	RM		
Plot Number	17	4	18	16	4	6	2	9		
Vascular Spp./ Relevé	4	2	5	2	9	2	5	8		
Bryophyte Spp./ Relevé	3	0	0	0	4	0	1	1		
Vascular Plant Cover (%)	25	40	45	35	55	20	20	5		
Bryophyte Cover (%)	6	0	0	0	70	0	50	30		
Running Number	1	2	3	4	5	6	7	8	SP	SS
Character Species:										
<i>Rhynchospora alba</i>	20	40	30	25	25	20	15	15	V	6
<i>Scheuchzeria palustris</i>	1	5	3			4	2		N	2
Other Species:										
<i>Eriophorum chamissonis</i>		40			1				II	4
<i>Sphagnum mendocinum</i>	1						50		II	4
<i>Sphagnum subsecundum</i>	3				50				II	4
<i>Sphagnum papillosum</i>	2				20			5	II	3
<i>Myrica gale</i>			5		30				II	3
<i>Carex limosa</i>				15			0.1		II	2
<i>Lycopodiella inundata</i>			15					2	II	2
<i>Menyanthes trifoliata</i>	2							8	II	2
<i>Drosera anglica</i>	5							1	II	1
<i>Drosera rotundifolia</i>					2			2	II	1
<i>Nuphar lutea</i> ssp. <i>polysepala</i>							2	1	II	+
<i>Vaccinium oxycoccus</i>					1		0.5		II	+
Minor Species: <i>Carex livida</i> 8(20)*, <i>Carex sitchensis</i> 3(5), <i>Kalmia microphylla</i> ssp. <i>occidentalis</i> 5(4), <i>Eriophorum angustifolium</i> 8(4), <i>Ledum groenlandicum</i> 5(2), <i>Trientalis arctica</i> 4(1), <i>Carex lasiocarpa</i> 5(1), <i>Carex utriculata</i> 5(1), <i>Myrica anomala</i> 5(1), <i>Straminergon stramineum</i> 5(1).										

* First number refers to running number, second number (in parentheses) is percent cover.

Table 20 *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association
(continued, p. 167)

Site	PM	FR	A	A	SU	MB	LT	NF	SD	MA	MR	RM	RM	TA	CF	MR	MB
Plot Number	2	6	19	1	6	13	3	10	11	5	1	10	8	10	7	13	11
Vascular Spp./ Relevé	2	6	2	2	3	1	3	5	1	3	3	7	6	6	6	3	2
Bryophyte Spp./ Relevé	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Vascular Plant Cover (%)	35	70	60	32	50	30	30	60	70	30	50	25	15	20	35	20	20
Bryophyte Cover (%)	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Running Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Character Species:																	
<i>Menyanthes trifoliata</i>	35	60	50	30	30	30	20	50	70	30	30	8	10	5	35	5	
<i>Nuphar lutea</i> ssp. <i>polysepala</i>										1	20	10	3	5	2	5	15
Other Species:																	
<i>Carex lasiocarpa</i>		40							2								
<i>Carex sitchensis</i>							10	3							0.1		4
<i>Rhynchospora alba</i>					10							1	1				
Minor Species: <i>Carex limosa</i> 3(15)*, 19(20), 23(1), 24(1), 25(10), <i>Myrica gale</i> 8(10), 19(1), 22(5), 23(0.1), 24(2), <i>Juncus supiniformis</i> 10(0.1), 12(1), 13(5), 15(1), 26(1), <i>Scheuchzeria palustris</i> 8(2), 21(10), 24(0.5), 25(2), <i>Carex viridula</i> ssp. <i>viridula</i> 11(1), 16(10), 26(10), <i>Eriophorum chamissonis</i> 4(2), 5(10), 14(5), <i>Drosera rotundifolia</i> 12(15), 13(0.1), 23(0.1), <i>Comarum palustre</i> 1(4), 2(0.1), 27(10), <i>Carex utriculata</i> 2(0.1), 14(5), 25(6), <i>Lycopus uniflorus</i> 24(2), 26(2), 25(5), <i>Eriophorum angustifolium</i> 12(2), 15(1), 23(5), <i>Schoenoplectus subterminalis</i> 20(55), 25(1), <i>Dulichium arundinaceum</i> 26(10), 27(20), <i>Utricularia minor</i> 7(10), 12(10), <i>Sphagnum papillosum</i> 13(0.1), 23(10), <i>Carex exsiccata</i> 26(0.1), 27(5), <i>Carex livida</i> 13(1), 14(0.1), <i>Veronica scutellata</i> 2(0.1), 24(0.1), <i>Wernstorfia exannulatus</i> ssp. <i>procerus</i> 1(75), <i>Brasenia schreberi</i> 19(10), <i>Utricularia macrorhiza</i> 19(5), <i>Salix lucida</i> ssp. <i>lasiandra</i> 27(5), <i>Lycopodiella inundata</i> 23(3), <i>Sphagnum mendocinum</i> 17(2), <i>Kalmia microphylla</i> ssp. <i>occidentalis</i> 23(1), <i>Deschampsia cespitosa</i> 23(1), <i>Leptodictyum riparium</i> 27(1), <i>Sphagnum riparium</i> 1(0.1), <i>Lysichiton americanus</i> 2(0.1), <i>Potamogeton</i> sp. 14(0.1), <i>Vaccinium uliginosum</i> 15(0.1), <i>Aulacomnium palustre</i> 23(0.1), <i>Sphagnum subsecundum</i> 23(0.1), <i>Ledum groenlandicum</i> 23(0.1), <i>Vaccinium oxycoccos</i> 23(0.1), <i>Galium trifidum</i> 27(0.1), <i>Agrostis oregonensis</i> 27(0.1).																	

*First number refers to running number, second number (in parentheses) is percent cover.

Table 20 *Menyanthes trifoliata* - *Nuphar lutea* ssp. *polysepala* association
(continued from p. 166)

Site:	NF	WB	MR	A	NF	SM	MR	SM	FB	FB										
Plot Number:	11	5	5	5	4	7	2	11	7	2										
Vascular Spp./ Relevé:	1	6	2	3	4	13	10	7	8	9										
Bryophyte Spp./ Relevé:	0	0	0	0	0	3	0	0	0	1										
Vascular Plant Cover (%):	20	50	65	45	70	50	25	20	30	45										
Bryophyte Cover (%):	0	0	0	0	0	10	0	0	0	1										
Running Number:	18	19	20	21	22	23	24	25	26	27	SP	SS								
Character Species:																				
<i>Menyanthes trifoliata</i>												IV	6							
<i>Nuphar lutea</i> ssp. <i>polysepala</i>	20	20	15	35							1	25	III	4						
Other Species:																				
<i>Carex lasiocarpa</i>												3	2	20	10	0.1	1	II	3	
<i>Carex sitchensis</i>												4	20	0.1	1			II	2	
<i>Rhynchospora alba</i>												1		5	3	0.2			II	1