CHAPTER 5: VEGETATION OF SPHAGNUM-DOMINATED PEATLANDS

As discussed in the previous chapters, peatland ecosystems have unique chemical, physical, and biological properties that have given rise to equally unique plant communities. As indicated in Chapter 1, extensive literature exists on the classification, description, and ecology of peatland ecosystems in Europe, the northeastern United States, Canada, and the Rocky Mountains. In addition to the references cited in Chapter 1, there is some other relatively recent literature on peatlands (Verhoeven 1992; Heinselman 1963, 1970; Chadde et al., 1998). Except for efforts on the classification and ecology of peatlands in British Columbia by the National Wetlands Working Group (1988), the Burns Bog Ecosystem Review (Hebda et al. 2000), and the preliminary classification of native, low elevation, freshwater vegetation in western Washington (Kunze 1994), scant information exists on peatlands within the more temperate lowland or maritime climates of the Pacific Northwest (Oregon, Washington, and British Columbia).

5.1 Introduction

There are a number of classification schemes and many different peatland types, but most use vegetation in addition to hydrology, chemistry and topological characteristics to differentiate among peatlands. The subject of this report are acidic peatlands that support acidophilic (acid-loving) and xerophytic vegetation, such as *Sphagnum* mosses and ericaceous shrubs. Ecosystems in Washington state appear to represent a mosaic of vegetation communities at various stages of succession and are herein referred to collectively as *Sphagnum*-dominated peatlands.

Although there has been some recognition of the unique ecological and societal values of peatlands in Washington, a statewide classification scheme has not been formally adopted or widely recognized in the scientific community. In 1990, the state legislature passed the Growth Management Act (GMA). This law required local governments to adopt regulations to protect environmentally critical or sensitive areas, including wetlands. Bogs have been defined and recognized in both local government regulations and in state forest practice laws that regulate timber harvesting. These definitions are based largely on the presence of indicator plant species, such as shrubs of the family Ericaceae (*Ledum*, *Kalmia*, *Vaccinium*), some trees, and mosses within the *Sphagnum* genus. The closest thing to a statewide or regional classification of bogs is included in the Preliminary Classification of Native, Low Elevation, Freshwater Wetland Vegetation in Western Washington (Kunze 1994) that was published by the Washington Department of Natural Resources. This work provides some relatively detailed descriptions of bog community types in Washington and is a primary source of the community types described in this chapter.

In addition to this preliminary classification scheme, there is a considerable amount of early work on the morphology, peat stratigraphy, and plant communities of *Sphagnum*-dominated peatlands in western Washington. Much of the pioneer work was done by G.B. Rigg (1925, 1940, 1950, 1958), Rigg and Richardson (1934), and Hansen (1941, 1943, 1947). In addition to these works, a few Masters theses (Fitzgerald 1966; Fors 1979) describe the vegetation communities in western Washington peatland ecosystems. Recent work consists primarily of qualitative studies conducted as part of local government efforts to identify and inventory these wetland areas as required by the GMA or unpublished gray

literature produced by environmental consultants for development proposals around these sensitive areas. More quantitative work was conducted as part of the Puget Sound Wetlands and Stormwater Management Research Program (PSWSMRP), a multi-year study examining the effects of development on freshwater wetlands in King County and Snohomish County (Azous and Horner 1997). Although the PSWSMRP study does contain quantitative information on water quality, hydrology, and vegetation, much of that information applies to wetlands that were not *Sphagnum*-dominated because that study did not focus specifically on peatlands.

Information on *Sphagnum*-dominated peatland plant associations in western Washington is based on the existing literature and personal observations of the author. It must be noted that there is considerable variability in the species composition in these communities and additional work is required to identify the range of community types and successional processes that have contributed to their formation. To maintain consistency with the work of Kunze (1994), the term community type is used to refer to plant associations. In this document, the terms community type and association are used interchangeably. Variants are a sub unit of a community type that is differentiated from other variants of that community type by different species composition. Dominant species are those that form at least 20 percent areal cover within a community. The terms indicator and dominants are used somewhat interchangeably and refer to those species that are characteristic of observed plant communities. As used by Kunze, indicators are species that are always present in a community type but apparently these are not always dominant species (Personal communication, L. Kunze, May 2001). In addition to dominant and indicator species, there are other species that are sometimes present or associated with a community type. These other or associate species provide little areal cover, are not indicator species, and are often found in many different community types as well as non-peat-forming wetlands. Associated species appear to have broader ecological tolerances than the acidophilic species typical of peatlands.

Regional comparisons are made among ecosystems in western Washington, Oregon, and British Columbia. In addition, apparent successional patterns, endangered, threatened or rare vascular plants, and introduced or invasive species are noted. These observations are based on the published information from numerous sources, including state and federal natural resource management agencies, local government, and consulting firms. Additional research is necessary to confirm regional variations in plant community associations, especially on rare or sensitive species, to identify the response of these ecosystems to disturbance, and to develop appropriate management and conservation measures at a regional level.

Sphagnum-dominated peatlands often occur within larger wetland complexes in western Washington. A number of common plant associations often are found in seasonally or permanently flooded areas within the lagg or marginal moat. Substrate in these areas varies from muck to peaty muck. It is likely that these communities are characterized by decomposition rates, water quality, and nutrient availability more typical of non-*Sphagnum*-dominated wetland ecosystems. Common plant associations include those dominated

by aquatic macrophytes, emergent plants, shrubs, trees, or a combination of these growth forms. Examples are given in Section 5.2.2. In addition to these associations, there are a number of others that are similar to the minerotrophic wetland community types described by Kunze (1994). The areal coverage and abundance of the dominant plants and species richness within these associations can be quite variable. These are classified as palustrine aquatic bed, palustrine scrub-shrub, and palustrine forested wetlands according to the U.S. Fish and Wildlife Services' classification system (Cowardin et al. 1979), which uses an areal coverage of greater than 30% of the uppermost stratum of vegetation to name the wetland type (e.g., aquatic bed, emergent, scrub-shrub, or forested). Some of these associations appear to be similar to those described by others (Kuhry et al. 1993; Vitt and Chee 1990) as rich fens or poor fens and may represent early seral phases in the successional sequence from rich fen to ombrogenous bog.

5.2 Puget Trough Peatlands

Sphagnum-dominated peatlands in the Puget Trough physiographic province (Figure 5.1) have developed primarily in poorly drained topographic depressions created by the advance and retreat of glaciers. Specific landscape features that have been recognized as those in which peatlands have evolved include moraines, kettles, oxbow lakes, braided channels of low-gradient streams and river terraces (Kunze 1994; National Wetlands Working Group 1988; Glazer 1987). Kunze (1994) classified low elevation peatland community types based on growth forms and dominance. She identifies four herb-dominated communities, two shrub-dominated communities (one with five variants), and four tree-dominated communities. Ranges of areal cover values for the dominant or indicator species and the presence of other species that are often associated with these communities also are reported by Kunze (1994). For simplicity and because the range of cover for the dominant or indicator species is so variable, only brief descriptions of these communities are reported here, and cover values are generally omitted. It should be noted that the Puget Trough physiographic province in this document is equivalent to the northern Puget Trough Region in Kunze (1994).

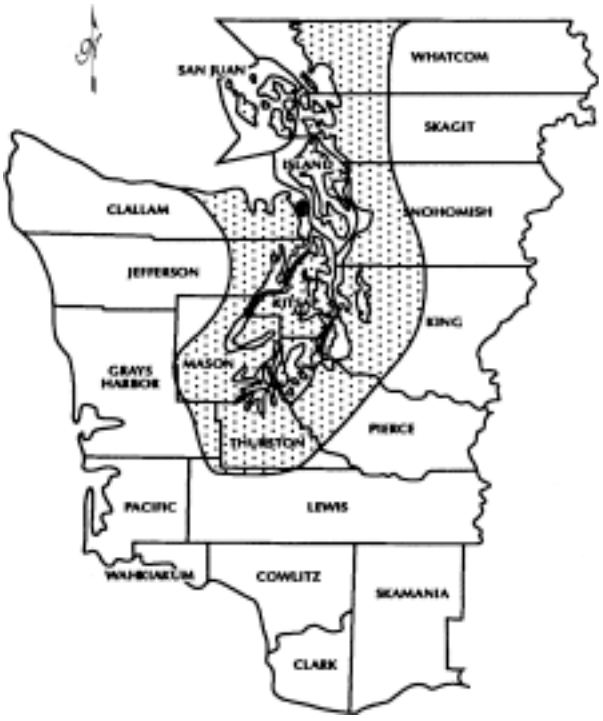

Figure 5.1 Puget Trough Province

Little work has been done by bryologists on the *Sphagnum* species found in western Washington ecosystems. It is expected that those species found in hummock and hollow habitats in coastal British Columbia are likely found in western Washington ecosystems also. Some work is now in progress to identify and enumerate those species found in our ecosystems. The species of *Sphagnum* that have been encountered in western Washington and their ecology is described in more detail in Chapter 4.

5.2.1 Herb-dominated Community Types

Herb-dominated community types appear to be early seral stages in peatland succession. Vitt (Personal communication, D. Vitt, September 2000) indicates that herb-dominated plant associations never occur in true, ombrogenic bogs. Based on limited water quality data, *Sphagnum*-dominated peatlands with herb-dominated communities appear to be wetter, typically permanently saturated and seasonally flooded, and in contact with more nutrient-rich, higher pH or geogenic waters. The sources of these waters are not well documented but could include both shallow groundwater and, sometimes, surface water from intermittent or perennial streams.

In ecosystems that appear to fit the classic hydrosere succession model (Moore and Bellamy 1974), these communities often occur at the edge of the advancing *Sphagnum* mat, adjacent to permanently inundated areas of the lake (also described as open water). In other ecosystems with pools or a lagg, these communities are also often found at the interface between the advancing *Sphagnum* mat and open water. Several authors (Fitzgerald 1966; Lebednik and Del Moral 1979; Rigg 1950) have suggested that these are pioneer communities. These communities may be similar to those that formed the sedge peat observed in the peat deposits of many of our ecosystems (see Rigg, 1958 and Rigg and Richardson, 1938 for peat profiles). These communities often form relatively narrow bands only a few meters wide.

In these communities, *Sphagnum* species have not been inventoried extensively but are likely to include species more characteristic of moister and more minerotrophic microsites, such as *Sphagnum squarrosum*, *Sphagnum angustifolium*, and *Sphagnum palustre*. Additional work is required to identify the composition of the *Sphagnum* mat within these communities (see Chapter 4 for other sources).

***Carex cusickii/Sphagnum* spp. Community Type**

This community is common and forms a narrow band at the edge of the *Sphagnum* mat and occasionally forms large floating mats over a pond or lake. The dominant species are *Carex cusickii* and *Sphagnum* species. Other indicator but not dominant species include *Potentilla palustris*, *Menyanthes trifoliata*, and *Agrostis scabra*. Other sedges, herbs, and ericaceous shrubs are often present in this community. The scientific and common names of dominant plants and other associates are shown in Table A-1 in Appendix C, Chapter 5.

Other authors (Fitzgerald 1966; Osvald 1933; Rigg 1925; National Wetlands Working Group 1988) have described pioneer communities upon which the *Sphagnum* mat advances over open water. These authors have identified various pioneer species, including *Menyanthes trifoliata*, *Potentilla palustris*,

Nuphar polysepalum, and *Lysichiton americanus* that are typically rooted in mineral sediment and often end up as small relict communities surrounded by more typical ericaceous shrub communities during later successional phases.

Lebednik and del Moral (1976) proposed an alternate hypothesis on the relict community theory in which *Lysichiton americanus* punctuates the *Sphagnum* mat within small hollows or pools. These authors believed that the *Lysichiton americanus* and associated forest moss species, such as *Aulacomnium androgynum, Rhytidiadelphus triquetrus,* and *Polytrichum juniperinum*, were invading and possibly enlarging holes in the mat following disturbance. Vitt (Personal communication, D. Vitt, September 2000) has indicated that some of these species appear to have very specific and narrow distributions. He indicates that *P. juniperinum* is found only on mineral soils and *A. androgynum* grows only on burnt stumps. Considering these statements, potential mechanisms for creating holes in the mat for these invaders include wind throw, trampling by humans or other animals, and fire. Fire has clearly influenced the formation of these ecosystems and has been noted as a disturbance mechanism most recently by Hebda et al. (2000) among others.

Carex aquatilis[1] */Sphagnum* spp. Community Type

This community is similar to the *Carex cusickii/Sphagnum* association occurring in permanently saturated and seasonally flooded areas next to inundated areas, often on floating mats. It too is may occur on more humified peat or muck soils. Dominant species in this community include *Carex aquatilis*, *Carex cusickii*, and *Potentilla palustris* growing in a mat of *Sphagnum* mosses. In addition, there is a mixture of herbaceous species more frequently found in minerotrophic wetlands and ericaceous shrubs typical of *Sphagnum*-dominated peatlands. The author has observed that when ericaceous shrubs are present, such as *Ledum groenlandicum*, *Kalmia microphylla* ssp. *occidentalis*, and *Vaccinium oxycoccos*, plants normally have a short growth form no taller than 30 cm (12 in). Kunze (1994) reports that this community is often intermixed with *Spiraea douglasii* and *Carex cusickii* community types.

Eriophorum chamissonis/Sphagnum spp. Community Type

According to Kunze (1994), the *Eriophorum chamissonis/Sphagnum* association is uncommon. It is found on very thin, floating mats incapable of supporting the weight of a person. The author believes it may be the seral phase predecessor of the two previous communities. Like the two sedge/*Sphagnum* community types, this community is permanently saturated and seasonally flooded and likely influenced by more minerotrophic water. Dominant species are *Eriophorum chamissonis* and *Sphagnum* species. The only other associated species include other sedges, most notably *Rhynchospora alba* and *Carex pauciflora*, and *Vaccinium oxycoccos*.

[1] Note: *Carex aquatilis* is given in Hitchcock and Cronquist, 1973, as *Carex sitchensis*.

Others (Osvald 1933; Rigg 1925, 1933) have described similar communities. Osvald (1933) reported similar associates in the hollows of bogs in British Columbia. A variant of this community is found in Olympic Peninsula ecosystems (see Section 5.3).

***Rhynchospora alba/Sphagnum* spp. Community Type**

The last herb-dominated community type described by Kunze (1994), the *Rhynchospora alba*/*Sphagnum* spp. community, is common throughout the region. It is frequently found in a relatively wide band either near the edge of the *Sphagnum* mat or in what appear to be slightly drier microsites upgradient of the *Carex cusickii* community type. It also may occur around depressions or hollows with a *Sphagnum* peat substrate. Like the other herb-dominated community types, it is permanently saturated and possibly seasonally inundated. Dominant species usually include *Rhynchospora alba*, *Sphagnum* species, and sometimes *Vaccinium oxycoccos*. *Drosera rotundifolia*, *Kalmia microphylla* ssp. *occidentalis*, and *Cladina rangiferina* are often present and sometimes dominant. When present, ericaceous shrubs, particularly *Vaccinium oxycoccos*, *Ledum groenlandicum,* and *Kalmia microphylla*, reportedly exhibit low growth forms.

Fors (1979) reported a similar pioneer community association in the Carlisle Bog on the Olympic Peninsula. Lebednik and del Moral (1976) and Fitzgerald (1966) described a similar sedge association dominated by *Rhynchospora alba*, *Vaccinium oxycoccos*, *Sphagnum subsecundum*, and the lichen *Cladina rangiferina*. Like the other herb-dominated community types, minerotrophic conditions appear to influence the development and possibly the persistence of this community. Associated species include a mixture of other sedges and other herbaceous species commonly found in minerotrophic ecosystems as well as *Ledum groenlandicum*. See Tables A-1 and A-2 in Appendix C, Chapter 5.

5.2.2 Other Herbaceous, Scrub-Shrub, and Forested Communities

There are several other herbaceous, scrub-shrub, and forested communities often associated with *Sphagnum*-dominated peatlands. These are often found around the perimeter of larger wetland complexes that also contain *Sphagnum*-dominated communities. These plant associations are more commonly found in non-peat-forming wetlands and often grow in a muck substrate or in the lagg around *Sphagnum*-dominated peatlands. They are also sometimes found waterward of *Sphagnum*-dominated peatland communities in shallowly inundated areas. Some of the plant associations frequently found in the lagg of western Washington peatlands include *Nuphar polysepalum*/*Utricularia vulgaris*/*Potentilla palustris*, *Brasenia schreberi*, *Malus fusca*[2]*/Spiraea douglasii/Lonicera involucrata*, *Spiraea douglasii/Cornus sericea/Lonicera involucrata*, *Myrica gale/Carex utriculata*, *Myrica gale/Carex aquatilis-Sanguisorba officinalis*, *Myrica gale/Lysichiton americanus*, and *Populus balsamifera* ssp. *trichocarpa*/*Alnus rubra*/*Rubus* spectabilis/*Carex obnupta*. In addition to these associations, Kunze (1994) describes other minerotrophic wetland community types growing in a peat substrate and often

[2] *Malus fusca* is identified as *Pyrus fusca* in Hitchcock and Cronquist, 1973.

occurring in the lagg areas of our ecosystems. In addition to these communities, Osvald (1933) describes a *Menyanthes trifoliata*/*Sphagnum* association.

5.2.3 Shrub-dominated Community Types

Assuming that the climax community in peatland succession is composed of forested types, shrub-dominated community types appear to vary from early to late seral stages in the *Sphagnum*-dominated peatland succession. Although a consistent trend has not been observed, some shrub communities appear to be wetter, typically permanently saturated and seasonally flooded, and may be strongly influenced by or be in contact with more nutrient-rich, higher pH or minerotrophic waters. The sources of these waters are not well documented, but could include both shallow groundwater and surface water from intermittent or perennial streams. Kunze (1994) recognized two communities: a *Kalmia*-*Ledum*/*Sphagnum* association with five variants and a *Spiraea douglasii*/*Sphagnum* association.

***Kalmia microphylla*/*Ledum groenlandicum*/*Sphagnum* spp. Community Type**

This community type and its variants are common throughout the region. Many of the species that occur within this association are circumboreal. In some areas, such as the northeastern United States and Alaska, there are similar communities that differ in that the dominant species are replaced by other congeneric species, especially ericads. The surface topography in this community consists of well-developed hummocks and hollows, which create a diverse array of drier (tops of hummocks) to wetter (hollows) microsites. Kunze (1994) suggests the dominant shrubs are either *Kalmia microphylla* or *Ledum groenlandicum*. In all of the peatlands investigated by the author in King County, *Ledum* and *Kalmia* were codominant, and *Vaccinium oxycoccos* also is often a codominant. In some cases, the primary differences in this community type appear to be in the density, height, and areal coverage of the shrubs, and the size of the hummocks and dominant understory associates, including mosses and lichens (see Figure 5.2).

In addition to Kunze's (1994) variants (described below), three variants of this association were described by Lebednik and del Moral (1976) in King's Lake Bog in King County, Washington. A shorter variant of this community, which includes *Potentilla palustris*, extends into the lake and was thought to be a pioneer community. Understory associates *Sphagnum subsecundum* and *Drosera rotundifolia* were reported. Another variant of this community, which is located adjacent to the sedge zone and the lake, includes stunted *Tsuga heterophylla*. A third variant of this community was described as a forest-shrub transition zone between the bog and upland forest and includes, in addition to the ericaceous shrubs, a mixture of other *Sphagnum*-dominated peatland and forest species, including *Tsuga heterophylla, Pteridium aquilinum*, G*aultheria shallon*, *Vaccinium ovalifolium*, *Vaccinium alaskense*, *Pleurozium schreberi*, *Hylocomium splendens, Eurynchium praelongum,* and *Rhytidiadelphus triquetrus*.

Figure 5.2 Tub Lake, King County, WA. Foreground: *Kalmia microphylla-Ledum groenlandicum*/*Sphagnum* spp. forested community.

Typical forest moss species appear to be common features in drier microhabitats of *Sphagnum*-dominated peatlands (tops of hummocks) and transition zones to upland areas.

Variant 1: *Kalmia microphylla*/*Sphagnum* spp.

This short-growth variant is common and may cover relatively large areas. Kunze (1994) indicates shrubs form a relatively open canopy and are typically <1 m tall (~3.3 ft). The author has observed that shrubs are often <0.5 m (~1.6 ft) and occasionally <0.3 m (~0.9 ft). This community frequently occurs as a mosaic with the *Ledum groenlandicum*/*Sphagnum* variant. It is one of the wetter variants and is found on variable substrate from relatively firm and dry peat to floating mats. Hummocks in this community range from poorly to well developed.

Vaccinium oxycoccos, *Ledum groenlandicum*, and *Sphagnum* are often codominant with *Kalmia microphylla* ssp. occidentalis. *Drosera rotundifolia* is common and conspicuous. Associated species that occur scattered within this community include many of those often found in non-peat-forming wetlands, including various sedges, *Typha latifolia*, *Viola palustris*, *Trientalis europea* ssp. *artica*, and evergreen trees typical of later seral or climax communities.

Variant 2: *Kalmia microphylla-Ledum groenlandicum*/*Xerophyllum tenax*/*Sphagnum* spp. This is a moderately tall (0.6 to 1.3 m) and drier community type found in areas within the southwestern portion of the region and in western Jefferson County and Clallam County. The water regime shifts from seasonally saturated and flooded in winter and spring, to dry during the summer drought. Based on the author's observations, substrate ranges from humified and mucky peat to fibrous, *Sphagnum*, sedge, and heath peat. Exposed mineral soils and signs of fire are sometimes present. Fire may be an important factor in the formation and persistence of this variant. Shrubs form a relatively open canopy. Coauthor's of this document have indicated that this community sometimes has well-formed hummocks up to 1 m (3.3 ft). According to Rigg (1958), peat deposits are generally shallow and composed primarily of fibrous and wood peat or muck. *Sphagnum* peat deposits can be nonexistent or up to a meter (3.3 ft) in places. It seems likely that this is an early seral phase that has not been significantly influenced by *Sphagnum*.

Dominant species include *Kalmia microphylla* ssp. *occidentalis*, *Ledum groenlandicum*, and *Xerophyllum tenax*. *Sphagnum* is listed as an indicator species but forms little areal coverage (<5 percent). *Sphagnum* species within this community are likely those that tolerate drier conditions or may be pioneer species. Alternatively, this may be a late successional phase in a seral sequence progressing towards upland. *Pteridium aquilinum* and low-growing *Gaultheria shallon* are usually present in this community. *Pteridium aquilinum* is sometimes co-dominant but *Gaultheria shallon* is not.

Relatively few associated species are found in this community. They include a mixture of herbs, shrubs, and trees found in *Sphagnum*-dominated peatlands, non-peat-forming wetlands, and upland forests in the region, including *Cornus unalaschkensis*[3], *Malus fusca*, *Maianthemum dilatatum*, *Vaccinium oxycoccos*, *Picea sitchensis*, *Pinus contorta*, and *Tsuga heterophylla*.

Variant 3: *Ledum groenlandicum*/*Sphagnum* spp.

Common throughout the region, the author has observed that this variant exhibits a taller, very dense, closed-canopy growth form, often between about 1 and 2 m (3.3 and 6.6 ft) but up to 3 m (9.8 ft). It occurs as a relatively narrow band between the adjacent, more typical scrub-shrub communities found in the lagg and the shorter variant of this community type growing toward the center of peatlands, which occasionally cover relatively large areas. Hummocks may be well developed and tall to lacking. Hebda and Biggs (1981) described a similar dry subtype in coastal British Columbia ecosystems.

Other than *Ledum groenlandicum*, dominant species include *Sphagnum* species and sometimes *Gaultheria shallon*. Areal coverage of *Gaultheria shallon* and *Sphagnum* within this community is highly variable, ranging from co-dominant to nearly absent. *Gaultheria shallon* and *Sphagnum* species are indicators but not always dominant in this community. Sphagnum species that occur here are likely those typical of drier, droughty microsites, but more investigation is needed to verify this hypothesis.

Associated species often found in this community are characteristic of those that occur in non-peat-forming wetlands and in the lagg, as well as climax peatland or upland forest. Common associates include *Picea sitchensis*, *Pinus monticola*, *Pinus contorta*, *Malus fusca*, *Salix* spp., *Vaccinium parvifolium*, and *Pteridium aquilinum*. These associates are usually widely scattered and form very little areal coverage. An example of this community type is shown in Figure 5.3.

Variant 4: *Ledum groenlandicum-Gaultheria shallon*/*Sphagnum* spp.

This variant, common throughout *Sphagnum*-dominated peatlands in the region, often covers large areas and is the primary community within these ecosystems. It occurs on firm peat where hummocks are typically well-developed. There is typically seasonal saturation during the wetter months and seasonally dry conditions during the summer drought. *Ledum groenlandicum* attains a moderate height, generally less than 1.2 m (~4 ft). *Gaultheria shallon* is a co-dominant species forming between 50 and 90% areal

[3] *Cornus unalaschkensis* is given as *Cornus canadensis* in Hitchcock and Cronquist, 1973.

coverage. According to Kunze (1994), *Kalmia microphylla* ssp. occidentalis is an indicator species forming as much as 10% cover but also is sometimes absent.

Figure 5.3 Jenkins Creek 27, King County, WA. Foreground: *Ledum groenlandicum*/*Sphagnum* shrub community. Shrubs to 1.5 meters. Background: *Tsuga heterophylla*/*Sphagnum* forested community. Photo: L. Kulzer

Other associates that are sometimes found in this variant include various sedges, other ericaceous shrubs, *Drosera rotundifolia*, and evergreen trees (See Tables A-1 and A-2 in Appendix C, Chapter 5). This variant is the primary shrub community at King's Lake Bog (Lebednik and del Moral 1976) and also appears to be common in bogs in coastal British Columbia (Hebda and Biggs 1981; Osvald 1933).

Variant 5: *Ledum groenlandicum*/*Carex utriculata*/*Sphagnum* spp.

Ledum displays a shorter growth form in this variant and generally occurs in wetter pockets and transitions zones, according to the author's observations. Shrubs are often <1 m (~3.3 ft) growing in a loose, permanently saturated and seasonally flooded peat and form a relatively closed to more open canopy. Hummocks are often small (<0.2 m or 0.6 ft) or absent. This community is frequently found in the center of *Sphagnum*-dominated peatlands and appears to be a mid-seral phase in the hydrosere sequence to a climax forested bog.

It was observed by this author that *Carex utriculata* may be a co-dominant with *Ledum groenlandicum*, protruding through the mat and forming discrete, dense aggregations or patches that exclude other species. Other dominant species are those *Sphagnum* spp. likely to occur in wetter hollows and lawn habitats. More research is required to characterize the peat moss species found in this community. *Kalmia microphylla ssp. occidentalis* is a common element. Trees when found in this community are typically seedlings <3 cm (~1 in). Other species that occur here, but are not dominant or indicators, include other sedges, *Drosera rotundifolia*, *Empetrum nigrum*, *Vaccinium oxycoccos,*and the lichen *Cladina rangiferina*.

Spiraea douglasii/*Sphagnum* spp. Community Type

A similar community type that generally lacks or contains little *Sphagnum* is commonly found throughout the region and often covers large areas. It frequently occurs as a band of vegetation in the lagg area or outer zones of well-humified peat or mucky peat substrates that are seasonally flooded and saturated. It may also be characteristic of disturbed ecosystems. This community is different and should not be confused with the peatland ecosystem described below. Regional studies (Azous and Horner, 1997) have shown that *Spiraea douglasii* is often present in non-peat-forming wetlands that have large annual water level fluctuations, which often result from development, logging or other hydrologic modifications within watersheds.

The peatland community described by Kunze (1994) is found primarily in glacial scours or kettles with small drainage basins in the southwestern portion of the State. It is not representative of the common, dense, often closed canopy *Spiraea* communities composed of plants up to 3 m (9.8 ft) tall that often occur in the laggs of peatlands. In most cases, plants are between about 0.6 and 1.2 m (2 and 4 ft) and form an open canopy. Kunze (1994) reportedly found it on terraces composed of a mixture of sphagnum, sedge, and heath peat. It was hypothesized that the shallow peat deposits on the terraces are seasonally flooded and influenced by minerotrophic waters.

Spiraea and Sphagnum are the two indicator species in this community type. Although *Nuphar polysepalum*, *Juncus balticus*, *Dulichium arundinaceum*, and *Sphagnum* are listed as codominant species, they are not identified as indicator species, which suggests they are sometimes absent or at least not dominant species. Cover of Sphagnum species typically varies from about 40 to 100% but is sometimes as low as 10% (Kunze 1994). Associated species include a mixture of species common in non-peatland and peatland wetlands, such as various sedges, *Gentiana sceptrum*, *Kalmia microphylla* ssp. *occidentalis*, *Ledum groenlandicum*, and *Malus fusca* (see Tables A-1 and A-2 in Appendix C, Chapter 5).

Kunze's community may be a relatively early seral community, whereas *Spiraea*-dominated communities found in laggs may represent relict bog communities that have been disturbed and are evolving into assemblages more typical of non-peat-forming wetlands. Kunze's (1994) observations of shallow mixed sedge, *Sphagnum*, and heath peat substrates suggest that communities on terraces may be early seral phases that are evolving into more typical *Sphagnum*-dominated peatland communities. More observations are needed to characterize the composition and variants of this community and the associated *Sphagnum* species that occur in them. Additional work would also be helpful to determine whether they are earlier seral phases or representative of disturbance. Constructing peat profiles across these ecosystems and using aerial photos to determine whether hydrological impacts have occurred may help answer questions about their seral nature.

5.2.4 Forested Community Types

Kunze (1994) describes four forested community types: *Pinus contorta/Ledum groenlandicum*/*Sphagnum* spp.; *Pinus monticola/Ledum groenlandicum*/*Sphagnum* spp.; *Tsuga heterophylla/Ledum groenlandicum*/*Sphagnum* spp.; and *Tsuga heterophylla*/*Sphagnum* spp. Canopy cover in these forested communities ranges from relatively open to closed. Tree height similarly varies from stunted saplings to mature trees more than 12 m tall (40 ft). Additional quantitative data and use of ordination and other quantitative methods to identify associations is needed to better describe these, and possibly other associations, in *Sphagnum*-dominated peatlands in Washington.

***Tsuga heterophylla*/*Ledum groenlandicum*/*Sphagnum* spp. Community Type**

This is a common community found throughout the region. The habitats where it occurs range from saturated, floating mats to much drier areas. It was observed by the author that substrates within this ecosystem are variable, ranging from unconsolidated, loose peat to a mixture of peat types (*Sphagnum*, fibrous, heath, and woody). The stature of the trees appears to vary depending on seral phase. Earlier seral phases appear to be characterized by immature, stunted, <3 m-tall (<10 ft), <10 cm (4 in) diameter at breast height (dbh) trees that are widely spaced. Later seral phases appear to be characterized by sexually mature, moderately-sized trees, up to 15 m-tall (50 ft), generally <25 cm (10 in) dbh, that are spaced more closely together. In all cases, the forest is characterized by a relatively open canopy. Understory vegetation is composed of a mixture of ericaceous shrubs similar to the *Kalmia microphylla -Ledum groenlandicum*/*Sphagnum* spp. community type. Hummocks are typically well developed in the areas between trees, but may be absent beneath the tree canopies. This community appears to represent a relatively late seral phase towards the mature bog forest climax.

Sphagnum cover is variable, ranging from zero beneath larger trees to 100 percent in the shrub-dominated areas between trees. *Pleurozium schreberi* is common and co-dominant on drier microsites, such as the sides and tops of large hummocks. *Sphagnum* species in this community likely range from those characteristic of wetter microsites in hollows to those representative of drier communities on the sides and tops of hummocks.

Associated species are variable and depend, in part, on the density of trees and shrubs. Common associates include *Kalmia microphylla ssp. occidentalis*, *Vaccinium oxycoccos*, *Picea sitchensis*, *Pinus monticola*, *Pteridium aquilinum*, *Lysichiton americanus*, a few other herbaceous species, and *Cladina rangiferina* (see Tables A-1 and A-2 in Appendic C, Chapter 5). Figure 5.4 shows an example of the community type developed around a small lake.

Figure 5.4 King's Lake Bog, King County, WA. *Tsuga heterophylla*/*Ledum groenlandicum*/*Sphagnum* forested community. Photo: L. Kulzer

Tsuga heterophylla/*Sphagnum* spp. Community Type

An uncommon community in this region, the *Tsuga heterophylla*/*Sphagnum* community type may be associated with deep *Sphagnum* peat with a water table at least 30 cm (12 in) below the peat surface. It is characterized by dense, sexually mature stands of *Tsuga heterophylla*, and may be associated with ombrogenic or raised bogs. Tree size is variable, but the canopy is fairly closed, and there is little understory vegetation except below openings in the canopy between trees. Kunze (Personal communication, L. Kunze, May 2001) found that trees 30 to 35 cm (12 to 14 in) dbh that were cored were more than 300 years old. She reports very low areal cover values for *Sphagnum*: 1 to 2 percent. Scattered associate species include *Kalmia microphylla*, *Maianthemum dilatatum*, *Trientalis europa* ssp. *arctica*, *Vaccinium oxycoccos*, and *Vaccinium parvifolium*.

This is likely a later seral phase that follows the *Tsuga heterophylla*/*Ledum groenlandicum*/*Sphagnum* spp. community. Rigg (1925) identifies coniferous forest bogs as a late successional stage community.

Pinus contorta/*Ledum groenlandicum*/*Sphagnum* spp. Community Type

This community is found scattered throughout the region. Generally occurring in relatively dry areas, it is occasionally seen in locations that are seasonally flooded and have a mixture of *Sphagnum*, fibrous, heath, and woody peat substrates. Kunze (1994) speculated that where trees are tall, peat soils may be thin, and as a result the trees are in contact with mineral soils.

Pinus contorta is the dominant conifer in this community type. Stand structure is quite variable ranging from open canopy composed of widely spaced and highly stunted sexually immature to a more closed canopy community composed of larger sexually mature and apparently unstunted trees. *Ledum* has a shorter growth form in the more open canopy community but exhibits a taller growth habit beneath shadier closed canopy communities. *Gaultheria* shallon is listed as an indicator and is sometimes a

dominant species. Sphagnum spp. sometimes form 50-90% areal cover beneath the trees and shrubs but can be absent (Kunze 1994).

Associated species are variable. Associated trees may include *Thuja plicata* and *Tsuga heterophylla*. Additional understory associates include other ericaceous shrubs, including *Empetrum* nigrum, *Vaccinium oxycoccos*, *V. parvifolium*, and *Kalmia microphylla*. *Drosera rotundifolia*, *Cladina rangiferina* and species often associated with non-*Sphagnum*-dominated wetlands are other common associates.

Dense stands of this community type appear to be similar to the pine woodland described by Hebda and Biggs (1981), whereas the more stunted and open stands appear to be similar to their heathland type. Rigg (1925, 1940) described *Pinus contorta* bogs. An association of *Pinus contorta*, *Gaultheria shallon*, and *Ledum groenlandicum* was described by the National Wetlands Working Group (1988).

***Pinus monticola*/*Ledum groenlandicum*/*Sphagnum* spp. Community Type**

The association of these species is uncommon in western Washington. According to Kunze (1994), the southern portion of the region contains remnants of this community type, which may have been more extensive historically. It is perhaps more common on the Olympic Peninsula where Rigg (1940) observed it in two *Sphagnum*-dominated peatlands. Disease, timber harvesting, and habitat modification appear to be primary reasons for loss of this habitat type. It is a drier community type that appears to occur on a mixture of *Sphagnum*, fibrous, heath, and woody peat, which may be only seasonally saturated at the surface. The co-authors of this document have observed large hummocks up to more than a meter (3.28 ft) in this community.

Remnants found in the southern portion of the region have scattered *Pinus monticola* and a tall but open shrub component growing in *Sphagnum*. *Ledum* and *Sphagnum* species are dominant in this community. *Pinus monticola* and *Spiraea douglasii* are other indicator species.

Most of the common associates are those often found in upland forests, including *Vaccinium parvifolium*, *Pteridium aquilinum*, *Pseudotsuga menziesii*, *Gaultheria shallon*, and *Tsuga heterophylla*. Rigg (1925) suggested that *Pseuodotsuga menziesii* is the last species to invade a bog, which indicates that this may be a late seral phase community type. *Vaccinium oxycoccos* and *Kalmia microphylla* ssp. *occidentalis* are scattered within this ecosystem, as are other species often found in bogs and non-*Sphagnum*-dominated wetlands, including *Lysichiton americanus*, *Eriophorum chamissonis*, and *Carex canescens*.

5.2.5 Endangered, Threatened, Sensitive, and Introduced Plants

There are a number of species that are regionally endangered, threatened, or sensitive. Other plant species are invaders or have been introduced. The status of the former is based on designations made by the Washington Natural Heritage Program (1997). Given the paucity of available information on western Washington peatlands, it is likely that there are other taxa that fit into these categories that are

not identified. Additional research is required to document and identify the abundance and distribution of these rare taxa in western Washington peatlands. Research done in peatlands in the northeastern U.S. (Glaser 1987) found that several vascular and non-vascular plants are restricted wholly, or largely, to those ecosystems. That and other research supports the need for additional research in our ecosystems to document the distribution of rare or introduced flora here.

Ranks are provided for each taxon based on those identified by the Washington Natural Heritage Program (1997). State rank (S) follows the Natural Heritage Program definitions:

1 = Critically imperiled because of extreme rarity or because it is particularly vulnerable to extinction or extirpation; typically 5 or fewer occurrences;

2 = Imperiled because of rarity or because it is vulnerable to extinction or extirpation; typically 6 to 20 occurrences;

3 = Either very rare and local throughout its range or found locally (even abundantly) in a restricted range; typically 21 to 100 occurrences;

4 = Apparently secure; typically more than 100 occurrences.

So, for example, a species with a designation of S2 is one that is imperiled because of rarity or is vulnerable to extinction or extirpation. It should be noted that a few other taxa designated for review and watch by the Washington Natural Heritage Program are not identified below because their degree of rarity, and extent to which they are threatened is uncertain (review species) or they are more abundant and/or less threatened in Washington than previously assumed (watch species).

Endangered, Threatened, and Sensitive Plants

Although additional studies are necessary to confirm their absence, it is unlikely there are any federally- or state-endangered or threatened species in these *Sphagnum*-dominated peatlands. *Howellia aquatilis* and *Lobelia dortmanii*, two state-threatened taxa, could be present in pools that lack *Sphagnum* or *Sphagnum* peat and the strongly acidic conditions, low nutrient, and low cation concentrations typically associated with *Sphagnum*-dominated peatlands. The congeneric species *Lobelia kalmii* is reportedly found in pools in the patterned fens of northern Minnesota (Glaser 1987), which suggests that if our species has similar tolerances, it may be found in pools within western Washington. *Howellia aquatilis* and *L. dortmanii* are ranked as S2. A third species, *Platanthera (Habernaria chorisiana* Cham.*) chorisiana*, also may occur in these ecosystems. It has a rank of S1.

Several species are on the list of the State sensitive taxa. Of these, many have been observed in *Sphagnum*-dominated wetlands in western Washington. At least 4 members of sedge family are State sensitive and known to occur in western Washington peatlands, including *Carex comosa* (S2), *C. pauciflora* (S2), *C. pluriflora* (S1S2), and *Eriophorum viridicarinatum* (S1). The rank for *C. pluriflora* is uncertain, but thought to be within this range, which is represented as S1S2.

In addition to the sedges noted above, there are a number of broad-leaved herbs listed as State sensitive species. Among these are *Gentiana douglasiana* (S1S2), *Hypericum majus* (S1), *Platanthera obtusata*

(S2) (*Habenaria obtusata* Banks ex. Pursh), *P. sparsiflora* (*Habenaria sparsiflora* S. Wats)(S1), *Plantago macrocarpa* (S2), *Sanguisorba menziesii* (S1S2), and *Spiranthes porrifolia* (S2). According to Zika (2000a, 2000b), natural populations of *H. majus* are rare in Washington because it is at the southern end of its transcontinental range. He adds that introduced populations of this species from European sources are apparently well established, especially on cranberry farms. Several of these State sensitive species are restricted primarily to *Sphagnum*-dominated peatlands, including the orchids *Platanthera (Habernaria) obtusata*, *P. sparsiflora*, and *Spiranthes porrifolia* (*S. romanzoffiana* Cham. var. *porrifolia* (Lindl.) Ames & Correl) and the cottongrass *Eriophorum viridicarinatum*.

A number of non-vascular plants, including peat mosses and lichens, may also occur in these ecosystems. These are rare plants, based on the same criteria as those used for vascular plants, such as occurrence pattern, vulnerability threats, degree of protection, and taxonomy. There is, however, insufficient information on these criteria to assign a statewide status (e.g., endangered, threatened, sensitive, review, or watch). Those species known, or likely, to occur in *Sphagnum*-dominated peatlands in western Washington include, *Dicranum muehlenbeckii*, *Drepanocladus crassiocostatus*, *Polytrichum strictum*, *Sphagnum austinii*, *S. centrale*, *S. contortum*, *S. jensenii*, and *S. riparium*. All are given a rank of S1. Nomenclature of these mosses follows Anderson et al. (1990) and Anderson (1990). Unlike mosses, lichens have been divided into two priority groups, priority 1 and priority 2. There are two priority 1 species of lichens that are known to occur in peatlands, *Usnea sphacelata* (S1) and *Cladina portentosa* (S2). A third species, *Usnea longissima* (S1) is identified as a priority 2 species. Nomenclature of lichens follows Esslinger and Egan (1995). In addition to these species, other rare lichens and fungi may occur in these areas.

Introduced Species

At least some of the non-native or introduced species in western Washington peatlands appear to have been introduced by commercial cranberry growers. It is uncertain how widespread some of these species might be outside the immediate area of cranberry bogs, which are found along the coast in southwestern Washington primarily in Grays Harbor County and Pacific County. Hebda et al. (2000) reported that 80 species of introduced vascular plants were observed in Burns Bog in British Columbia. They found that these were associated with cultivated fields or disturbed areas and few were found within undisturbed portions of the bog. These authors indicated that 12 of the introduced species are invasive or potentially invasive because they often become dominant species and change the structure of the vegetation. They also reported that six of these species, European birch, *Juncus pelocarpus*, *Oxycoccos macrocarpus*, *Vaccinium corymbosum*, and *Rubus laciniatus* have become well established in British Columbia. It is uncertain whether any of these species are found in western Washington.

Other non-native species may have been introduced in western Washington by plant lovers or also possibly by cranberry growers. There are a number of carnivorous plants present in at least some of our

peatlands in Skagit County and Kittitas County (Weinmann and Weinmann 2000, 2001). These include the pitcher plants, *Sarracenia purpurea*, *S. leucophylla*, *S. flava*, and *Darlingtonia californica* and the Venus flytrap, *Dionaea muscipula*. The *Sarracenia* spp. are native to the southeastern or northeastern United States or parts of Canada. *Darlingtonia* is native to more southerly areas of the western United States from central Oregon to northern California. *Dionaea* is found in the southeastern United States from the Carolinas to Florida. Two other species, *Juncus canadensis* and *Eriophorum virginicum* were observed in the same peatland in Skagit County. These species are native to the northeastern United States and southeastern Canada. At least some of these species, including *J. canadensis*, *E. virginicum*, and *S. purpurea* are spreading within the peatlands in which they were observed (Personal communication, F. Weinmann, September 2000).

In addition to non-native species that have been accidentally or intentionally introduced, there are a few other species that are or may be found in western Washington peatlands. The distribution and abundance of most of these species are unknown. According to Fred Weinmann (Personal communication, 2000), one species, *Juncus effusus* var. *effusus* is widespread. Another species reported in western Washington peatlands is *Juncus bulbosus*. At least one species, *Juncus brevicaudatus* has been observed in *Sphagnum*-dominated peatlands in British Columbia, Canada. It is unknown whether this non-native plant has been observed in western Washington.

Although it is uncertain how at least some of these species have become established in western Washington peatlands, some have been introduced by cranberry growers and others may be opportunistic invaders and indicators of changing hydrology or water chemistry in peatlands. Hebda et al. (2000) reported that introduced species in the Burns Bog ecosystem in British Columbia were often associated with peat-mined areas and areas where hydrology has been altered. In any case, additional research is needed to determine the distribution and abundance of these species and whether they may be spreading as a result of natural or anthropogenic disturbances to these ecosystems.

5.3 Olympic Peninsula and Southwestern Washington

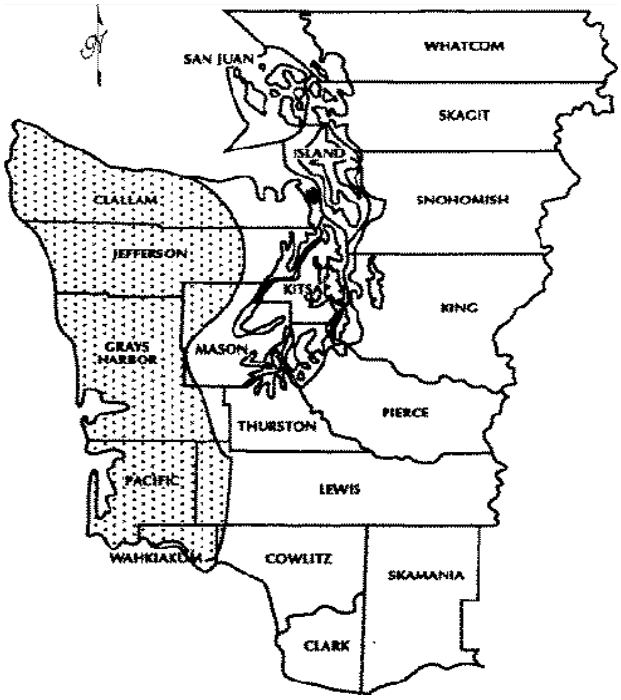

FIGURE 5.5 Olympic Peninsula and Southwestern WA physiographic province

Similar to that in the Puget Trough region, Kunze (1994) identified several herb-dominated, shrub-dominated, and forest-dominated communities on the Olympic Peninsula and in Southwestern Washington. She indicated that bogs in the lowland areas of the Olympic Peninsula and southwestern Washington (see Figure 5.5) are most similar to those in the coastal areas of British Columbia, which have been described by the National Wetlands Working Group (1988) and others (Vitt et al. 1990).

Like many of the *Sphagnum*-dominated peatlands in the Puget Trough, some of those on the Olympic Peninsula and southwestern Washington appear to have evolved in depressions following the classic hydrosere model of succession. These types of ecosystems have been classified as basin bogs or basin fens in Canada (National Wetlands Working Group 1988). Plant communities in these ecosystems are generally similar to those in the Puget Trough.

Other *Sphagnum*-dominated peatlands occur on slopes, flat to rolling ground, and along low-gradient streams. At least some of these ecosystems on flat or sloping ground may have evolved as a result of paludification (see discussion on Succession, Section 5.5). They are known as prairies by the local populace and occur on relatively shallow peat deposits only a meter or so deep (3 to 4 ft) (Rigg 1958). Some of these ecosystems, like Carlisle Bog near the town of Carlisle, Washington, are relatively large – to hundreds of hectares (several hundred acres) or more. Because of the relatively shallow peat deposits or veneers in these bogs that overlay mineral soils, they appear to contain, or are influenced by, more minerotrophic surface and shallow groundwaters. In some locations, mineral soils and rocks are visible at the bog surface. The wetter, cooler climate in this region (see Chapter 2) may create a larger positive water balance, high groundwater levels near the ground surface, and conditions favorable to paludification.

Prairie-type peatlands are often seasonally flooded during the wetter months and can become quite dry during the summer drought. Some have defined outlets, but never defined inlets (Kunze 1994). Shallow depressions or troughs occur in these ecosystems and those on slopes have their long axis perpendicular to the slope similar to the flarks, or netlike fens, in patterned peatlands (Glaser 1987). These are wetter

microsites that are seasonally flooded, permanently saturated, and characterized by herb-dominated communities composed of sedges, cottongrass, and other herbs. Drier portions of these prairie peatlands are dominated by very low-growing ericaceous shrubs, such as *Empetrum nigrum* as well as the lily *Xerophyllum tenax*. According to Kunze (1994), some of the prairie ecosystems are surrounded by marginal ditches or laggs. Shrub-dominated plant communities of *Spiraea* spp. or *Malus fusca* occur in the laggs. Upgradient of the laggs, plant communities transition to wet forest communities or shrublands, depending on topography. These ecosystems may fit the rich fen classification of the National Wetland Working Group (1988) for similar peatlands in Canada.

Along the outer coast in this region, broad peat terraces occur along well-defined stream channels in nearly flat drainages. Plant community types in these landforms consist of a mosaic of *Sphagnum*-dominated peatlands and wetland communities that are more characteristic of non-peat-forming wetlands. These ecosystems appear to fit Damman's (1986) definition of limnogenous peatlands and may be early seral phases that eventually proceed to fens and finally ombrogenous bogs. The hydrologic regime in these ecosystems is seasonal flooding during the wetter months and saturation throughout the rest of the year. These peatlands are influenced by more nutrient-rich or minerotrophic water at least seasonally, and Kunze (1994) indicates most are characterized by shrub communities dominated by *Myrica gale*.

5.3.1 Herb-dominated Community Types

Based on Kunze (1994), there are six herb-dominated community types: *Carex livida*/*Sphagnum* spp., *Carex utriculata*[4]/*Sphagnum* spp., *Carex utriculata*-*C. aquatilis* var. *sitchensis*-*Sanguisorba officinalis*/*Sphagnum* spp., *Eriophorum chamissonis*/*Sphagnum* spp., *Juncus supiniformis*/*Sphagnum* spp., and *Rhynchospora alba*/*Sphagnum* spp. Hummocks are generally absent or poorly formed**.**

***Carex livida*/*Sphagnum* spp. Community Type**

This community is found primarily in western Jefferson and Clallam counties on a saturated mixture of *Sphagnum*, fibrous, and heath peat along seeps and intermittent drainages that may lack well defined channels. Woody peat is also often present. It is most common along stream terraces and on slopes, but also occurs on flat or rolling topography and in basins.

Sphagnum species are dominant and vascular plant cover is often sparse. *Vaccinium oxycoccos*, *Carex livida*, *Carex interior*, and *Sanguisorba officinalis* are indicator species and often co-dominant. Growth-forms of *Ledum groenlandicum* and *Kalmia microphylla* ssp. *occidentalis* are typically shorter (or stunted) and account for little of the total areal cover, but they are always present.

Other less abundant but common associates include *Carex obnupta*, *Rhynchospora alba*, *Tofieldia glutinosa*, *Gentiana douglasiana*, and *Platanthera (Habernaria) dilatata*. Other, less common associates include *Agrostis* spp., *Anemone oregana*, various sedges, *Drosera rotundifolia*, *Menyanthes trifoliata*,

[4] Note: *Carex utriculata* was misnamed as *Carex rostrata* in Hitchcock and Cronquist, 1973.

rushes, *Viola palustris*, *Panicum occidentale*, and *Nephrophyllidium crista-galli*. Many of these species are commonly found in non-peat-forming wetlands.

Kunze (1994) noted that small hummocks dominated by *Thuja plicata*, *Ledum groenlandicum*, *Kalmia microphylla*, and *Gaultheria shallon* occur within this community. However, she did not consider these hummocks as part of the community type.

***Carex utriculata*/*Sphagnum* spp. Community Type**

This community type is common mostly on slopes and in basins in western Jefferson and Clallam counties. The mixed *Sphagnum* and fibrous peat soils are either shallowly flooded (to a depth of a few cm or inches) or permanently saturated.

Dominant species are *Sphagnum* and *Carex utriculata*. This community type often forms a mosaic with the *Carex livida*/*Sphagnum* community type, but is easily distinguished by the abundance and cover of *Carex utriculata*. Figure 5.6 shows an example of this community type. There are many associates characterized by a mixture of species commonly found in both peatlands and non-peat-forming wetlands. Many of the associates common in the *Carex livida*/ *Sphagnum* community type also are found here.

In addition, several trees and shrubs are present in this community, including *Pinus contorta*, *Pinus monticola*, *Thuja plicata*, *Linnaea borealis*, and *Rhamnus purshiana* (Table A-2, Appendic C, Chapter 5).

Figure 5.6 Carlisle Lakes peat area, Grays Harbor County, WA. Foreground: *Carex utriculata*/*Sphagnum* herb community. Center: *Ledum groenlandicum*/*Sphagnum* shrub community. Background: *Pinus contorta*/*Ledum groenlandicum*/*Sphagnum* forested community. Photo: S. Luchessa

These are typically absent from the former *Carex livida*/*Sphagnum* spp. association, possibly suggesting that this is a later seral phase. According to Kunze (1994), *Thuja plicata* occur scattered, stunted, and up to about 1 m (3.3 ft) tall. Examination of existing peat profiles (Rigg 1958) for bogs with these communities or collection of new peat cores could answer questions relative to the age of this seral phase.

Carex utriculata-Carex aquatilis-Sanguisorba officinalis/*Sphagnum* spp. Community Type

This community type is common in ecosystems found in basins and on stream terraces along the coastal areas of Grays Harbor County and Pacific County. Its development may be influenced by minerotrophic waters. Substrate is a mixture of *Sphagnum* and sedge peat that is seasonally flooded and permanently saturated.

The vegetation in this community is tall and dense compared to that of *Carex utriculata*/*Sphagnum*. Sedges and *Sphagnum* species are the dominant plants. *Carex utriculata* and *Carex aquatilis* are often co-dominant but sometimes collectively form relatively low areal cover. According to Kunze (1994), cover of *C.utriculata* ranges from 10-75% and *C.aquatilis* ranges from 10-30%. *Gentiana sceptrum* is usually present and *Sanguisorba officinalis* is an indicator species. Both can be co-dominant. Occasionally, *Carex obnupta* is abundant (Personal communication, L. Kunze, May 2001). Except for *Vaccinium oxycoccos*, ericaceous shrubs are conspicuously absent from this community. Associates are fewer but similar to those of the two previous communities, except for *Myrica gale*, which is present in this community but absent from the previous two communities.

This community is typically interspersed in a mosaic pattern with *Myrica gale* communities. It is similar to the *Myrica gale*/*Carex aquatilis*-*Sanguisorba officinalis*/*Spagnum* spp.variant of the *Myrica gale*/*Sanguisorba officinalis*/*Sphagnum* spp. community type but has almost no *Myrica gale* and lower overall species richness.

Eriophorum chamissonis/*Sphagnum* spp. Community Type

This community is rare in the region, occurring in basins on thin, floating *Sphagnum* mats that do not support the weight of a human. The peat substrate is saturated at the surface all year long. It typically occurs as a narrow band at the edge of a *Sphagnum* mat and appears to be a pioneer community type for *Sphagnum*-dominated peatlands in this region.

Eriophorum chamissonis and *Sphagnum* spp. are the dominant plants and indicator species in this community. The few associates in this community include *Carex pluriflora*, *Lysichiton americanus*, *Vaccinium oxycoccos*, and *Ledum groenlandicum* (see Table A-2 in Appendix C, Chapter 5). The author observed this is a wetter community type and *Ledum groenlandicum* is common, but usually exhibits a shorter growth-form (<30 cm or 12 in).

This community type is similar to others in this region and in the Puget Trough region. The *Rhynchospora alba*/*Sphagnum* spp. association in this region is much like it, but occurs in somewhat drier areas. The *Eriophorum chamissonis*/*Sphagnum* community in the Puget Trough region occurs in a similar habitat and is an early seral phase, but lacks *Rhynchospora alba*. In addition, *Carex pluriflora* appears to replace *Carex pauciflora* here.

Juncus supiniformis/*Sphagnum* spp. Community Type

The *Juncus supiniformis*/*Sphagnum* spp. community is common in small ponds and seasonally flooded depressions and on slopes in western Jefferson County and Clallam County. Mixed sedge and *Sphagnum* peat is seasonally flooded, but the surface layer of the peat dries in most cases during the summer drought. The underlying peat typically remains saturated all year.

The abundance of *Juncus supiniformis* and sparseness of other plants are clear indicators of this community type. Although *Sphagnum* peat is an indicator of this community, there is seldom any living *Sphagnum* species present (Kunze 1994). Species often associated with this community include *Rhynchospora alba*, *Hypericum anagalloides*, *Carex livida*, and *Carex utriculata*. The latter two species typically occur around the margins of this community type.

This community may be an indicator of disturbance. Kunze (1994) hypothesized that the depressions or ponds in which this community is frequently found may be elk wallows. This author has noted that *Sphagnum* is susceptible to trampling impacts, which may support this disturbance hypothesis. Additional investigation is needed to determine if this community forms from a natural successional process or a response to disturbance.

Rhynchospora alba/*Sphagnum* spp. Community Type

The *Rhynchospora alba*/*Sphagnum* spp. community occurs north of Grays Harbor in basins, flat or rolling topography, and on slopes. It is similar to that of the same name found in the Puget Trough region and typically occurs on floating mats adjacent to open water, in wet depressions, or along seeps. Substrate is soft *Sphagnum* peat that often sinks when stepped on. It appears to be an early seral phase.

This community is similar to the *Carex livida*/*Sphagnum* community type in this region but is distinguished by the dominance of *Rhynchospora alba*. In addition to *Rhynchospora alba*, *Sphagnum* species are typically dominant, though frequently none are living (Kunze 1994). In rare instances, *Sphagnum* is not a dominant and covers only small areas. *Vaccinium oxycoccos* is an indicator species and sometimes co-dominant and *Kalmia microphylla* is a common associate. When *Kalmia microphylla* is present, it typically displays a shorter growth-form (<0.6 m or < 2 ft). Other common associates include a mixture of herbaceous species and shrubs commonly found in both *Sphagnum*-dominated peatlands and non-peat-forming wetlands, and a similar assemblage as found in other herb-dominated bog community types in this region (see Tables A 2, Appendix C, Chapter 5).

This community type is found in wetter portions of peatlands. The National Wetlands Workings Group (1988) reported that *Rhynchospora alba* is common in the wettest portion of sloping bogs in coastal British Columbia. Others (Vitt and Slack 1975) associated the distribution of this species with moisture and lack of shade. Figure 5.7 shows an example of this community type intergraded with the *Eriophorum chamissonis*/ *Sphagnum* and *Carex utriculata* /*Sphagnum* community types.

Figure 5.7 Carlisle Lakes peat area, Grays Harbor County, WA. Foreground: *Rhynchospora alba*/*Sphagnum* community interspersed with *Eriophorum chammissonis*/*Sphagnum* and *Carex utriculata*/*Sphagnum herb communities*. Photo: S. Luchessa

5.3.2 Shrub-dominated Community Types

Shrub-dominated community types are typically drier ecotypes than herb-dominated communities. Hummocks are often present and can be quite prominent up to a meter (3.3 ft) or more tall. Tops and sides of hummocks are generally drier, more exposed microsites than the wetter, shadier hollows between hummocks. However, *Myrica gale*-dominated communities are typically associated with wetter habitats and lack hummocks. They also tend to occur where there is at least seasonal influence by minerotrophic water (Personal communication, L. Kunze, May 2001). Other shrub communities are usually drier ecotypes. Some of the wetter community types may be earlier seral phases and associated with less extensive peat deposits, whereas drier communities appear to typically be associated with deeper deposits. Kunze (Personal communication) noted that the driest habitats occur on the thinnest peat deposits. However, more data are needed to verify whether these relationships always hold true.

Kalmia microphylla-Ledum groenlandicum/*Sphagnum* spp. Community Type

This community is common throughout this region. It occurs in basins, flat or rolling topography, slopes, and peat terraces along streams. The substrate is mixed *Sphagnum*, sedge, and heath peats that range from saturated to seasonally dry. Hummocks tend to be well developed. The community type is characterized by the presence of *Kalmia microphylla* ssp. *occidentalis* and *Ledum groenlandicum*, *Sphagnum* species, and the lack of *Myrica gale.* Kunze (1994) identified four variants of this community type, which appear to be at least partially dependent on moisture gradient. Some variants are clearly associated with wetter areas, whereas others are associated with drier conditions. *Sphagnum* species are indicator species but not always dominant. Those species present likely include various species associated with the different moisture gradients present in the hummocks and hollows. More research is needed to document the composition of bryophyte communities.

Variant 1: *Kalmia microphylla-Ledum groenlandicum*/*Carex utriculata*/*Sphagnum* spp.

This variant is common in wetter areas of *Sphagnum*-dominated peatlands in southwestern Washington and northern Grays Harbor County. Substrate within this community is a mixture of *Sphagnum*, sedge, and heath peat that is permanently saturated and can be seasonally flooded.

Kalmia microphylla ssp. *occidentalis*, *Ledum groenlandicum*, *Carex utriculata*, and *Sphagnum* species are indicator species and co-dominant. The author noted variable shrub height ranging from about 1 m (3.3 ft) in undisturbed areas to 2 m (6.6 ft) in drained systems. Height appeared to be in part dependent on the level of disturbance.

Other species commonly found in this community include *Vaccinium oxycoccos*, *Gentiana sceptrum*, *Cornus unalaschkensis*, *Blechnum spicant*, *Carex aquatilis*, *Trientalis europa* ssp. *arctica*, and *Maianthemum dilatatum* (see Tables A 2, Appendix C, Chapter 5).

Variant 2: *Kalmia microphylla-Ledum groenlandicum*/*Xerophyllum tenax*/*Sphagnum* spp.

This community appears to be uncommon and may be restricted to western Jefferson and Clallam counties. The same association occurs in the southwestern portion of the Puget Trough region. This is a drier variant characterized by seasonal saturation or flooding in the wetter months and drier conditions during the summer drought.

Species composition of this community is described in the Puget Trough region. The *Kalmia microphylla -Ledum groenlandicum-Gaultheria shallon*/*Pteridium aquilinum*/*Sphagnum* spp. variant in this region, which is also found in Jefferson and Clallam counties, is similar. Two of the indicator species for that variant, *Blechnum spicant* and *Calamagrostis nutkaensis*, are not found in this community.

Variant 3: *Kalmia microphylla-Ledum groenlandicum-Gaultheria shallon*/*Pteridium aquilinum*/*Sphagnum* spp.

A drier variant of the community type, this variant is found mostly on slopes or ridges in prairies in western Clallam County. It is found on thin, mixed *Sphagnum*, sedge, and woody peat overlaying mineral soils that are seasonally saturated but become relatively dry during the summer. Kunze (1994) speculated that it could be associated with past fires.

Although shrub height is typically relatively short, to about 0.3 m (1 ft) and open, plants can be tall and dense. *Ledum groenlandicum* is always a dominant species, and *Kalmia microphylla*, *Gaultheria shallon*, *Blechnum spicant*, *Pteridium aquilinum*, and *Sphagnum* species are indicators and generally co-dominants. *Calamagrostis nutkaensis* is listed as an indicator species, which is sometimes dominant and sometimes absent. Common associates include scattered and somewhat stunted *Thuja plicata* and *Tsuga heterophylla*. Other than many of the species frequently found in *Sphagnum*-dominated peatlands and non-*Sphagnum* dominated wetlands in the region, noteworthy associates include *Empetrum nigrum*, *Panicum occidentale*, *Lycopodium clavatum*, *Gentiana douglasiana*, *G. sceptrum*, and *Spiraea douglasii*.

Stunted *Picea sitchensis*. The presence of stunted trees suggests this may be a mid-level seral phase, or perhaps there are still sufficient nutrients to allow trees to survive.

Variant 4: *Kalmia microphylla-Ledum groenlandicum-Vaccinium oxycoccos*/*Sphagnum* spp.

This wetter variant is found throughout the region. It contains mixed heath, sedge, and *Sphagnum* peat and occurs within basins and portions of ecosystems in flat to rolling terrain. Woody debris is also often in the peat. Soils are seasonally flooded and wet to saturated year-round. *Sphagnum* hummocks, which are well developed may be only seasonally saturated and become drier during the summer.

Kalmia microphylla ssp. *occidentalis*, *Ledum groenlandicum*, and *Sphagnum* species are co-dominants. These shrubs have a moderately tall growth form, up to about 1.3 m (4.3 ft). *Vaccinium oxycoccos* is an indicator and sometimes a co-dominant beneath the canopy of the taller ericad shrubs. *Carex obnupta* is listed as an indicator and can be co-dominant to absent.

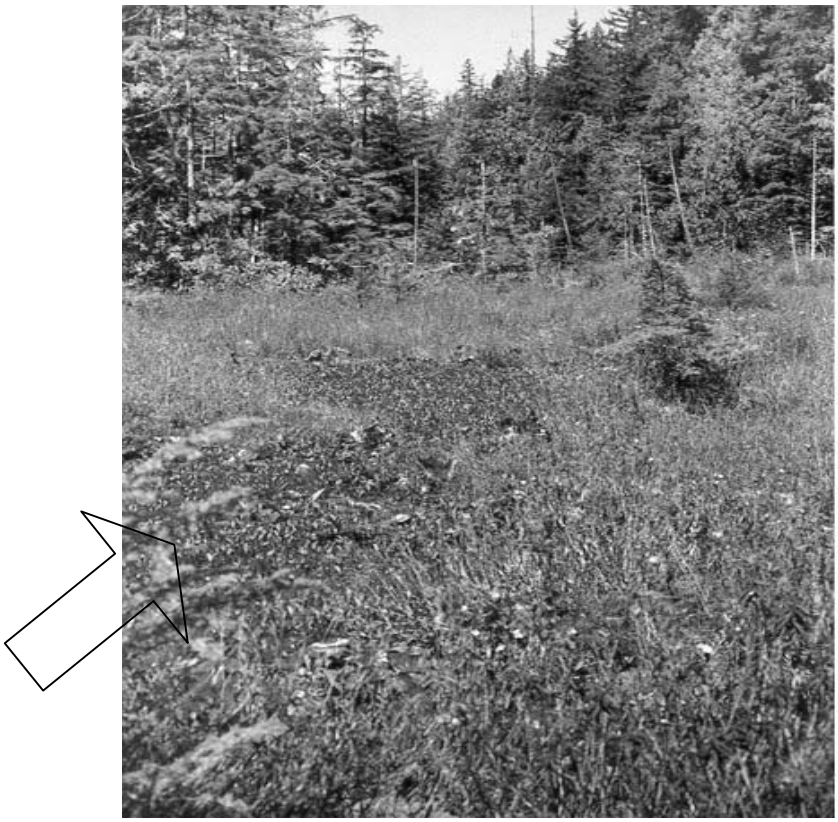

Figure 5.8 Devil's Lake, Jefferson County, WA. Foreground: *Kalmia microphylla*/Ledum groenlandicum/*Vaccinium oxycoccos*/*Sphagnum* shrub community type. Note *Menyanthes trifoliata* in adjacent shallowly inundated area (arrow). Photo: L. Kulzer

This is a species-rich community. Other sedges are common in the *Sphagnum* mat. In addition, there are many other herbs, shrubs, and trees characteristic of both *Sphagnum*-dominated peatlands, uplands, and more typical, nutrient-rich wetlands in the region. Many of these occur in the previously described community types. Others that appear to be more characteristic of this variant include *Drosera rotundifolia*, *Deschampsia cespitosa*, *Blechnum spicant*, *Platanthera (Habernaria) dilatata*, *Lycopus uniflorus*, *Rhynchospora alba*, *Carex pluriflora*, *Calamagrostis canadensis*, *Calamagrostis nutkaensis*, *Spiranthes porrifolia*, *Potentilla palustris*, *Vaccinium uliginosum*, and *Nephrophyllidium crista-galli*. Widely scattered and stunted evergreen trees, including *Pinus monticola*, *Pinus contorta*, *Thuja plicata*, and *Picea sitchensis*, also occur in this variant on the drier tops of hummocks (see Figure 5.8).

A similar variant of this community has been observed in domed and flat bogs of coastal British Columbia (National Wetlands Working Group 1988; Banner and Pojar 1987). Many of the species found in coastal British Columbia also occur in ecosystems within southwestern Washington and on the Olympic Peninsula.

***Ledum groenlandicum-Myrica gale*/*Sphagnum* spp. Community Type**

Much like the *Kalmia microphylla -Ledum groenlandicum*/*Sphagnum* spp. community, this one is a wetter, seasonally flooded, and permanently saturated community common on terraces along streams and also in basins. Minerotrophic waters may influence the species composition and growth forms found in mixed sedge, heath, and *Sphagnum* peat where this community usually occurs.

In addition to *Ledum groenlandicum*, *Myrica gale* and *Sphagnum* are co-dominant in this variant. *Kalmia microphylla* is often a co-dominant shrub, but is sometimes absent. Associated species that may best differentiate this community type from others include *Gentiana sceptrum*, *Dulichium arundinaceum*, *Rhamnus purshiana*, and *Tsuga heterophylla*. Other associated species include several sedges, *Menyanthes trifoliata*, *Pteridium aquilinum*, *Blechnum spicant*, *Nephrophyllidium crista-galli*, and others common in other shrub- and herb-dominated community types.

A tall shrub type, similar to this community, was described from ombrogenous, slope bogs in coastal British Columbia (National Wetlands Working Group 1988). In those ecosystems, *Myrica gale* is confined to the edges of meandering streams. *Juniperus communis* is a dominant shrub that is not present in Washington's *Sphagnum*-dominated peatlands. Dwarf *Pinus contorta* is the dominant tree, and *Chamaecyparis nootkatensis* and *Thuja plicata* are less common.

***Myrica gale*/*Sanguisorba officinalis*/*Sphagnum* spp. Community Type**

This community type is frequently found in the wetter and cooler portion of this region on the west side of the Olympic Peninsula from northern Grays Harbor County to the Strait of Juan de Fuca particularly on peat terraces along streams. Mixed *Sphagnum*, sedge, and heath peat is seasonally flooded with nutrient-rich water and remains wet all year. *Myrica gale* and *Sphagnum* are the dominant species. *Sanguisorba officinalis* is always present and abundant, and sometimes a co-dominant species in the three variants of this community type. Two of these variants contain a sedge as a co-dominant species (*Carex utriculata* and *Carex aquatilis*), and the third contains a co-dominant grass, *Deschampsia cespitosa*. These variants also may be differentiated by some of the other associated species. All three variants are wetter ecotypes that are seasonally flooded with minerotrophic waters and wet all year. In addition, all three share a common substrate type of mixed sedge, heath, and *Sphagnum* peat. Hummocks, if present, are no larger than 0.3 m (1 ft). Figure 5.9 shows an example of this community type.

Variant 1: *Myrica gale*/*Carex utriculata-Nephrophyllidium crista-galli-Sanguisorba officinalis*/*Sphagnum* spp.

Figure 5.9 North Bay peat area, Grays Harbor County, WA. Foreground: *Myrica gale*/*Sanguisorba officinalis*/*Sphagnum* shrub community. Background: *Pinus contorta*/*Thuja plicata*/*Myrica gale*/*Sphagnum* forested community type. Photo: L. Kulzer

This variant is most common on peat terraces along low-gradient streams and sloughs in northwestern Grays Harbor County, but also extends north in Jefferson and Clallam Counties.

In addition to *Myrica gale* and *Sphagnum*, *Sanguisorba officinalis* and *Carex utriculata* are indicators and usually co-dominant species. Occasionally *Myrica gale*, *Sanguisorba officinalis* and *Carex utriculata* have areal covers of less than 20% (i.e., not dominant). *Nephyrophyllidium crista-galli* is an indicator of this variant but not a dominant. *Gentiana douglasiana*, *Juncus ensifolius*, and *Rubus pedatus* are associates that may differentiate this variant from others.

Kunze (1994) described two growth forms of this community based on the height of *Myrica gale*. A lower growth form, contains *Myrica gale* plants up to about 1.3 m (4.3 ft). In the other growth form, *Myrica gale* plants are taller and more robust, reaching heights of between about 1.5 and 2 m (4.9 and 6.6 ft).

The National Wetlands Working Group (1988) described a similar community found at Whyac Lake on Vancouver Island, British Columbia.

Variant 2: *Myrica gale*/*Carex aquatilis-Sanguisorba officinalis*/*Sphagnum* spp.

An uncommon community type, this variant occurs on peat terraces along sloughs in northwestern Grays Harbor County and western Clallam County.

Myrica gale, Sphagnum species, *Carex aquatilis*, and *Sanguisorba officinalis* are indicators of this variant and often co-dominants. Other common associates include those frequently found in other *Sphagnum*-dominated peatland community types, as well as others. Associates that may be more indicative of this

variant include *Dodecatheon jeffryi*, *Agrostis aequivalvis*, *Drosera rotundifolia*, *Juncus nevadensis*, *Viola palustris*, and *Nuphar polysepalum*.

Kunze (1994) described two growth forms of this variant: a shorter variant with smaller, *Myrica gale* plants usually less than 0.3 m (1 ft) and a taller one with larger *Myrica gale* plants generally at least 1.3 m (4.3 ft) tall. A more species-rich assemblage of associate species occurs in the short variant. A *Myrica gale*/*Carex aquatilis* community type, which may be similar to this one, was described by Banner et al. (1986) from a fen ecosystem in coastal British Columbia.

Variant 3: *Myrica gale*/*Deschampsia cespitosa-Sanguisorba officinalis*/*Sphagnum* spp.

Like the previous community, this one occurs on seasonally flooded peat terraces adjacent to low-gradient streams and is common in northwestern Grays Harbor County.

In this variant *Myrica gale* has a low growth form and is usually an indicator and a dominant species. Other indicators and sometimes co-dominant species include *Sphagnum*, *Sanguisorba officinalis*, and *Deschampsia cespitosa*. *Carex livida* and *Gentiana sceptrum* also are indicators but apparently not dominants. Associates include *Kalmia microphylla* ssp. *occidentalis*, *Nephyrophyllidium crista-galli*, and *Juncus ensifolius*.

This community is apparently not found in the Puget Trough region. If often occurs interspersed with the *Carex livida*/*Sphagnum* community type in the southwestern Washington and Olympic Peninsula region.

***Myrica gale-Spiraea douglasii*/*Sphagnum* spp. Community Type**

This community occurs on peat deposits in basins and along sloughs in western Clallam County. Mixed *Sphagnum*, sedge, and heath peat are seasonally flooded with nutrient-rich water and remain wet all year.

Shrubs in this community are typically tall and dense. *Myrica gale* and *Sphagnum* spp. are indicators and usually co-dominant. In addition, *Spiraea douglasii* and *Trientalis europa* ssp. *arctica* are indicators and sometimes co-dominant species.

There are many associate species in this species-rich community. *Boykinia intermedia*, *Calamagrostis canadensis*, *Ranunculus flammula*, and *Potentilla anserina* ssp. *pacifica* may differentiate this community from other shrub types. A host of other species common in other *Sphagnum*-dominated peatland community types and other wetlands in the region also are present (see Tables A-2, Appendix C, Chapter 5).

This community is similar to other *Myrica gale*-dominated shrub communities, but clearly differentiable. Shrub height and density are typically greater in this variant. In addition, the presence and abundance of *Trientalis europa* ssp. *arctica* and *Spiraea douglasii* distinguish it from other *Myrica gale* variants of this community type.

5.3.3 Tree-dominated Community Types

Tree-dominated seres are less common and indicative of later seral phases of *Sphagnum*-dominated peatlands. Four community types are described: *Pinus contorta*/*Ledum groenlandicum*/*Sphagnum* spp., *Pinus contorta*-*Thuja plicata*/*Myrica gale*/*Sphagnum* spp., *Thuja plicata*-*Tsuga heterophylla*/*Gaultheria shallon*/*Lysichiton americanus*/*Sphagnum* spp., and *Tsuga heterophylla*/*Ledum groenlandicum*/*Sphagnum* spp. Tree and shrub cover in these community types is quite variable. Later seral phases are generally characterized by higher areal cover of trees and lower areal cover of shrubs and associated species. Although the *Tsuga heterophylla*-dominated community types are thought to likely represent the final sere for these ecosystems, there are few examples of mature, climax bog forest communities in the State (Rigg 1925). These communities generally have well-formed hummocks.

***Pinus contorta*/*Ledum groenlandicum*/*Sphagnum* spp. Community Type**

This community is common throughout the region in seasonally dry basins, such as old dune troughs, in coastal areas in Grays Harbor County and Pacific County. Substrate includes a mixture of *Sphagnum* and heath peat that may overlay sand or other mineral soils. Large woody debris is also common. In some cases, there is evidence of fire, which appears to have influenced peat deposits and vegetation succession.

The stand structure of *Pinus contorta* is variable, ranging from open to more closed. In communities characterized by stunted trees and open canopy, there are low-growing shrublands dominated by *Kalmia microphylla* and *Ledum groenlandicum*. In other ecosystems, *Pinus contorta* is pole-sized and forms a more closed canopy beneath which grows a shrub community of predominantly *Ledum groenlandicum* and *Gaultheria shallon*. Where there is evidence of past fires, there is little or no living *Sphagnum* spp. and *Pteridium aquilinum* is among the dominant species. Figure 5.10 shows this community type in the background.

There are a number of associated species characteristic of *Sphagnum*-dominated peatlands, non-*Sphagnum*-dominated wetlands, and upland forests in this community. Associates more characterisitic of *Sphagnum*-dominated peatlands include *Anemone oregana var. felix*, *Eriophorum chamissonis*, *Empetrum nigrum*, *Myrica gale*, *Xerophyllum tenax*, *Nephrophyllidium crista-galli*, and *Cladina rangiferina*. Associates common in non-*Sphagnum*-dominated wetlands that appear to characterize this community include *Thuja plicata*, *Lysichiton americanus*, and *Rhamnus purshiana*. *Linnaea borealis* and *Cornus unalaschkensis* are associated species more characteristic of upland forests.

This community is similar to the *Pinus contorta*-*Thuja plicata/Myrica gale*/*Sphagnum* spp. community type in this region and the one of the same name in the Puget Trough region. It appears to differ from the Puget Trough region association in several respects, including the diversity of herbaceous species, more minerotrophic conditions, and depth of peat deposits.

Figure 5.10 Carlisle Lakes peat area, Grays Harbor County, WA. Foreground right: *Kalmia microphylla*/*Ledum groenlandicum*/*Vaccinium oxycoccos*/*Sphagnum* shrub community type. Background: *Pinus contorta*/*Ledum groenlandicum*/*Sphagnum* forested community type. Photo: S. Luchessa

Other investigators (National Wetlands Working Group 1988; Banner et al. 1987) have described a tall shrub type in slope bogs of coastal British Columbia that share many of the same species. Some of the species found in ecosystems in slope bogs of coastal British Columbia, such as *Juniperus communis*, *Drosera anglica, Eriophorum angustifolium, Loisleuria procumbens*, and *Vaccinium vitis-idaea*, do not appear to occur in lowland Washington *Sphagnum*-dominated peatlands. Additional work is required to determine whether there may be specific regionally endemic flora in *Sphagnum*-dominated peatlands in Washington that compare to those in coastal British Columbia.

Pinus contorta-Thuja plicata/*Myrica gale*/*Sphagnum* spp. Community Type

Slopes, basins, and stream terraces in Grays Harbor County, western Clallam County, and possibly western Jefferson County often contain this community type. Water levels vary from just below to slightly above the surface of the mixed *Sphagnum*, sedge, heath, and woody peat.

Pinus contorta and *Thuja plicata* are the dominant trees in the open canopy of this community. *Tsuga heterophylla* is sometimes co-dominant. Trees are relatively mature, but typically smaller than 8 m (~26 ft). *Myrica gale* and *Sphagnum* are usually co-dominant. *Ledum groenlandicum*, *Gaultheria shallon*, and *Lysichiton americanus* are usually present and sometimes co-dominant.

This community is species-rich in other understory associates. Some that appear to be more specific to this community include *Agrostis aequivalvis*, *Agrostis exarata*, *Carex leptalea*, *Athyrium filix-femina*, *Calamagrostic nootkaensis*, *Dodecatheon jeffryi*, *Platanthera (Habernaria) dilatata*, *Oenanthe sarmentosa*, and *Senecio triangularis*. Decomposing large woody debris seems to provide a suitable

substrate and habitat for species more typically associated with upland forests, such as *Vaccinium ovatum*, *Cornus unalaschkensis*, and *Rubus ursinus*.

This community may be a seral phase between the *Myrica gale* community types and the *Thuja plicata*-*Tsuga heterophylla*/*Gaultheria shallon*/*Lysichiton americanus*/*Sphagnum* spp. community type (Kunze 1994). Similar *Pinus contorta*-dominated community types have been described from bogs in coastal British Columbia (Banner et al. 1987). One of the floristic differences between similar communities in coastal British Columbia is the presence of *Chamaecyparis nootkatensis*, which is found in Washington, but not typically associated with *Sphagnum*-dominated peatlands.

Thuja plicata-*Tsuga heterophylla*/*Gaultheria shallon*/*Lysichiton americanus*/*Sphagnum* spp. Community Type

This tree-dominated community type is common throughout the region in basins and on slopes. Mixed *Sphagnum*, sedge, heath, and woody peat substrates range from seasonally flooded to saturated. Downed large woody debris is frequently found and provides habitats that contribute to a mosaic of upland and wetland plant associations.

Dominant trees that form an open canopy include *Thuja plicata* and *Tsuga heterophylla*. Trees may grow relatively large and often have broken tops. At least some living *Sphagnum* is present, and it is often a co-dominant. Other indicators and sometimes dominant plants include *Gaultheria shallon and Blechnum spicant*. Other indicator but not dominant species include several plants characteristic of uplands and non-*Sphagnum*-dominated wetlands, such as *Menziesia ferruginea, Rhamnus purshiana, Vaccinium* spp., *and Lysichiton americanus*.

There are many associate species in this community. Associates that may differentiate this from other forested peatland community types include *Abies amabilis*, *Pseudotsuga menziesii*, *Agrostis oregonensis* and *Calamagrostis canadensis*. Many associates in this community are found in other *Sphagnum*-dominated peatland communities common in this region as well as non-peat-forming wetlands (see Table A-2, Appendix C, Chapter 5). *Gaultheria shallon*, *Menziesia ferruginea*, and *Vaccinium* spp. characteristic of more upland sites, are often growing on decomposing logs and mounds of soil formed by trees that have blown down (Figure 5.11).

This community is similar to the *Pinus contorta*-*Thuja plicata*/*Myrica gale*/*Sphagnum* spp. type in this region. *Myrica gale*, a dominant species there, is absent in this apparently drier community.

Similar plant communities have been recorded by other investigators in slope bogs of coastal British Columbia. The National Wetlands Working Group (1988) described a unevenly-aged, open canopy forest type dominated by *Thuja plicata*, *Chamaecyparis nootkatensis*, and *Pinus contorta*. Tree height was seldom over 20 m (66 ft) with snags and apparently decadent (“spike-topped”) *Chamaecyparis nootkatensis* and *Thuja plicata*. These authors similarly found a mixture of acid-adapted as well as more typical forest species in the well-developed herb and dwarf shrub strata within this community. The

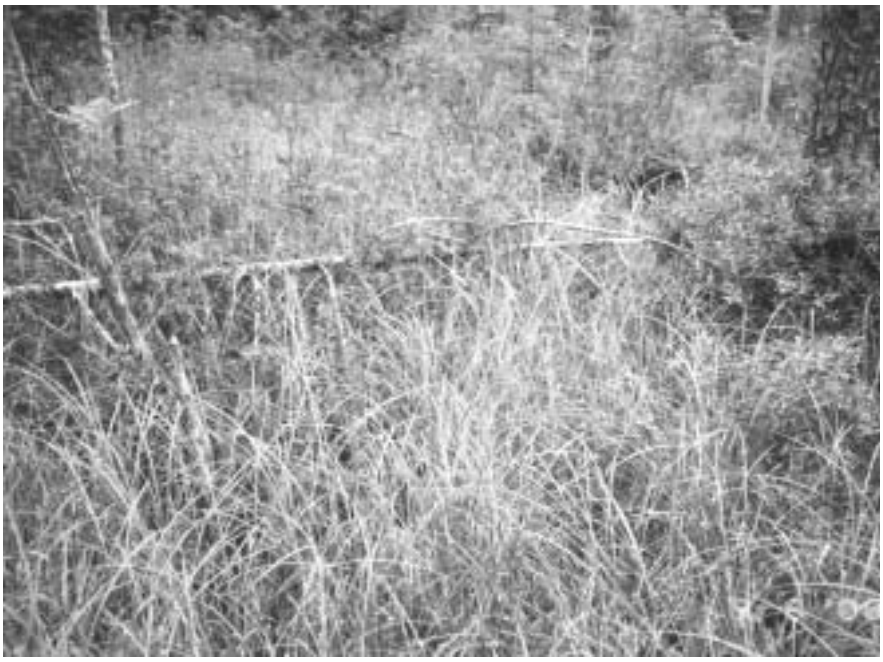

Figure 5.11 Small forested fen, Grays Harbor, WA. *Thuja plicata*/*Tsuga heterophylla*/*Gaultheria shallon*/*Lysichiton americanus*/*Sphagnum* forested community type. Note *Carex echinata* ssp. *phyllomanica* in foreground. Photo: L. Kulzer

bryophyte associations likewise were reported to include a mixture of species representative of both bog and forest communities. More research is needed to determine if bryophyte communities in *Sphagnum*-dominated peatlands in Washington exhibit similar patterns.

***Tsuga heterophylla*/*Ledum groenlandicum*/*Sphagnum* spp. Community Type**

This community type is similar to one of the same name in the Puget Trough region and occurs in basins and flat to rolling topography in western Clallam County within this region. Peat substrates composed of a mixture of *Sphagnum*, heath, and woody peat are wet all year, but may not be seasonally flooded.

Tsuga heterophylla and *Thuja plicata* trees are stunted and form an open canopy. The well-developed shrub stratum is dominated by *Ledum groenlandicum* that is between 0.6 and 1.3 m (2 and 4 ft) tall. *Gaultheria shallon* and *Sphagnum* species are other indicators that are usually abundant and often dominant species. *Thuja plicata* is often common here but it is not identified by Kunze (1994) in communities within the Puget Trough region.

Several of the herbaceous understory associates are, however, the same as those found in the Puget Trough community. Other associate species that appear to be specific to communities of this type in the southwestern Washington and Olympic Peninsula region, include several species of sedges, *Gentiana sceptrum*, *Rhamnus purshiana*, *Linnaea borealis*, *Drosera rotundifolia*, and *Malus fusca*. Additional work is required to determine if these associates are truly limited to ecosystems in southwestern Washington and the Olympic Peninsula.

5.3.4 Endangered, Threatened, and Sensitive Plants

The criteria for determining the state rank of rare species are presented in the Puget Trough section describing rare flora. In addition, a more detailed description of rare flora known, or likely to, occur in

Sphagnum-dominated peatlands is presented in the Puget Trough section. Several of those species cited in Puget Trough province on rare flora may be largely restricted in their distribution to the Olympic Peninsula and Southwestern Washington areas, including *Gentiana douglasiana, Plantago macrocarpa*, *Carex pluriflora*, and *Spiranthes porrifolia*.

Introduced Species

As previously mentioned, a number of species may have been inadvertently introduced by commercial cranberry growers. Several species native to eastern North America have been observed in cranberry fields in Oregon, including *Carex chordorrhiza*, *Juncus brevicaudatus*, *Juncus canadensis*, *Juncus pelocarpus*, *Spiraea tomentosa*, and *Hypericum boreale* (Zika, in press). Of these, only *J. canadensis* and *H. boreale* are known to occur in this region. The author has observed *J. canadensis* in at least one undisturbed ecosystem on the Olympic Peninsula. Other species observed by Zika (in press) in Oregon cranberry fields include *Vaccinium macrocarpon* and *Lysimachia terrestris*. Kunze (Personal communication, L. Kunze, May 2001) indicated that *Lysimachia terrestris* is found in at least some ecosystems in southwestern Washington. It is uncertain if other species are present in cranberry fields in western Washington or in undisturbed *Sphagnum*-dominated peatlands in this region. Peter Zika (2000) also recently identified a number of *Hypericum* species that appear to have been introduced by commercial cranberry growers who transplanted cranberries (*Vaccinium* spp.) and other species native to eastern North America in our region. Introduced species include *Hypericum boreale*, *H. canadense*, *H. ellipticum*, *H. mutilum*, and *Triadenum fraseri*. He reports that of these species, *H. boreale* is the most widespread. Others, such as *H. ellipticum*, may be restricted to cranberry fields.

Other than some of the introduced species that may be confined to commercial cranberry fields in Grays Harbor County and Pacific County, it is unclear if there are any differences in the abundance and distribution of introduced species in the different physiographic regions. There may have been more extensive alterations and disturbance to peatlands in this region from logging and cranberry growing operations. Based on the depths of peat deposits cited by Rigg (1958), these ecosystems appear to be much younger and more species rich than those in the Puget Trough. The water chemistry in *Sphagnum*-dominated peatlands in this region also may be less acidic and more fertile, although no water chemistry data were located for this physiographic region. If these factors occurred, they might favor and contribute to the establishment and spread of introduced species in this physiographic region.

5.4 Physiographic Distribution

Several plant species appear to be geographically isolated between the provinces or near the southern end of their range. According to Kunze (1994), *Myrica gale*, *Nephrophyllidium crista-galli*, *Sanguisorba officinalis*, and *Carex livida* generally do not extend into Oregon or north and east into the Puget Trough region. Some of the species, however, are found in coastal areas of British Columbia within the wetter

climate of the Pacific Oceanic Wetlands Region of Canada (National Wetlands Working Group 1988). In addition, other plants that are common in coastal British Columbia ecosystems appear rare in ours, such as *Chamaecyparis nootkatensis*, *Juniperus communis*, *Andromeda polifolia*, *Scirpus caespitosus*, *Carex anthoxanthea*, and *Carex pluriflora* (Kunze 1994). Three of these species, *Andromeda polifolia*, *Carex anthoxanthea*, and *Carex pluriflora,* appear to be rare or uncommon in Washington and are more frequently occurring at more northerly latitudes and colder climates in British Columbia and Alaska**.** Pojar and MacKinnon (1994) do not show the distribution of these species extending into Washington.

Interestingly, western Washington *Sphagnum*-dominated peatlands also appear to be at or just beyond the northern limit of some other species that are common in the ecosystems observed in Oregon. Christy (1979) noted that there has been little investigation of *Sphagnum*-dominated wetlands in Oregon. He also found what appear to be regional differences in some of the dominant species. Most conspicuously, the insectivorous plant *Darlingtonia californica* is common and forms dense communities in the ecosystems in Oregon, most, if not all of which, have formed on stabilized interdunal swales. There are no naturally reproducing populations of *Darlingtonia californica* in Washington. Weinmann and Weinmann (2000) have identified an introduced population in a bog in Skagit County. Two other species that are notably absent or relatively uncommon in western Washington peatlands, but common in western Oregon, are the ericads *Ledum glandulosum* and *Myrica californica*. *L. glandulosum* is found in some coastal peatlands in Pacific County and may extend into the Olympic Peninsula. However, it is near the northern end of its range in southwestern Washington and appears to be largely replaced by the congeneric *L. groenlandicum* in peatlands on the Olympic Peninsula and in the Puget Trough. It does, however, occur in eastern Washington peatlands and moist forests just east of the Cascade crest. *Myrica californica* may be part of the early seral phase communities in interdunal swales. It is common in coastal dune areas in Grays Harbor and Pacific counties and has been reported in some of the Olympic Peninsula peatlands but appears to be uncommon.

5.5 Succession

Several mechanisms or theories of plant succession in *Sphagnum*-dominated peatlands have been widely reported in the literature. The most common of these is the classic hydrosere, also know as lake in-fill, or quaking bog succession model (Figure 5.12). This model appears to be common in many of our systems that are associated with poorly drained topographic depressions. It has been advocated and supported by Rigg (1958) and others (Transeau 1903, Dachnowski 1925, Moore and Bellamy 1974, Mitsch and Gosselink 1993). In this successional model, small lakes become filled from the edges in towards the middle over a period of thousands of years. A mat of reeds, sedges, and grasses forms a pioneer community and floating mat upon which other herbaceous plants develop. At some point, *Sphagnum* colonizes the mat, and as *Sphagnum* peat accumulates the mat becomes increasingly isolated from mineral water. In the absence of disturbance, such as changes in climate and hydrology,

the hydrosere sequence is from open water (lake) to aquatic bed-dominated plant communities, to sedge meadow, to *Sphagnum* lawn or flats, to *Sphagnum* and evergreen scrub-shrub dominated bogs, and finally to a climax bog forest. Mitsch and Gosselink (1993) indicate that this process occurs only in small lakes that have little wave action and culminates in a classic concentric, raised bog. According to peat profiles of our *Sphagnum*-dominated peatlands developed by Rigg (1958), this successional process is common, especially for those systems that have evolved in depressions.

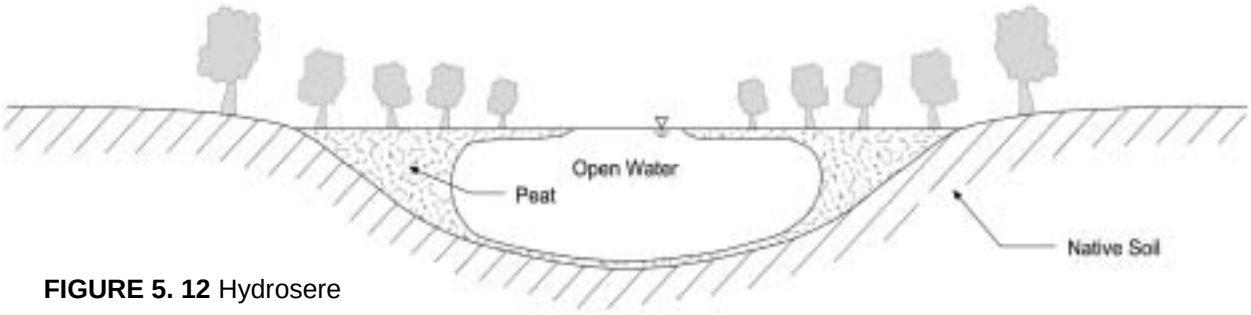

FIGURE 5. 12 Hydrosere mechanism of succession.

Other successional models have been suggested as well. Another process of peatland formation called paludification occurs when peat expands beyond the boundaries of a topographic depression or basin and encroaches into formerly dry lands. As described by Mitsch and Gosselink (1993), this process (as with others) may be triggered by climatic events, changes in geomorphology, logging, and beaver dams. As *Sphagnum* encroaches into the forest and covers the mineral soils, the lower layers of the accumulated peat become compressed over time and impede drainage or become impermeable. This causes conditions to become increasingly wet and acidic, favoring acidophilic species. This process appears to be responsible for the formation of the so-called prairie ecosystems on the Olympic Peninsula and southwestern Washington.

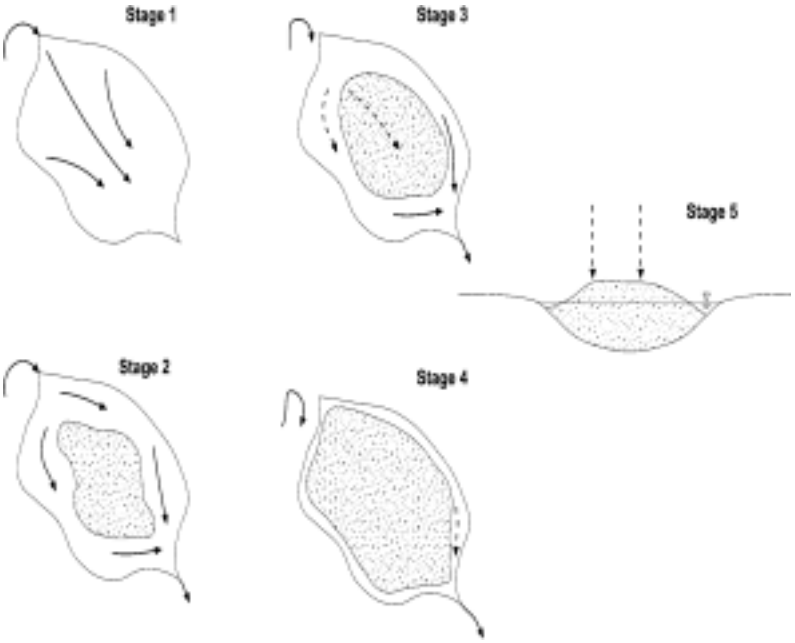

FIGURE 5. 13 Flow-through model of succession.

A third successional process, a flow-through succession model (Figure 5.13), was proposed by Moore and Bellamy (1974) for basins with surface water inlets and outlets. This process is also known

as topogenous development (Mitsch and Gosselink 1993). In this model, a peatland develops from the center of a basin with inflow and outflow and radiates outward. As the peatland develops (topogenous development), it alters the flow of surface and groundwater into, and out of, the basin. In this model, gyttja (or sedimentary deposits), and marsh vegetation result in the accumulation of organic matter. Marsh vegetation contributes to the build-up of organic material until the deposits rise above the water level and surface water flow is diverted around the peat. Over several thousand years, the marsh evolves into a poor fen and culminates in an ombrogenous bog.

5.6 Hydrology

Wetland scientists and ecologists generally agree that hydrology is perhaps the most important factor influencing wetlands. In geogenous systems, the level and duration of flooding contributes to clearly distinguishable communities along a moisture and topographic gradient. According to the U.S. Fish and Wildlife Service classification system for freshwater wetlands (Cowardin et al.1979), permanently inundated areas develop communities of aquatic macrophytes. Plant communities dominated by emergent plants inhabit seasonally flooded and permanently saturated areas, and scrub-shrub and forested community types are typically associated with somewhat drier microsites. Similar patterns along moisture gradients have been observed in *Sphagnum*-dominated peatlands, particularly those that have evolved in basins.

The duration and frequency of inundation and, perhaps more importantly, anaerobic conditions influence water quality and chemistry, microclimate, nutrient cycling and availability, and plant community composition. Increased development within the watersheds of these systems may change the amount, quantity, and quality of surface water and groundwater input into these systems. Perhaps more importantly, they may alter the hydroperiod and duration of anaerobic conditions. Conversion of forested upland areas into impervious surfaces results in reduced groundwater recharge, which may reduce shallow groundwater discharges to peatlands. In addition, stormwater runoff containing high levels of nutrients may alter peatland chemistry, making conditions more favorable for plants more typical of geogenous wetlands. Such changes may lead to reverse succession towards shrub- and tree-dominated swamps more typical of nutrient-rich ecosystems. This may lead to the loss of flora and fauna that are regionally endemic or typically found in *Sphagnum*-dominated peatlands.

Changes in hydrology and the periodicity of surface and groundwater inputs to *Sphagnum*-dominated peatlands may contribute to increased decomposition and nutrient cycling and greater nutrient availability. Anaerobic and acidic conditions in acidic peatlands are conducive to very specific communities of decomposers and relatively low decomposition and nutrient cycling rates. As long as these processes remain unchanged, peat accumulates and there is a natural successional process towards a climax bog forest.

5.7 Chapter References

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