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Ecosystems of British Columbia

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Chapter 1: Introduction

by

J. Pojar and D. Meidinger

INTRODUCTION

This report describes terrestrial ecosystems of British Columbia within the framework of the British Columbia Ministry of Forests' biogeoclimatic ecosystem classification. This system of classification is widely used in British Columbia and gives foresters, biologists, agrologists, other resource managers, and naturalists a common framework for a fundamental knowledge of landscape ecology. It thus provides a basis for ecosystem management and other practical decision-making.

Readers interested in specific applications of the classification should consult the appropriate regional field guides and reports published by the B.C. Ministry of Forests. Here we merely introduce the philosophy, principles, and methods of biogeoclimatic ecosystem classification, and give the reader some appreciation of the diversity of terrestrial ecosystems in British Columbia. We also want to reinforce the concept of the ecosystem as the fundamental unit of ecology and management.

Over the past 15 years, an enormous amount of new information about forest ecology in British Columbia has been gathered; ecosystem classification has become institutionalized; and several changes, modifications, and refinements have been made to previous schemes. Although outlined in Pojar (1983), much of the following information is new or updated.

A BRIEF HISTORY OF ECOLOGICAL CLASSIFICATION IN BRITISH COLUMBIA

The first forester to classify the Canadian forests as a whole was B.E. Fernow (Howe 1926), who produced a classification and map of 13 forest regions that were, essentially, climatic regions (Fernow 1908, 1912). As chairman of the Forestry Committee of the Commission of Conservation of the Dominion government, Fernow also initiated a forest survey of British Columbia. This work was undertaken by R.D. Craig and H.N. Whitford and took 5 years to complete. They classified forest types on the basis of composition, climate, soil conditions, and physiography. In addition, they treated each commercial tree species separately as to distribution, proportion of occurrence in the various types, silvicultural characteristics, rate of growth, and yield of marketable products. Whitford and Craig (1918) classified the forest lands of British Columbia into 12 climatic types that are not much different from the 14 biogeoclimatic zones presently recognized by the Ministry of Forests.

In addition to the federal work, small, local, essentially descriptive surveys were done by the provincial government from 1912 to the early 1940's. These surveys were probably a result of the establishment of a provincial forestry department in 1912.

In 1937, W.E.D. Halliday published *A Forest Classification for Canada*. In subsequent editions of 1959 and 1972, J.S. Rowe produced a classification and map with eight forest regions and numerous forest sections, based mainly on dominant trees and physical geography. British Columbia has five of these forest regions, in addition to grassland and tundra regions.

Zoologists, for decades, used the classification of biotic regions developed by Munro and Cowan (1947). This classification divided the province into 15 biotic regions that were used to describe the distribution of birds and mammals (Cowan and Guiguet 1975).

Soil surveys in British Columbia began in the 1930's, and in the 1940's R.H. Spilsbury (who previously had been mapping soils) began developing his site type approach to forest land classification. In 1947, this work culminated in a joint publication with D.S. Smith entitled *Forest Site Types of the Pacific Northwest* (Spilsbury and Smith 1947). Spilsbury also collaborated with E.W. Tisdale in studies of soil-plant relationships in the southern Interior (Spilsbury and Tisdale 1944), and with V.J. Krajina of the University of British Columbia, shortly after the latter's arrival from Czechoslovakia in 1949. Krajina and Spilsbury worked mostly in the Douglas-fir forests of Vancouver Island.

During the 1950's, the Research Division of the B.C. Forest Service was involved in ecological classification studies on Vancouver Island, in the central Interior, and throughout much of the range of lodgepole pine (see Illingworth and Arlidge 1960). The Forest Service conducted several co-operative studies involving other organizations in the 1960's (e.g., Green and Keser 1965; Keser 1962[1], 1969; Lacate *et al.* 1965; Spilsbury *et al.* 1965; Sprout *et al.* 1966). These studies primarily involved integrated systems of mapping and interpretation oriented to the needs of practicing foresters. Until the 1970's, however, there was only limited interest by forest managers in the practical application of an ecosystem classification (Schmidt 1977). In the 1970's, the Forest Service embarked on an ambitious, province-wide program of ecosystem classification and interpretation. This program, which follows the biogeoclimatic system, is described in the next chapter.

Starting in 1949, V.J. Krajina of the Department of Botany, University of British Columbia, began developing the biogeoclimatic ecosystem classification of the province. Dr. Krajina and a host of graduate students carried out numerous investigations throughout British Columbia. The original studies are too numerous to cite here, but will be mentioned in the following chapters. Krajina's system has been summarized in Krajina (1965, 1969), Bell (1971), Mueller-Dombois and Ellenberg (1974), Beil *et al.* (1976), Kojima (1981), Pojar (1983, 1985), Klinka and Krajina (1986), Pojar *et al.* (1987), and Meidinger and MacKinnon (1989). Biogeoclimatic ecosystem classification (BEC) is the most pervasive ecological classification system in British Columbia, not only because of the vigorous heritage of Krajina and his co-workers, but also because the B.C. Forest Service and most forest companies have adopted the system for their own continuing use.

Roughly contemporaneous with Krajina's work was that of L. Hamet-Ahti, who proposed a vegetation zonation of the province in the Fenno-Scandian tradition of classification (Hamet-Ahti 1965). This system is also fundamentally climatic, with zones stratified along gradients of latitude, altitude, and moisture.

[1] Keser, N. 1962. Paradise Lake joint project - working plan. B.C. For. Serv., Res. Div. Victoria, B.C. Unpublished report.

The habitat type system developed by Daubenmire (1952, 1968) in eastern Washington and northern Idaho, and applied by the U.S. Forest Service throughout the western United States, was used briefly by MacMillan Bloedel Limited on their holdings in coastal British Columbia (Packee 1974, 1979[2]). Compared to BEC, the habitat type system is simpler but relies mostly on vegetation. The habitat type approach was followed by A. McLean in south central British Columbia (e.g., McLean 1970), and more recently by E.C. Packee (1976) and W.J. Beese (1981) on Vancouver Island.

The B.C. Ministry of Environment also has an ecological classification for inventory and analysis of natural resources called biophysical habitat classification (Demarchi and Lea 1989). This approach originated with the Canada Land Inventory and the British Columbia Land Inventory of the 1960's and early 1970's (see Lacate 1969) and was originally a system that emphasized separate component classifications and mapping (Walmsley 1976; Walmsley and van Barneveld 1977). It has subsequently been developed into both an integrated and hierarchical system. To provide a regional physiographic and climatic context to the biophysical framework, Demarchi (1988) developed an "ecoregion" classification for British Columbia (see Ecoregion Classification section in Chapter 2). Within each ecoregion unit, biogeoclimatic subzones are used to help identify zonal climates and ecosystems. The biophysical classification system is used primarily for identifying habitat capability and suitability for animals, and for special projects dealing with wildlife habitat enhancement and development-related resource analyses.

A short-lived approach to ecological classification was developed around 1980 by D. Moon and C. Selby of Agriculture Canada, Vancouver. Their system involved the separate sampling, classification, and mapping of soil and vegetation units, and a subsequent attempt to unite soil and vegetation components into a management-oriented classification of landscape patterns or sequences. This system was essentially a component classification, whereas biogeoclimatic and habitat type classifications are strongly integrative, and biophysical classification has component, integrative, and technical (e.g., in capability classification) aspects. The Moon-Selby approach was tried on some forests of northern Vancouver Island (Moon and Selby 1981) and wetlands in the Cariboo-Chilcotin area (Selby and Moon 1981).

One outcome of the Canadian program of environmental land survey was the Ecoclimatic Regions of Canada (Ecoregions Working Group 1989). Ecoclimatic regions are similar in concept to British Columbia's biogeoclimatic subzones, but at the scale of mapping (1:7 500 000), the variation within the province was not adequately represented. Hence, this national effort generalized ecoclimatic *complexes* for much of British Columbia.

Another broad level of ecological stratification of Canada is the classification of ecozones by Wiken (1986), which represents the highest level of the environmental land survey. British Columbia is represented by five ecozones: Boreal Cordillera, Boreal Plains, Taiga Plains, Montane Cordillera, and Pacific Maritime.

[2] Packee, E.C. 1979. Keys to the vegetation zones and vegetation series of south coastal British Columbia. MacMillan Bloedel Limited, Nanaimo, B.C.

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Chapter 2: Concepts

by

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BIOGEOCLIMATIC ECOSYSTEM CLASSIFICATION

Since 1975, the B.C. Ministry of Forests has been systematically developing an ecosystem classification of the forest and range lands of the province (Schmidt 1977). The classification is based, with some modifications, on the biogeoclimatic system developed in the 1960's and 1970's by Dr. V.J. Krajina and his students at the University of British Columbia (see Krajina 1969, 1972). The system incorporates primarily climate, soil, and vegetation data. The resulting biogeoclimatic ecosystem classification (BEC) provides a framework for resource management, as well as for scientific research.

Objectives

The goal of the ecosystem classification program of the Ministry of Forests is the improvement of forest management in British Columbia. To meet that goal, the overall objective of the program has been to develop a "permanent," land-based, ecological classification which organizes our knowledge of ecosystems and serves as a framework within which to manage resources. In other words, the classification program aims both to organize and apply our knowledge of the structure, function, and relationships of terrestrial ecosystems.

The program has five specific objectives:

1. to characterize, describe, and map the broad biogeoclimatic units (zone, subzone, variant) of British Columbia;
2. to characterize and describe the major forest and range sites (ecosystems) within each biogeoclimatic unit;
3. to provide aids to field identification of these biogeoclimatic and site units;
4. to develop management interpretations for the site units or groups of similar site units (treatment units); and
5. to promote the concept of the ecosystem as the fundamental unit of resource management.

Over the past several years, the entire data base of the program (over 10 000 ecological plots) has been re-analyzed and synthesized from a provincial perspective. This is causing some changes to the classification and nomenclature (some of which are presented in this report), which will be evident in forthcoming publications from the program.

Principles and Philosophy

A thorough characterization of BEC is given in Pojar *et al*. (1987). The concepts and classification summary presented here are an abbreviated account of that material.

Before describing the classification system, it is useful to review some of the basic concepts.

Ecosystem

"Ecosystem" is the term used for the sum total of vegetation, animals, and physical environment in whatever size segment of the world is chosen for study (Fosberg 1967). Ecosystems are interacting complexes of living organisms (plants, fungi, bacteria, animals) and the physical environment (soil, air, water, bedrock) immediately affecting them. The ecosystem, as defined by Tansley (1935), has long served as the basic conceptual and functional unit of ecology. However, Tansley's concept of ecosystem is too broad to be easily integrated into a formal classification. Krajina (1960), therefore, proposed that Sukachev's (Sukachev and Dylis 1964) "biogeocoenose" be adopted because, for practical purposes, it best represented a basic ecosystem. A biogeocoenose is a special case of the ecosystem, but the two terms are used here interchangeably.

For our purposes, then, a terrestrial ecosystem (biogeocoenose) is a unit or portion of the landscape and the life on and in it. It is a landscape segment relatively uniform in the composition, structure, and properties of both the biotic and abiotic environments, and in their interactions.

Numerous organisms such as fungi, earthworms, bacteria, insects, birds, and mammals are as much a part of a forest ecosystem as are trees, shrubs, herbs, and mosses. Within the ecosystem exists a complex and dynamic set of relationships among these organisms and between them and their physical environment. For simplicity, however, the classification system deals primarily with two components of the ecosystem: vegetation and soil. The model of ecosystem function is that of Major (1951): vegetation and soils are products of climate, organisms, topography, parent material, and time. Plants and soil, considered simultaneously, integrate all ecosystem components and reflect ecosystem functioning. They are easy to observe and assess, and are considered to be the most convenient and suitable ecosystem features upon which to base the classification.

Thus, for convenience, an ecosystem can be characterized by a plant community (a volume of relatively uniform vegetation) and the soil polypedon (a volume, to the depth of the solum, of relatively uniform soil) on which the plant community occurs. An ecosystem has geographical bounds; its size is determined by the extent of the plant community and the associated soil polypedon. The lateral boundaries may be abrupt, but more commonly they are gradual. As a result, an individual ecosystem usually contains some variation in biotic and abiotic characteristics.

Climate

Climate is the most important determinant of the nature of terrestrial ecosystems. As used here, climate refers to the regional climate (Major 1951, 1963) that influences the ecosystems over an extended period of time. It is usually expressed as statistics derived from normals of precipitation and temperature; and is classified according to general atmospheric phenomena and their interactions (e.g., Koppen 1936; Trewartha 1968; Major 1977). In our case, however, climate is classified using the concept of zonal ecosystems. Because climatic data are scant or lacking in many areas and climatic analysis alone will not produce a practical ecosystem classification, a reliable functional link between climate and ecosystems is needed. The concept of the zonal (or climatic climax) ecosystem provides this link.

The zonal ecosystem is that which best reflects the mesoclimate or regional climate of an area. The integrated influence of climate on the vegetation, soil, and other ecosystem components is most strongly expressed in those ecosystems least influenced by local relief or by physical and chemical properties of soil parent materials. Such ecosystems have the following characteristics:

1. middle slope position on the meso-slope in mountainous terrain (meso-slope is the slope segment that directly affects site water movement); upper slope position in subdued terrain;
2. slope position, gradient, aspect, and location that does not result in a strong modification of climate (e.g., frost pocket, snow drift area, steep south or north aspect);
3. gentle to moderate (5-30%) slope; in dry or cold climates, on slopes to less than 5%; in wet climates, on slopes up to 50%; and
4. soils that have: (a) a moderately deep to deep (50-100^{+} cm) rooting zone, (b) no restricting horizon within the rooting zone, (c) loamy texture with coarse fragment content less than 50% by volume, and (d) free drainage.

Hence, the biogeochemical cycles and energy exchange pathways of zonal ecosystems are more or less independent of local relief and soil parent material, and are in equilibrium with the regional climate.

Other ecosystems in a given area are influenced more strongly by local physiography and the physical and chemical properties of soil parent materials. They can be drier, wetter, richer, or poorer than zonal ecosystems; and overall they do not provide as clear a reflection of the regional climate.

Because zonal ecosystems are characteristic of the regional climate that dominates their development, they are used to characterize biogeoclimatic units, which represent broad geographical areas of similar macroclimate. The distribution of zonal ecosystems also determines the geographical extent of the biogeoclimatic units.

Climax and succession

The term “climax” in ecology refers to a condition of dynamic equilibrium, a steady state rather than a static endpoint. A climax ecosystem is in theory a stable, permanent occupant of the landscape, self-perpetuating unless disturbed by outside forces or modifying factors. The living components of a climax ecosystem are in equilibrium with the prevailing factors of the physical environment, and the member species are in dynamic balance with one another.

In climax vegetation, the species of plants are self-perpetuating. Tree species of a climax forest are present as seedlings, saplings, and subcanopy and canopy trees. Similarly, climax shrubs, herbs, mosses, liverworts, and lichens are present in all stages from seedling or sporeling to maturity.

Climatic climax ecosystems reflect the development potential of the prevailing regional climate. Other types of climax ecosystems occur where certain environmental factors have a greater influence on ecosystem development than does the regional climate. An edaphic climax differs from the climatic climax due to extreme soil or substrate conditions such as very coarse texture, high base saturation, or poor drainage. A topographic climax reflects compensating effects of topography on local climate (e.g., a steep south slope). A topoedaphic climax results from the combined influence of soil and topography (e.g., shallow, stony soil on a steep south slope). A fire climax can result from recurrent wildfire.

Ecosystems arrive at climax through a process of change called ecological succession, the progressive development of ecosystems through time. The BEC system implicitly accepts the so-called traditional view of succession (Drury and Nisbet 1973). Sequences of successional stages are called seres. Several seral or successional stages are recognizable in ecosystem development from, for example, an original bare surface to a mature forest. In theory, succession ends in a mature, climax ecosystem.

Many forest ecosystems in British Columbia have escaped large-scale catastrophic destruction by fire, wind, and other agents (Parminter 1983 a,b,c, 1984). Succession can continue over centuries; large tracts of climax forest occur throughout the wetter parts of the province. Many other areas of British Columbia are dominated by ecosystems that have not attained climax and perhaps never will. In such areas, the classification must be developed primarily with maturing seral stands (usually 70 years and older). Because seral stands usually exhibit definite successional trends, potential climax trees can be predicted from stand structure and relative shade tolerances of tree species. The understory in these stands is generally well developed and can be used as an indicator of site quality, successional development, and the potential natural vegetation of a site.

Ecological equivalence

The same climax vegetation can occur over a range of sites because of the compensating effects of environmental factors on plants. In consequence, even a climax plant association may represent ecosystems from different regional climates and with different soils. The plant community that develops on a particular site also varies according to the site, disturbance, chance, and time. Hence, several different plant communities can occur on the same site. To address the problems of environmental compensation and temporary variations in vegetation, ecosystems can be organized according to the principle of biological (Cajander 1926) or ecological (Bacusis 1969) equivalence. This principle implies that sites with the same or equivalent physical properties have the same vegetation potential, and underlies site classification according to BEC.

Soil moisture regime

Soil moisture regime (SMR) is the average amount of soil water annually available for evapotranspiration by vascular plants over several years. Krajina (1969) adopted nine SMR classes (see Figure 1). Thus, in a relative sense, the driest soil in any regional climate is always "very xeric" (0) and the wettest is "hydric" (8). We use the subjective synthesis of soil properties to infer the **relative** soil moisture regime (Table 1).

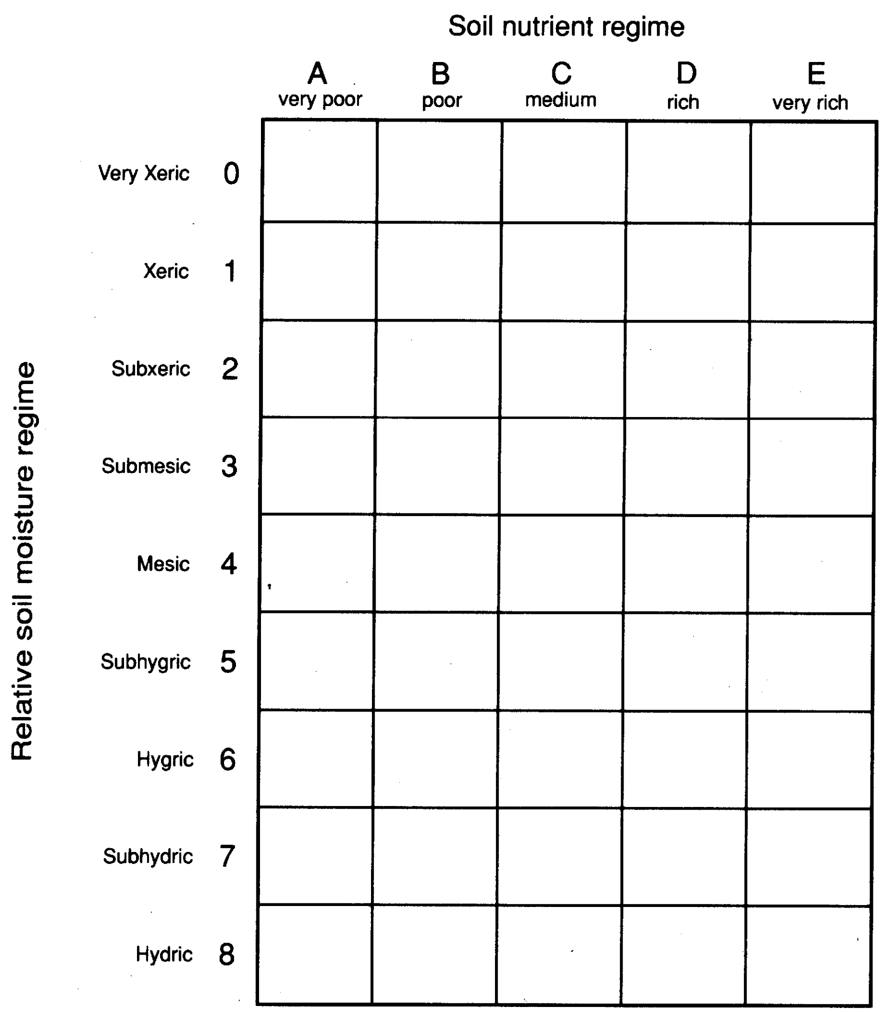

FIGURE 1. Edatopic grid of soil moisture and nutrient regimes.

TABLE 1. Relative soil moisture regime classes and characteristics[a]

MOISTURE REGIME	DEFINING CHARACTERISTICS: DESCRIPTION	DEFINING CHARACTERISTICS: PRIMARY WATER SOURCE	FIELD RECOGNITION CHARACTERISTICS: SLOPE POSITION	SOIL PROPERTIES: TEXTURE	SOIL PROPERTIES: DRAINAGE	SOIL PROPERTIES: DEPTH TO IMPERMEABLE LAYER	SOIL PROPERTIES: HUMUS FORM DEPTH	SOIL PROPERTIES: AVAILABLE WATER STOR. CAP.	SLOPE GRADIENT
VERY XERIC 0	Water removed extremely rapidly in relation to supply, soil is moist for a neglible time after ppt	precipitation	ridge crests, shedding	very coarse (gravelly-S), abundant coarse fragments	very rapid	very shallow (<0.5m)	very shallow	extremely low	very steep
XERIC 1	Water removed very rapidly in relation to supply; soil is moist for brief periods following ppt	precipitation			rapid				
SUBXERIC 2	Water removed rapidly in relation to supply; soil is moist for short periods following ppt	precipitation	upper slopes, shedding	coarse to mod. coarse (LS-SL), mod. coarse frag.	rapid to well	shallow (<1m)	shallow	very low	steep
SUBMESIC 3	Water removed rapidly in relation to supply; water available for moderately short periods following ppt	precipitation						low	moderate
MESIC 4	Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year. Available soil moisture reflects climatic inputs	precipitation in moderately to fine-textured soils & limited seepage in coarse textured soils	mid-slope, normal, rolling to level	moderate to fine (L-SiL), few coarse fragments	well to moderately well	moderately deep (1-2m)	moderately deep	moderate	
SUBHYGRIC 5	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possibly mottling below 20 cm	precipitation and seepage	lower slopes, receiving	variable, depending on seepage	moderately well to imperfect	deep (>2m)	deep	high	slight
HYGRIC 6	Water removed slowly enough to keep the soil wet for most of the growing season; permanent seepage and mottling present; possible weak gleying	seepage			imperfect to poor	variable, depending on seepage		variable, depending on seepage	
SUBHYDRIC 7	Water removed slowly enough to keep the water table at or near the surface for most of the year; gleyed mineral or organic soils; permanent seepage less than 30 cm below the surface	seepage or permanent water table			poor to very poor		very deep		
HYDRIC 8	Water removed so slowly that the water table is at or above the soil surface all year; gleyed mineral or organic soils	permanent water table	depressions, receiving	variable, depending on seepage	very poor	variable, depending on seepage		variable, depending on seepage	flat

[a] From Walmsley *et al.* (1980), and Luttmerding *et al.* (1990).

To assess the moisture regime of a site quantitatively, Klinka *et al.* (1984) suggested the use of a water balance approach. They proposed a classification of **actual** soil moisture regimes (ASMR), using the occurrence and duration of phases of water use, the ratio between actual and potential evapotranspiration (AET:PET), and the occurrence and depth of the water table (see Table 2).

The ASMR classes can be related to the relative soil moisture classes for each regional climate (Green *et al.* 1984; Lloyd *et al.* 1990). In this report, ASMR's are used in the ecosystem descriptions.

TABLE 2. Classification of actual soil moisture regimes

Differentia	Class
Rooting-zone groundwater absent during the growing season	
Water deficit occurs (soil-stored reserve water is used up and drought begins if current precipitation is insufficient for plant needs)	
Deficit > 5 months (AET/PET ≤ 55%)	excessively dry
Deficit > 3 months but ≤ 5 months (AET/PET ≤ 75 but > 55%)	very dry
Deficit > 1.5 months but ≤ 3 months (AET/PET ≤ 90 but > 75%)	moderately dry
Deficit > 0 but ≤ 1.5 months (AET/PET > 90%)	slightly dry
No water deficit occurs	
Utilization (and recharge) occurs (current need for water exceeds supply and soil-stored water is used)	fresh
No utilization (current need for water does not exceed supply; temporary groundwater table may be present)	moist
Rooting-zone groundwater present during the growing season (water supply exceeds demand)	
Groundwater table > 30 cm deep	very moist
Groundwater table > 0 but ≤ 30 cm deep	wet
Groundwater table at or above the ground surface	very wet

Soil nutrient regime

Soil nutrient regime (SNR) is the amount of essential soil nutrients that are available to vascular plants over a period of several years. Complex relationships among climate, topography, soil, and organisms complicate evaluation of SNR's, especially if one is trying to determine quantitative criteria. Krajina adopted six SNR classes, five of which are presented in Figure 1. The sixth, which is only presented where appropriate, is an ultrarich category (F). The classes are assessed according to a subjective synthesis of soil properties (Figure 2).

Edatopic grid

The edatopic grid is a moisture/nutrient grid of relative SMR and SNR (Figure 1). For most regional climates, a grid of eight (0-7) RSMR's and five SNR's is used to display relationships among the site units occurring in the climate. Wetlands with a RSMR of 8 have seldom been sampled in our work to date.

Classification System

The BEC system is a hierarchical classification scheme with three levels of integration: regional, local, and chronological (Figure 3). Coupled with this, BEC combines three classifications: climatic (or zonal), vegetation, and site. At the regional level, the vegetation/soil relationships are used to infer the regional climate; this climatic or zonal classification defines biogeoclimatic units. At the local level, ecosystems are classified using vegetation and soils information, into vegetation and site units. At the chronological level, ecosystems are organized according to site-specific chronosequences. To do this, the vegetation units recognized for a particular site unit are arranged according to site history and successional status.

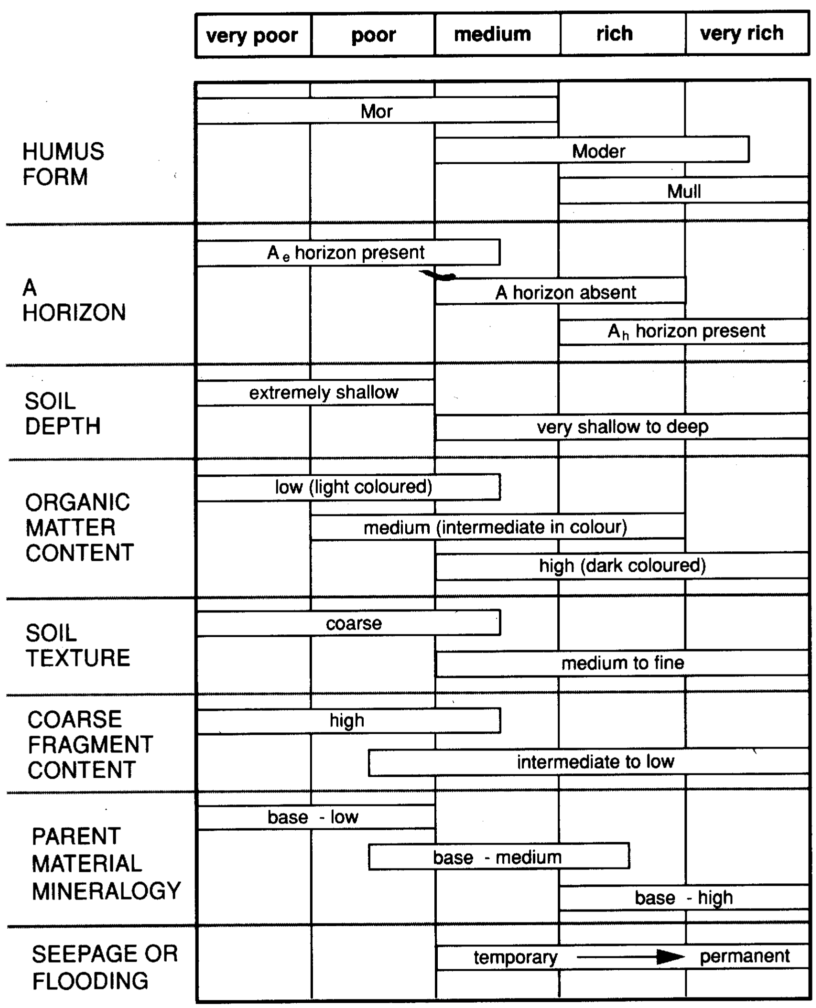

FIGURE 2. Relationships between site properties and soil nutrient regime.

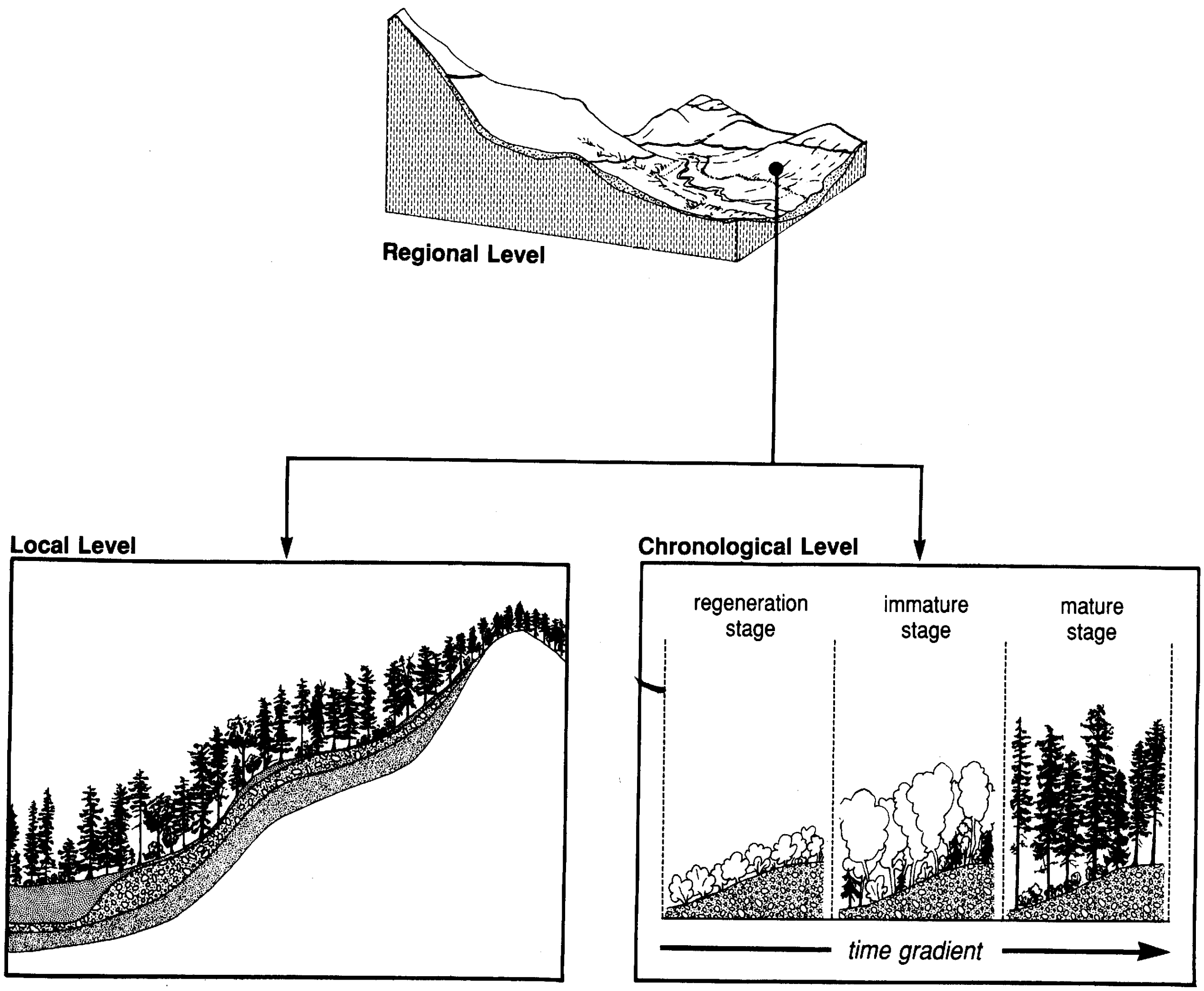

FIGURE 3. Levels of integration in the classification system.

For practical purposes, users need only be concerned with the zonal and site classifications (Figure 4); the vegetation classification, however, is integral to developing both of these (Figure 5).

Vegetation classification

Vegetation is emphasized because it is considered to be the best integrator of the combined influence of a variety of environmental factors affecting the site, and because floristic criteria can be determined to differentiate units.

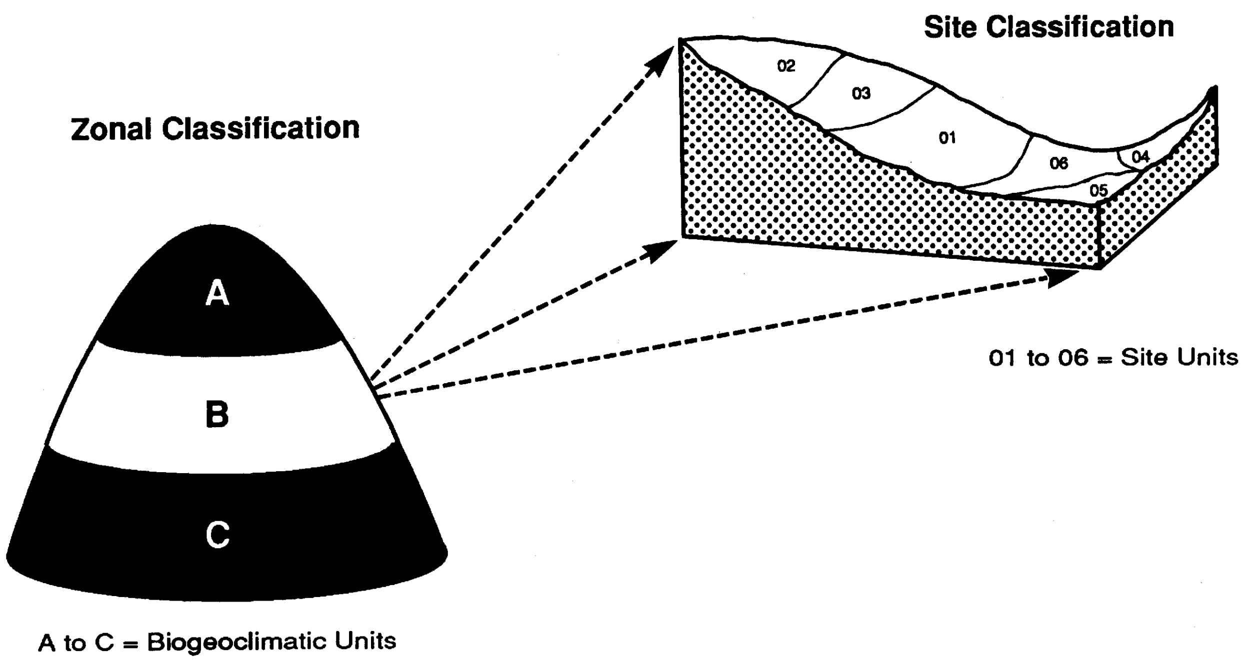

FIGURE 4. Schematic relations between zonal and site classifications.

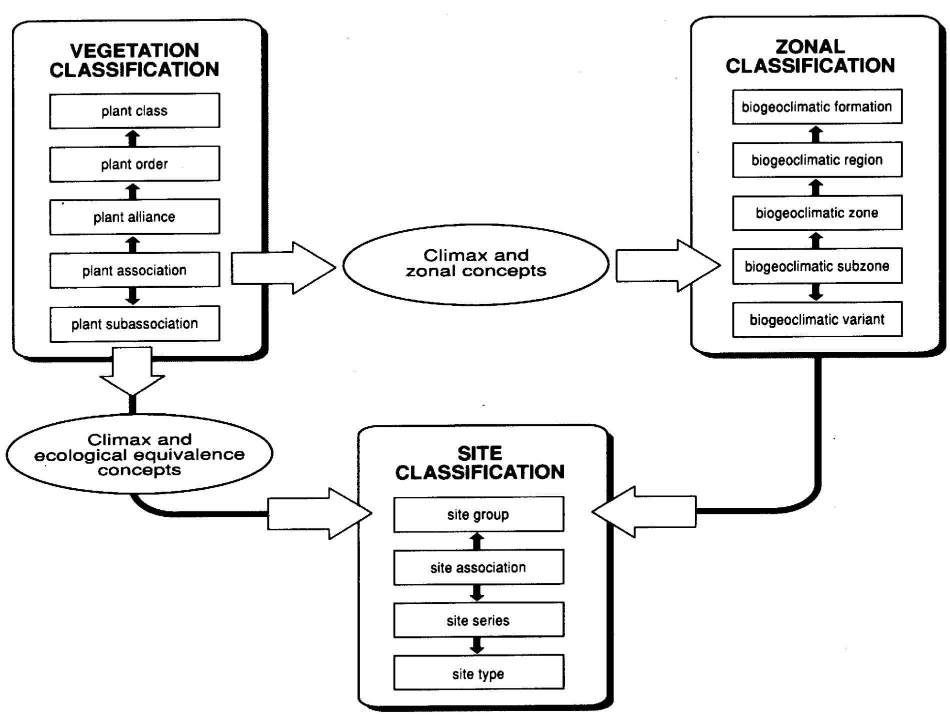

FIGURE 5. Categories and relationships of vegetation, zonal, and site classifications.

In keeping with the Braun-Blanquet approach (Westhoff and van der Maarel 1980), vegetation units are floristically uniform classes of plant communities. They are arranged in a hierarchy where the **plant association** is the basic unit; **alliances**, **orders**, and **classes** are groups of associations, and **subassociations** are divisions of an association (Figure 5). Vegetation units are differentiated using "diagnostic combinations of species" (Table 3). These are species that distinguish one vegetation unit from another, when the unit is considered within the context

TABLE 3. Differentia and examples for classifications and categories of Biogeoclimatic Ecosystem Classification

Category	Differentia	Example
	Vegetation classification	
Class	exclusive DCS[a]	*Picea (glauca, engelmannii)*
Order	exclusive DCS	*Picea (engelmannii* x *glauca) - Pleurozium*
Alliance	exclusive DCS	*Picea - Vaccinium*
Association	exclusive DCS	*Picea - Vaccinium*
Subassociation	exclusive DCS or non-exclusive DCS with 2 or more species	*Picea - Vaccinium; typicum*
	Zonal classification	
Formation	climatic group (Koppen/Trewartha)	Microthermal Coniferous Forest
Region	climatic type (Koppen/Trewartha); DCS derived from zonal and non-zonal climax ecosystems	Canadian Boreal Forest
Zone	zonal plant order (DCS derived from zonal climax ecosystems)	Sub-Boreal Spruce (SBS)
Subzone	zonal plant association (DCS derived from zonal climax ecosystems)	Moist Cold Central SBS (SBSmc)
Variant	zonal plant subassociation (exclusive or non-exclusive DCS derived from zonal climax ecosystems)	Babine SBSmc (SBSmc2)
	Site classification	
Association	range of biogeoclimatic subzones or variants, soil moisture regimes, soil nutrient regimes, and if appropriate, an additional environmental factor or property controlling vegetation of the parent plant association	Sxw[b] - Huckleberry
Series	biogeoclimatic subzone or variant	SBSmc2/Sxw - Huckleberry
Type	one or more factors or properties that are identified as the major source of edaphic variation within the site association	SBSmc2/Sxw - Huckleberry/Sandy

[a] DCS = diagnostic combination of species; must include at least one differential - or dominant differential - species.

Differential (d): species that is clearly associated with more than one unit in a hierarchy; presence class III and at least two presence classes greater than in other units of the same category and circumscription.

Dominant differential (dd): species that does not meet the presence criteria above but shows clear dominance in more than one unit in a hierarchy; presence class III, mean species significance 5 and two or more signficance classes greater than in other units of the same category and circumscription.

Present classes as percent of frequency: I = 0-20, II = 21-40, III = 41-60, IV = 61-80, V = 81-100. Species significance classes and percent cover: + = 0.1-0.3, 1 = 0.4-1.0, 2 = 1.1-2.2, 3 = 2.3-5.0, 4 = 5.1-10.0, 5 = 10.1-20.0, 6 = 20.1-33.0, 7 = 33.1-50.0, 8 = 50.1-75.0, 9 = 75.1-100.

[b] Sxw = *Picea engelmannii* x *glauca.*

of the circumscribing vegetation unit from the next highest level. Determining diagnostic species requires that tables of vegetation data be compared and a hierarchy formed. Tree species, or forest types, are emphasized at the upper levels of the hierarchy (classes/orders), and understory vegetation at the lower levels.

Although the vegetation classification could be developed for any vegetation data, regardless of age of the stand or sward, we have concentrated on classifying the late successional ecosystems because they are most useful to our classification and its present application.Vegetation units are named after one to four plant species that dominate or characterize the unit (see, for example, Table 3).

Vegetation classification determines the plant associations and subassociations. These units are important for determining biogeoclimatic subzones and variants, and site associations.

Zonal (climatic) classification

Biogeoclimatic units are the result of zonal (climatic) classification and represent classes of ecosystems under the influence of the same regional climate. As in vegetation classification, there is a hierarchy of units, with the biogeoclimatic subzone being the basic unit (Figure 5). Subzones are grouped into zones, regions, and formations, and divided into variants. In addition, phases are recognized and used, although the phase is not a formal category in the classification.

A **biogeoclimatic subzone** has a distinct climax (or near-climax) plant association on zonal sites (Table 3). A subzone thus consists of unique sequences of geographically related ecosystems in which climatic climax ecosystems are members of the same zonal plant association. Such sequences are influenced by one type of regional climate. Since subzones are the basic units of zonal classification, they are the first to be recognized in the classification process.

Subzones contain considerable variation, for which we have provided the category of **biogeoclimatic variant**. Variants reflect further differences in regional climate and are generally recognized for areas that are slightly drier, wetter, snowier, warmer, or colder than other areas in the subzone. These climatic differences result in corresponding differences in vegetation, soil, and ecosystem productivity. The differences in vegetation are evident as a distinct climax plant subassociation (Table 3). They can also be manifested as changes in the proportion and vigour of certain plant species, or as variations in successional development or the overall pattern of vegetation over the landscape. Differences in soils can be confined to the variation in intensity of certain soil-forming processes; they need not be markedly expressed in morphological features.

The **biogeoclimatic phase** accommodates the variation, resulting from local relief, in the regional climate of subzones and variants. Phases are useful in designating significant, extensive areas of ecosystems that are, for topographic or topoedaphic reasons, atypical for the regional climate. Examples could be extensive areas of grassland occurring only on steep, south slopes in an otherwise forested subzone; enclaves of apparently coastal forest on moist, northeastern slopes in an interior, continental subzone; or valley-bottom, frost-pocket areas in mountainous terrain. The biogeoclimatic phase relates to local climate and hence is not a formal category in the classification, but phases can be identified and mapped for management or descriptive purposes.

We group subzones with affinities in climatic characteristics and zonal ecosystems into **biogeoclimatic zones**. A zone is a large geographic area with a broadly homogeneous macroclimate. A zone has characteristic webs of energy flow and nutrient cycling and typical patterns of vegetation and soil. We characterize zones as having a distinct zonal plant order; that is, the vegetation classification groups zonal plant associations in the category of plant order. Zones also have characteristic, prevailing soil-forming processes, and one or more typical, major, climax species of tree, shrub, herb, and/or moss.

Zones are usually named after one or more of the dominant climax species in zonal ecosystems (the Alpine Tundra Zone is a self-explanatory exception), and a geographic or climatic modifier.

Subzone names are derived from classes of relative precipitation and temperature or continentality. Variants receive short geographic labels.

Zones are given a two- to four-letter code, corresponding to the name. For example, the Coastal Douglas-fir zone code is CDF (see zone chapters for others).[3] Subzone codes correspond to the climatic modifiers (Figure 6); variants are numbered from south to north; phases are noted by an alphabetic code. For example,

$$\underbrace{\textbf{ICH}}_{\text{zone}}\,\underbrace{\textbf{mc}}_{\text{subzone}}\,\underbrace{\textbf{1}}_{\text{variant}}\,\underbrace{\textbf{a}}_{\text{phase}}$$

refers to the coastal (a) phase, of the Nass (1) variant, of the Moist Cold (mc) subzone, of the Interior Cedar — Hemlock (ICH) zone.

Site classification

Site units represent groups of sites or ecosystems that, regardless of present vegetation, have the same, or equivalent, environmental properties and potential vegetation. Vegetation units do not provide the most efficient, convenient, or stable framework for ecosystem classification because vegetation changes over time, thereby continually dating the results of its classification. For this reason we use the potential vegetation of a group of sites, along with selected environmental properties, to delineate site units.

The potential vegetation of a group of sites, as determined by our climax or near-climax plant associations and subassociations, provides the initial delimitation of **site associations**, the basic unit of site classification. The site association can be considered as all ecosystems capable of producing vegetation belonging to the

[3] Codes also presented in Table 4, p. 56-57.

same plant association (or subassociation, in some cases) at climax. Thus, a site association is a group of related ecosystems physically and biologically similar enough that they have or would have similar vegetation at climax. One site association can include a variety of disturbance-induced, or seral, ecosystems, but succession should ultimately result in similar plant communities at climax throughout the association. The use of plants from the climax plant association to name site associations does not imply that climax vegetation dominates the present landscape. Many ecosystems in the province reflect some form of disturbance and are in various stages of succession towards climax.

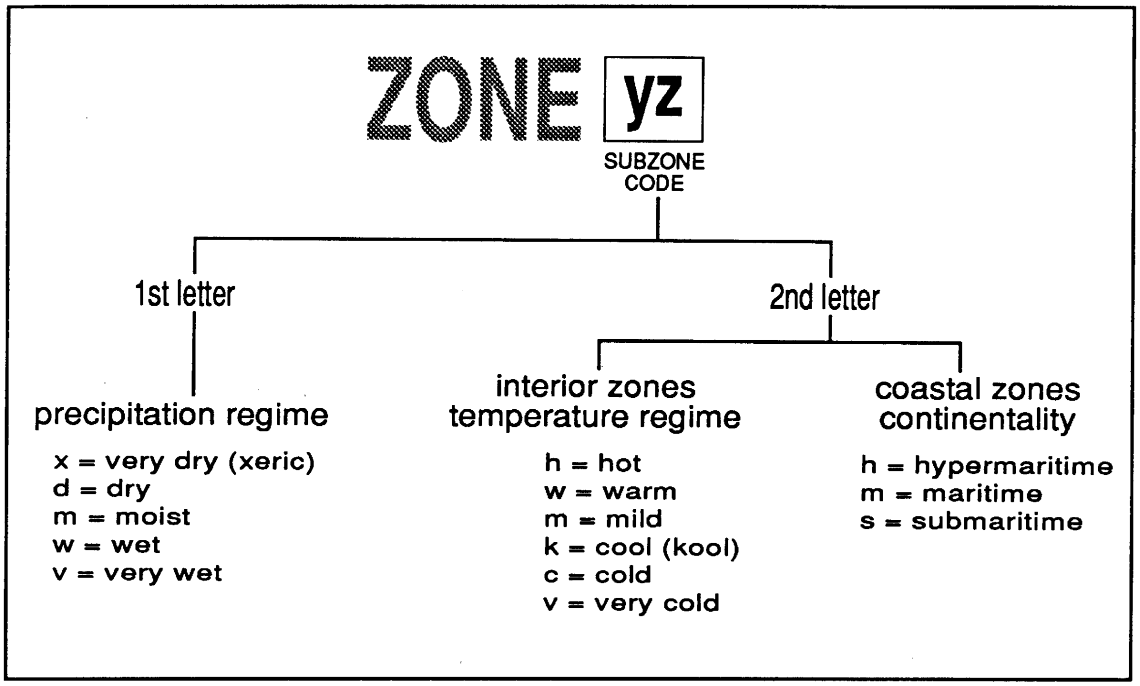

FIGURE 6. System of naming and coding subzones. Precipitation and temperature regimes, and degree of continentality, are all relative within the biogeoclimatic zone.

Site associations can be differentiated from one another by the range of environmental properties outlined in Table 3. It is these site properties that are used to identify a site association in an early successional stage. The site association is equivalent to the habitat type of Daubenmire (1968) and Pfister *et al.* (1977) and conceptually similar to the forest type of several European classifications (see Jahn 1982).

The name of site associations follows the name of the parent plant association or subassociation as closely as possible. Common names of one to four species are used and tree species codes are usually substituted to shorten the name. For example, the parent plant association of the Sxw — Huckleberry site association is the *Picea —Vaccinium* plant association (Table 3).

A site association can contain ecosystems from several different climates and so be variable in actual site conditions. Dividing the association into **site series** using subzones and variants (Table 3) produces site units that are climatically, and therefore usually edaphically, more uniform. As a result, site series are more predictable in their response to management.

Site series have the same name as the site association, prefixed by the biogeoclimatic subzone or variant and a “slash” (see Table 3). Each site series is also given a two-digit numeric code. So, for example, the SBSmc2/Sxw — Huckleberry site series (Table 3) is coded SBSmc2/01 in all field guides and data forms.

Ideally, the name for a site series would incorporate features of physiography and soils, but in reality that is impractical. However, a reference to the SBSmc2/Sxw — Horsetail site series signifies that group of ecosystems which occurs at the base of slopes or in depressions, over poorly to moderately drained fluvial, morainal, or lacustrine parent materials; which has developed Gleysols, Dystric Brunisols or Cumulic Regosols and Hydromoder or Mormoder humus forms[4]; which generally has an excess of soil water and an abundance of nutrients but often poor soil aeration; and which at climax develops vegetation that may be characterized by the *Picea — Equisetum* plant association. Provided the classification is adequately described, explained, and understood, a relatively simple name can convey a great deal of useful information about individual ecosystems in the field.

To form edaphically more consistent units, site series are partitioned into **site types** according to one or more edaphic properties thought to affect ecosystem response to management. Site types reflect the compensating effects of various site conditions within a uniform climate which, together in different combinations, produce similar vegetation. Of all the ecosystem units, they are uniform in the largest number of environmental characteristics.

Site types are named with a single edaphic modifier and are given a two-digit numeric code. For example, the Sandy site type in Table 3 might be coded as follows: SBSmc2/01/02. Often the site series is also the operational unit on which we base silvicultural and other management decisions. For example, to make prescriptions the forester usually only need know that a sub-boreal site belongs to the Pine — Huckleberry — Cladonia or the Spruce — Horsetail site series. In some cases, however, the site series must be subdivided into more operationally significant units. This is especially true of widespread site series that encompass a range of habitat conditions.

The **site phase** can be used for better site differentiation and identification. It is not a formal unit in the classification, but it can be used to subdivide site series or site types. For example, recognition of two general particle size classes (coarse and fine) as two phases of widespread sub-boreal site series gives much more meaning to silvicultural interpretations of these units. In other cases, site phases could be based on slope classes, aspect, parent materials, soil climate, or bedrock geology. Recognizing

[4] Humus form (forest floor) terminology after Klinka *et al.* (1981).

any change in such characteristics can be important because they influence an ecosystem's response to external disturbances. Use of the phase also allows more consistent prediction of ecosystem response to management treatments.

A phase is named according to the differentiating criteria and is given an alphabetical code. For example, a coarse-textured phase of a SBSmc2/01 site series would be coded SBSmc2/01(a).

The representation of edaphic variation within the site series as site phases or site types is related to the number of sample plots and the perceived need for more consistent classes. Because site types are more edaphically uniform, a greater number of sample plots is required to characterize types adequately. A classifier may choose only to recognize phases where the data base is limited. As well, where the "direct" interpretations to be made for the edaphically consistent units are few and straightforward and the edaphic variation is complex, the classifier could recognize a few phases instead of several to many types.

In some cases, another informal unit termed the site variation is used to describe vegetative trends or floristic features that diverge from the central concept of the association. Usually such variation is related to short-term successional factors and it involves recent stand history. Variations could be recognized on the basis of stocking, species composition of the tree stratum, understory structure and composition, etc.

Successional classification

Successional (often termed "seral") classification in BEC involves an integration of the site and vegetation classifications and the determination of structural stage of development. Klinka *et al.* (1985) and Hamilton (1988) have presented their concepts of how this could take place. Since very little classification of successional ecosystems has occurred using BEC (see Klinka *et al.* 1985; DeLong 1988; Lloyd *et al.* 1990), some differences in the recognized structural stages exist.

Over most of our managed and natural forests there is a complex pattern of seral ecosystems. As previously explained, the BEC system makes sense of the array of ecosystems through site classification. After that, the series of successional ecosystems that occur on a site unit can be classified into seral plant associations and seral structural stages. The result is the application of a seral plant association name to one or more seral stages. Depending on the use for the classification and the relationship between the seral stages and plant associations, the presentation will emphasize either the seral stage or the association. A code for the stage (or several stages) is used to identify the seral stage/association segment of a site series in field guides and data banks. For example, a pole-sapling stage of the SBSmc2/01 would be coded SBSmc2/01-PS.

Methods

Field procedures of the Ministry of Forests' classification program follow those detailed in the manual *Describing Ecosystems in the Field* (Walmsley *et al*. 1980; Luttmerding *et al*. 1990). Analytic and synthetic methods adopted by the Ministry have been described by Klinka *et al*. (1979, 1977[5]), and are similar to those of Krajina and his students (e.g., Brooke *et al*. 1970; Wali and Krajina 1973; Kojima and Krajina 1975). Nevertheless, it seems that the Ministry's methods are still not well understood and need further explanation.

Plot sampling

Field sampling is stratified on the basis of biogeoclimatic units and soil moisture and nutrient regimes. Based on reconnaissance and other available information, tentative biogeoclimatic units are often delineated before plot selection. An edatopic grid (Figure 2) is used as an aid to stratification within each biogeoclimatic unit. We try to sample five or more plots representing each of the possible combinations of moisture and nutrients. Intensity of sampling varies according to the areal extent of the ecosystem, its apparent diversity, and its importance for forestry or range management. Sampling intensity also depends on available access and the nature and scale of the project.

We sample selectively. Sample plots are located in habitats that are as uniform as possible; heterogeneous, transitional, or disturbed sites are avoided. To date, most sampling has been confined to climax or near-climax ecosystems. Plots are located so as to represent particular combinations of moisture and nutrients (see Table 1, Figure 2). Slope position, indicator plant species, relative tree growth, soil texture, seepage, and base status of parent materials are used as clues to moisture and nutrient regimes. The professional judgement of experienced fieldworkers in selecting representative ecosystems is an important part of the approach.

The smallest unit of sampling in ecosystem studies is the "sample plot" (also termed "sample plot" by Mueller-Dombois and Ellenberg [1974] for vegetation sampling, and termed "pedon" by Soil Survey Staff [1975] for soil sampling). Plot size in forest stands is usually 400-500 m^2; plot shape is variable but usually square or rectangular. Plot size is reduced for grassland, wetland, or alpine sampling. At each site, the standardized provincial site, soil, humus form, vegetation, and mensuration data sheets are completed according to the procedures in Luttmerding *et al*. (1990).

Analysis

The information collected from the sample plots must be analysed and integrated into a usable classification. To do this, we code vegetation and selected soil, physical, and mensurational data for tabulation by a computer program

[5] Klinka, K., J.P. Kimmins, J.T. Standish, and S. Phelps. 1977. Initial data synthesis in the synecological classification. B.C. Min. For., Vancouver, B.C. Unpublished manuscript.

developed by Klinka and Phelps[6] and expanded by Meidinger *et al*. (1987) and Emanuel[7,8]. The program sorts, organizes, and presents these data; it does not perform any classification. This procedure aids in the traditional Braun-Blanquet method of classification by tabular analysis (see Mueller-Dombois and Ellenberg 1974), mainly by reducing manual procedures and transcription errors.

The program produces environment, vegetation, and vegetation summary tables. The classifier specifies the tentative ecosystem units, relying largely on personal knowledge and judgement. The program summarizes environment and vegetation data according to the specified units. The summary vegetation table then presents species presence (frequency of occurrence in sample plots) and mean cover or species significance (an estimate of both cover and abundance) for all plant species in all differentiated units. Successive working tables can be rapidly produced; additions, corrections, and rearrangements can be easily made.

The classifier generally groups plots by tentative biogeoclimatic unit and by estimated moisture/nutrient regime. The vegetation tables list species by stratum or layer (trees, shrubs, herbs, etc.) in order of presence and mean percent cover for each ecosystem unit. Plots or groups of plots that are floristically different may be separated or moved to another group. Plots that appear similar in moisture and nutrient regime are experimentally merged. Similar groupings from other biogeoclimatic units are compared and then fit into the vegetation hierarchy. Through this process of computer-assisted, experimental grouping, rearrangement, and refining of groups, the plant and site associations are defined (Poore 1962). Site associations may then be subdivided into site series, types, or phases, often on the basis of edaphic factors as summarized by the environment tables.

Mapping

Biogeoclimatic mapping begins with a review of available ecosystem classifications within or near the mapping area. Biogeoclimatic units are characterized and summarized in synopsis form. A draft map, based on physiography and the extrapolation of elevational limits, may be prepared. Field mapping is done along selected transects by ground and air survey. The ground survey includes brief descriptions (rapid reconnaissance) of vegetation and soils; special attention is paid to zonal ecosystems. Boundaries drawn in the field are based on the type and occurrence of zonal ecosystems, floristic combinations, and the distribution of azonal, edaphic climax ecosystems. Final boundaries are drawn after fieldwork and data analysis have been completed. Boundaries outside transects are extrapolated on the basis of elevation and physiography.

A revision (at 1:2 000 000) of Krajina's maps of the biogeoclimatic zones of British Columbia has been prepared by the B.C. Ministry of Forests (1988). Colour biogeoclimatic unit maps, including zones, subzones, and variants, of the Coast and

[6] Ibid.

[7] Emanuel, J. 1985. A vegetation classification program. Univ. B.C., Faculty of Forestry, Vancouver, B.C. Unpublished manuscript.

[8] Emanuel, J. 1990. VTAB-PC Version 1.1. Software and documentation for personal computer version of VTAB. B.C. Min. For., Victoria, B.C.

northern Interior have been mapped at scales of 1:500 000 to 1:600 000 (Nuszdorfer *et al*. 1984; McLeod and Meidinger 1986; Pojar *et al*. 1988). Maps in draft form at scales of 1:100 000 to 1:500 000 are available for the rest of the province through the Forest Service regional offices.

Ecosystem mapping assists area-specific land management by providing managers with information on the location and distribution of site units. Mitchell *et al*. (1989) outline the methods for ecosystem mapping, using the Ministry's experience to date (e.g., Klinka *et al*. 1980b; Inselberg *et al*. 1982; Lindeburgh and Trowbridge 1984; Banner *et al*. 1985; Mitchell and Eremko 1987).

Ecosystem mapping follows sampling and classification. A key to site units may be prepared, using readily identifiable features of the vegetation and physical environment. Mapping is based on a combination of ground and air surveys and interpretation of available air photographs (usually black and white at 1:15840 or 1:20000). Photo-interpretation relies on characteristics of the tree layer and identifiable environmental characteristics such as elevation, topographic position, and slope gradient. Map delineations are tentatively labelled as to their component site units and are then field-checked to verify boundaries and labels. Map units vary according to the intensity and scale of mapping. Some map units are site series, types, or phases; others are complexes of site units.

Uses

A multifactor, integrative, hierarchical classification can be put to many uses, depending on the parameters incorporated in the classification and the needs and objectives of its users. As a natural taxonomic classification (i.e., one based on the characteristics of ecosystems themselves), ecosystem classification provides an ideal framework for other scientific research, including plant autecology and synecology, soil investigations, climatology, and biogeography. The classification also forms the basis for the selection and establishment of a system of natural areas or ecological reserves in British Columbia (Krajina *et al*. 1978; B.C. Ministry of Parks 1989). With its strong climatic foundations, the classification can provide useful information to agrologists and horticulturists. Through its interpretive and predictive powers, however, the ecosystem classification in British Columbia has made its most valuable contributions to the field of natural resource management.

Sound management of natural resources requires knowledge and understanding of large amounts of information about diverse yet inter-related physical and biological resources, including water, soil, timber, range, wildlife, and recreation. Traditionally, resource managers have carried out separate inventories of each resource of importance in an area, then attempted to analyse the different factors and weigh the consequences of various combinations of uses.

An ecosystem classification organizes knowledge about various resources, at both generalized and detailed levels. It provides a framework for the presentation of information, interpretations, and predictions about ecosystems. It serves as a common denominator for developing, comparing, and evaluating management strategies, and predicting the consequences of management decisions on complex systems. Hence, ecosystem classification is well suited to helping us achieve the objectives of integrated resource management — objectives that have long been pursued but difficult to reach.

To date, most ecosystem classification in British Columbia has been applied to the management of timber, range and wildlife resources. Management interpretations and recommendations have dealt with: tree or forage species selection for logged-over or grazed areas; residue management (especially slashburning); site preparation; seedling stock type; stocking standards; and silvicultural systems. The classification also provides an ideal framework for growth and yield studies, a systematic basis for seed zone and seed orchard establishment; a site-specific guide to thinning, fertilization, and prescribed burning; and a broad regional base for forest planning and land use allocation. Some examples of the practical applications and interpretive value of BEC can be found in Klinka and Carter (1980), Klinka *et al.* (1980 a,b, 1984), Pojar *et al.* (1984), Green *et al.* (1984), Utzig *et al.* (1986), Cariboo Forest Region (1987), Meidinger *et al.* (1988), DeLong (1988), and Lloyd *et al.* (1990).

ECOREGION CLASSIFICATION[9]

An ecoregion classification has been developed and mapped for British Columbia to provide a systematic view of the broad geographic relationships of the province (Demarchi 1988; Demarchi *et al.* 1990). This classification is based on the interaction of macroclimatic processes (Marsh 1988) and physiography (Holland 1976; Mathews 1986). The major practical difference between the ecoregion classification and the biogeoclimatic ecosystem classification (BEC) is that, in mountainous terrain, ecoregion classification stratifies the landscape into geographical units that circumscribe all elevations, whereas BEC delineates altitudinal belts of ecological zones within geographical units.

The ecoregion classification of British Columbia is a hierarchical system (Figure 7) whose levels have been defined as follows:

1. Ecodomain	-	an area of broad climatic uniformity	(4 units in B.C.)
2. Ecodivision	-	an area of broad climatic and physiographic uniformity	(7 units in B.C.)
3. Ecoprovince	-	an area with consistent climate or oceanography, relief and plate tectonics	(10 units in B.C.)
4. Ecoregion	-	an area with major physiographic and minor macroclimatic or oceanographic variation	(33 units in B.C.)
5. Ecosection	-	an area with minor physiographic and macroclimatic or oceanographic variation	(72 units in B.C. + 11 ecoregions with no subdivisions)

[9] Contributed by D.A. Demarchi.

The ecodomains and ecodivisions are very broad and place British Columbia in a global context. Ecoprovinces, ecoregions, and ecosections are progressively more detailed and narrow in scope and relate the province to other parts of North America and the Pacific Ocean, or segments of the province to each other. The lower three classes describe areas of similar climate, physiography, zonation, and wildlife potential.

This mountainous province has another level of complexity, that of topo-climatic zonation. Within each terrestrial ecoregion are climatic zones that are reflected by the plant and animal communities present (see Figure 8). These zones are best dealt with through BEC (Figure 7) (Krajina 1965; Pojar *et al*. 1987; B.C. Ministry of Forests 1988).

Ecoregions have been mapped for the entire province at two scales: 1:2 000 000 (Demarchi 1988) and 1:500 000 (Pojar *et al*. 1988; Wildlife Branch 1989). As well, they have been described in terms of characteristic climate, physiography, vegetation or ocean currents, and fauna (Demarchi *et al*. 1990).

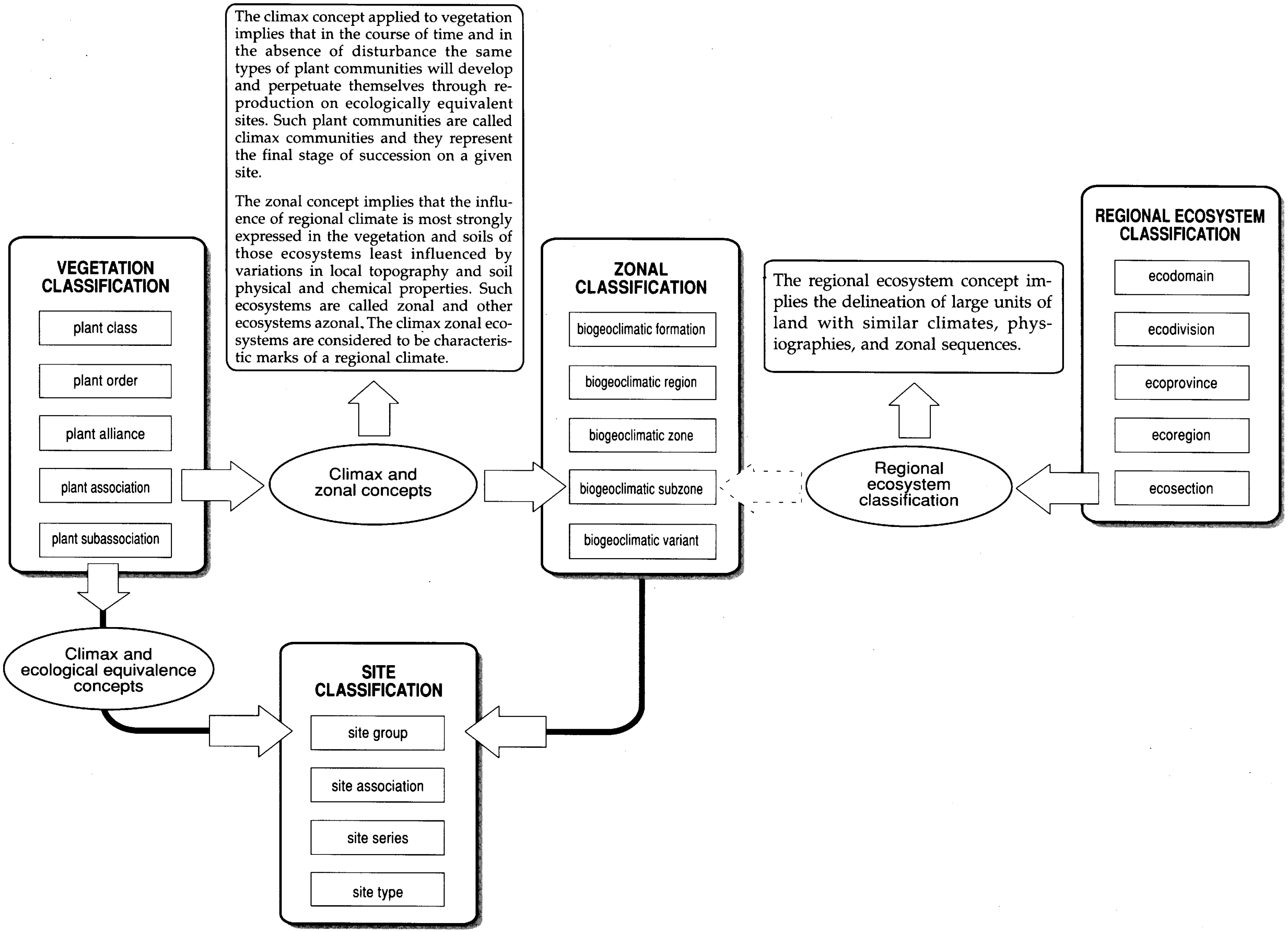

FIGURE 7. **Relationship between ecoregion and biogeoclimatic classification. Modified from Pojar *et al.* (1988).**

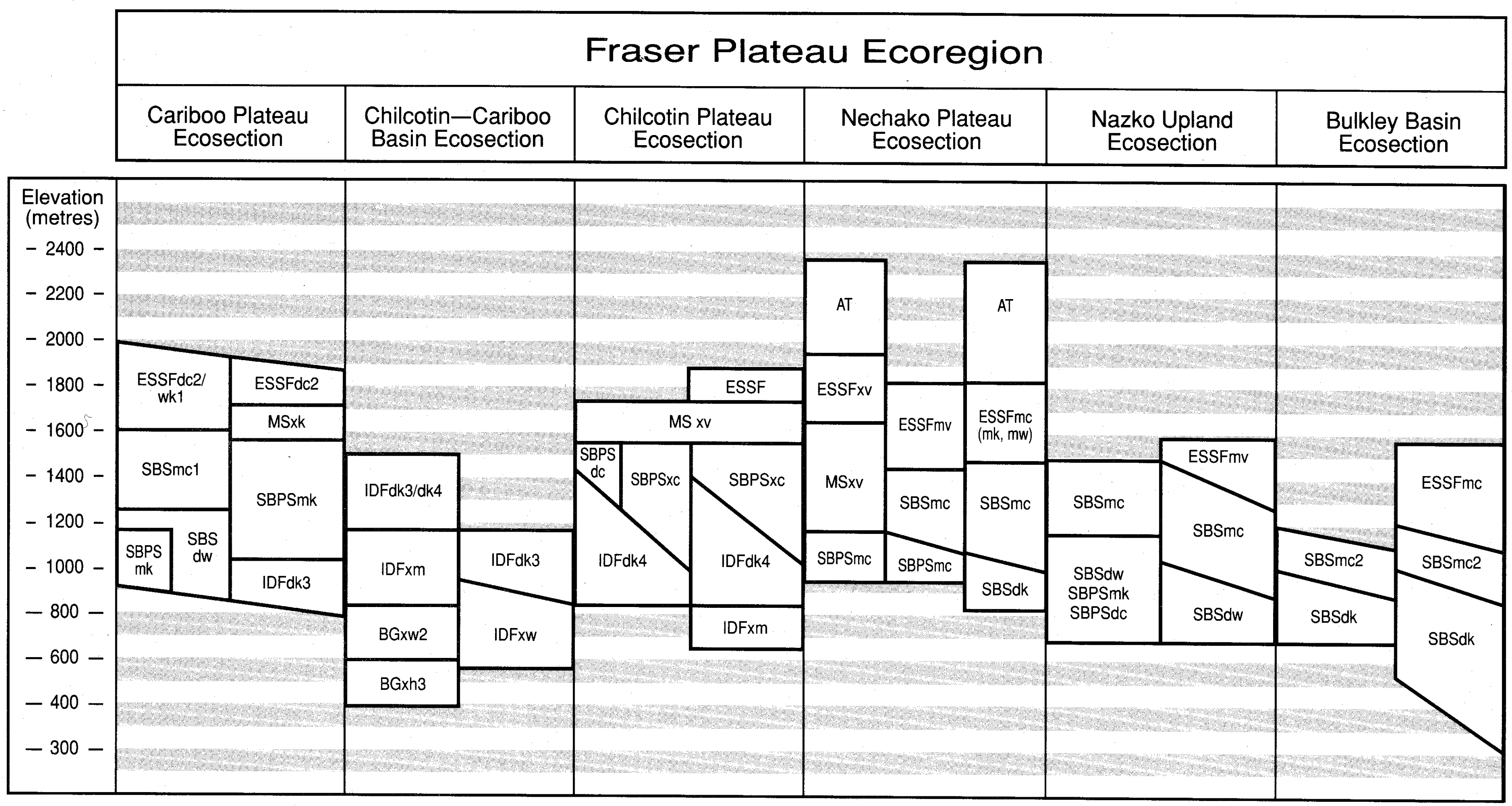

FIGURE 8. Relationship of biogeoclimatic units to ecosection units in the Fraser Plateau Ecoregion.

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Chapter 3:
British Columbia: The Environmental Setting

by

J. Pojar and D. Meidinger

INTRODUCTION

British Columbia is a large and diverse province, more variable physically and biologically than any comparable region in Canada. The province spans 11 degrees of latitude and 25 degrees of longitude and covers 948 600 km^2. Mountains feature prominently in the geography, environment, and culture of British Columbia; so too does the coast, which is intricate in detail and fringed with islands throughout its length.

Broadly speaking, British Columbia is a cool, moist, mountainous, forested region. However, the province also has areas with Mediterranean-type, semi-arid, subarctic, and alpine climates. It has extensive plateaus, plains, and basins as well as several roughly parallel series of mountains. Forests dominate the vegetation but there are also extensive areas of grasslands, wetlands, scrub, and tundra. All nine main groups of soils (soil orders) found in Canada occur in British Columbia, as do nearly all 28 major subdivisions of the soil orders (great groups).

This chapter describes the general physical and biotic features of British Columbia in terms of physiography, climate, soil, and vegetation. Much of the information has been drawn from Valentine *et al*. (1978) and other sources listed under General References. The intent is to set the stage for a description of British Columbia's 14 biogeoclimatic zones, each of which represents a distinctive combination of climate, physiography, vegetation, and soil.

PHYSIOGRAPHY

Valentine *et al*. (1978) divided British Columbia into five primarily physiographic regions (Figure 9) based on the 10 primary subdivisions of Holland (1976).

Coast Mountains and Islands

Two parallel mountain belts (the discontinuous St. Elias — Insular mountains and the Coast — Cascade mountains) and an intervening, largely submerged Coastal Trough form this region. Glacial landforms, including cirques that occur at all elevations, dominate the St. Elias and Queen Charlotte Mountains. Vancouver Island consists largely of glacial landforms and erosion surface remnants. The terrain of the Coast and Cascade mountains is typical of intrusive igneous rocks that have undergone mountain glaciation. Within these mountains, thick deposits of glacial drift are restricted to valley bottoms and adjacent lower slopes. However, the lowlands and islands of the Coastal Trough often have thick blankets of drift, although they also include some large areas of glacially scoured rock surfaces.

Interior Plateau

The flat to gently rolling uplands of this region represent a mature, low relief landscape capped by lava flows in some areas. The northern two-thirds of the region

FIGURE 9. Generalized physiographic regions of British Columbia.

(Fraser and Nechako plateaus) is largely undissected except by the Fraser River and its major tributaries. The degree of dissection is much greater in the southern part of the Interior Plateau (Thompson Plateau), where the Fraser and Thompson rivers occupy deep, steep-sided valleys. The eastern margin of the region (in the Quesnel, Shuswap, and Okanagan highlands) also has relatively rugged, deeply dissected terrain. Thick deposits of glacial drift mantle virtually the entire surface of the Interior Plateau, except for rock outcrops, lava cliffs, and steep, rocky slopes above the entrenched rivers.

Columbia Mountains and Southern Rockies

The Columbia Mountains, the southern Rocky Mountain Trench, and the southern Rocky Mountains make up this region, which occupies southeastern British Columbia. Four rugged mountain belts (the Monashee, Selkirk, Purcell, and Cariboo mountains) together constitute the Columbia Mountains. Glacial drift is widespread on floors and gentler lower slopes of the intervening valleys; steeper slopes consist of rock outcrops and rubbly colluvium. The floor of the steep-sided, depressional Rocky Mountain Trench is covered by glacial and fluvial deposits. The southern Rocky Mountains are built of folded and faulted sedimentary rocks; the topography reflects the structural control of the bedrock. The distribution of drift in the Rockies is similar to that in the Columbia Mountains, but colluvial landforms are more widespread. The well-jointed sedimentary rocks of the Rockies disintegrate rapidly to form talus slopes and rubbly colluvial fans and aprons.

Northern and Central Plateaus and Mountains

This region contains a diverse collection of plateaus, mountains, and plains north of roughly 56°N latitude. The northern plateaus (the Stikine and Yukon plateaus, primarily) display the flat to rolling topography of mature erosional surfaces, and are variously dissected by streams. Pleistocene ice covered virtually all plateau areas and left widespread deposits of drift. The mountain systems (Skeena, Cassiar, Omineca, and northern Rocky mountains) in this region are lower and more subdued than the Coast and southeastern mountains. Deep drift is widespread in broad valleys, while the mountains themselves commonly have a thin cover of drift except on the higher ridges and peaks. The Nass Basin and Liard Plain are relatively low-elevation areas of gentle topography included within the region. Both areas have extensive drift cover and numerous lake basins.

Great Plains

The plains occur over flat-lying or gently dipping sandstones and shales in northeastern British Columbia. Surfaces are generally flat to gently rolling, with little relief except where they are incised by the Peace and Liard rivers and their tributaries. Most of the region is covered by drift, including large areas of outwash gravels and sands and some lacustrine clays and silts, as well as extensive till plains.

CLIMATE

Climate also reflects the dual nature of British Columbia's environment — the fundamental themes of the mountains and the sea. The Pacific Ocean and the mountains are the two major determinants of the province's climates. The Pacific is a reservoir of heat and moisture. In winter, frontal systems spawned over the North Pacific move onto the coastline and eastward across the province, encountering successive mountain barriers that trend northwest-southeast, or roughly perpendicular to upper air flow. The mountain ranges largely determine the overall distribution of precipitation and the balance between Pacific and continental air masses in the various regions of British Columbia. The wettest climates of British Columbia (and Canada) occur on the coast, especially near the mountains on the windward slopes of Vancouver Island, the Queen Charlotte Islands, and the mainland Coast Mountains. Here, moist air carried by prevailing westerly winds drops large amounts of rain or snow as it is forced up the mountain slopes. The air descends over the eastern slopes and is warmed by compression, causing the clouds to thin out. The pronounced rainshadow cast by the massive Coast Mountains results in the driest climates of British Columbia, located in the valley bottoms of the south-central Interior. The air releases additional moisture as it again ascends the Columbia, Skeena, Omineca, and Cassiar mountains, and finally the Rocky Mountains.

Not only do the mountains impede eastward-moving air masses, they also restrict the westward flow of cold continental Arctic air masses from east of the Rocky Mountains. Thus, except for the unprotected Great Plains Region of the northeast, British Columbia has a more moderate winter climate than does the vast central part of Canada.

The prevailing westerlies weaken during the summer. The summer climate is controlled by a large, semi-permanent high pressure centre in the Pacific, which greatly reduces the frequency and intensity of Pacific storms. The Interior in spring has little precipitation, but early summer is often relatively wet. By mid-summer, however, interior storms and precipitation decline again. In middle and late summer the "Pacific high" often exerts dominance over western North America, giving warm, clear weather to much of British Columbia.

SOIL

Many different kinds of soil have developed throughout British Columbia as a result of different intensities of soil-forming processes, including the interaction of parent material, climate, biota, topography, and time. The Canadian System of Soil Classification (Agriculture Canada 1987) has been developed to order and label the different soils. It groups soils according to the way they are formed. Nine major groups of soils (soil orders) occur in British Columbia.

Brunisolic soils occur primarily in forested areas where relatively low rates of weathering have induced only moderate development from the original parent material. The slow weathering and/or restricted development may be due to climate (long winters and low temperatures in cold climates, lack of soil moisture in dry climates), coarse texture of the parent materials, or the geological youth of recently deposited parent material.

Dark, fertile Chernozemic soils have formed primarily under grasslands in the warm, dry, south central interior of the province. Chernozems are typical of areas where low rainfall, high summer temperatures, and high rates of evapotranspiration inhibit tree growth, limit soil leaching, and lead to the accumulation of organic matter in the topsoil.

Cryosolic soils contain permafrost and occur as mineral soils at high elevations and as organic soils in the peat bogs of northeastern British Columbia. Low soil temperatures inhibit chemical reactions and microbial activity, but physical weathering is active.

Gleysolic soils are saturated for long periods of the year and their profiles show evidence of anaerobic, reducing conditions. Gleysols occur throughout the province wherever water does not drain away as fast as it is added to the soil. Gleysols dominate high watertable areas in the lower Fraser Valley, and are also widespread over some of the large flat plains of northern British Columbia. Elsewhere they occupy depressions on plateaus or lower, moisture-receiving slope positions in mountainous terrain.

Soils of the Luvisolic order are characterized by a zone or horizon of clay accumulation in the subsoil as a result of leaching from above. This clay-rich horizon may restrict penetration by roots, air, and water. Luvisolic soils have formed under forest cover in areas which have either higher rainfall or lower temperatures with less evapotranspiration or finer textured parent materials than areas dominated by Brunisolic or Chernozemic soils. Luvisolic soils cover much of the Interior Plateau and a large part of the Great Plains.

Organic soils consist mainly of organic matter and develop mostly under saturated conditions where dead vegetation accumulates faster than it is decomposed. Organic soils typically occupy poorly drained depressions and support wetland vegetation, although they can also develop on sloping terrain in very wet climates. However, the folisols are a group of organic soils formed under upland forest conditions, are freely drained, and are commonly found on the north coast and in coastal subalpine forests. Organic soils dominate the landscape along the north coast and in parts of the Great Plains.

Podzolic soils generally form under coniferous forest in temperate, wet or cold, moist climates. Podzols are typically well drained, coarse textured, and undergo intense leaching of clay, organic matter, iron, and aluminum from upper to lower mineral horizons. Podzols dominate most of the coastal region, the interior wet belt, and the mountain systems of British Columbia.

Regosolic soils are very weakly developed and often very shallow, although some may have significant accumulations of organic matter in the surface layer. Regosolic parent materials are only slightly modified because they are recent (as on floodplains or beaches), unstable (as on eroding slopes), or in harsh environments where rates of chemical weathering and microbial activity are very low. Regosols do not cover extensive areas in British Columbia except in the high mountains.

Soils of the Solonetzic order contain high amounts of exchangeable sodium or sodium and magnesium salts in the subsoil. The salts cause the soil to become sticky and massive when wet, and very hard and blocky when dry. The high salt content limits plant growth and in some cases only salt-tolerant plants survive. Solonetzic soils are common in dry parts of the southern Interior, but are restricted to poorly drained depressions. In these areas, soil water drains into the depressions where it evaporates, leaving an accumulation of salts. In the Peace River district of northeastern British Columbia, saline soils are widespread in some areas. Here the salts originate in saline marine bedrock.

TERRESTRIAL VEGETATION

The vegetation of British Columbia ranges from wet coastal forest to dry interior grassland, from sea level salt marsh to alpine tundra, and from Garry oak parkland to black spruce muskeg. Numerous systems of vegetation classification exist and could be applied to the province's plant cover. However, for the brief outline that follows, a primarily physiognomic scheme based on that of Fosberg (1967) seems most appropriate.

Coniferous Forest

Evergreen coniferous forest dominates the province's vegetative cover. The majority of the coastal forest at low to medium elevations is dominated by western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*), with Douglas-fir (*Pseudotsuga menziesii*) abundant in the south and amabilis fir (*Abies amabilis*) and Sitka spruce (*Picea sitchensis*) abundant in the north. Arbutus (*Arbutus menziesii* — a broad-leaved evergreen tree) typically joins Douglas-fir in much of the drier forest near the sea in the Strait of Georgia region. Mountain hemlock (*Tsuga mertensiana*), amabilis fir, and, to a lesser extent, yellow-cedar (*Chamaecyparis nootkatensis*) predominate in the coastal subalpine forest.

Ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*P. menziesii*) dominate the dry forest, parkland, and savanna of the southern Interior. Western larch (*Larix occidentalis*), a deciduous conifer, is a common associate in southeastern British Columbia.

Lodgepole pine (*Pinus contorta*) and Douglas-fir form extensive stands over much of the southern half of the Interior Plateau. Douglas-fir gradually drops out from the northern half, where white spruce (*Picea glauca*), hybrid white spruce (*P. engelmannii* x *glauca*), and subalpine fir (*Abies lasiocarpa*) join lodgepole pine as the dominant conifers.

The wetter parts of the Columbia and Southern Rocky mountains region are occupied by forests of western hemlock and western redcedar, with admixtures of western white pine (*Pinus monticola*), Douglas-fir, western larch, grand fir (*Abies grandis*), Engelmann spruce (*Picea engelmannii*), hybrid white spruce, and subalpine fir.

The upper elevation forest and parkland of the southern two-thirds of interior British Columbia consist primarily of mixtures of Engelmann spruce, subalpine fir, and lodgepole pine, with whitebark pine (*Pinus albicaulis*) fairly common on drier sites.

The low and middle elevation forest of northern British Columbia is boreal in character and dominated by white spruce, black spruce (*Picea mariana*), and lodgepole pine. Northern subalpine forest consists primarily of white spruce and subalpine fir.

Deciduous Forest

Trembling aspen (*Populus tremuloides*) is the most widespread and abundant deciduous tree species in British Columbia. Aspen stands (which may occur as closed forest or in parkland) are abundant throughout the Interior Plateau and in the boreal forest region, but they are less frequent in the wetter parts of the southeastern province and at higher elevations, and are uncommon at the coast.

Red alder (*Alnus rubra*) is a fast-growing pioneer species that forms dense stands on much cut-over or otherwise disturbed land all along the coast.

Black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) commonly forms alluvial forests throughout the province, except on the outer coast. Balsam poplar (*P. balsamifera* ssp. *balsamifera*) largely replaces black cottonwood in northern British Columbia.

Paper birch (*Betula papyrifera*) is widespread in the Interior but seldom dominates extensive stands. It usually occurs in mixture with conifers and other deciduous trees.

Bigleaf maple (*Acer macrophyllum*) is common in second-growth forest in southwestern British Columbia, but it also rarely dominates stands.

Garry oak (*Quercus garryana*) is virtually restricted to southeastern Vancouver Island and adjacent Gulf Islands, where it forms a distinctive type of deciduous forest and parkland or savanna.

Scrub

Shrubby vegetation dominates the landscape in parts of three lowland areas of British Columbia:

1. the dry southern Interior, where *Artemisia tridentata* (big sagebrush), *Chrysothamnus nauseosus* (rabbit-brush), and (locally) *Purshia tridentata* (antelope-brush) form closed and open scrub types with several grasses, generally called shrub-steppe;
2. the North, where a medium-tall scrub of willows (*Salix* spp.) is abundant in burned-over areas, and a low scrub of dwarf evergreen shrubs (*Ledum*

groenlandicum [Labrador tea], *Chamaedaphne calyculata* [leatherleaf]) or of willows and *Betula glandulosa* (scrub birch), together with stunted black spruce, covers much of the extensive peatlands of the Great Plains Region; and

3. the outer northern Coast, where a scrub of stunted shore pine (*Pinus contorta* var. *contorta*), yellow-cedar and redcedar, hemlocks, and *Juniperus communis* (common juniper), *Ledum groenlandicum*, *Gaultheria shallon* (salal), *Kalmia microphylla* ssp. *occidentalis (bog-laurel)*, *Vaccinium* spp. (blueberries and huckleberries), and *Empetrum nigrum* (crowberry) forms part of the coastal muskeg that is widespread on flat to moderately sloping peatlands.

Scrub is also dominant at high elevations throughout the province. Willows form subalpine and alpine scrub over much of the Interior; *Betula glandulosa* often occurs with the willows, especially in the North. Species of *Vaccinium* form high elevation scrub, especially on coastal and snowier interior mountains. Slide tracks and some north coastal alpine communities are dominated by *Alnus crispa* ssp. *sinuata* (Sitka alder). Dwarf scrub is another widespread, abundant form of high elevation vegetation. Dwarf shrubs, evergreen-leaved (such as *Cassiope* and *Phyllodoce* spp. [mountain-heathers], *Empetrum nigrum*, *Dryas* spp. [mountain-avens]) or deciduous (*Salix* spp., *Vaccinium* spp.), dominate many subalpine and alpine heath and tundra communities.

Elsewhere in the province scrub can be extensive or (more often) localized, and usually develops after fire or as wetland vegetation.

Grass

In this treatment, grass vegetation consists primarily of grasses and other grass-like plants. Hence, as a form of vegetation it includes marshes and grassy tundra as well as typical grassland vegetation.

Grasslands dominated by bunchgrasses, other grasses, and shrubs occur in valley bottoms and on several plateaus in south central British Columbia, from the Riske Creek area in the Chilcotin district south to the international border. Similar grasslands occupy smaller areas in southeastern British Columbia. *Agropyron spicatum* (bluebunch wheatgrass) is the most widespread and dominant species. Other abundant or frequent species include *Festuca scabrella* (rough fescue), *F. idahoensis* (Idaho fescue), *Poa sandbergii* (Sandberg's bluegrass), *Koeleria macrantha* (junegrass), *Bromus tectorum* (cheatgrass), *Stipa comata* (needle-and-thread grass), *S. richardsonii* (spreading needlegrass), *S. spartea* (porcupinegrass), *Poa pratensis* (Kentucky bluegrass), *Artemisia tridentata, A. frigida* (pasture sage), and *Chrysothamnus nauseosus*.

The drier, rainshadow areas of southwestern British Columbia have small pockets of grassland, usually on warm, rocky, south-facing slopes, and are associated with dry Douglas-fir, arbutus, and Garry oak woodland. These vernal grasslands are dominated by annual species of *Bromus* (bromegrass), *Vulpia* (fescue), and *Aira* (hairgrass). They include many introduced species as well as showy, spring-flowering forbs, and are closely related to the annual grasslands of Oregon and California.

In the northern two-thirds of the province, lower elevation grasslands are usually localized and restricted to steep, south-facing slopes. Some typical species are *Agropyron trachycaulum* (slender wheatgrass), *Festuca altaica* (Altai fescue), *Calamagrostis purpurascens* (purple reedgrass), *Stipa richardsonii*, *S. occidentalis* var. *minor* (stiff needlegrass), *Elymus innovatus* (fuzzy-spiked wildrye), *Poa glauca* (glaucous bluegrass), *Artemisia frigida*, and *A. campestris* (northern wormwood).

High elevation grass vegetation occurs throughout the province in the drier alpine areas. Dominant grasses vary from south to north, but include *Festuca scabrella*, *F. viridula* (green fescue), *F. altaica*, *F. brachyphylla* (alpine fescue), *Poa arctica* (arctic bluegrass), *Hierochloe alpina* (alpine sweetgrass), and *Calamagrostis purpurascens*. Species of the sedge family often dominate or co-dominate the vegetation. Some typical species are *Carex phaeocephala* (dunhead sedge), *C. spectabilis* (showy sedge), *C. podocarpa* (short-stalked sedge), *C. microchaeta* (small-awned sedge), *C. nardina* (spikenard sedge), *C. albonigra* (two-toned sedge), *C. obtusata* (blunt sedge), *C. scirpoidea* ssp. *pseudoscirpoidea* (single-spiked sedge), *C. capitata* (capitate sedge), and *Kobresia myosuroides* (Bellard's kobresia).

Wetland grass types include several different kinds of marsh and fen vegetation. Freshwater marshes and fens are usually dominated by sedges or grasses. Some typical species include *Carex aquatilis* (water sedge), *C. rostrata* (beaked sedge), *C. vesicaria* (inflated sedge), *C. nigricans* (black alpine sedge), *Scirpus lacustris* (great bulrush), *Trichophorum caespitosum* (tufted clubrush), *Phalaris arundinacea* (reed canarygrass), and *Phragmites communis* (common reed), among many others. Coastal saline marshes are frequent but usually not extensive; their most characteristic dominant species are *Carex lyngbyei* (Lyngbye's sedge) and *Deschampsia cespitosa* (tufted hairgrass). Alkaline marshes occur in the dry southern Interior and have species such as *Distichlis stricta* (alkali saltgrass), *Muehlenbergia asperifolia* (alkali muhly), *Hordeum jubatum* (foxtail barley), *Juncus balticus* (wire rush), *Scirpus* spp. (bulrushes), *Salicornia europaea* (European glasswort), and *Suaeda depressa* (seablite).

Broad-leaved Herb

Timberline meadows are the only widespread, natural, broad-leaved herbaceous vegetation type in British Columbia. Such meadows are most abundant at high elevations of the southern two-thirds of the interior of the province.

Seasonal herb meadows also occur locally in the Strait of Georgia region, in some openings in the dry forest of the southern Interior, and in some recent clearcut or burned openings generally.

Bryoid

Vegetation dominated by mosses, liverworts, or lichens usually occurs in environments too harsh for vascular plants. British Columbia, for example, has raised *Sphagnum* bogs, rock outcrops partially covered by lichens and mosses such as *Rhacomitrium*, *Polytrichum*, and *Dicranum*, and alpine lichen tundra.

WILDLIFE[10]

A wide variety of vertebrate wildlife species occurs in British Columbia. This includes 448 species of birds, 143 species of mammals, 19 species of reptiles, and 20 species of amphibians (Cannings and Harcombe 1990). The four fundamental environmental needs of terrestrial vertebrates are food, cover, water, and space. The productivity and quality of food can limit the abundance of a particular wildlife species, as can the absence of thermal or escape cover. All wildlife species require water. Some, such as Beaver, River Otter, and Painted Turtle, require free-standing water as a principal component of their habitat. Other species require only dew, snow, or succulent vegetation to fulfill their water requirements. All wildlife also need a certain living space. Spatial requirements vary among seasons and species, and are often observed as territorial and home range behaviour. Overcrowding leads to severe competition for available forage and cover.

Terrestrial vertebrates use the land in a variety of ways, but one of the main factors that influences their habitat use in British Columbia is the avoidance of harsh winter conditions. Most bird species make continental migrations to warm southern climates. Amphibians and reptiles hibernate in deep crevasses or buried in moist soil, while some mammals (such as bears and ground squirrels) hibernate in specially constructed burrows, nests, and dens. Most ungulates and their attendant predators migrate to areas of low snowfall. Only a few species, such as Caribou, White-tailed Ptarmigan, and Wolverine, seek areas of deeper snow in winter.

The abundance and diversity of wildlife species vary among biogeoclimatic zones. This is a function of the location, continuity, and latitude of the zone. The location of a zone, relative to other zones and the ocean, affects the number of species, because wildlife can occur simply because they are abundant in an adjacent zone — sort of a spill-over effect. Large, continuous zones have more species than small, fragmented zones, as would be predicted by the theory of island biogeography (MacArthur and Wilson 1967). Latitudinal differences reflect an overall geographic pattern, where more species occur in warm southern communities than in north temperate and Arctic communities (Ricklefs 1988). Within individual zones, the diversity of wildlife species increases with increased habitat productivity and structural heterogeneity (Ricklefs 1988).

Coniferous forests make up a large portion of the total wildlife habitat in British Columbia. Within the coniferous forest, wildlife diversity is affected by elevation, topography, moisture, and successional stage. Low-elevation sites provide habitat for more species than high-elevation sites because of milder climates. The lowest elevations are also important to most wintering ungulates (except Caribou, Mountain Goat, and Thinhorn Sheep) because of reduced snow depths.

The effect of plant community succession on wildlife diversity can be dramatic, regardless of whether the succession is natural or man-caused. Natural succession can result from climatic change, volcanic activity, landslides, erosion, wildfire, or insect attack. Man-caused succession represents change caused by, for example, prevention

[10] Contributed by W.L. Harper and D.A. Demarchi.

of wildfire, livestock grazing, logging, and burning. Early successional plant communities often inhibit the "original" wildlife species, but produce good conditions for other species. Moose, Snowshoe Hare, and Ruffed Grouse are examples of species that do well in the young forests that result from burning or logging, although they usually require cover in adjacent older stands.

Some wildlife species require old-growth forest for part or all of their habitat requirements. Climax forest stands, often referred to as old growth, occur in all of the forested biogeoclimatic zones. In these forests, it is usually the structural components, such as standing dead trees, broken-topped and decaying live trees, large fallen logs, and abundant arboreal lichens that are important to wildlife. This high structural diversity and complexity results in high overall wildlife diversity, although the density of individual species can be less than in earlier successional stages. There are at least 16 wildlife species in British Columbia that find optimal habitat in old-growth forests (Meslow *et al*. 1981; Carey 1989). Many more depend on old-growth forests for part of their habitat needs. Caribou, Marten, Northern Flying Squirrel, Keen's Long-eared Myotis, Pileated Woodpecker, Vaux's Swift, and Pacific Giant Salamander are examples of climax-adapted species that do best in old-growth forest habitats. Young seral forests simply do not contain the structural components of habitat necessary for the survival and reproduction of many of these animals.

Old-growth forests are only one of the habitats that concern resource managers. Estuaries, wetlands, riparian habitats, shrub-steppe, and ungulate winter ranges also require careful management and protection from excessive development in order to support the wildlife populations that depend on them. These habitats also support a particularly high diversity and abundance of wildlife, due to their high vegetative productivity and structural heterogeneity.

Semi-arid ecosystems of the southern Interior also support a wide diversity of vegetation types and wildlife species. Although not extensive in total area, these ecosystems are very important as habitat for various threatened and endangered species in British Columbia. Low snow depths in these ecosystems also make them very important for wintering ungulates.

The diversity of wildlife in British Columbia is vulnerable to habitat destruction because of the unique and specific way each species selects and uses its habitat (Demarchi and Demarchi 1987). In contrast to the often subtle ways wildlife use the land, human use can be indiscriminate and critical wildlife habitats can quickly become dissected, isolated, submerged, or buried. Intensive forestry, with its emphasis on clearcutting and maximization of conifer production, can benefit a few wildlife species in the short term, but is detrimental to many more species in the long term. Intensive agriculture pre-empts use by most native wildlife species. Hydroelectric development floods the most productive wildlife habitats in valley bottoms. Open-pit mines, highways, and utility corridors also occupy habitat and thus remove it from use by wildlife. As the human population increases, residential communities expand, invariably onto areas that were once wildlife habitat. Furthermore, all of these so-called developments increase access to the hinterland, and can lead to increased hunting pressure on game species. These impacts on wildlife species and their habitats are the result of the growing demands of an ever-increasing population. The only way wildlife can be preserved in the face of this increasing demand for resources is through careful, thoughtful, and effective management. This includes planning for the protection of wildlife habitat, access control, and regulation of the harvest.

The great variety of terrestrial habitats and vertebrate species in British Columbia makes resource planning complex. Fortunately, species habitat needs can be defined at various scales and levels of detail through the ecological classifications at our disposal. The ecoregion classification, which is based on macroclimate and regional landforms, is useful for stratifying regional ecosystems for highly mobile wildlife (Demarchi 1988; Demarchi *et al.* 1990). For example, migratory ungulates can use several different biogeoclimatic zones in different seasons for different purposes. The wildlife habitat handbook project (Harcombe 1988) organizes biological data on 70 mammal, 50 bird, 11 reptile, and 8 amphibian species for various ecosystems within the Southern Interior Ecoprovince. Presentation of this information on the relationship between animals and their habitats is designed to allow resource managers to predict the consequences of various land use decisions.

The biogeoclimatic system works well for describing forest habitats of wildlife such as bears, Caribou, furbearers, rodents, upland game birds, and reptiles. On the other hand, site series or biophysical habitat units (Demarchi and Lea 1989) are useful for defining site-specific habitat components, such as escape terrain, migration routes, feeding areas, and denning sites, and azonal habitats such as rocky cliffs, talus, riparian areas, and wetlands. Animals that depend on these azonal habitats relate more to their structural attributes than to the zones in which the habitats occur.

BIOGEOCLIMATIC ZONES

The B.C. Ministry of Forests currently recognizes 14 biogeoclimatic zones in the province. This section provides a brief overview of the zones; in-depth descriptions of each zone are presented in the next 14 chapters.

The 14 zones are presented in Figure 10. Eight representative cross sections from four segments of the province are shown in Figure 11. These display typical elevational sequences of biogeoclimatic zones from the eight areas. For example, in Cross Section One (Dall Lake to Tetsa River), the sequence is Boreal White and Black Spruce zone at lower elevations, Spruce — Willow — Birch zone at middle elevations, and Alpine Tundra at the higher elevations.

Climatic characteristics for the biogeoclimatic zones are summarized in Table 4. Maximum (max) and minimum (min) values for long-term climate stations in the zone are presented for each climate variable. As well, values for a representative climate station are shown. Because of the lack of long-term climate stations for the Alpine Tundra, Spruce — Willow — Birch, and Mountain Hemlock zones, only data for a representative station are shown.

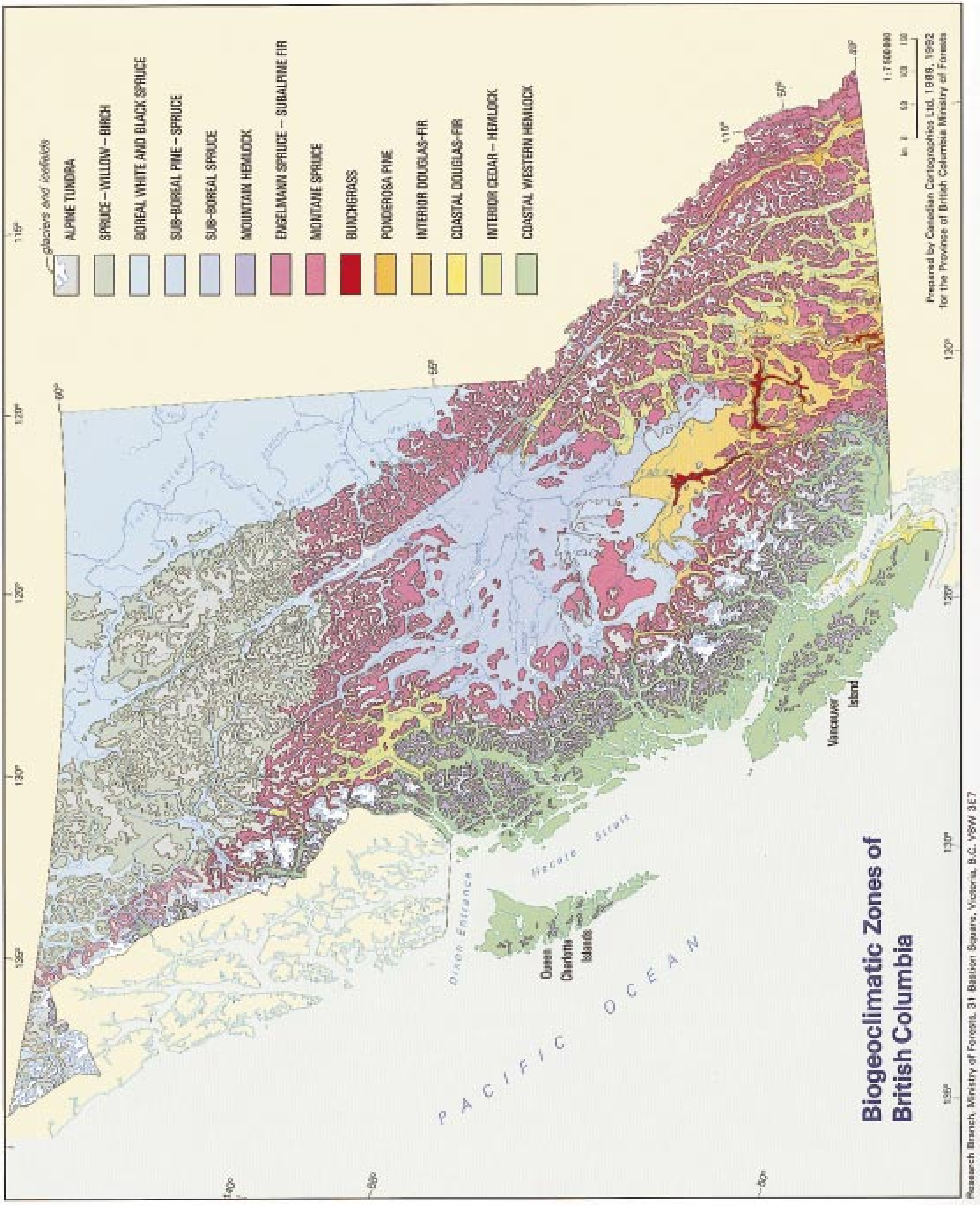


FIGURE 10. Biogeoclimatic zones of British Columbia.

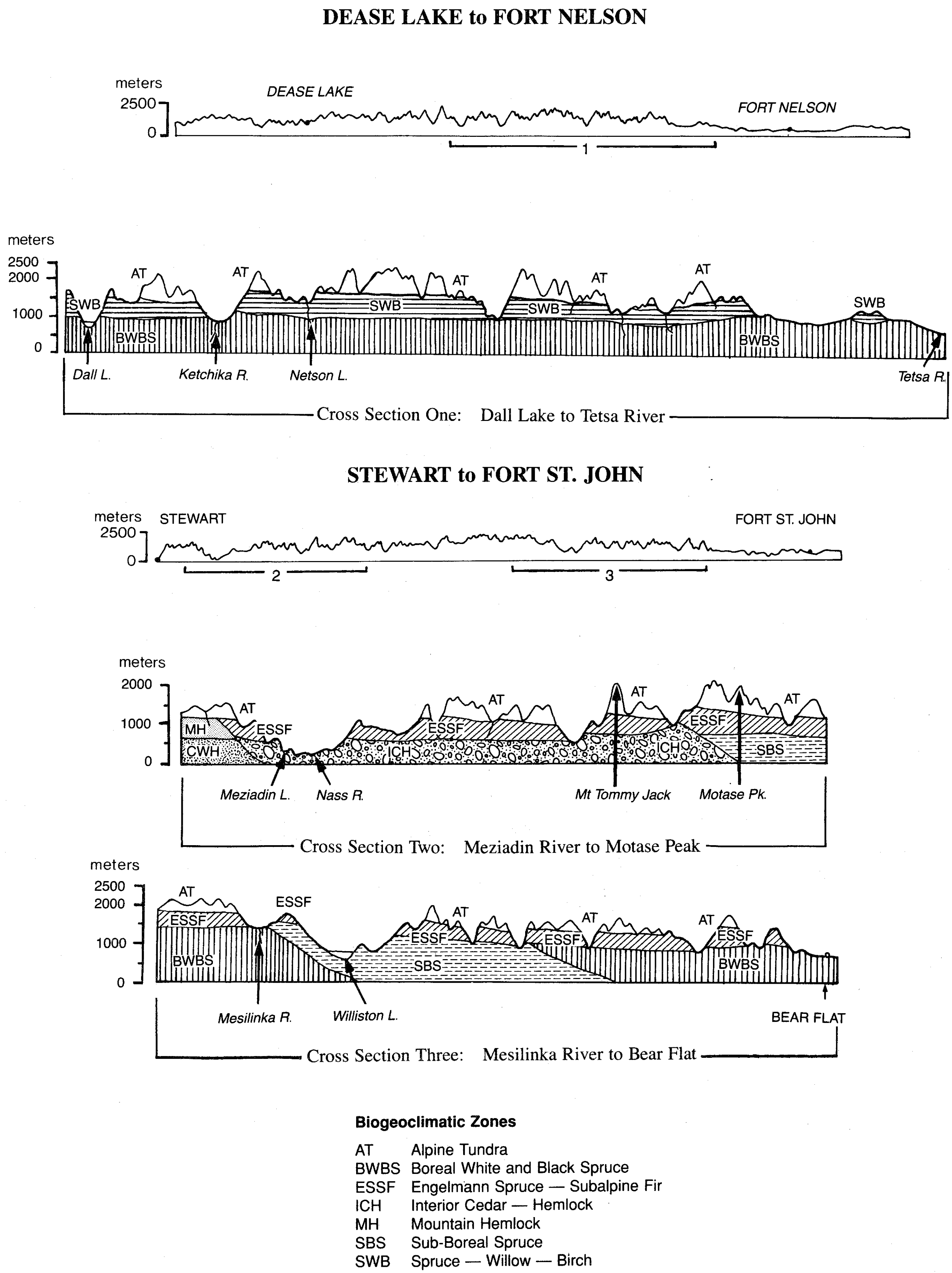
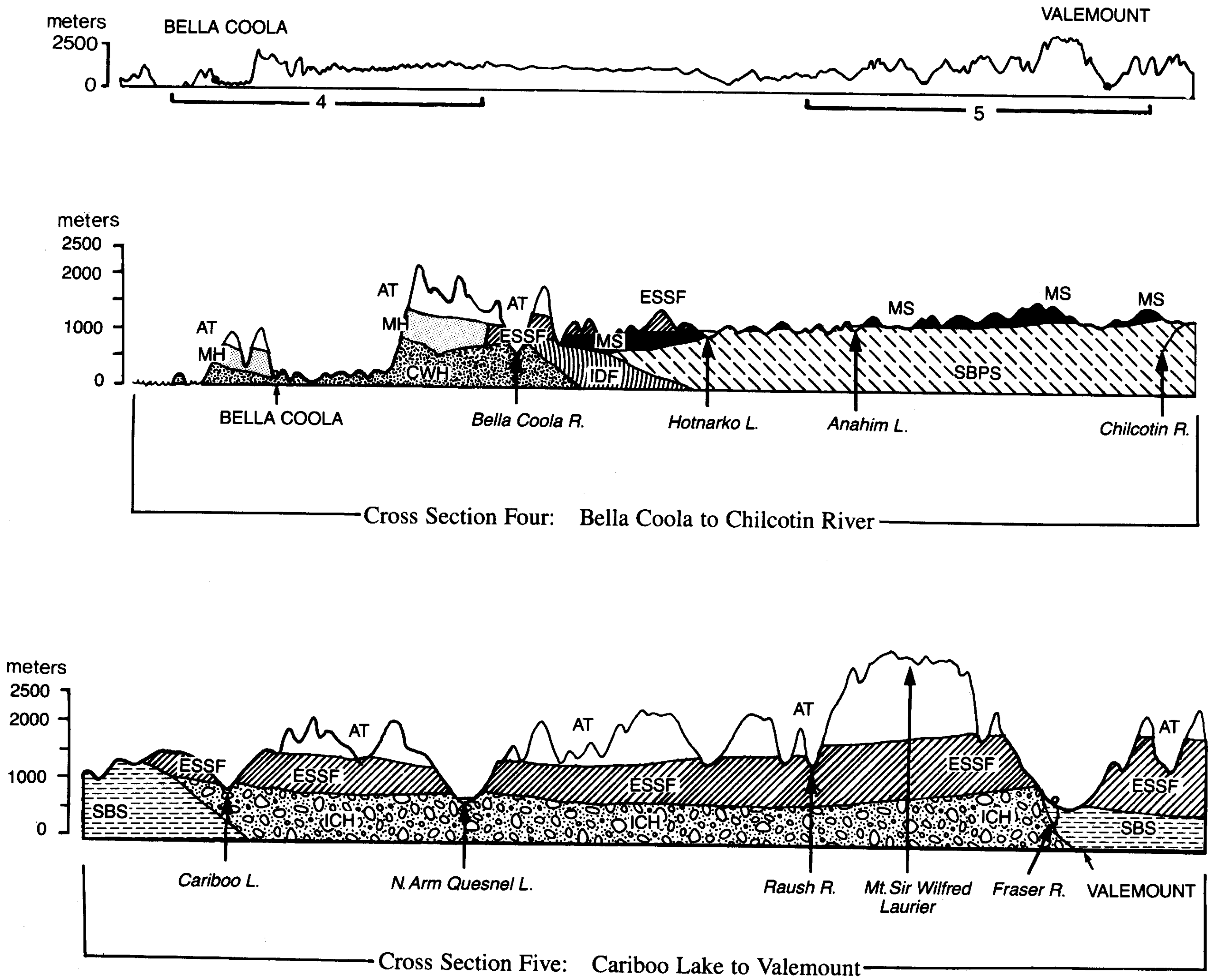


FIGURE 11. Eight representative cross sections of biogeoclimatic zones.

BELLA COOLA to VALEMOUNT

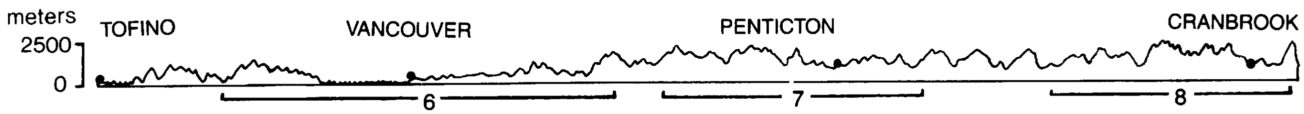


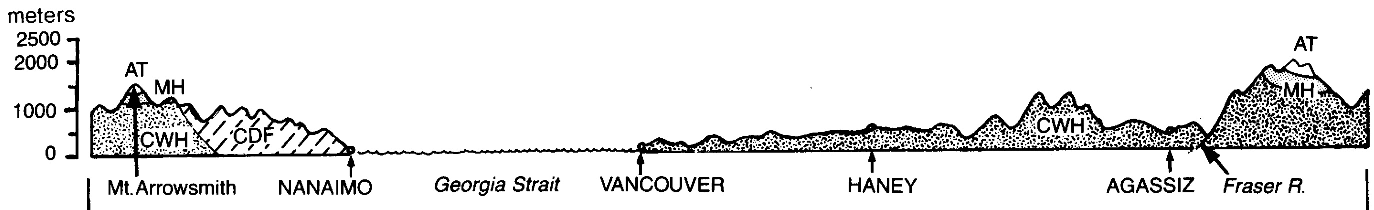
Biogeoclimatic Zones

AT	Alpine Tundra
CWH	Coastal Western Hemlock
ESSF	Engelmann Spruce — Subalpine Fir
ICH	Interior Cedar — Hemlock
IDF	Interior Douglas-fir
MH	Mountain Hemlock
MS	Montane Spruce
SBPS	Sub-Boreal Pine — Spruce
SBS	Sub-Boreal Spruce

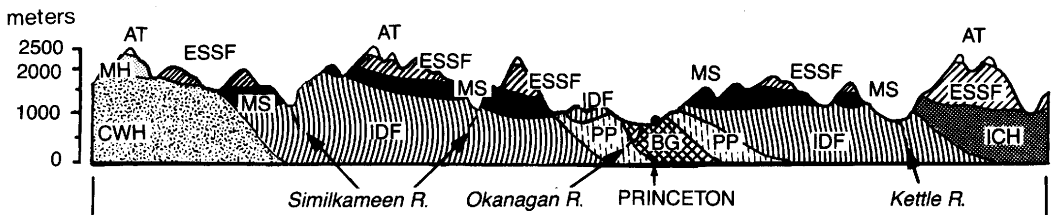
FIGURE 11. Continued.

TOFINO to CRANBROOK

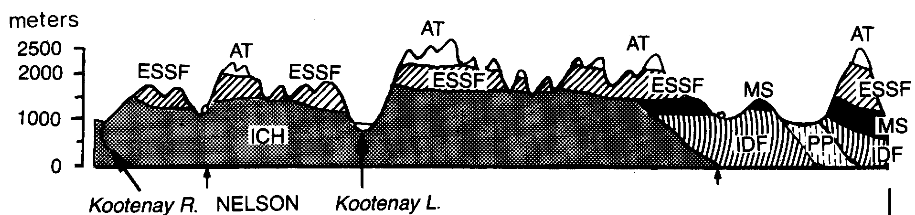




Cross Section Six: Vancouver Island to Fraser River



Cross Section Seven: Similkameen River to Kettle River



Cross Section Eight: Kootenay River to Cranbrook

Biogeoclimatic Zones

AT	Alpine Tundra
BG	Bunchgrass
CDF	Coastal Douglas-fir
CWH	Coastal Western Hemlock
ESSF	Engelmann Spruce — Subalpine Fir
ICH	Interior Cedar — Hemlock
IDF	Interior Douglas-fir
MH	Mountain Hemlock
MS	Montane Spruce
PP	Ponderosa Pine

FIGURE 11. Concluded.

TABLE 4. Climatic characteristics for the biogeoclimatic zones of British Columbia

Zone	Range and reference station	Lat. (° ′)	Long. (° ′)	Elevation (m)	Mean annual precip. (mm)	Mean summer precip. (May-Sept) (mm)	Mean precip. of driest month (mm)	Mean precip. of wettest month (mm)	Driest month	Wettest month
AT	Old Glory Mtn.	49 09	117 55	2347	755.5	287.0	40.0	84.1	Jul	Dec
BG	Max			588	335.7	174.5	17.3	55.4		
	Min			297	205.6	98.0	8.0	27.3		
	Kamloops	50 40	120 20	379	241.7	111.4	8.0	36.1	Mar	Jan
BWBS	Max			840	503.7	305.3	24.3	879.0		
	Min			382	327.1	144.7	8.3	41.1		
	Fort Nelson A	58 50	122 35	382	451.8	297.9	16.7	84.3	Apr	Jul
CDF	Max			223	1262.6	238.3	38.6	232.9		
	Min			8	647.2	107.3	13.4	119.2		
	Victoria Int'l A	48 39	123 26	19	872.9	141.9	18.1	157.3	Jul	Dec
CWH	Max			671	4386.8	1162.0	151.0	625.4		
	Min			0	990.2	159.3	16.8	145.7		
	Haney UBC RF Admin	49 16	122 34	143	2140.1	467.8	65.5	331.7	Jul	Dec
ESSF	Max			1862	1995.4	424.5	64.8	297.4		
	Min			863	514.1	204.6	26.6	57.4		
	Boss Mountain	52 06	120 53	1532	1177.1	401.6	63.5	140.6	May	Dec
ICH	Max			1085	1419.0	439.3	57.2	224.3		
	Min			314	497.7	199.9	21.4	57.8		
	Revelstoke	51 00	118 12	456	1063.7	325.0	51.4	177.0	Apr	Jan
IDF	Max			1128	1198.9	290.7	37.6	208.8		
	Min			122	295.1	107.5	13.5	34.8		
	150 Mile House	52 07	121 56	738	414.2	214.0	15.8	60.7	Apr	Jun
MH	Hollyburn Ridge	49 23	123 12	930	2954.3	694.4	106.9	434.8	Jul	Dec
MS	Max			1554	663.8	252.1	38.5	108.1		
	Min			1128	380.8	158.2	17.9	45.2		
	Peachland Brenda Mines	49 52	120 00	1520	638.3	197.0	29.3	89.1	Apr	Dec
PP	Max			939	604.5	270.3	30.7	77.6		
	Min			244	319.5	86.3	11.0	34.5		
	Kelowna	49 54	119 28	354	332.2	136.3	15.3	45.1	Apr	Dec
SBPS	Max			1219	517.8	299.8	21.1	86.5		
	Min			914	464.1	242.6	20.8	36.4		
	Alexis Creek Tautri Creek	52 33	123 11	1219	464.1	242.6	20.8	57.6	Apr	Jun
SBS	Max			1245	1588.2	352.6	36.8	278.7		
	Min			488	438.9	188.9	15.2	49.8		
	Prince George A	53 63	122 40	676	628.3	300.8	27.4	68.2	Apr	Aug
SWB	Cassiar	59 17	129 50	1078	699.5	275.1	25.7	84.2	Apr	Oct

Zone key

AT Alpine Tundra
BG Bunchgrass
BWBS Boreal White and Black Spruce
CDF Coastal Douglas-fir
CWH Coastal Western Hemlock
ESSF Engelmann Spruce — Subalpine Fir
ICH Interior Cedar — Hemlock
IDF Interior Douglas-fir
MH Mountain Hemlock
MS Montane Spruce
PP Ponderosa Pine
SBPS Sub-Boreal Pine — Spruce
SBS Sub-Boreal Spruce
SWB Spruce — Willow — Birch

Mean annual snowfall (cm)	No. of months with snow	Mean annual temp (°C)	Mean temp. coldest month (°C)	Extreme min. temp (°C)	Mean temp. warmest month (°C)	Extreme max. temp (°C)	No. of months with mean temp (°C)		No. of frost free days	Frost free period (days)	Accumulated degree (°C) days	
							>10	<0			above 5	below 0
551.4	12	-1.8	-11.1	-37.8	9.5	27.2	0	7	103	21	427	1763
99.6	9	10.0	-2.7	-22.2	22.4	43.9	6	4	252	181	2516	878
50.5	6	5.9	-10.8	-42.8	18.0	37.2	5	2	182	122	1771	230
67.2	7	8.7	-5.4	-38.3	21.4	41.7	5	3	236	166	2320	418
268.8	12	1.3	-17.7	-47.2	16.6	40.6	3	7	172	115	1268	2742
134.9	9	-2.9	-24.5	-58.9	12.0	30.6	2	5	119	44	709	1692
186.5	10	-1.4	-23.8	-51.7	16.6	36.7	3	5	146	106	1266	2643
95.2	6	10.5	4.1	-11.7	18.0	40.6	6	0	349	304	2121	43
17.2	5	9.2	1.8	-21.1	15.4	31.1	5	0	260	155	1794	9
49.9	6	9.5	3.1	-15.6	16.3	36.1	5	0	305	201	1863	25
840.8	9	10.5	4.7	-10.6	18.7	40.6	6	5	344	272	2205	493
25.2	5	4.5	-6.6	-30.6	13.1	22.8	3	0	188	116	1059	5
81.6	7	9.2	1.4	-20.0	16.8	35.0	5	0	291	198	1882	59
1431.0	12	1.8	-7.9	-35.6	13.3	35.6	2	6	140	79	801	1189
246.5	9	1.1	-10.9	-46.7	11.3	28.3	2	5	110	32	629	879
782.1	11	1.1	-10.1	-41.1	12.1	31.1	2	6	140	75	671	1189
733.6	9	8.9	-2.9	-26.1	20.8	42.8	5	5	243	184	2140	820
122.3	7	4.1	-10.1	-46.1	16.3	33.3	4	2	169	95	1267	238
421.8	8	6.9	-6.1	-34.4	19.0	40.6	5	3	221	149	1808	468
283.4	10	9.6	-2.6	-26.7	21.3	43.3	5	5	279	204	2366	1260
82.0	7	1.6	-13.1	-50.0	13.2	33.9	3	2	101	24	903	235
144.5	9	4.2	-10.7	-45.0	15.8	36.1	4	5	163	79	1346	906
820.2	10	5.0	-2.3	-26.7	13.2	33.3	3	2	198	126	919	307
397.8	11	4.7	-7.8	-37.2	17.4	36.7	4	5	177	126	1310	890
193.2	9	1.7	-12.5	-43.9	13.2	33.5	3	5	107	20	891	847
397.8	10	2.7	-7.8	-38.9	14.2	33.5	3	5	152	92	991	884
170.8	9	9.6	-2.7	-26.7	21.6	42.2	6	5	256	173	2442	816
80.8	6	4.8	-8.6	-45.6	17.2	36.1	5	2	166	89	1505	258
96.9	7	8.6	-3.3	-31.1	20.4	38.9	5	3	226	160	2075	268
195.2	10	2.5	-12.3	-42.8	14.3	33.3	3	7	152	61	1044	1405
177.5	9	0.4	-13.8	-51.1	9.2	31.1	2	5	85	12	697	1140
195.2	10	0.4	-13.8	-51.1	11.6	32.2	2	5	85	12	697	1405
378.9	10	5.0	-7.7	-38.3	16.9	40.6	5	5	182	119	1510	1369
110.5	8	1.7	-14.6	-51.7	12.9	32.2	3	4	130	45	884	792
241.7	9	3.3	-12.1	-50.0	15.1	34.4	3	5	170	85	1198	1057
395.0	11	-3.2	-19.2	-47.2	11.2	29.4	1	7	103	37	534	2298

This climatic summary provides an overview of the zone's climate based on the available data. The data do not always show the complete range of climatic conditions because climate stations are not distributed so as to be representative of the entire landscape.

Table 5 shows the occurrence and abundance of tree species in the zones. Figure 12 compares the zonal vegetation of the 14 zones, i.e., the vegetation occurring on zonal sites.

ZONE DESCRIPTIONS

Chapters 5-18 present further information on the 14 biogeoclimatic zones. The zones are arranged geographically: coastal, southern Interior, and northern Interior; and follow a sequence of warm to cool within each.

Each chapter describes the location, distribution, climate (see Table 4), dominant plant species (which in most cases are trees; see Table 5), general ecological conditions, general features of zonal ecosystems and subzones, and the range of variation in each zone. This information is followed by descriptions of three or four common site associations for a given subzone (the most typical, if possible) of the zone; a section on wildlife; and a brief discussion of major resource uses. Some chapters also include a brief section on classification, where the present treatment departs from that of Krajina. Appendix 1 presents a complete listing of site associations in British Columbia.

The description of each zone is accompanied by a map of the zone's occurrence, a climatic diagram (see Figure 13) for a representative station, and a diagram of topographic relationships among the common site associations (see Figure 14). Selected references are presented for each zone at the end of the report.

Nomenclature follows Douglas *et al*. (1989, 1990 a,b) for gymnosperms, pteridophytes, and dicotyledons; Taylor and MacBryde (1977) for monocots; Stotler and Crandall-Stotler (1977) for the liverworts; Ireland *et al*. (1987) for the mosses; and Noble *et al*. (1987) for the lichens. Common names follow Meidinger (1987). A complete listing of plant series cited in this report is given in Appendix 2.

In the chapters that follow, tables of native mammals, birds, reptiles, and amphibians are presented for each biogeoclimatic zone. These tables are not comprehensive. They present only a selection of representative native vertebrates that can occupy the various habitats within each zone. The tables also include a list of wildlife species being considered for designation as Threatened and Endangered (Red List) or Sensitive (Blue List). The order that species appear in the tables is based solely on taxonomy, not on importance. The order generally followed was: ungulates, carnivores, bats, hares and pikas, rodents, insectivores, hawks and falcons, owls, upland game birds, loons, grebes, pelicans and cormorants, herons, cranes, pigeons, waterfowl, shorebirds, goatsuckers, swifts, hummingbirds, woodpeckers, passerine birds, snakes, lizards, turtles, frogs and toads, and salamanders. English common names of species follow Cannings and Harcombe (1990).

TABLE 5. Occurrence[a] of trees in the biogeoclimatic zones of British Columbia

Gymnosperms	BG	PP	IDF	ICH	MS	SBPS	SBS	BWBS	SWB	MH	CDF	CWH	ESSF	AT[b]
Abies amabilis (amabilis fir)	-	-	-	+	-	-	-	-	-	+++	-	+++	(+)	-
A. grandis (grand fir)	-	-	++	++	+	-	-	-	-	-	++	+	-	-
A. lasiocarpa (subalpine fir)	-	-	-	++	+++	(+)	+++	++	+++	++	-	+	+++	-
Chamaecyparis nootkatensis (yellow-cedar)	-	-	-	-	-	-	-	-	-	+++	-	++	(+)	-
Juniperus scopulorum (Rocky Mountain juniper)	+	+	++	-	-	-	+	(+)	-	-	++	(+)	-	-
Larix laricina (tamarack)	-	-	-	-	-	-	(+)	++	-	-	-	-	-	-
L. lyallii (alpine larch)	-	-	-	-	-	-	-	-	-	-	-	-	++	-
L. occidentalis (western larch)	-	+	+++	++	+++	-	-	-	-	-	-	-	+	-
Picea engelmannii (Engelmann spruce)	-	-	+	++	+++	-	-	-	-	+	-	-	+++	-
P. engelmannii x *glauca* (hybrid white spruce)	-	(+)	++	++	+++	+	+++	-	-	-	-	-	++	-
P. glauca (white spruce)	-	(+)	+	-	+	+++	++	+++	+++	-	-	-	+	-
P. glauca x *sitchensis* (Roche spruce)	-	-	-	++	-	-	-	-	-	(+)	-	++	-	-
P. mariana (black spruce)	-	-	-	+	-	-	++	+++	+	-	-	-	-	-
P. sitchensis (Sitka spruce)	-	-	-	-	-	-	-	-	-	+	+	+++	-	-
Pinus albicaulis (whitebark pine)	-	-	-	-	-	-	-	-	-	+	-	-	++	-
P. banksiana (jack pine)	-	-	-	-	-	-	-	(+)	-	-	-	-	-	-
P. contorta (lodgepole pine)	(+)	-	+++	++	+++	+++	+++	+++	++	+	++	++	+++	-
P. flexilis (limber pine)	-	-	(+)	-	-	-	-	-	-	-	-	-	(+)	-
P. monticola (western white pine)	-	-	+	++	+	-	-	-	-	+	+	++	+	-
P. ponderosa (ponderosa pine)	+	+++	+++	+	-	-	-	-	-	-	-	-	-	-
Pseudotsuga menziesii (Douglas-fir)	+	++	+++	++	+++	+	++	-	-	(+)	+++	+++	+	-
Taxus brevifolia (western yew)	-	-	+	++	-	-	-	-	-	-	++	++	-	-
Thuja plicata (western redcedar)	-	(+)	++	+++	+	-	+	-	-	+	++	+++	+	-
Tsuga heterophylla (western hemlock)	-	-	+	+++	+	-	(+)	-	-	++	+	+++	+	-
T. mertensiana (mountain hemlock)	-	-	-	+	-	-	-	-	-	+++	-	+	++	-

TABLE 5. Continued

Angiosperms	BG	PP	IDF	ICH	MS	SBPS	SBS	BWBS	SWB	MH	CDF	CWH	ESSF	AT[b]
Acer macrophyllum (bigleaf maple)	-	-	+	-	-	-	-	-	-	-	++	++	-	-
Alnus rubra (red alder)	-	-	-	-	-	-	-	-	-	-	+++	+++	-	-
Arbutus menziesii (arbutus)	-	-	-	-	-	-	-	-	-	-	++	+	-	-
Betula neoalaskana (Alaska paper birch)	-	-	-	-	-	-	-	++	-	-	-	-	-	-
B. occidentalis (water birch)	+	+	+	(+)	-	-	(+)	+	-	-	-	-	-	-
B. papyrifera (paper birch)	+	+	++	++	+	-	++	++	-	-	+	+	-	-
Cornus nuttallii (western flowering dogwood)	-	-	+	-	-	-	-	-	-	-	++	++	-	-
Populus balsamifera ssp. *balsamifera* (balsam poplar)	-	-	-	-	-	-	+	++	+	-	-	-	-	-
P. balsamifera ssp. *trichocarpa* (black cottonwood)	+	+	+	++	+	+	++	+	-	-	++	++	+	-
P. tremuloides (trembling aspen)	+	++	+++	++	++	+	+++	+++	+	-	+	+	+	
Prunus emarginata (bitter cherry)	-	-	+[c]	++[c]	-	-	+[c]	-	-	-	++	+	-	-
Quercus garryana (Garry oak)	-	-	-	-	-	-	-	-	-	-	++	(+)	-	-
Rhamnus purshiana (cascara)	-	-	-	++[d]	-	-	-	-	-	-	++	+	-	-

[a] Occurrence classes: +++(abundant); ++(common); +(present but uncommon); (+)(very rare); -(absent).
[b] Tree species occur only in krummholz form in the Alpine Tundra zone.
[c] *P. emarginata* occurs in these zones, but only rarely as a (small) tree.
[d] Rarely as a small tree.

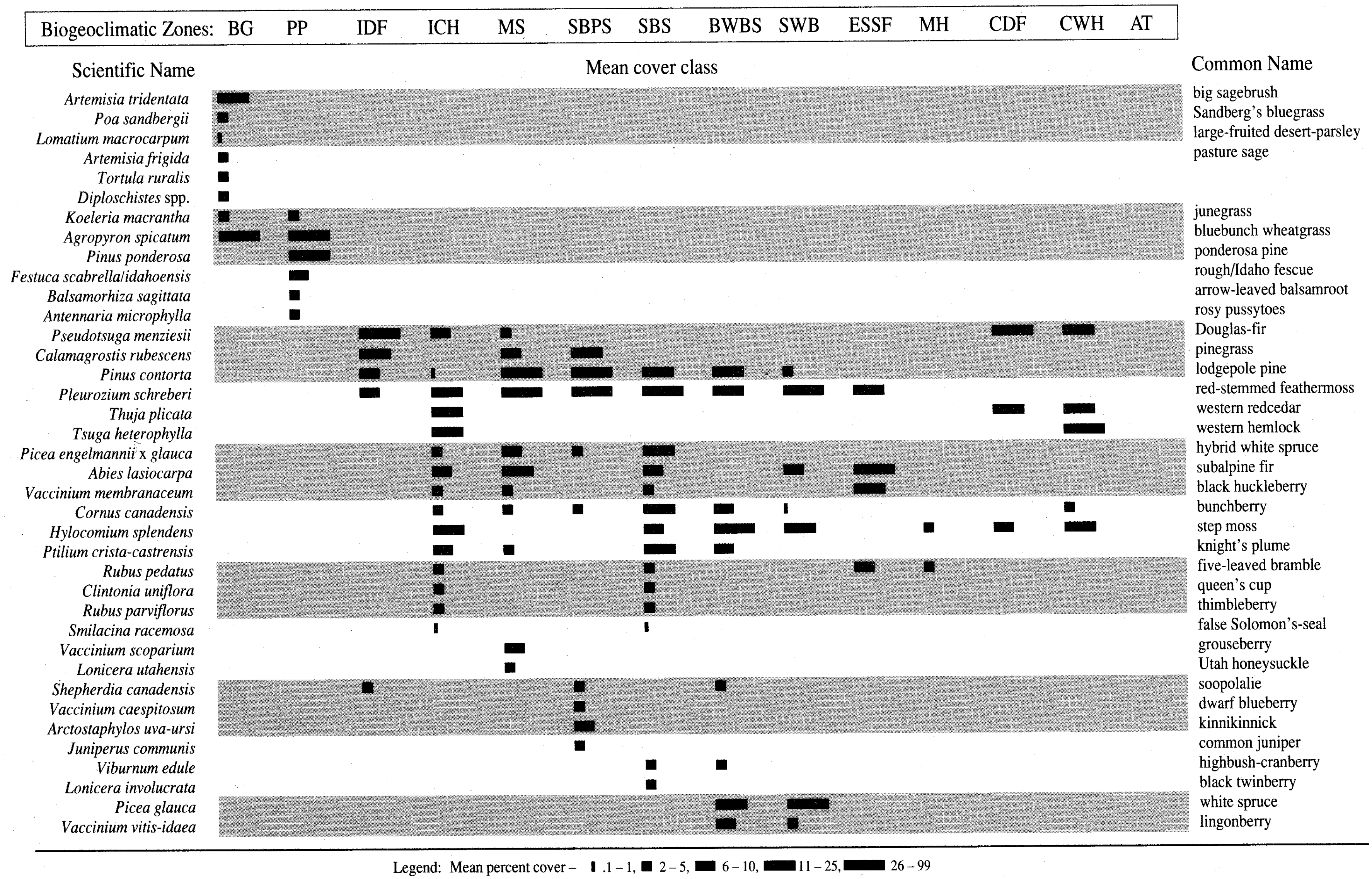


FIGURE 12. Zonal vegetation of the biogeoclimatic zones of British Columbia.

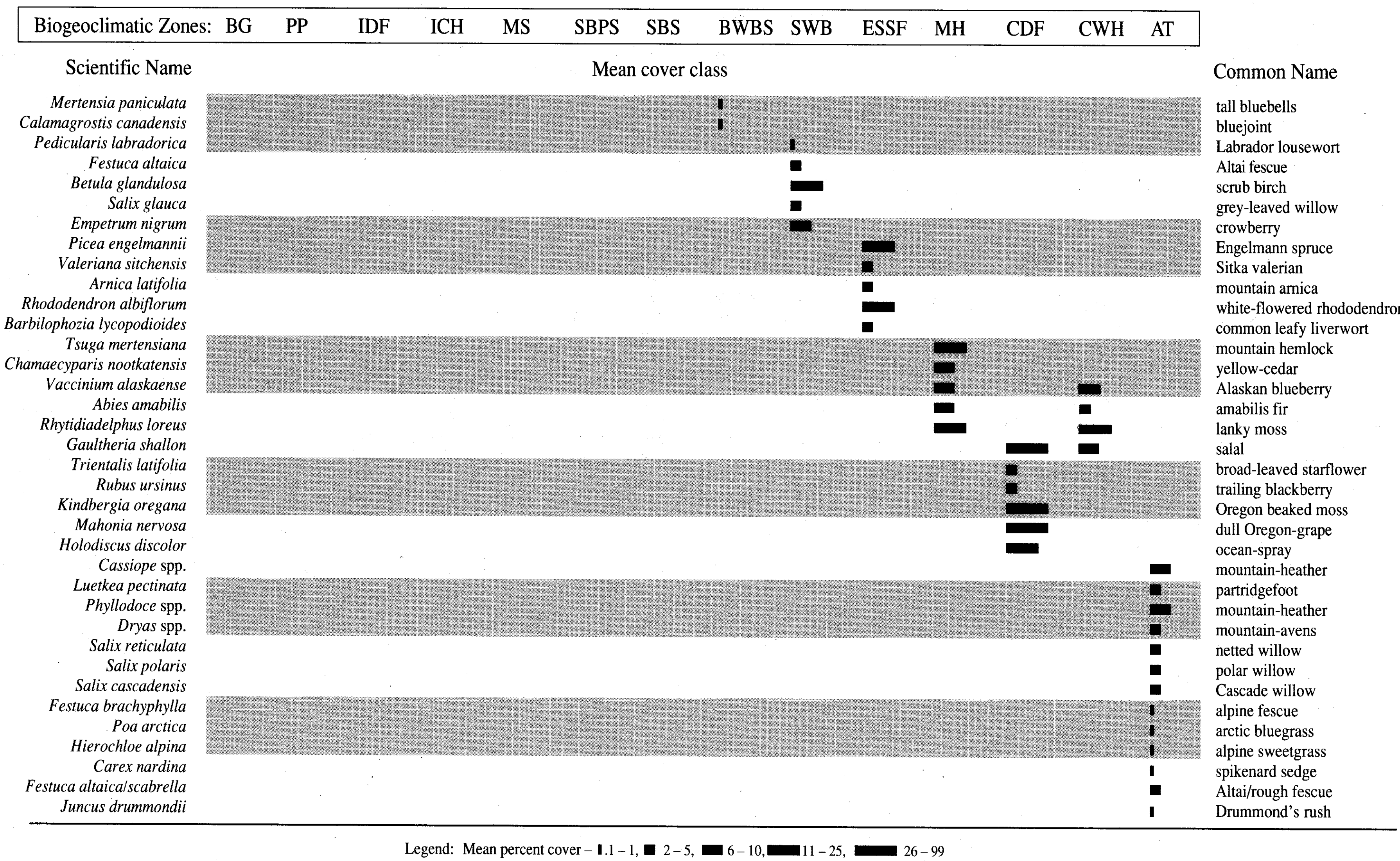
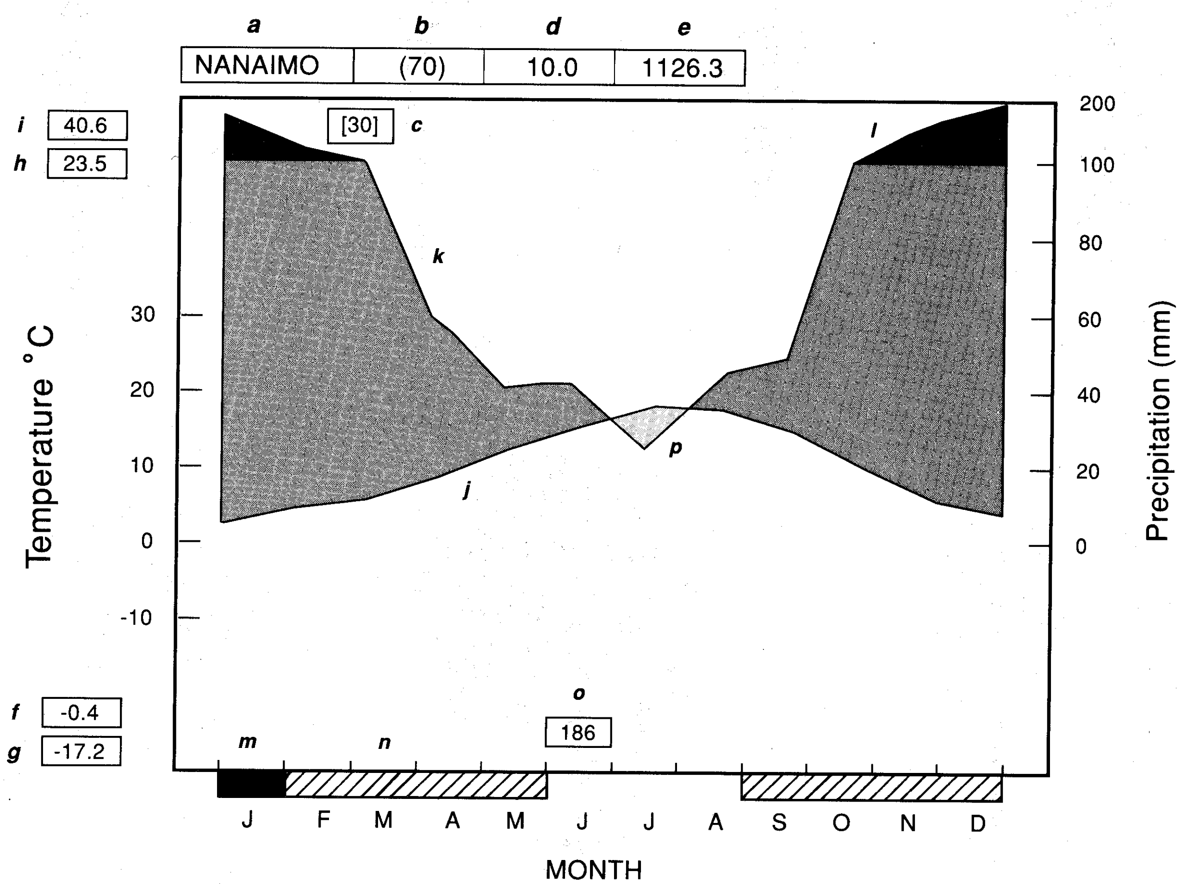


FIGURE 12. Continued.



a = Station.
b = Height above sea level (m).
c = Duration (years) of observations ([adj] - Adjusted to the nearest long period station).
d = Mean annual temperature (°C).
e = Mean annual precipitation (mm).
f = Mean daily minimum temperature of the coldest month.
g = Lowest temperature recorded.
h = Mean daily maximum temperature of the warmest month.
i = Highest temperature recorded.
j = Curve of mean monthly temperature.
k = Curve of mean monthly precipitation.
l = Mean monthly rain >100 mm (black scale reduced by 1/10).
m = Months with mean daily minimum temperature < 0°C (black).
n = Months with absolute temperature < 0°C (frost occurs).
o = Mean duration (days) of frost-free period.
p = Period of relative drought.

FIGURE 13. Explanation of climatic diagrams.

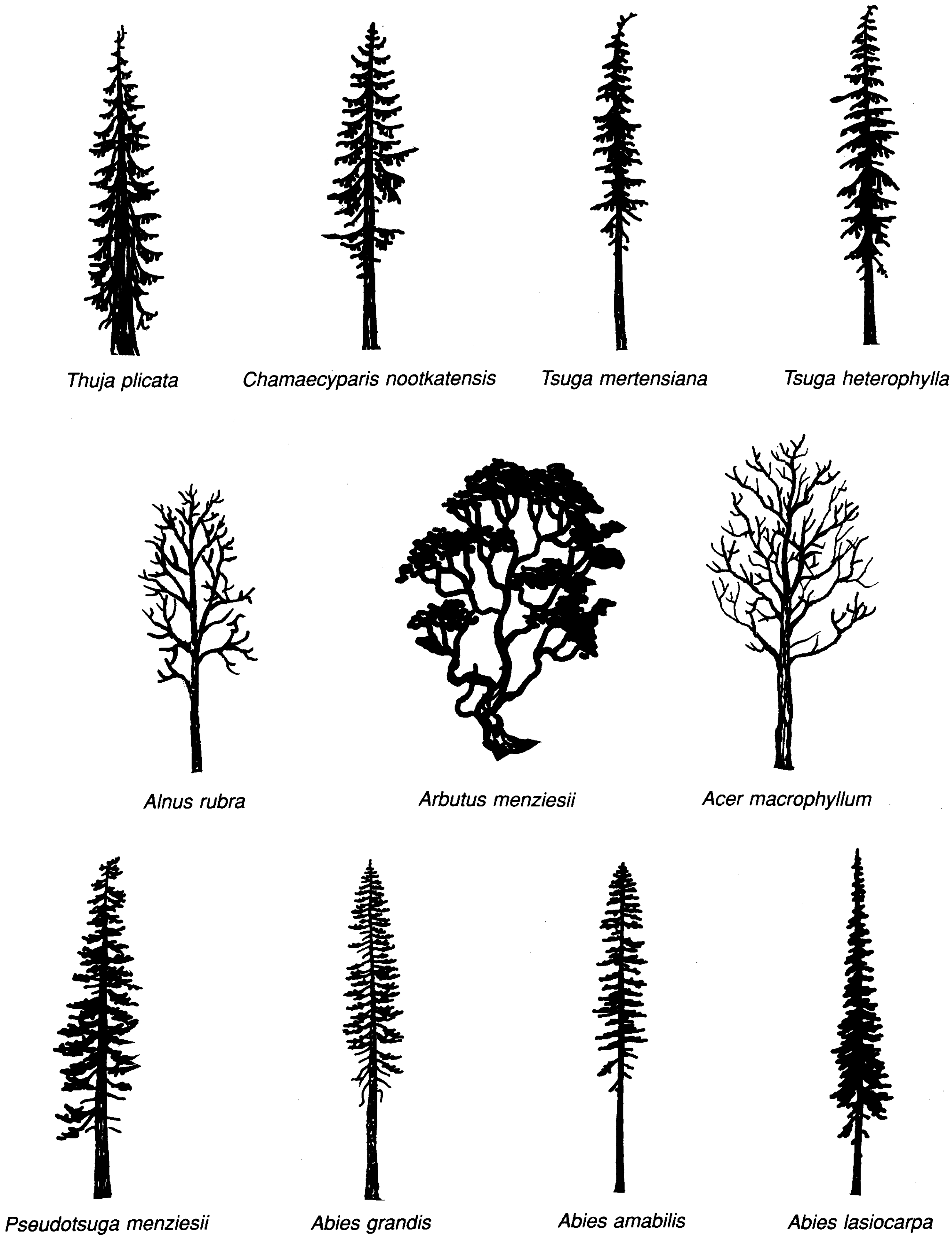


FIGURE 14. Tree species silhouettes used in schematic slope diagrams.

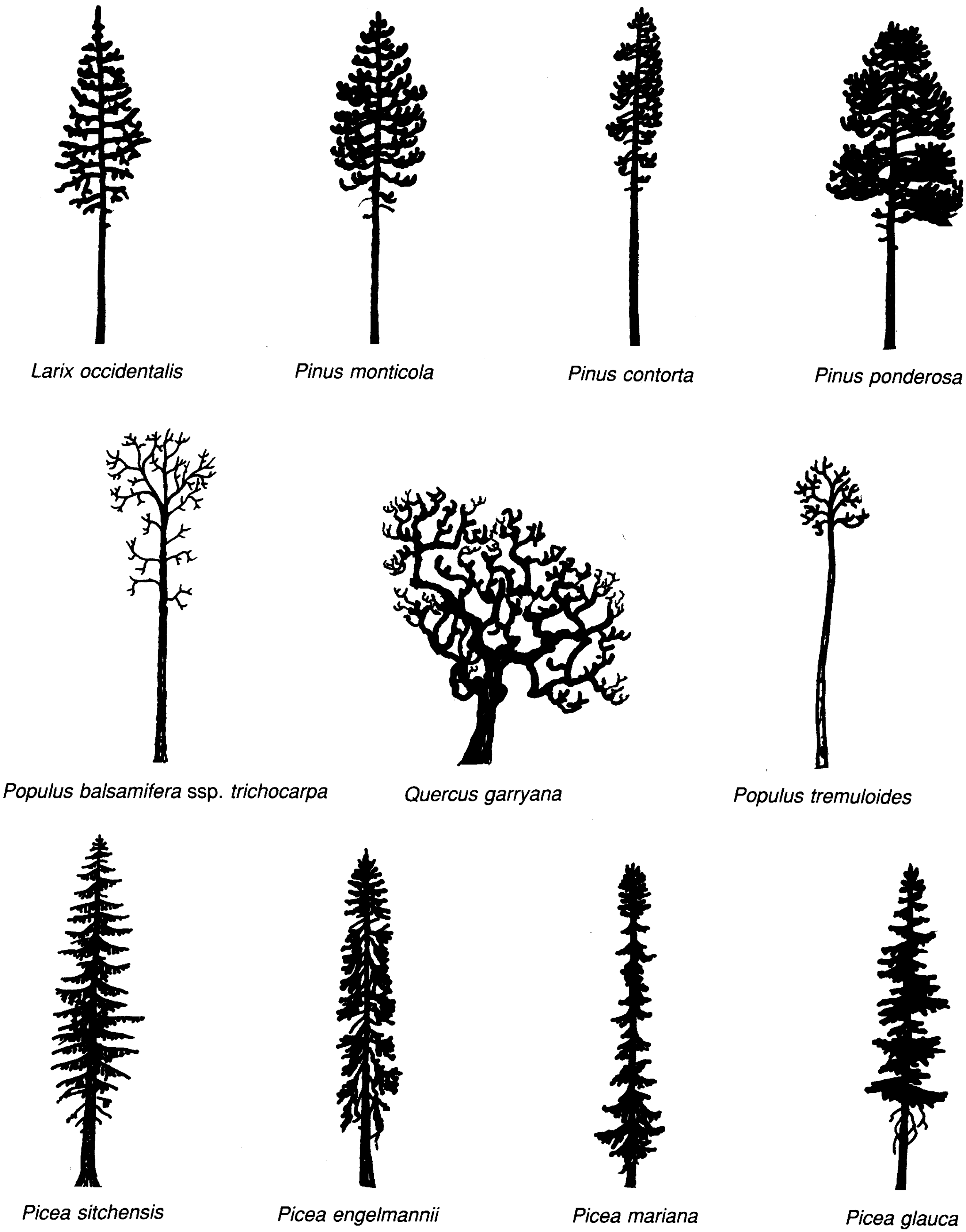


FIGURE 14. Continued.

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Chapter 4: Resource Values

by

A. MacKinnon, W.L. Harper, S. Chatwin, and B.M. Wikeem

INTRODUCTION

British Columbia has a great diversity of ecosystems. These ecosystems provide us with many resources. The ecosystems are used and managed in many ways to provide products that are important to the economic and physical well-being of the people of this province.

The "value" of some of these resources is presented in this chapter in order to give a provincial perspective to the resource value comments in each of the biogeoclimatic zone chapters.

AGRICULTURE

A very small percentage of British Columbia's land is suitable for agricultural production. Less than 1% (2.4 million ha) is highly productive (that is, rated Class 1, 2 or 3 — capable of growing a wide variety of crops — in the Canada Land Inventory agricultural land capability ratings). An additional 2.6 million ha of Class 4 agricultural land are available to grow some crops, and 6.7 million ha of Class 5 soils are capable only of producing perennial forage crops (B.C. Ministry of Crown Lands 1989). Most of the best agricultural land in the province (approximately 4.7 million ha) is protected in the Agricultural Land Reserve, in an effort to preserve that land for agriculture and to encourage agricultural production.

According to the latest figures available (1986), British Columbia had 19 063 farms, 5% fewer than in 1981. The number of large farms is increasing, the number of small farms decreasing. Improved land decreased 5% (to 900 000 ha) and unimproved land increased 23% (to 1.5 million ha). Total farmland increased by 11% (to 2.4 million ha) from 1981 to 1986. About 60% of the farmland is owned by operators, the rest, a significant portion of which is Crown land, is rented.

British Columbia has Canada's second highest percentage (28%) of farms with gross sales less than $2500; and highest proportion (51%) of operators who work off the farm (Statistics Canada 1987).

A wide variety of crops are produced on the province's farms. Fifty-three percent of all the area under crops is in tame hay. As well, British Columbia leads Canada in growing the following crops: cranberries (93% of the total area in Canada), apricots (66%), sweet cherries (60%), raspberries (57%), and brussel sprouts (56%).

FORESTRY

Eighty-five percent of British Columbia's land is located in the "provincial forests" — the commercial forests on which wood is harvested. These lands support more than 8 billion m^3 of mature timber, about 95% of it coniferous. British Columbia's standing softwood timber represents about 50% of the Canadian — and 20% of the

North American — total (B.C. Provincial Government 1989). Forest productivity is high (mean annual increment [MAI] 6.4 m^3/ha per year) in most of the Coastal Western Hemlock (CWH), Coastal Douglas-fir (CDF) and Interior Cedar — Hemlock (ICH) zones; medium (MAI = 3.5-6.3 m^3/ha per year) in most of the central and southern Interior (Sub-Boreal Spruce [SBS], Sub-Boreal Pine — Spruce [SBPS], Montane Spruce [MS], and Interior Douglas-fir [IDF] zones), low (MAI = 0.8-3.4 m^3/ha per year) in subalpine areas, dry southern Interior, and northern Interior (Engelmann Spruce — Subalpine Fir [ESSF], Mountain Hemlock [MH], Ponderosa Pine [PP], Bunchgrass [BG], and Boreal White and Black Spruce [BWBS] zones); and very low (MAI 0.8 m^3/ha per year) in the northern subalpine Spruce — Willow — Birch [SWB]) zone.

In fiscal year 1988-89, about 85 million m^3 of timber was cut, 76 million m^3 on Crown lands and 9 million m^3 on private lands (B.C. Ministry of Forests 1990a). Volumes cut can be summarized by species (Table 6), but not by biogeoclimatic zone. Some assumptions can be made about the latter, however, based on species distribution: *Larix* spp. (largely *L. occidentalis*) are from the IDF and MS zones, and the southern ICH; *Thuja plicata* is from the CDF and (largely) CWH on the Coast, the IDF and (largely) ICH in the Interior; *Chamaecyparis nootkatensis* is from the MH and CWH; Douglas-fir is from the CDF and southern CWH on the Coast, the IDF, MS, and drier parts of the ICH in the Interior; and the other species are more widely distributed.

TABLE 6. Volume of all wood products billed in fiscal year 1988/89, by species (from B.C. Ministry of Forests 1990a)

Species	**′000 m^3**
Abies spp.	11 226
Chamaecyparis nootkatensis	925
Larix spp.	660
Picea spp.	16 518
Pinus contorta	20 956
Pinus monticola	289
Pseudotsuga menziesii	9 398
Thuja plicata	8 641
Tsuga spp.	15 253
Other species	1 323
TOTAL	**85 189**

These volumes were cut from an area of about 270 400 hectares, 237 500 hectares on Crown land and 32 900 hectares on private land, but again the information is not available for each biogeoclimatic zone.

The timber cut in 1988 was manufactured into about 37 million m^3 of dimension lumber, 1.8 million m^3 of plywood, 7 million tonnes of pulp, 2.9 million tonnes of paper and paperboard, and 1.6 million tonnes of newsprint. Cutting, hauling, manufacturing and selling British Columbia's forest products directly employed about 7% of the province's workers in 1988. Exports totalled $13 billion ($7.3 billion from wood products, $6 billion from paper products), about 48% of the total value of shipments of British Columbia's manufactured products (B.C. Provincial Government 1989). Though fluctuating strongly with the strength of our export markets, the volume and value of products produced by our forest industry have generally increased over the past decade. The latest Ministry Annual Report (B.C. Ministry of Forests 1990) shows total shipments of all products for 1988/89 to be up 4.4% from 1987/88.

Silviculture contracting is another important area of income and employment generation from forestry in British Columbia. In 1988, more than 900 000 person-days of employment were provided in the reforestation effort.

FORESTS AND COMMUNITY WATERSHEDS

Forested watersheds are by far the main water supply for the majority of British Columbians. Table 7 shows a breakdown of the general source of domestic water for the province. Eighty percent of the population obtains its water from small rivers and lakes located within forests. The remaining 20% of the population draws water from large lakes, reservoirs, large rivers, or groundwater supplies.

The quality and quantity of water within a watershed is largely a function of the intact forest cover. Tree cover controls snow storage and melt rates by snow interception, shading, and wind ablation, influencing both yield and streamflow. Peak flows with their consequent high soil erosion rates are reduced by an intact forest cover. In snow-dominated forested watersheds, seasonal snow melt rates are less and runoff from rain-on-snow events is less than in deforested watersheds. In coastal watersheds, fog drip from branches can also be an important source of summer flow.

TABLE 7. Domestic water sources in British Columbia

Population	Percent of B.C. population	Water supply source
1 205 000	50.3	Greater Vancouver Water District - Capilano, Seymour, Coquitlam watersheds
216 000	9.0	Greater Victoria Water District - Sooke River Watersheds
221 000	9.2	Main stem or large lakes
245 000	10.2	Wells, springs and miscellaneous individual sources
512 000	21.3	Community watersheds
2 400 000	**100.0**	

Water quality is maintained best in forested watersheds. On the coast, forested watersheds have landslide rates many times less than comparable logged watersheds. Slope stability is enhanced by the tree roots anchoring the steeply sloped soils. An intact forest cover shields the soil from raindrop erosion, as do the organic soil horizons. Overland flow of water is extremely rare in forested watersheds because of the high surface infiltration through the well-structured forest soils, and because of the macro-permeability provided by earthworm holes, burrows, and rotted root channels. As a consequence, rates of surface soil erosion are very low in forested watersheds.

In some watersheds, streambank erosion is one of the main sources of sediment supply. Streambank vegetation, however, can reduce streambank erosion and maintain stream channel morphology. A wide buffer of streamside forest can also act to filter sediment washing off adjacent disturbed hillslopes.

The importance of maintaining forested slopes in many community watersheds is illustrated by the high proportion of small watersheds that make up the provincial water supply. Small watersheds are, of course, much more susceptible to alterations in water flow or quality, because any disturbance will affect a high proportion of the watershed area. As shown in Table 8, there are 285 watersheds in British Columbia that serve as community water supplies. The majority of these watersheds (175) have an area of less than 15.6 km^2. These "Category I" watersheds are designated as having maximum protection from disturbance of forest cover. They serve 41% of the provincial population, yet they make up only 0.09% of the land area of British Columbia. The high value of small forested watersheds is emphasized by the fact that they serve, on average, nearly 700 people per 2.5 km^2 of watershed area.

Forests play a vital role in regulating water supply and maintaining pristine water quality in British Columbia. The relatively small percentage of the provincial forest land base that is within community watersheds combined with the high proportion of the population that depends on this type of water supply, indicates the high value of forests in watersheds.

TABLE 8. Population served by watersheds of different sizes

Watershed designation	No. of watersheds	Total population (No.)	Total population (%)	Total land area (km^2)	Population served per km^2
Category I (<15.6 km^2)	175	210 085	41.0	836	251.3
Category II (15.6-90.6 km^2)	79	178 368	34.9	3 227	55.3
Category III (>90.6 km^2)	31	123 529	24.1	7 224	17.1
Totals	**285**	**511 982**	**100.0**	**11 287**	**n/a**

RANGE

Crown range provides spring, fall, and summer forage to mainly cow/calf and yearling operations in British Columbia. Nearly 1 million animal unit months (AUM's), or 60% of the total forage requirement for beef production in the province, were produced on Crown rangeland in 1989/89 (B.C. Ministry of Forests 1990a). The remaining 40% (600 000 AUM's) was produced on approximately one million ha of private pasture and rangeland.

Rangeland is often considered as land dominated by grasses, grasslike plants, forbs, or shrubs that are suitable for grazing or browsing by domestic livestock and certain wildlife. Range managers typically include as rangeland open, non-forested, plant communities such as natural grasslands, savannas, shrublands, deserts, tundra, coastal marshes, and wet meadows (Kothmann 1974). Forest land, however, may also be considered as range, particularly when the tree overstory has been removed by logging or burning, or when the forest canopy is sufficiently sparse to allow an understory of herbs and shrubs for grazing (Blaisdell *et al*. 1970).

The range resource in British Columbia is floristically diverse because of the wide variations in climate, physical characteristics, and historical use throughout the province. Both elevation and latitude play important roles in determining the kinds of plant communities that are available for domestic grazing.

Except for the Peace River area, the estimated 11 million ha of rangeland in British Columbia lies between the Coast Range and Rocky Mountains and spans a diversity of ecosystems including grasslands, wetlands, montane and subalpine forestlands, and alplands. Forest land is a particularly important component of the forage base, totalling nearly 80% of the provincial Crown range resource.

Eleven of the 14 biogeoclimatic zones in British Columbia are used to some extent for domestic livestock grazing (Table 9). The most important zones, in terms of forage production and extent, include the Bunchgrass, Ponderosa Pine, Interior Douglas-fir, Montane Spruce, Sub-Boreal Pine — Spruce, Sub-Boreal Spruce, and Boreal Black and White Spruce zones. The Mountain Hemlock, Coastal Douglas-fir, and Coastal Western Hemlock zones are not considered part of the range resource, although some local grazing does occur in these zones.

Considerable information is available describing range values for low-elevation grassland and southern forested biogeoclimatic zones (Tisdale 1947, 1950; Tisdale and McLean 1957; van Ryswyk *et al*. 1966; McLean 1970; McLean *et al*. 1971), but significantly less is known about the potential for livestock and the effects of grazing on high-elevation and northern zones. Few data are available describing range values for subzones, site associations, or seral plant communities, although descriptions at these levels would be more useful for range management than zonal descriptions would be. Similarly, the extent of provincial rangelands within each biogeoclimatic unit has not been documented.

TABLE 9. Biogeoclimatic zones used for livestock grazing in British Columbia, by Forest Region

Biogeoclimatic Zone	Forest Region					
	Nelson	Kamloops	Cariboo	Prince George	Prince Rupert	Vancouver
Alpine Tundra	X	X	X	X		X
Spruce — Willow — Birch				X		
Boreal White and Black Spruce				X		
Sub-Boreal Pine — Spruce		X	X	X	X	
Sub-Boreal Spruce		X	X	X	X	
Mountain Hemlock						
Engelmann Spruce — Subalpine Fir	X	X	X			
Montane Spruce	X	X	X			
Bunchgrass		X	X			
Ponderosa Pine	X	X	X			
Interior Douglas-fir	X	X	X			
Coastal Douglas-fir						
Interior Cedar — Hemlock	X	X	X		X	
Coastal Western Hemlock						

RECREATION

Recreational opportunities in British Columbia are managed by a variety of municipal, provincial, and federal government agencies. The three largest agencies involved are Parks Canada (national parks), the B.C. Ministry of Parks (provincial parks), and the B.C. Ministry of Forests (the provincial forest). The areas managed and the use of each are detailed in Table 10 (methods of recording use vary widely, and so any comparisons should be treated with caution).

Parks Canada manages four national parks (Glacier, Kootenay, Mt. Revelstoke, and Yoho), two national park reserves (South Moresby and Pacific Rim), three national historic parks (Fort Langley, Fort Rodd Hill, and Fort St. James), and many natural historic sites in British Columbia. The majority of the 6.7 million visits to Parks Canada sites in the province in 1987/88 were to the national parks and park reserves.

The 384 parks and recreation areas managed by the B.C. Ministry of Parks include 297 "Class A" parks (highest degree of protection) totalling over 4 million ha; 2 "Class B" parks (restricted resource development allowed) with an area of 25 000 ha; 30 "Class C" parks (community-type parks in Regional Districts) totalling 950 ha; 54 Recreation Areas (allowing multiple use when compatible with recreation) of 1.2 million ha; and one Wilderness Conservancy (a separate wilderness designation) of 132 000 ha. Use of provincial parks increased approximately 25% between 1983/84 and 1987/88 (B.C. Ministry of Environment and Parks 1988).

TABLE 10. Recreational use of federal parks, provincial parks, and B.C. Ministry of Forests recreation sites and trails (all fiscal year 1987/88)

Responsible Ministry	B.C. Ministry of Parks[a]	B.C. Ministry of Forests[b]	Parks Canada[c]
Number of parks/ recreation sites	384	1234	9
Total area (ha)	5 362 602	-	4 412 000
Trail length (km)	-	7995	-
Wilderness areas (ha)	-	132 000	-
Total recorded visits 1987/88	19 642 016	1 841 791	6 984 369

[a] B.C. Ministry of Environment and Parks (1988).
[b] B.C. Ministry of Forests and Lands (1989).
[c] Canadian Parks Service Monthly Attendance. Environment Canada, Canadian Parks Service, Socioeconomic Information Division. Ottawa, Ont. (Monthly periodical).

The B.C. Ministry of Forests manages recreational resources on provincial forest lands, which make up approximately 85% of the province. Recreation sites and trails have been established "to provide the opportunity for recreation experiences and benefits by protecting recreation resources ... and managing their use," and wilderness areas have been designated "to maintain and protect a wilderness resource ... and provide the opportunity for a wilderness experience."[11] Logging is prohibited in wilderness areas; mining may be (this depends on the management objectives for the area). Because much of the recreation activity is dispersed throughout the provincial forest, rather than being concentrated on particular sites and trials, the recreation resource must be managed and integrated with other resources. The Ministry of Forests has created a Recreation Inventory (including recreation features, along with other biophysical and cultural amenity resources such as visual landscape sensitivities and values) and a Recreation Opportunity Spectrum (ROS) (a classification of the degree of remoteness and naturalness of an area). These have been mapped at a 1:50 000 scale for most of the province.

WILDLIFE

British Columbia's wildlife resource supports many uses and provides many benefits — recreational, scientific, sustenance-related, cultural, and commercial. B.C. Ministry of Environment has estimated that over 1 million people each year are engaged in recreational and commercial uses of wildlife in British Columbia. The total value of wildlife related activities to provincial residents exceeds $1 billion annually (Wildlife Branch 1989).

[11] B.C. Ministry of Forests (1990b)

Non-consumptive wildlife viewing accounts for the majority of this use. About 1.3 million residents of British Columbia (65% of the adult population) had indirect non-hunting encounters with wildlife while on outings during 1983 (Reid *et al*. 1986). In addition, about 500 000 residents (24% of the adult population) participated in direct non-hunting wildlife activities, where the main purpose was recreation involving non-consumptive uses, primarily viewing, feeding, identifying, and photographing wildlife (Wildlife Branch 1989).

Currently there are approximately 130 000 licensed resident hunters in British Columbia. Resident hunting is concentrated on deer (Mule Deer, Black-tailed Deer, and White-tailed Deer), upland gamebirds, Moose, waterfowl, small game, Elk, and Black Bear (Reid 1985a).

Big game guiding, primarily of non-resident hunters, is a significant economic activity, particularly in the North and in the East Kootenays. Non-resident hunting is concentrated on Moose, Black Bear, Deer, Elk, Mountain Goat, Mountain Sheep, Caribou, and Grizzly Bear (Reid 1985b).

Trapping is also an important use of wildlife, particularly in rural and northern communities. Marten and squirrels are the most common pelts taken, followed by Muskrat and Beaver. Weasels, Mink, Lynx, and Coyote also make up a significant proportion of the total harvest. In response to fashion demands, Marten accounted for 71% of the raw fur sales value in 1987/88, followed by Lynx (9%), Beaver (7%), Mink (5%), and others (8%).

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Chapter 5: Coastal Douglas-fir Zone

by

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LOCATION AND DISTRIBUTION

The Coastal Douglas-fir zone (CDF) is limited to a small part of southeastern Vancouver Island, several islands in the Gulf of Georgia, and a narrow strip of the adjacent mainland (Figure 15). It is confined to elevations mostly below 150 m. Climate and plant communities similar to those of the CDF in British Columbia occur in Washington in the Puget Trough and on the San Juan Islands, and in Oregon in the Willamette Valley (Franklin and Dyrness 1973).

ECOLOGICAL CONDITIONS

The CDF lies in the rainshadow of the Vancouver Island and Olympic mountains. It has warm, dry summers and mild, wet winters. Based on long-term weather stations (Table 4), the mean annual temperature ranges from 9.2 to 10.5°C, and the absolute minimum temperature ranges from -21.1 to -11.7°C. The climate diagram for the representative weather station (Figure 16) shows that the monthly average of the daily minimum temperatures never falls below 0°C. Where mineral soil is exposed, the water near the soil surface can freeze periodically, causing frost heaving. However, soil frost is extremely unlikely if the soil surface is protected by a forest floor (humus layer) or a cover of vegetation.

Mean annual precipitation varies from 647 to 1263 mm; very little (5% or so) falls as snow from November to April. In most winters the snow melts within a week of falling. Dense young stands of trees in the pole stage are susceptible to damage by this snow, which is usually wet and heavy.

The majority of forests that are found today in the CDF have regenerated after logging that occurred at the turn of the century. Old growth remains in only a few areas, such as parks. The coastal variety of Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) is the most common tree species in upland forests. It can regenerate under the canopy of mature and partly open stands on most habitats. Western redcedar, grand fir, arbutus (the only evergreen broadleaf tree in British Columbia), Garry oak, and red alder frequently accompany Douglas-fir, depending on site moisture and nutrient regime. Less common trees in the CDF include shore pine, Sitka spruce (rare), western hemlock (rare), bitter cherry (*Prunus emarginata*), western flowering dogwood (*Cornus nuttallii*), bigleaf maple, black cottonwood, and trembling aspen (rare). The tree species composition of forest stands varies considerably as a result of widespread human disturbance.

The vegetation of the CDF includes about 50 rare species (Straley *et al*. 1985) restricted to the zone. Most of these are at the northern limit of their distribution and include species of seaside, aquatic, rock outcrop, and forested habitats. The CDF also contains a rare plant species endemic to British Columbia — *Limnanthes macounii* (Macoun's meadowfoam).

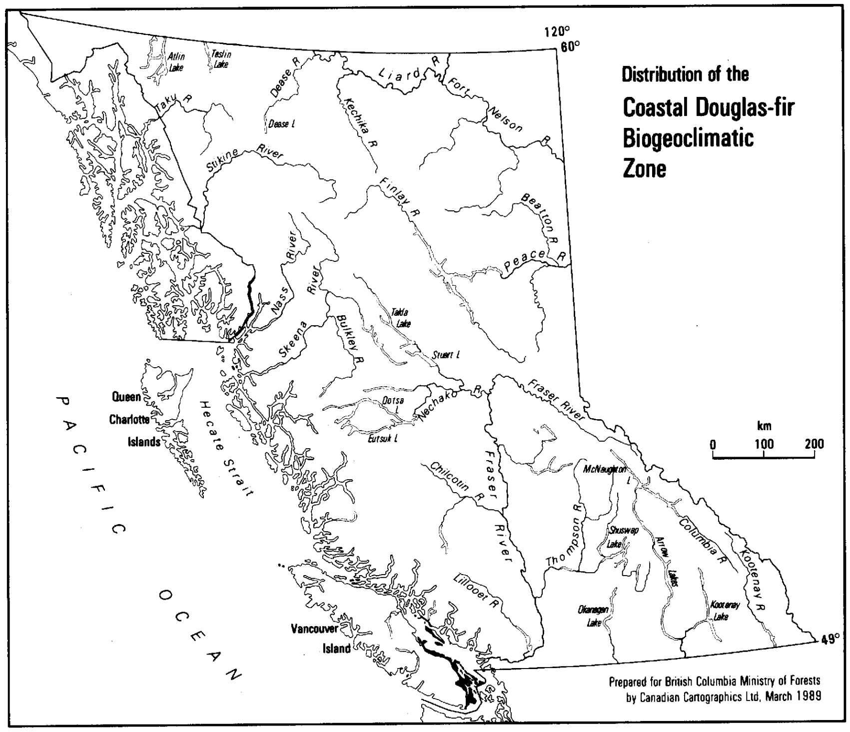

FIGURE 15. Coastal Douglas-fir zone.

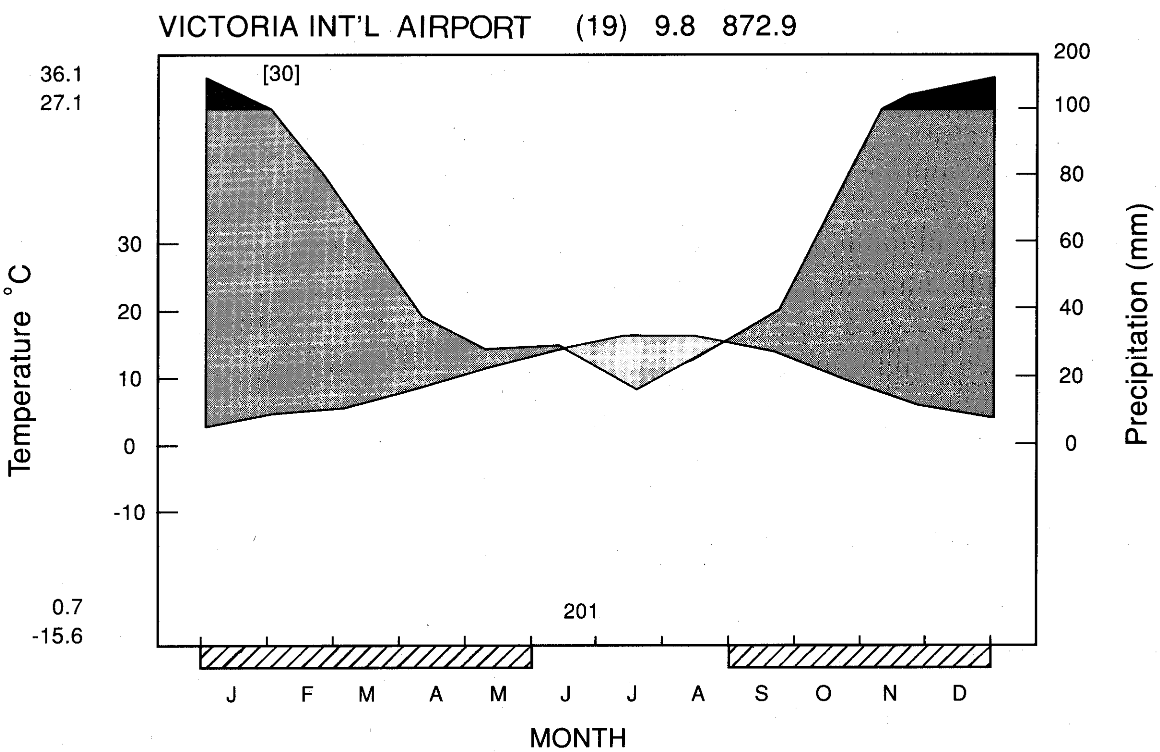

FIGURE 16. Representative climatic diagram for the Coastal Douglas-fir zone.

The Garry oak — rock outcrop and Garry oak savanna or parkland ecosystems contain many of these rare species, such as *Aster curtus* (white-topped aster), *Balsamorhiza deltoidea* (deltoid balsamroot), *Camassia leichtlinii* (great camas), and *Castilleja levisecta* (golden Indian paintbrush).

In addition, many species of a broader southern distribution are restricted to these Garry oak ecosystems in the CDF. These include showy flowers such as *Camassia quamash* (common camas), *Dodecatheon hendersonii* (broad-leaved shootingstar), and *Sisyrinchium douglasii* (satin-flower), which contribute to the beautiful spring floral display of these "saanich" ecosystems. Encroaching urban development and invasion of the weedy *Cytisus scoparius* (Scotch broom) are threatening these important and unique ecosystems.

Alluvial forests and wetlands are rare in the CDF as a result of urbanization and agriculture.

Soils in the CDF are generally derived from morainal, colluvial, and marine deposits. The accumulation of organic materials in semi- to well-decomposed organic deposits is uncommon. Soils are usually Brunisols, grading with increased precipitation to Humo-Ferric Podzols. Zonal soils are mostly Dystric or Eutric Brunisols; the soils developing under Garry oak typically include a melanized (Ah) horizon and are Melanic Brunisols. Humus development is characterized by Moder to weak Mor formation.

NOTES ON CLASSIFICATION

Krajina (1965) initially recognized dry and wet subzones of this zone. The wet subzone is now classified in the Coastal Western Hemlock zone (Eastern Very Dry Maritime [CWHxm1] variant) as a result of a review of information and changes in the methods of classification. Thus, only one "maritime" subzone of the CDF is now recognized. Variants of this Moist Maritime CDF (CDFmm) subzone have not been identified. With increasing elevation, latitude, and distance inland from the coast, the CDFmm subzone is replaced by the CWHxm1 variant.

Most of the data for classification of site associations in the CDFmm were collected by Roemer (1972). Additional information and changes in classification concepts over the past 10 years have caused some changes to the classification of ecosystem units. An overview of the current status of some site associations follows.

SOME REPRESENTATIVE SITE ASSOCIATIONS

These four common site associations represent plant communities that occupy a gradient of soil moisture regimes ranging from very dry to wet and that have not been disturbed for a minimum of 50 years. Topographic position of the site is frequently correlated with this soil moisture regime, allowing site associations to be depicted as in Figure 17. The four site associations listed are not found in any other biogeoclimatic zone.

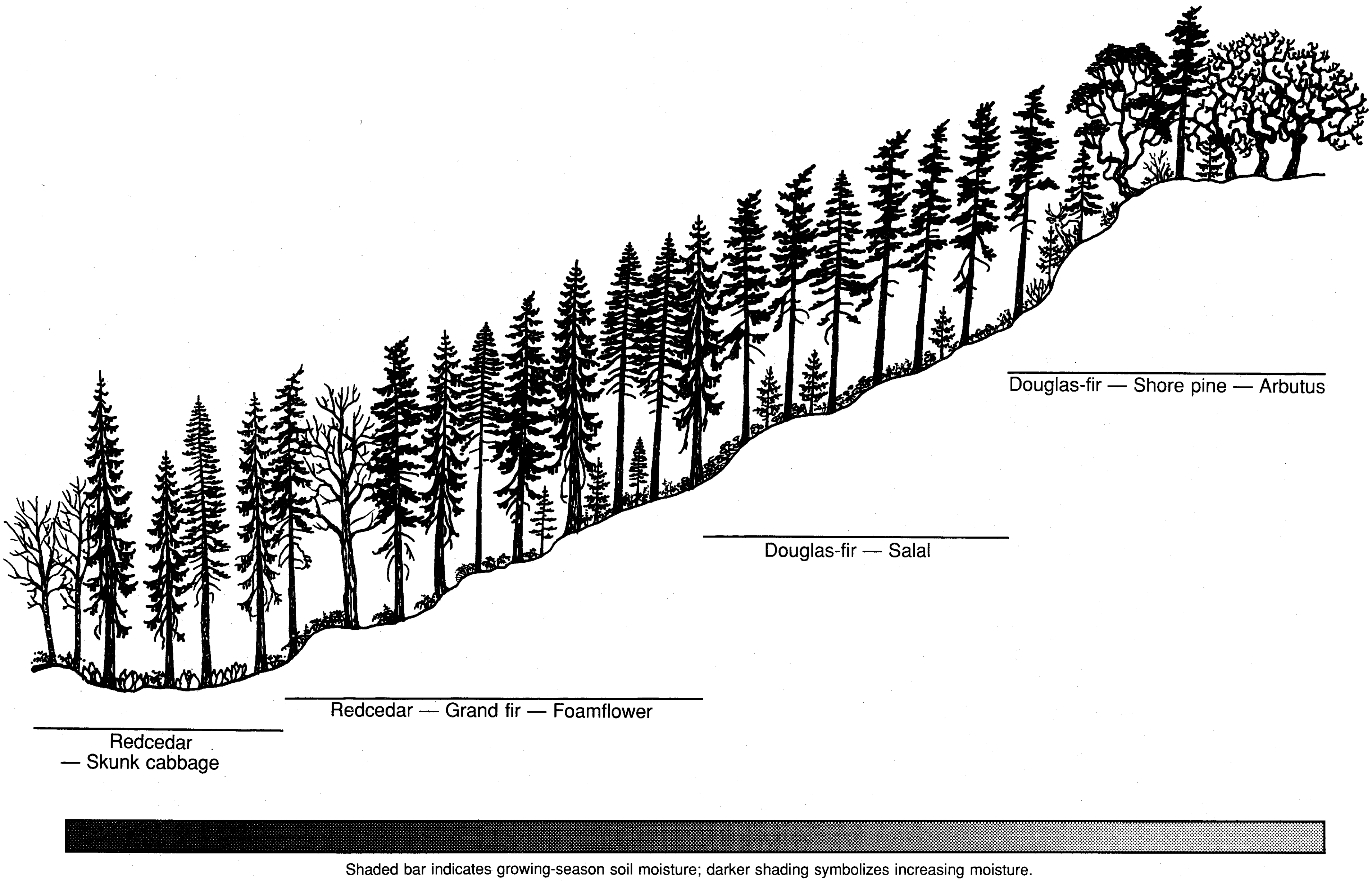

FIGURE 17. Simplified schematic diagram of topographic relationships among four common site associations of the Coastal Douglas-fir zone.

Douglas-fir — Salal

This is the zonal site association; it has a moderately dry soil moisture regime and a very poor to medium soil nutrient regime. Mature stands have a canopy cover that is continuous except for openings caused by rock outcrops or shallow soil. The tree layer is dominated by Douglas-fir, usually with a component of grand fir and western redcedar. Western flowering dogwood is often present. In this site association, Douglas-fir can regenerate beneath the small canopy gaps that result from the death of trees.

The shrub layer in mature stands is well developed, containing mainly *Gaultheria shallon* (salal) and *Mahonia nervosa* (dull Oregon-grape) with lesser amounts of *Vaccinium parvifolium* (red huckleberry) and *Rosa gymnocarpa* (baldhip rose).

The herb layer, though less well developed than the shrub layer, is still prominent. It is dominated by *Pteridium aquilinum* (bracken), *Rubus ursinus* (trailing blackberry), and frequently *Symphoricarpos mollis* (trailing snowberry). Additionally, species such as *Festuca subulata* (bearded fescue) and *Lonicera ciliosa* (western trumpet honeysuckle) are often found.

Kindbergia oregana (Oregon beaked moss) is the predominant moss of the well-developed moss layer. Other species that often have high cover are *Hylocomium splendens* (step moss) and *Rhytidiadelphus triquetrus* (electrified cat's-tail moss).

The soils of zonal sites usually belong to the Dystric Brunisol soil great group, but Sombric Brunisols and Humo-Ferric Podzols are occasionally present, too. The humus forms are usually Moders, but Mormoders also occur.

Douglas-fir — Shore pine — Arbutus

This site association has a very dry soil moisture regime and a very poor to medium soil nutrient regime. The tree canopy is often interrupted because of the rock outcrops and pockets of shallow soil. A characteristic floristic feature of this site association is the presence of Douglas-fir regeneration in the understory of the tree canopy. Mature stands are dominated by Douglas-fir and arbutus. Garry oak is often present as a minor tree species.

The shrub layer contains *Holodiscus discolor* (ocean-spray), *Mahonia nervosa*, and *Rosa gymnocarpa*. *Mahonia aquifolium* (tall Oregon-grape) and *Amelanchier alnifolia* (saskatoon) are also present in minor amounts. The herb layer usually includes *Bromus vulgaris* (Columbia brome), *Lathyrus nevadensis* (purple peavine), *Lonicera ciliosa*, *Melica subulata* (Alaska oniongrass), *Trientalis latifolia* (broad-leaved starflower), *Erythronium oreganum* (white fawn lily), *Sanicula crassicaulis* (Pacific sanicle), and *Rubus ursinus*; and often contains *Festuca occidentalis* (western fescue), *F. subulata*, and *Galium aparine* (cleavers).

Kindbergia oregana and *Rhytidiadelphus triquetrus* are the predominant mosses. Another species that often has a high cover is *Hylocomium splendens*.

The shrub, herb, and moss layers of the Douglas-fir — Shore pine — Arbutus site association are all well developed. Douglas-fir regenerates on these sites.

The soils usually belong to the Dystric Brunisol soil great group. Humus forms are usually classified as Xeromors or Moders.

Redcedar — Grand fir — Foamflower

This site association has a slightly dry to fresh soil moisture regime and a rich to very rich soil nutrient regime. Such sites are often used for agriculture rather than forestry.

Where the site association is forested, the tree stratum consists of Douglas-fir, grand fir, western redcedar, bigleaf maple, and western flowering dogwood. Western redcedar occurs in the understory. However, its growth rate is slow until an opening occurs in the canopy above. Douglas-fir is not able to grow below an intact tree canopy in this site association.

Gaultheria shallon and *Mahonia nervosa*, and *Taxus brevifolia* (western yew) are present in the shrub layer.

In the herb layer, *Achlys triphylla* (vanilla-leaf), *Galium triflorum* (sweet-scented bedstraw), *Polystichum munitum* (sword fern), *Rubus ursinus*, *Tiarella trifoliata* (three-leaved foamflower), *Trientalis latifolia*, and *Trillium ovatum* (western trillium) usually occur. With the exception of sword fern, the herb layer generally has low cover.

Kindbergia oregana and *Leucolepis menziesii* (palm tree moss) are frequently found in the moss layer. This layer is not well developed.

The soils are usually Sombric Brunisols, although Dystric Brunisols are also found. Incipient gleying may be present in both soil types. The humus forms are usually classified as Mulls, but Moders are also present.

Redcedar — Skunk cabbage

This site association is found where the soil moisture regime is wet and the soil nutrient regime is rich to very rich. In many cases, these sites have been drained and are used for agriculture.

Where natural vegetation remains, trees tend to be restricted to elevated microsites, largely because of the increased availability of oxygen for root respiration there. Thus, the tree canopy is not continuous on this site association. Western redcedar and red alder are the major tree species; occasionally, bigleaf maple and western hemlock are also present. Douglas-fir is not adapted to growing on these sites. Tree regeneration occurs on the elevated microsites but does not grow well until the older trees occupying the microsites die.

The moderately well-developed shrub layer is dominated by *Rubus spectabilis* (salmonberry). It also contains *Oemleria cerasiformis* (Indian-plum) and *Sambucus racemosa* (red elderberry) as major species.

The herb layer is well developed. Herbs that predominate include *Athyrium filix-femina* (lady fern), *Dryopteris expansa* (spiny wood fern), *Equisetum telmateia* (giant horsetail), *Lysichiton americanum* (skunk cabbage), *Maianthemum dilatatum* (false lily-of-the-valley), *Polystichum munitum*, *Stachys cooleyi* (Cooley's hedge-nettle), and *Tiarella trifoliata*.

The moderately well-developed moss layer contains *Kindbergia praelonga*, *Leucolepis menziesii*, and *Plagiomnium insigne*.

The soils usually belong to the Gleysol or Organic soil order. The humus forms are usually classified as Hydromulls.

WILDLIFE HABITATS

The factors that most influence the assemblage of animal species in this zone (Table 11) are the mild, moist winters and the warm, dry summers. The CDF receives the least snowfall, both in terms of amount and duration, of any zone in British Columbia. Another factor that influences wildlife is the location of this zone leeward of the Vancouver Island Mountains, on coastal plains and small islands in the Strait of Georgia. Indeed, the island nature of most CDF habitat, on both Vancouver Island and the smaller Gulf Islands, means that it will have fewer wildlife species than had it occurred on the mainland. Black-tailed Deer are the most abundant large ungulate, although Roosevelt Elk were present before the conversion of the coastal plain into agricultural fields and small communities. Both Black Bear and Cougar are common throughout, but are usually eliminated when they enter rural and urban areas. Their numbers are therefore not as high as they could be. Recently, the Gray Wolf has invaded Vancouver Island, too; and while they are more abundant in the Coastal Western Hemlock zone to the north and west, they occasionally enter the CDF in search of deer.

Many species of waterbirds spend the winter months on the estuaries and sheltered waters within this zone. Typical waterfowl include species such as Mallard, American Wigeon, Lesser Scaup, Harlequin Duck, Trumpeter Swan, Bufflehead, Hooded Merganser, Western Gull, Glaucous-winged Gull, and California Gull. Only a few species breed here, such as the colony-nesting Great Blue Heron, Mallard, and the re-introduced, non-migratory Canada Goose.

Mature and old-growth coniferous forests are important for birds that eat conifer seeds, or wood-boring and bark insects. Species that breed in these forest habitats are: Pileated Woodpecker, Yellow-bellied Sapsucker, Hairy Woodpecker, Downy Woodpecker, Steller's Jay, Raven, Chestnut-backed Chickadee, Brown Creeper, Winter Wren, and Varied Thrush. Some species are highly specialized such as the Western Flycatcher, which only inhabits thickets in depressions, ravines, or along waterways.

Deciduous thickets and shrubbery offer a variety of flying insects and seeds for breeding populations of House Wren, Hutton's Vireo, Black-headed Grosbeak, and White-crowned Sparrow.

The many small islets offshore Vancouver Island provide nesting security for colony-nesting birds such as the Glaucous-winged Gull, Brandt's Cormorant, and Double-crested Cormorant.

TABLE 11. Selected wildlife habitats and species in the Coastal Douglas-fir zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth coniferous forests	Limited areal extent, dwindling	Black-tailed Deer, Black Bear, Cougar, Gray Wolf, Marten, California Myotis, Red Squirrel, Deer Mouse Great Horned Owl, Saw-whet Owl, Barred Owl, Blue Grouse, Ruffed Grouse, Band-tailed Pigeon, Pileated Woodpecker, Yellow-bellied Sapsucker, Downy Woodpecker, Hairy Woodpecker, Common Raven, Steller's Jay, Western Flycatcher, Brown Creeper, Chestnut-backed Chickadee, Red-breasted Nuthatch, Winter Wren, Varied Thrush, Anna's Hummingbird Western Toad, Pacific Treefrog, Western Red-backed Salamander, Ensatina Salamander, Northwestern Salamander	∇ Keen's Long-eared Myotis, Townsend's Big-eared Bat, Marbled Murrelet, Sharp-tailed Snake ♦ Bald Eagle, Clouded Salamander
Young seral and managed second-growth forests	Extensive	Black-tailed Deer, Black Bear, Cougar, Gray Wolf, Marten, Deer Mouse Great Horned Owl, Barred Owl, Blue Grouse, Ruffed Grouse, Band-tailed Pigeon, Northern Flicker, Hairy Woodpecker, Common Raven, Gray Jay, Steller's Jay, Chestnut-backed Chickadee, Red-breasted Nuthatch, Winter Wren Western Toad, Pacific Treefrog, Western Red-backed Salamander, Ensatina Salamander, Northwestern Salamander	∇ Townsend's Big-eared Bat
Mixed coniferous and deciduous forests	Common, not extensive	Black-tailed Deer, Black Bear, Gray Wolf, Marten, Raccoon, California Myotis, Red Squirrel, Deer Mouse Red-tailed Hawk, Northern Saw-whet Owl, Blue Grouse, Ruffed Grouse, Common Merganser, Steller's Jay, Hairy Woodpecker, House Wren, Hutton's Vireo, Black-headed Grosbeak, White-crowned Sparrow, Townsend's Warbler Northern Alligator Lizard, Pacific Treefrog, Ensatina Salamander, Northwestern Salamander	∇ Marbled Murrelet

TABLE 11. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Garry oak — arbutus forests	Limited areal extent, dwindling	Black-tailed Deer, Yuma Myotis, Deer Mouse Coopers' Hawk, Merlin, Western Screech-Owl, Great Horned Owl, Turkey Vulture, Pileated Woodpecker, Downy Woodpecker, Northern Flicker, Common Raven, Northwestern Crow, American Robin, Varied Thrush, Band-tailed Pigeon, Dark-eyed Junco, Rufous-sided Towhee, Fox Sparrow, Song Sparrow, Hutton's Vireo, Chestnut-backed Chickadee, Bushtit, Bewick's Wren, Brown Creeper, Rufous Hummingbird Western Garter Snake, Northwestern Garter Snake, Northern Alligator Lizard	∇ Lewis' Woodpecker
Clearcuts, burns, seepage sites	Limited areal extent	Black-tailed Deer, Black Bear Turkey Vulture, Blue Grouse, Lewis' Woodpecker, Band-tailed Pigeon, Willow Flycatcher, American Robin, Swainson's Thrush, Cedar Waxwing, Purple Finch Red-legged Frog	
Agricultural areas	Common	Raccoon, Spotted Skunk Cooper's Hawk, Red-tailed Hawk, Rough-legged Hawk, Northern Harrier, Short-eared Owl, Mew Gull, Glaucous-winged Gull, Northwestern Crow, Brewer's Blackbird	♦ Common Barn-Owl, Purple Martin
Riparian areas, wetlands, meadows, floodplains, lakes, and streams	Limited areal extent	Black-tailed Deer, Black Bear, Gray Wolf, Raccoon, River Otter, Mink, Deer Mouse, Wandering Shrew, Vagrant Shrew Osprey, Short-eared Owl, Blue Grouse, Ruffed Grouse, Trumpeter Swan, Canada Goose, Ring-necked Duck, Redhead, Harlequin Duck, Wood Duck, Red-throated Loon, Common Merganser, Wilson's Phalarope, Black Tern, Mew Gull, American Dipper Western Garter Snake, Northwestern Garter Snake, Painted Turtle, Western Toad, Bullfrog, Red-legged Frog, Northwestern Salamander, Long-toed Salamander, Rough-skinned Newt	∇ Sharp-tailed Snake ♦ Bald Eagle, Great Blue Heron, Green-backed Heron, Yellow-headed Blackbird, Purple Martin
Marine cliffs and rocky islets	Common	Northern Sea Lion, Harbor Seal Black Oystercatcher, Double-crested Cormorant, Pelagic Cormorant, Pigeon Guillemot, Rock Sandpiper, Glaucous-winged Gull, Surfbird	∇ Keen's Long-eared Myotis, Anatum Peregrine Falcon ♦ Bald Eagle, Brandt's Cormorant

TABLE 11. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Estuaries, shallow bays, intertidal and sub-tidal marine	Limited areal extent	Black-tailed Deer, Black Bear, Gray Wolf, Raccoon, Mink, River Otter, Northern Sea Lion, Harbour Seal, Killer Whale, Harbor Porpoise Northern Pygmy-owl, Sharp-shinned Hawk, Turkey Vulture, Red-throated Loon, Yellow-throated Loon, Trumpeter Swan, Canada Goose, Brant, Barrow's Goldeneye, Black Scoter, Surf Scoter, White-winged Scoter, Mallard, Northern Shoveller, American Wigeon, Lesser Scaup, Green-winged Teal, Pigeon Guillemot, Glaucous-winged Gull, California Gull, Northwestern Crow	♦ Bald Eagle, Great Blue Heron

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Wildlife abundance and diversity in an urban setting are related to the density of development. Areas that are interspersed with parks, landscaped gardens, and native forests have more of the habitat requirements for more species than areas dominated by buildings and pavement. Non-native species such as the Rock Dove, House Sparrow, European Starling, Roof Rat, Norway Rat, and House Mouse do well in developed urban areas. Some native species have also adapted to city life, for example, the Herring Gull, Common Nighthawk, Barn Swallow, Raccoon, and Little Brown Myotis often use buildings for nests and burrows.

Several animal species have been introduced to this zone. The Ring-necked Pheasant and California Quail have become established in agricultural areas and in upland habitats dominated by *Cytisus scoparius*. The Eurasian Skylark occurs in similar habitat on the Saanich Peninsula. The Eastern Cottontail and Striped Skunk have been released on southern Vancouver Island and are spreading northward along the Nanaimo Lowlands. Fallow Deer were released on Sidney and James Islands where they have proliferated and severely overbrowsed the vegetation. Painted Turtles, the result of accidental releases, occur in only a few ponds on the Nanaimo Lowland, while the Bullfrog was deliberately released into wetlands on the Nanaimo Lowland and the Gulf Islands in order to develop a frog-leg industry.

RESOURCE VALUES

The major portion of the land base in the CDF is not dedicated to forestry. However, many sites in the CDF have a high capability to produce timber and many fee-simple (so-called "private") properties are managed for forestry. Low summer precipitation resulting in a soil moisture deficit is the major factor limiting growth on sites that are likely to be managed for forestry. Thus, soil water conservation should be a major management consideration in timber production.

A large part of the CDF is used for residential and industrial purposes. Industry is concentrated in the urban centers of Duncan, Nanaimo, Powell River, and Victoria. Residential use is greatest in urban centers but is also a major land use elsewhere, as on the Gulf Islands. The CDF includes many small parks that are popular hiking, camping, and boating destinations.

Intensive agriculture is usually associated with flat-lying glaciomarine or gently sloping, water-reworked morainal materials. Where medium- to fine-textured, coarse-fragment free soils occur, they are well suited to agriculture. Agricultural production includes: field crops (primarily hay and other fodder crops for livestock), field vegetables (primarily sweet corn, cauliflower, and carrots), small fruit (berries and apples), nursery/floriculture, livestock, and dairy products (B.C. Ministry of Agriculture and Food 1984).

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Chapter 6: Coastal Western Hemlock Zone

by

J. Pojar, K. Klinka, and D.A. Demarchi

LOCATION AND DISTRIBUTION

The Coastal Western Hemlock zone (CWH) occurs at low to middle elevations mostly west of the coastal mountains, along the entire British Columbia coast (Figure 18) and on into both Alaska and Washington/Oregon. The zone covers much of Vancouver Island, the Queen Charlotte Islands, and the Coast Mountains. It penetrates the coastal mountain barrier somewhat in major river valleys, especially along the Fraser and Skeena rivers. The CWH occupies elevations from sea level to 900 m on windward slopes in the south and mid-coast (1050 m on leeward slopes), and to 300 m in the north. The Mountain Hemlock zone is usually the subalpine zone above the CWH.

ECOLOGICAL CONDITIONS

The CWH is, on average, the rainiest biogeoclimatic zone in British Columbia (Table 4). The zone typically has a cool mesothermal climate: cool summers (although hot dry spells can be frequent) and, like the Coastal Douglas-fir zone (CDF), mild winters (Figure 19). Mean annual temperature is about 8°C and ranges from 5.2 to 10.5°C among the CWH subzones. The mean monthly temperature is above 10°C for 4-6 months of the year. The mean temperature of the coldest month is 0.2°C and ranges from -6.6 to 4.7°C among the subzones. Mean annual precipitation for the zone as a whole is 2228 mm, and ranges from 1000 to 4400 mm (and probably more in some areas). Less than 15% of total precipitation occurs as snowfall in the south, but as much as 40-50% in the northern parts of the zone.

Western hemlock is usually the most common species in the forest cover. It regenerates freely under the canopy of mature stands on zonal sites and elsewhere if sufficient acid raw humus or decaying wood has accumulated on the forest floor. Western redcedar occurs frequently throughout the zone south of 56°N latitude. Douglas-fir is widespread south from Dean Channel or roughly 53° (the species reaches its northern limit along the coast at Kemano), but is most abundant in drier parts of the zone. Amabilis fir and yellow-cedar are common only in wetter parts of the zone. Amabilis fir often dominates forests at upper elevations or more northerly latitudes of the zone, but does not range north much beyond the Nass River, and is absent from the Queen Charlotte Islands. Shore (lodgepole) pine is common on very dry or very wet (boggy) sites throughout the zone. Grand fir, western white pine, and bigleaf maple occur in warmer and drier, southern parts of the zone. Red alder is a widespread species on logged-over or otherwise disturbed sites; black cottonwood usually occurs only along large rivers with extensive floodplains. Sitka spruce is also a widespread species, but is largely restricted in the south to specialized habitats such as floodplains and exposed beaches. However, north of Vancouver Island it gains in importance, occurring over a wide variety of habitats and even forming a minor component of climatic climax ecosystems on the Queen Charlotte Islands and on the northern mainland.

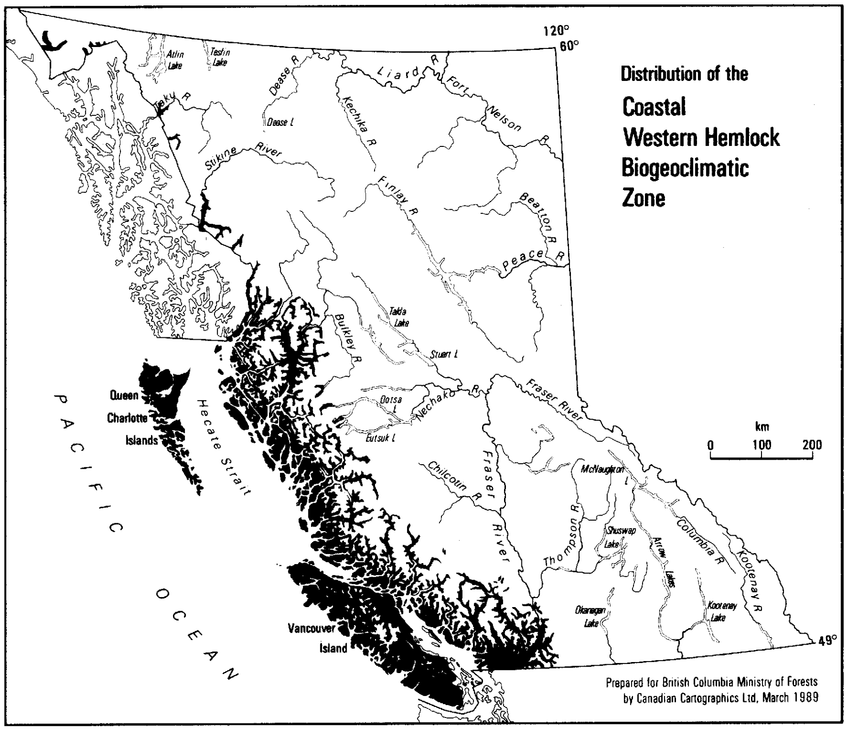

FIGURE 18. Coastal Western Hemlock zone.

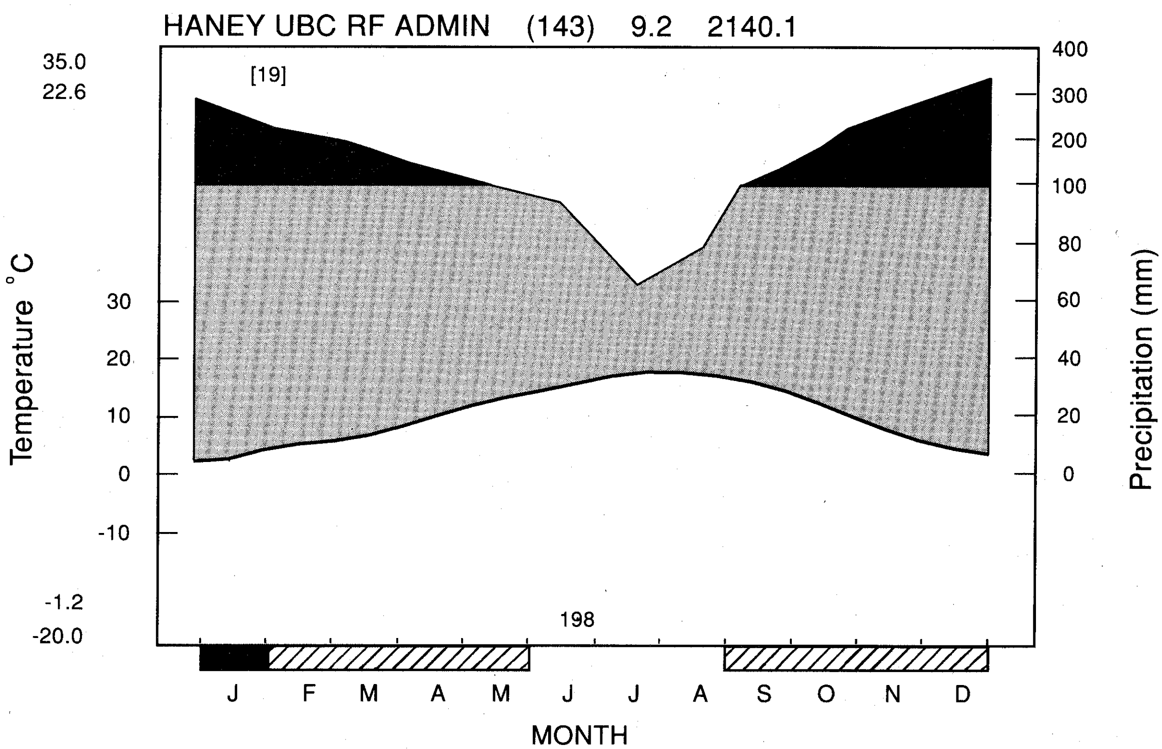

FIGURE 19. Representative climatic diagram for the Coastal Western Hemlock zone.

Characteristic floristic features of zonal ecosystems in the CWH are: (a) the prominence of western hemlock; (b) the sparse herb layer; (c) the predominance of several moss species (especially *Hylocomium splendens* [step moss] and *Rhytidiadelphus loreus* [lanky moss]).

Zonal hypermaritime forests are dominated by mixtures of western hemlock, western redcedar, Sitka spruce, and variable amounts of yellow-cedar. Amabilis fir is only locally abundant. Yellow-cedar, shore pine, and mountain hemlock increase in abundance in scrubby forests of the outer coast. Highly productive stands of western hemlock — Sitka spruce or western hemlock — amabilis fir occur on well-drained soils, often on steep slopes. Well-drained fluvial sites support excellent stands of Sitka spruce, western hemlock, western redcedar, red alder, and sometimes amabilis fir. Bogs are strikingly abundant over much of the hypermaritime landscape, especially on the coastal lowlands (e.g., Hecate Lowland, Nahwitti Lowland, Queen Charlotte Lowland). The extensive peatlands form a mosaic of blanket bog, bog woodland, and scrub forest on the subdued terrain.

Western hemlock, amabilis fir, western redcedar, Sitka spruce, and (especially with increasing elevation) yellow-cedar dominate the forests of the wetter maritime subzones, which cover the majority of the zone as a whole. Western hemlock and amabilis fir dominate the canopy of late seral stands. Windthrow plays an important role in the persistence of these species; relatively young and more or less even-aged stands are common as a result. Western redcedar stands typically occupy steep slopes or sites that regenerated following fire and/or have not been disturbed by windthrow for several centuries. Typical zonal stands are characterized by the Western hemlock — Amabilis fir — Alaskan blueberry association. This vegetation type features a well-developed shrub layer of ericaceous species (*Vaccinium alaskaense* [Alaskan blueberry], *V. parvifolium* [red huckleberry], *Gaultheria shallon* [salal]) and advance regeneration of western hemlock and amabilis fir, a poorly developed herb layer typified by *Blechnum spicant* (deer fern), and a well-developed moss layer dominated by *Rhytidiadelphus loreus*, *Hylocomium splendens*, and *Kindbergia oregana* (Oregon beaked moss).

Drier maritime forests typically have a substantial component of Douglas-fir along with western hemlock and western redcedar. *Gaultheria shallon*, *Mahonia nervosa* (dull Oregon-grape), and *Vaccinium parvifolium* typify the poorly to moderately developed shrub layer. *Kindbergia oregana*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, and *Plagiothecium undulatum* (flat moss) dominate the well-developed moss layer.

Submaritime forests are characterized by the scarcity of typically coastal species such as *Gaultheria shallon* and yellow-cedar, and the presence of typically interior or continental species like *Pleurozium schreberi* (red-stemmed feathermoss) and *Clintonia uniflora* (queen's cup). Douglas-fir is an abundant species in zonal stands, along with western hemlock, redcedar, and variable amounts of amabilis fir. The shrub layer is characterized by *Vaccinium alaskaense*, *V. ovalifolium* (oval-leaved blueberry), and *Menziesia ferruginea* (false azalea). As well as *Clintonia uniflora*, common herbs in the sparse herb layer are *Orthilia secunda* (one-sided wintergreen), *Cornus canadensis* (bunchberry), *Linnaea borealis* (twinflower), and *Goodyera oblongifolia* (rattlesnake-plantain). The well-developed moss layer contains *Pleurozium schreberi*, *Rhytidiadelphus loreus*, *R. triquetrus* (electrified cat's-tail moss), and *Rhytidiopsis robusta* (pipecleaner moss).

Characteristic soil processes include accumulation of acid organic matter on the forest floor (Mor formation), leaching, eluviation, illuviation, and gleying. The soils of zonal ecosystems are most often Humo-Ferric Podzols which, with increasing precipitation, grade into Ferro-Humic Podzols. Many Podzols in the CWH lack an eluvial (Ae) horizon, apparently because, in this part of the soil profile, the heavy leaching is offset by the rapid addition of organic colloids and weathering of iron and aluminum.

Soil-forming processes in the wettest portions of the zone are dominated by the gradual build-up of organic matter at the ground surface. In these areas, zonal soils are usually either folic phases of Podzols (if the organic layer is 15-40 cm thick) or Folisols (organic layer thicker than 40 cm or at least 10 cm thick if over bedrock or fragmental material; see Trowbridge *et al.* 1985).

Mors are the prevailing humus forms. In the wet climate of this zone, leaching of nutrients from the mineral soil is rapid. Furthermore, many soils derived from acidic parent materials such as granodiorites are low in clay minerals and poor in nutrients to begin with. Thus, the pool of nutrients contained in the vegetation and surface organic matter is extremely important in helping to maintain ecosystem productivity, especially on coarse-textured, nutritionally poor soils.

NOTES ON CLASSIFICATION

Analysis of floristic and climatic data suggested two major revisions to the zonal classification (see Klinka *et al.* 1990): (1) amalgamation of the former Wetter CDF (CDFb) subzone (Klinka *et al.* 1984) with the former Vancouver Island Drier Maritime CWH (CWHa1) variant to form the Very Dry Maritime CWH (CWHxm) subzone; and (2) designation of the former Coastal Cedars — Pine — Hemlock (CCPH) zone (Pojar 1983) as the Very Wet Hypermaritime CWH (CWHvh) subzone.

SUBZONES

Ten subzones are delineated in the CWH zone (Table 12). They can be separated along gradients of continentality (hypermaritime, maritime, and submaritime subzones) and precipitation (very dry, dry, moist, wet, and very wet) (Figure 20, Table 13). Species characteristic of the hypermaritime subzones include *Blechnum spicant*, *Coptis aspleniifolia* (fern-leaved goldthread), Sitka spruce, and *Scapania bolanderi*, and of the submaritime subzones *Clintonia uniflora*, *Orthilia secunda*, and *Pleurozium schreberi*. Species characteristic of the drier subzones include Douglas-fir, *Polystichum* *munitum* (sword fern), and *Pteridium aquilinum* (bracken), and of the wetter subzones, amabilis fir, *Menziesia ferruginea*, *Vaccinium alaskaense*, and *V. ovalifolium*.

The hypermaritime subzones occur on the outer mainland coast, on the outer west coast of Vancouver Island, and on the Queen Charlotte Islands, while the submaritime subzones are restricted to the leeward side of the Coast Mountains. The drier subzones are found only in the central and southern portion of the zone — in the rain shadows of the Olympic Mountains, Vancouver Island Ranges, and Coast Mountains.

TABLE 12. Synopsis of subzones in the Coastal Western Hemlock zone (CWH)

Subzone	Code	Old code
Wet Hypermaritime CWH	CWHwh	(g/e/qc)
Very Wet Hypermaritime CWH	CWHvh	(d/CCPH)
Very Dry Maritime CWH	CWHxm	(a1/CDFb)
Dry Maritime CWH	CWHdm	(a2)
Moist Maritime CWH	CWHmm	(b3/b4)
Wet Maritime CWH	CWHwm	(j)
Very Wet Maritime CWH	CWHvm	(b1/b2/i1/i2)
Dry Submaritime CWH	CWHds	(c/h1/h2)
Moist Submaritime CWH	CWHms	(b5/b6/h3)
Wet Submaritime CWH	CWHws	(b7/i3/f1/f2)

SOME REPRESENTATIVE SITE ASSOCIATIONS

The site associations described below form a typical sequence in the CWHdm subzone (Figure 21).

Western hemlock — Flat moss

The Western hemlock — Flat moss association includes slightly dry to fresh and nutrient-very poor to -medium soils that occur on well to moderately well drained, middle slopes and gently sloping heights of land. The associated soils are sandy- to loamy-skeletal, moderately deep to deep, Orthic Humo-Ferric Podzols with Humimor humus forms. Relative to other sites, there are neither significant losses nor additions of moisture and nutrients; therefore, vegetation and soils of this association approximate the zonal ecosystem for the CWHdm subzone.

Mature stands are usually well stocked with Douglas-fir, western hemlock, and western redcedar (in the lower tree stratum). Both Douglas-fir and western hemlock can form pure stands in secondary succession.

The shrub layer is usually poorly developed in fully stocked stands. There is always advance regeneration of western hemlock; occurrence of *Acer circinatum* (vine maple), *Gaultheria shallon, Mahonia nervosa*, and *Vaccinium parvifolium* depends on

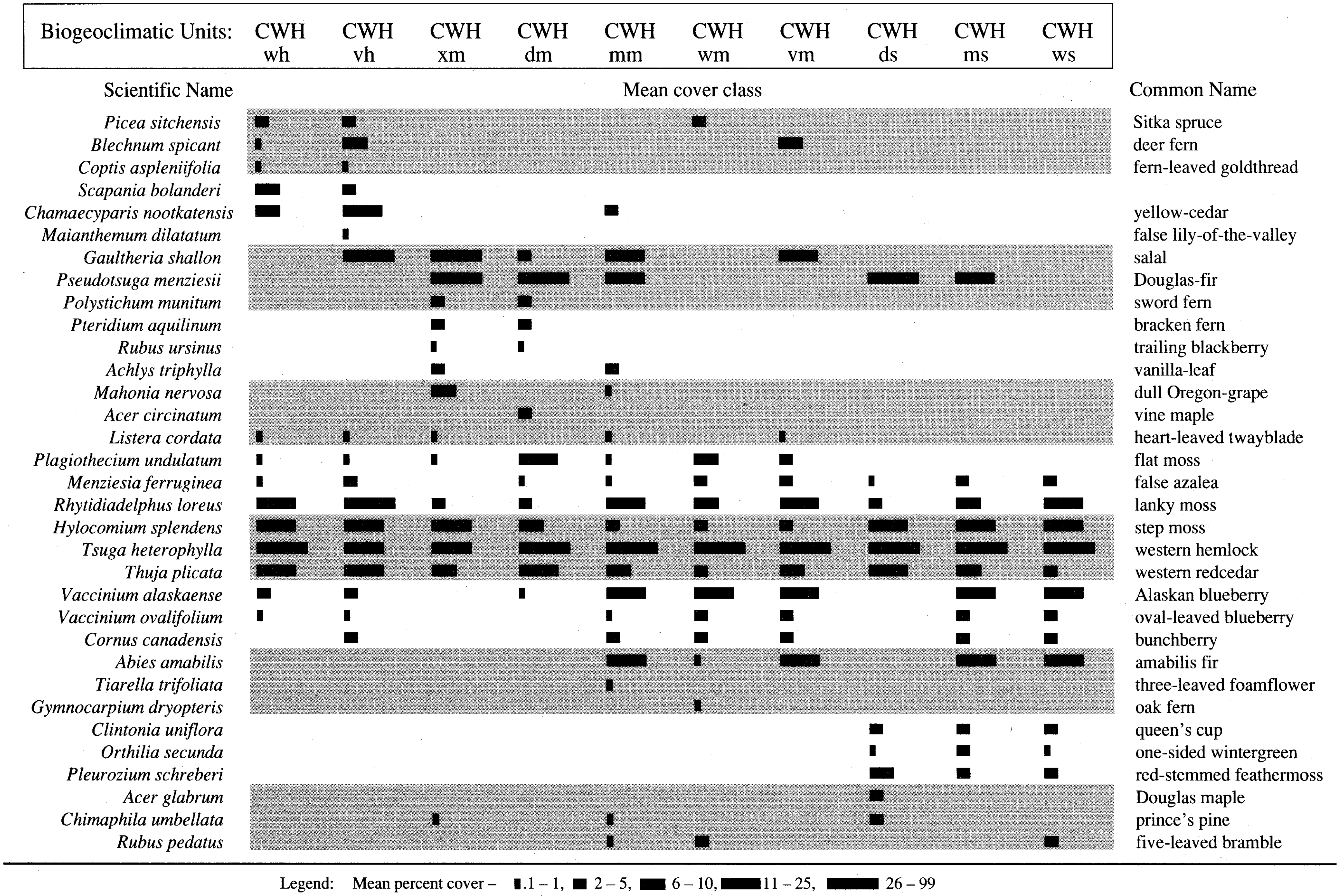

FIGURE 20. Zonal vegetation of subzones of the Coastal Western Hemlock zone.

TABLE 13. Means and standard deviations (in parentheses) of selected climatic characteristics for CWH subzones[a]

Climatic characteristics	CWHwh	CWHvh	CWHxm	CWHdm	CWHmm	CWHwm	CWHvm	CWHds	CWHms	CWHws
Number of stations for precipitation data	5	28	81	53	13	6	34	9	5	4
Mean annual precipitation (mm)	1349 (146)	2951 (657)	1505 (385)	1827 (326)	2349 (453)	2124 (342)	2787 (680)	1627 (367)	1683 (312)	1449 (410)
Mean precipitation April-Sept. (mm)	433 (61)	890 (193)	363 (96)	498 (89)	470 (50)	780 (242)	752 (200)	419 (109)	423 (90)	412 (148)
Mean ppt. of the driest summer month (mm)	54 (10)	96 (22)	39 (13)	53 (10)	45 (5)	86 (29)	75 (21)	45 (11)	40 (4)	45 (18)
Mean ppt. of the wettest winter month (mm)	204 (21)	431 (113)	251 (70)	292 (55)	400 (75)	362 (44)	436 (103)	259 (54)	262 (48)	244 (64)
Number of stations for temperature data	5	21	54	53	13	6	21	7	3	4
Mean annual temperature (°C)	7.6 (0.2)	8.2 (0.9)	9.3 (0.6)	9.8 (0.4)	5.7 (0.9)	5.5 (0.3)	8.2 (1.1)	7.8 (1.2)	5.9 (0.8)	5.5 (0.8)
Mean temperature of the warmest month (°C)	14.6 (0.3)	13.9 (0.8)	17.0 (0.8)	17.6 (0.5)	14.1 (1.0)	14.1 (0.8)	16.0 (1.1)	17.4 (1.4)	15.1 (0.8)	15.5 (1.0)
Mean temperature of the coldest month (°C)	1.3 (0.6)	3.0 (1.4)	1.8 (0.9)	1.9 (0.7)	-2.2 (1.1)	-4.2 (1.3)	0.3 (2.7)	-3.0 (2.3)	-4.2 (0.8)	-6.0 (0.6)
Number of months with mean temperature >10°C	4.0 (0.0)	4.4 (0.7)	5.4 (0.5)	5.7 (0.4)	3.9 (0.5)	3.8 (0.4)	4.9 (0.6)	5.0 (0.6)	4.3 (0.6)	4.2 (0.5)
Index of continentality[b]	6 (2)	3 (2)	14 (3)	15 (2)	16 (2)	17 (4)	14 (6)	24 (7)	23 (0)	24 (3)

[a] Symbols for CWH subzones are defined in Table 12.
[b] Index of continentality = [1.7(mean T_{JULY} - mean T_{JAN})/$\sin_{DEGREES\ LATITUDE}$]-20.4, where T - temperature (°C) (after Rose and Grant 1976).

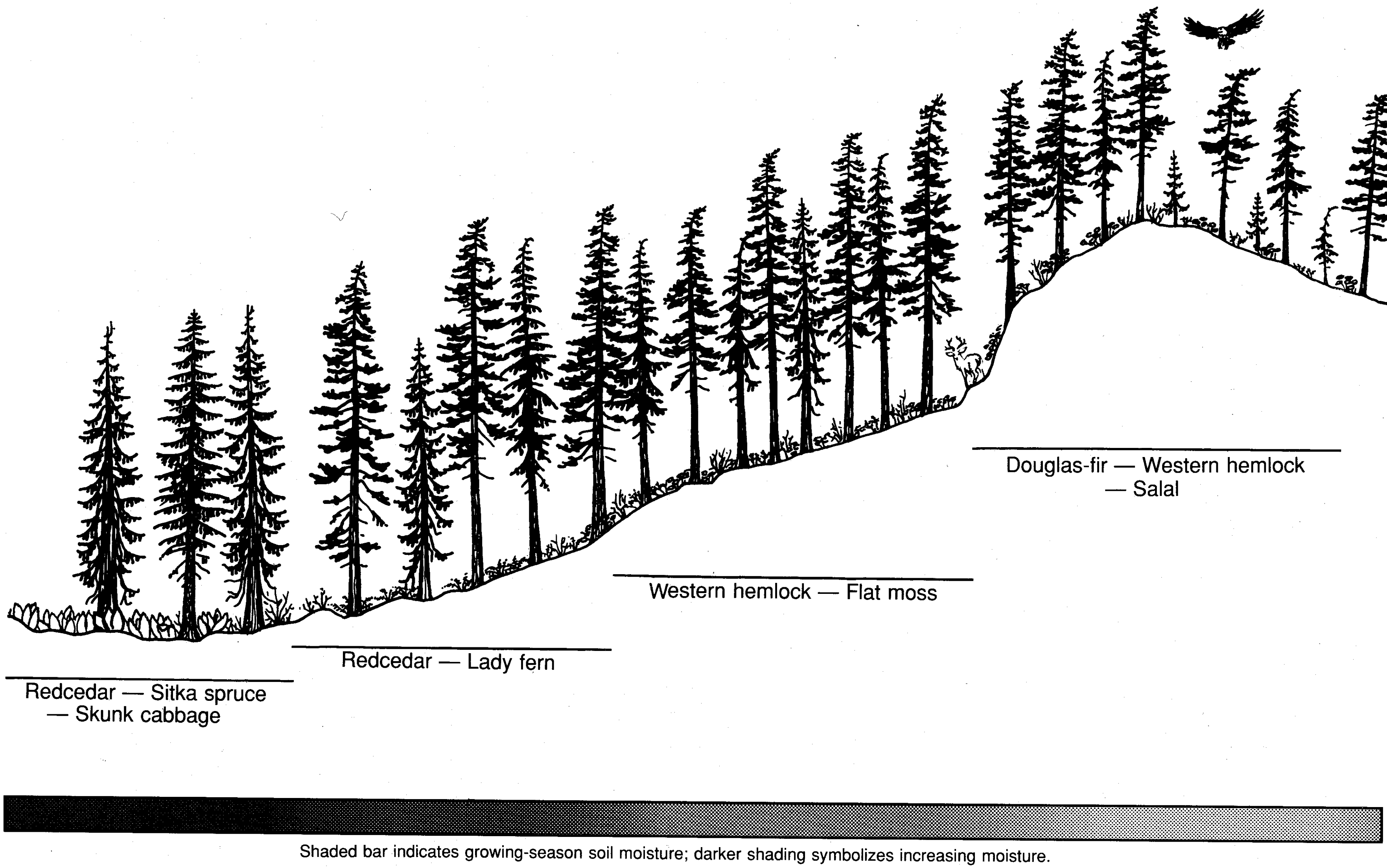

FIGURE 21. Simplified schematic diagram of topographic relationships among four common site associations in a dry, maritime subzone of the Coastal Western Hemlock zone.

light in the understory and surface materials. Similarly, the herb layer is very poorly developed with infrequent *Linnaea borealis, Polystichum munitum, Rubus ursinus* (trailing blackberry), and *Trientalis latifolia* (broad-leaved starflower). The moss layer is well developed, featuring *Kindbergia oregana* in early successional stages, and *Hylocomium splendens, Rhytidiadelphus loreus,* and *Plagiothecium undulatum* (flat moss) in late successional stages.

Douglas-fir — Western hemlock — Salal

This association includes moderately dry and nutrient-very poor to -medium, water-shedding sites that occur on rapidly drained, coarse-skeletal soil materials on upper slopes or valley bottoms in the CWHxm, CWHmm, and CWHdm. Soils are moderately deep Orthic Humo-Ferric Podzols with Hemimor humus forms. A growing-season water deficit and severe nitrogen deficiency are the main constraints to better forest growth.

Mature stands are usually well stocked with Douglas-fir (in the upper tree stratum), western hemlock, and western redcedar (in the lower tree stratum).

The shrub layer is very well developed with *Gaultheria shallon* (salal) dominant and *Mahonia nervosa* and *Vaccinium parvifolium* scattered. Advance regeneration of western hemlock and western redcedar is common in late-seral stands. The herb layer is very poorly developed, with *Pteridium aquilinum* as the only constant species. The moderately developed moss layer includes primarily *Kindbergia oregana* and *Hylocomium splendens*; lichens and xerophytic mosses are infrequent.

Redcedar — Lady fern

This association includes moist to very moist and nutrient-rich to -very rich, water-receiving sites that occur on imperfectly drained lower slopes in the CWHxm and CWHdm subzones. The associated soils are sandy- to loamy-skeletal, moderately deep to deep Sombric Humo-Ferric Podzols with Moder or Mull humus forms. Relative to other sites, the soils are either inherently nutrient-rich or enriched by seepage. Under these climatic and edaphic conditions, Douglas-fir and western redcedar attain their best growth.

Second-growth stands usually feature Douglas-fir; however, the presence of western redcedar stumps suggests that the final stage of secondary succession will be dominated by the latter, shade-tolerant species.

Acer circinatum and *Rubus spectabilis* (salmonberry) dominate the well-developed shrub layer. In the floristically rich herb layer, the constant species are *Athyrium filix-femina* (lady fern), *Galium triflorum* (sweet-scented bedstraw), *Polystichum munitum*, and *Tiarella trifoliata* (three-leaved foamflower). In the less well-developed moss layer, *Leucolepis menziesii* (palm tree moss) and *Plagiomnium insigne* indicate friable forest floors.

Redcedar — Sitka spruce — Skunk cabbage

Wet and nutrient-medium to -very rich sites throughout lower elevations of the CWH are represented by the Redcedar — Sitka spruce — Skunk cabbage association. These water-collecting sites occur on lower slopes below the Redcedar — Lady fern site association or in depressions. The associated soils are poorly drained Gleysols or Humisols affected by slowly moving seepage.

Western redcedar and western hemlock dominate the open canopy, reflecting the pattern of relatively drier (usually raised organic mounds) and depressional microsites.

Gaultheria shallon, *Vaccinium parvifolium* (on acid organic mounds), and *Rubus spectabilis* (in depressions) dominate the moderately well-developed shrub layer. Herbs are largely confined to depressions and include *Athyrium filix-femina*, *Lysichiton americanum* (skunk cabbage), *Streptopus amplexifolius* (clasping-leaved twistedstalk), and *Tiarella trifoliata*. The moderately well-developed moss layer is dominated by *Hylocomium splendens, Rhytidiadelphus loreus*, and *Plagiothecium undulatum* on acid organic mounds, and by *Conocephalum conicum, Kindbergia praelonga, Pellia epiphylla,* and *Rhizomnium magnifolium* in depressions.

WILDLIFE HABITATS

The factors that most influence the assemblage of wildlife species in this zone (Table 14) are: its location and distribution — sea level to 1050 m on windward slopes and from southern Vancouver Island and the Fraser Lowland north to Alaska; the landforms that range among small coastal islands, coastal plains, estuaries, bedrock-controlled, rolling uplands and steep, rugged mountain slopes, often with exposed bedrock; the cool, mild, maritime climate; and the usually dense coniferous forests. In addition, this zone probably has a greater diversity and abundance of habitat elements than any other zone in the province. The greatest diversity of birds, amphibians, and reptiles in British Columbia is found within the Fraser Lowland portion of this zone, and almost all of the coastal, colony-nesting bird habitats are found in the CWH.

Black-tailed Deer, Black Bear, Grizzly Bear, and Gray Wolf are the most common large mammals. Black Bear occur throughout, as do Black-tailed Deer (since they were introduced to the Queen Charlotte Islands). Gray Wolf are only absent from the Queen Charlotte Islands, and Grizzly Bear and Mountain Goat occur only on the mainland. The marine environment, including the small, rocky coastal islands, provides good protection from predators and nesting habitat for many species of colony-nesting marine birds. Low, near-tidal islets are important haul-out areas for California and Steller’s Sea-lion, Harbor Seal, Northern Fur Seal, and Northern Elephant Seal. Mountain Goat occupy rugged southerly aspects with exposed bedrock, often descending to forested cliffs near sea level in the winter.

TABLE 14. Selected wildlife habitats and species in the Coastal Western Hemlock zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth coniferous forests	Limited areal extent, dwindling	Mountain Goat, Black-tailed Deer, Black Bear, Cougar, Gray Wolf, Marten, California Myotis, Douglas Squirrel, Columbian Mouse, Southern Red-backed Vole, Deer Mouse Great Horned Owl, Saw-whet Owl, Barred Owl, Blue Grouse, Ruffed Grouse, Band-tailed Pigeon, Pileated Woodpecker, Northern Flicker, Hairy Woodpecker, Common Raven, Gray Jay, Steller's Jay, Varied Thrush, Chestnut-backed Chickadee, Red-breasted Nuthatch, Winter Wren, Vaux's Swift Western Toad, Pacific Treefrog, Western Red-backed Salamander, Ensatina Salamander, Northwestern Salamander	∇ Keen's Long-eared Myotis, Spotted Owl, Marbled Murrelet ♦ Roosevelt Elk, Grizzly Bear, Mountain Beaver, Townsend's Chipmunk, Sitka Mouse, Shrew-mole, Trowbridge's Shrew, Bald Eagle, Tailed Frog, Pacific Giant Salamander, Clouded Salamander
Young seral and managed second-growth forests	Extensive	Black-tailed Deer, Black Bear, Cougar, Gray Wolf, Marten, Columbian Mouse, Deer Mouse Great Horned Owl, Barred Owl, Blue Grouse, Ruffed Grouse, Band-tailed Pigeon, Northern Flicker, Hairy Woodpecker, Common Raven, Gray Jay, Steller's Jay, Chestnut-backed Chickadee, Red-breasted Nuthatch, Winter Wren, Varied Thrush Western Toad, Pacific Treefrog, Western Red-backed Salamander, Ensatina Salamander, Northwestern Salamander	♦ Roosevelt Elk, Grizzly Bear
Mixed coniferous and deciduous forests	Common	Black-tailed Deer, Black Bear, Gray Wolf, Marten, California Myotis, Douglas Squirrel, Columbian Mouse, Deer Mouse Red-tailed Hawk, Northern Saw-whet Owl, Blue Grouse, Common Merganser, Steller's Jay, Hairy Woodpecker, Pine Grosbeak, Townsend's Warbler Northern Alligator Lizard, Pacific Treefrog, Ensatina Salamander, Northwestern Salamander	∇ Marbled Murrelet ♦ Roosevelt Elk
Rocky cliffs, talus, and sparsely vegetated rocks	Extensive	Mountain Goat, Little Brown Myotis, Common Pika, Northwestern Chipmunk, Bushy-tailed Woodrat Common Raven, Black Swift, Cliff Swallow	∇ Keen's Long-eared Myotis

TABLE 14. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Avalanche tracks and seepage sites	Common	Black-tailed Deer, Black Bear Blue Grouse, Lewis' Woodpecker, Band-tailed Pigeon, Willow Flycatcher, Swainson's Thrush, Cedar Waxwing, Purple Finch Red-legged Frog	∇ Vancouver Island Marmot ♦ Grizzly Bear, Mountain Beaver
Upland grassy areas	Rare	Northern Saw-whet Owl, Lincoln Sparrow	♦ Least Sandpiper, Purple Martin
Agricultural areas	Extensive in lowland areas	Coyote, Spotted Skunk, Coast Mole Cooper's Hawk, Red-tailed Hawk, Rough-legged Hawk, Northern Harrier, Short-eared Owl, Mew Gull, Glaucous-winged Gull, Northwestern Crow, Brewer's Blackbird	♦ Mountain Beaver, Shrew-Mole, Townsend's Mole, Common Barn-Owl, Purple Martin
Riparian areas, wetlands, meadows, floodplains, lakes, and streams	Common	Black-tailed Deer, Black Bear, Gray Wolf, River Otter, Mink, Deer Mouse, Wandering Shrew Osprey, Short-eared Owl, Snowy Owl, Ruffed Grouse, Trumpeter Swan, Sandhill Crane, Ring-necked Duck, Redhead, Harlequin Duck, Wood Duck, Red-throated Loon, Common Merganser, Wilson's Phalarope, Black Tern, Mew Gull, American Dipper Common Garter Snake, Western Garter Snake, Northwestern Garter Snake, Painted Turtle, Western Toad, Bullfrog, Red-legged Frog, Northwestern Salamander, Long-toed Salamander, Rough-skinned Newt	♦ Roosevelt Elk, Grizzly Bear, Mountain Beaver, Townsend's Chipmunk, Pacific Jumping Mouse, Pacific Water Shrew, Bald Eagle, Great Blue Heron, Green-backed Heron, Yellow-headed Blackbird, Purple Martin, Tailed Frog, Pacific Giant Salamander
Offshore forested islands	Common		♦ Bald Eagle, Peale's Peregrine Falcon, Ancient Murrelet, Rhinocerous Auklet, Cassin's Auklet, Parakeet Auklet, Fork-tailed Storm-Petrel, Leach's Storm-Petrel
Offshore grassy and shrubby islands	Limited areal extent		♦ Peale's Peregrine Falcon, Rhinocerous Auklet, Fork-tailed Storm-Petrel, Leach's Storm Petrel, Tufted Puffin, Cassin's Auklet
Marine cliffs and rocky islets	Common	Northern Sea Lion, Northern Fur Seal, Northern Elephant Seal, Harbor Seal Black-legged Kittiwake, Black Oystercatcher, Double-crested Cormorant, Pelagic Cormorant, Pigeon Guillemot, Glaucous-winged Gull, Black Swift	∇ Keen's Long-eared Myotis, Horned Puffin, Thick-billed Murre ♦ Bald Eagle, Peale's Peregrine Falcon, Brandt's Cormorant, Common Murre

TABLE 14. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Estuaries, shallow bays, intertidal and sub-tidal marine	Limited areal extent	Black-tailed Deer, Black Bear, Gray Wolf, Raccoon, Mink, River Otter, Northern Sea Lion, Harbor Seal, Killer Whale, Harbor Porpoise Northern Pygmy-owl, Sharp-shinned Hawk, Red-throated Loon, Yellow-throated Loon, Trumpeter Swan, Canada Goose, Brant, Barrow's Goldeneye, Black Scoter, Surf Scoter, White-winged Scoter, Mallard, Northern Shoveller, American Wigeon, Green-winged Teal, Pigeon Guillemot, Northwestern Crow	∇ Sea Otter, Marbled Murrelet ♦ Roosevelt Elk, Grizzly Bear, Bald Eagle, Great Blue Heron, Common Murre, Ancient Murrelet, Rhinoceros Auklet, Cassin's Auklet, Parakeet Auklet

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Climax or old-growth forests provide both food and nesting habitat for a large variety of birds. The deep, dense canopy is an excellent interceptor of snow, while litterfall of arboreal lichens and needles provides winter forage for Black-tailed Deer. After clearcutting, the succulent regrowth provides an abundance of forage for Black-tailed Deer, Black Bear, Grizzly Bear, and Roosevelt Elk (on Vancouver Island), as well as habitat for Blue Grouse, Band-tailed Pigeon, Lewis' Woodpecker, Traill's Flycatcher, American Robin, Swainson's Thrush, Cedar Waxwing, and Purple Finch. Forest regeneration is usually rapid and forest openings can quickly develop a dense canopy of young trees with sparse understory vegetation. Many species of birds, such as Spotted Owl, Great Horned Owl, Saw-whet Owl, Northern Flicker, Pileated Woodpecker, Hairy Woodpecker, Hammond's Flycatcher, Gray Jay, Steller's Jay, Common Raven, Chestnut-backed Chickadee, Red-breasted Nuthatch, Winter Wren, and Varied Thrush, use the conifer forests because of the presence of other birds and rodents, bark and wood-boring insects, and conifer seeds. Many species of amphibians occur because of the damp litter on the floor of mature forests, including Northwestern Salamander, Western Red-backed Salamander, Ensatina Salamander, Clouded Salamander, and Western Toad. The Pacific Giant Salamander and Tailed Frog both require steep cold mountain streams in old-growth forests as breeding habitat, and damp litter on the forest floor to survive as metamorphosed adults.

Many large and small rivers cross this zone, with large and small riparian areas. Nearly all the rivers and streams are used for spawning by salmon, and most of their young spend some time in these streams. These fish, in addition to the lush vegetation and berries, provide ample food for Grizzly Bear and Black Bear. These riparian areas support some of the densest populations of Grizzly Bear and Black Bear in the province. Other species that depend on the anadromous fish are River Otter, Mink, Common Merganser, Common Goldeneye, Bald Eagle, and many species of gulls. The annual Eulichan (candlefish) run also provides a spring feast for seals, sea lions, gulls, and Bald Eagle on the lower reaches of many coastal rivers. Many species of reptiles and amphibians use riparian areas and wetlands within the forest, including the Common Garter Snake, Western Terrestrial Garter Snake, and Red-legged Frog, although the Queen Charlotte Islands have no reptiles and only one amphibian — the Northern Toad.

As these rivers and streams enter the marine environment they form estuaries, which, like the rivers behind them, range from small to very large (e.g., the Fraser River estuary). The nutrient-rich, protected waters of these estuaries provide shelter for over-wintering waterbirds, such as diving and dabbling ducks, Trumpeter Swan, grebes, scoters, and gulls. Most of the province's estuaries occur in this zone.

Steep, rocky islets are used by colony nesting seabirds such as the Pelagic and Double-crested Cormorants, Ancient Murrelet, Forked-tailed Storm-Petrel, Leach's Storm-Petrel, Cassin's Auklet, Rhinocerous Auklet, Pigeon Guillemot, Tufted Puffin, and Common Murre. Peale's Peregrine Falcon nest on rocky ledges near colonies of Ancient Murrelets on the Queen Charlotte Islands, and Bald Eagle perch on large conifers along major rivers and on the forested islets and headlands.

Extensive areas of sparsely vegetated, steep rock occur in many of the fjords in this zone. The massive rock walls are poor habitat for most wildlife species, except Mountain Goat which sometimes use these areas as escape terrain.

Extensive urban and agriculture developments have taken place in the Fraser Lowland, displacing large mammals such as Roosevelt Elk, Grizzly Bear, and Gray Wolf. While Black-tailed Deer, Cougar, and Black Bear survive here, their numbers are greatly reduced. Draining of wetlands, especially Sumas Lake, and diking of the Fraser River, which has subsequently stopped the development of back-channels and sloughs, has reduced the number of over-wintering waterbirds. There has been minor compensation when forest has been turned into agricultural land, enabling these birds to feed on exposed crops and insects.

The extensive urban areas in the Lower Mainland portion of this zone support a variety of native and introduced wildlife species whose abundance and diversity are related to the density of development. Non-native species include the Rock Dove, House Sparrow, European Starling, Crested Myna, Gray Squirrel, Roof Rat, Norway Rat, and House Mouse. Native species that have adapted to urban habitats include the Black-tailed Deer, Coyote, Striped Skunk, Raccoon, Little Brown Myotis, Herring

Gull, Common Nighthawk, Barn Owl, and Barn Swallow. Even these urban species are more abundant in areas that are interspersed with parks, gardens, and native forest.

Several animal species have been introduced to certain parts of the CWH. On the Queen Charlotte Islands, Rocky Mountain Elk, Black-tailed Deer, Raccoon, Beaver, and Pacific Treefrog have all been directly introduced. Roosevelt Elk were directly introduced to the Sechelt Peninsula, and Gray Squirrel to the Lower Mainland. The Spotted Skunk and North American Opossum were introduced to Washington State and have since expanded their range into the Lower Mainland. The Crested Myna maintains a small population near urban areas centred around Greater Vancouver, but it has not expanded its range much since being introduced in the 1890's. In contrast, the European Starling extended its range during a similar time period from the Eastern United States to the west coast of North America, including the Coastal Western Hemlock zone.

The only subspecies to have recently become extinct in this zone is the Dawson Caribou, from the Queen Charlotte Islands.

RESOURCE VALUES

The CWH is the most productive forest region in Canada. In the drier portion of the zone, Douglas-fir, grand fir, western white pine, and western redcedar, and in the wetter portion, amabilis fir, Sitka spruce, western hemlock, and yellow-cedar, exhibit their best growth. Thus, a majority of CWH ecosystems are used primarily for forestry, a management strategy that warrants the application of intensified silvicultural practices. As a result of mountainous relief and high precipitation, soil conservation appears to be the primary management concern in sustaining the productive potential of forest ecosystems.

Medium- to fine-textured, coarse fragment-free soils in the driest portion of the zone are suitable for agriculture. However, the combination of unfavourable topography and humid climate renders most of the zone unsuitable for agricultural use.

Recreational pursuits in the CWH include hiking, hunting, fishing, and wildlife viewing. Marine-based sports such as sea-kayaking, boating, and sailing are very pleasant along the scenic coastline of much of the zone. "Big trees" are common in this zone and are a very popular recreational destination.

Although there is an abundance of furbearers in this zone, fur harvest is generally low.

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Chapter 7: Mountain Hemlock Zone

by

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LOCATION AND DISTRIBUTION

The subalpine elevations of the coastal mountains fall in the Mountain Hemlock zone (MH). This zone occurs all along the coast in British Columbia (Figure 22), and extends north through southeastern Alaska and south into Washington and Oregon. The MH occupies elevations of 900-1800 m in the south (lower on windward slopes, higher on leeward slopes), and 400 to 1000 m in the north. The zone occurs primarily on the Coast Mountains of the mainland and on the Insular Mountains of Vancouver Island and the Queen Charlotte Islands, above the Coastal Western Hemlock zone.

ECOLOGICAL CONDITIONS

The coastal subalpine climate is characterized by short, cool summers, and long, cool, wet winters, with heavy snow cover for several months (Figure 23 and Table 4). Mean annual temperature among the subzones varies from 0 to 5°C. Average monthly temperature remains below 0°C for 1-5 months, and above 10°C for 1-3 months. Mean annual precipitation probably ranges from 1700 to 5000 mm, of which 20% to 70% is snow. The deep winter snowpack is slow to disappear, and a short vegetative season is the result. Spring and summer are often relatively dry (especially on the south coast), whereas autumn and winter are very wet.

Mountain hemlock, amabilis fir, and yellow-cedar (as a tree, usually in moist habitats) are the most common tree species in the zone. It could be that these species depend on unfrozen ground beneath the snow cover (Krajina 1969; Brooke *et al.* 1970). Mountain hemlock and amabilis fir regenerate in abundance under the canopy of mature forest in many ecosystems, although advance regeneration of amabilis fir is often more abundant in dense, fully stocked stands. Mountain hemlock (the climatic climax species of the zone) eventually becomes established in the advanced stages of stand development, after openings of various sizes have developed in the forest canopy.

Other tree species that occur in the MH are: western hemlock and western redcedar (at lower elevations throughout the zone); Douglas-fir and western white pine (at lower elevations in the south); Sitka spruce (at lower elevations in the north); lodgepole pine (on very dry sites); subalpine fir and whitebark pine (near timberline). Subalpine fir increases in abundance in those transitional, colder portions of the MH that lie leeward of the higher elevations of the coastal mountains, along the boundary with the Engelmann Spruce — Subalpine Fir zone.

Tree growth becomes progressively poorer with increasing elevation because of the shorter growing season, increased duration of snow cover, and cooler temperatures. Forests are not continuous in the MH and are largely confined to lower elevations of the zone. With increasing elevation, the forest thins out into parkland, with trees in isolated clumps and irregular small patches, and along ridge crests where the snow melts earlier. The tree clumps form a mosaic with subalpine heath, meadow, and fen vegetation.

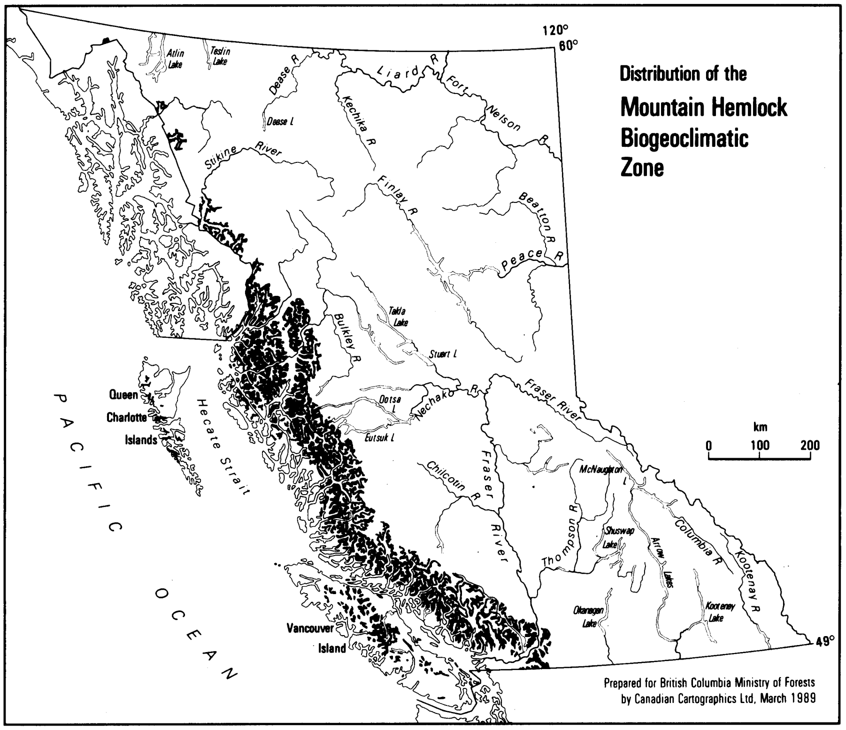


FIGURE 22. Mountain Hemlock zone.

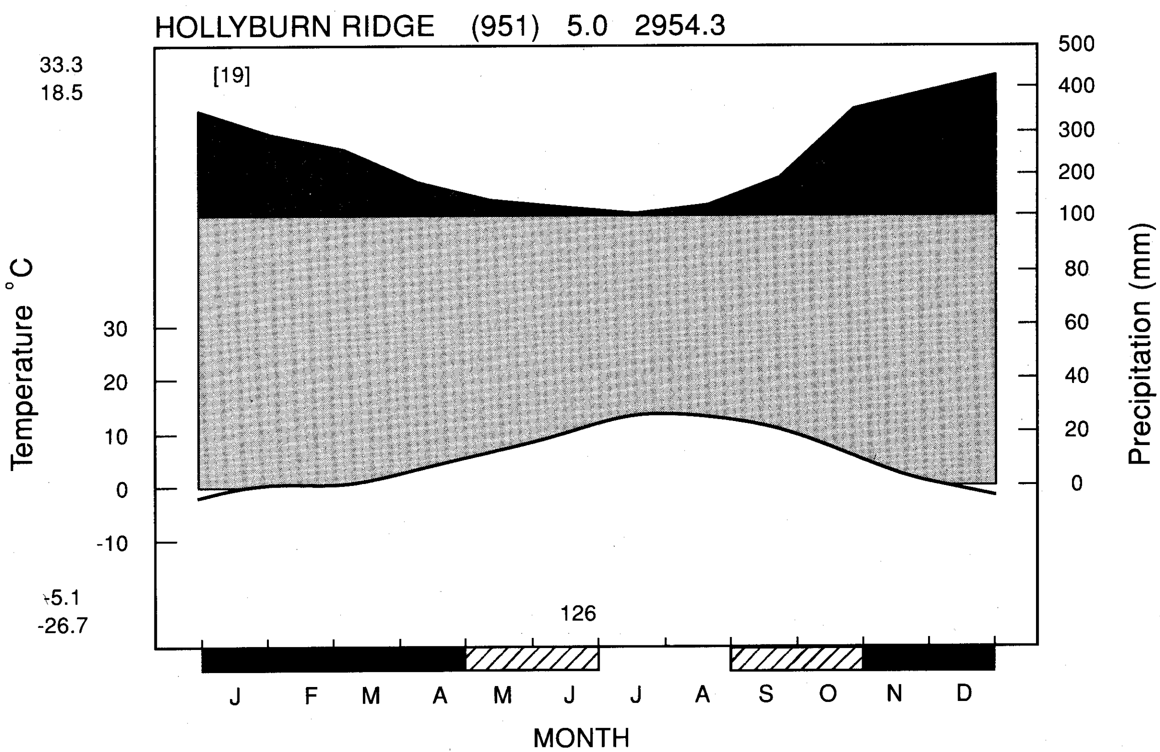


FIGURE 23. Representative climatic diagram for the Mountain Hemlock zone.

The predominance of shrubs of the family Ericaceae is a characteristic feature of the zone. *Vaccinium ovalifolium* (oval-leaved blueberry), *V. alaskaense* (Alaskan blueberry), *V. membranaceum* (black huckleberry), *Cladothamnus pyrolaeflorus* (copperbush), *Menziesia ferruginea* (false azalea), and *Rhododendron albiflorum* (white-flowered rhododendron) can be dominants in continuous forest, and in parkland *Vaccinium deliciosum* (blue-leaved huckleberry), *Phyllodoce empetriformis* (pink mountain-heather), *P. glanduliflora* (yellow mountain-heather), *Cassiope mertensiana* (white mountain-heather), *C. stelleriana* (Alaskan mountain-heather), and *C. lycopodioides* (club-moss mountain-heather) can join the list. The relatively low importance of herbs, the dominance of bryophytes, and the high significance of advance regeneration of amabilis fir and mountain hemlock are additional characteristic floristic features of climatic climax ecosystems.

Characteristic soil processes in the MH are the accumulation of acid, snow-compacted organic matter on the forest floor, mycelial Mor humus formation, gleying (many soils are moist to saturated throughout the year), leaching, eluviation, and illuviation. Podzols and Folisols are the predominant soils. Although the time over which soils have developed is comparatively short, they have often acquired strong morphological characteristics. The low temperature and high moisture content of most soils promote slow litter decomposition. Thus, they often have a high content of organic matter. Roots of mountain hemlock and sometimes amabilis fir are largely confined to the forest floor, indicating the essential role of the humus layers in tree regeneration and growth.

Subalpine heath is dominated by *Cassiope mertensiana* and *Phyllodoce empetriformis* in the south; *C. stelleriana*, *C. lycopodioides*, and *P. glanduliflora* gain importance along the north coast. Common associates are *Luetkea pectinata* (partridgefoot), *Lycopodium alpinum* (alpine clubmoss), *Empetrum nigrum* (crowberry), *Vaccinium deliciosum* and/or *V. membranaceum*, *Vahlodea atropurpurea* (mountain hairgrass), *Hieracium gracile* (slender hawkweed), *Barbilophozia floerkei* (mountain leafy liverwort), and *Dicranum* spp.

In subalpine parkland, lush, diverse herb meadows colonize seepage areas and stream edges. Typical subalpine meadow species include *Veratrum viride* (Indian hellebore), *Valeriana sitchensis* (Sitka valerian), *Senecio triangularis* (arrow-leaved groundsel), *Petasites frigidus* var. *frigidus* (sweet coltsfoot), *Caltha leptosepala* (white marsh-marigold), *Leptarrhena pyrolifolia* (leatherleaf saxifrage), *Ranunculus eschscholtzii* (subalpine buttercup), *Mimulus lewisii* (pink monkey-flower), *Epilobium latifolium* (broad-leaved willowherb), *Erigeron peregrinus* (subalpine daisy), *Parnassia fimbriata* (fringed grass-of-Parnassus), *Mitella pentandra* (five-stamened mitrewort), *Pedicularis ornithorhyncha* (bird's-beak lousewort), *Castilleja miniata* (common red paintbrush), *C. parviflora* (small-flowered paintbrush), and *Arnica latifolia* (mountain arnica).

The *Carex nigricans* (black alpine sedge) association represents a very characteristic, wet, semi-terrestrial ecosystem that develops in subalpine snow basins, where snow lies on the surface for 9 months or longer each year.

SUBZONES

Four subzones are delineated in the MH (Table 15). They can be separated primarily along a gradient of continentality (hypermaritime and maritime subzones) and according to vegetation physiognomy (parkland and forested subzones) (Figure 24). Species characteristic of the hypermaritime subzones include *Blechnum spicant* (deer fern), *Chamaecyparis nootkatensis* (yellow-cedar), *Coptis aspleniifolia* (fern-leaved goldthread), *Hylocomium splendens* (step moss), and *Rhytidiadelphus loreus* (lanky moss). Species characteristic of the maritime subzones include *Abies amabilis* (amabilis fir) and *Vaccinium membranaceum*. In addition to the discontinuous forest cover, parkland subzones feature alpine elements, such as species of *Phyllodoce* and *Cassiope*.

TABLE 15. Synopsis of subzones in the Mountain Hemlock zone (MH)

Subzone	Code	Old code
Wet Hypermaritime Parkland MH	MHwhp	(cp/fp)
Wet Hypermaritime MH	MHwh	(c/f)
Moist Maritime Parkland MH	MHmmp	(ap/bp/dp/ep)
Moist Maritime MH	MHmm	(a/b/d/e)

The hypermaritime subzones occur on the outer mainland coast, outer west coast of Vancouver Island, and Queen Charlotte Islands. Most of the MH on the mainland and Vancouver Island is from the maritime subzones.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following descriptions treat four common associations found in the forested Moist Maritime MH subzone (Figure 25). The information has been drawn from an excellent study by Brooke *et al*. (1970).

Mountain hemlock — Amabilis fir — Blueberry

Fresh and nutrient-very poor to -medium sites that have a potential to develop zonal climax vegetation are represented by the Mountain hemlock — Amabilis fir — Blueberry association. These sites occupy benches, upper slopes, and broad ridges. Dominant soils are Ferro-Humic Podzols; typical humus forms are acid, compacted Mycohumimors and Mycohemimors. Some of the soils can be gleyed from temporary seepage during early summer. The soils remain wet during fall and winter due to heavy fall rains and wet winter snowpack.

Mountain hemlock and, to a lesser extent, amabilis fir dominate the well-developed tree layer. Yellow-cedar and western hemlock are minor species.

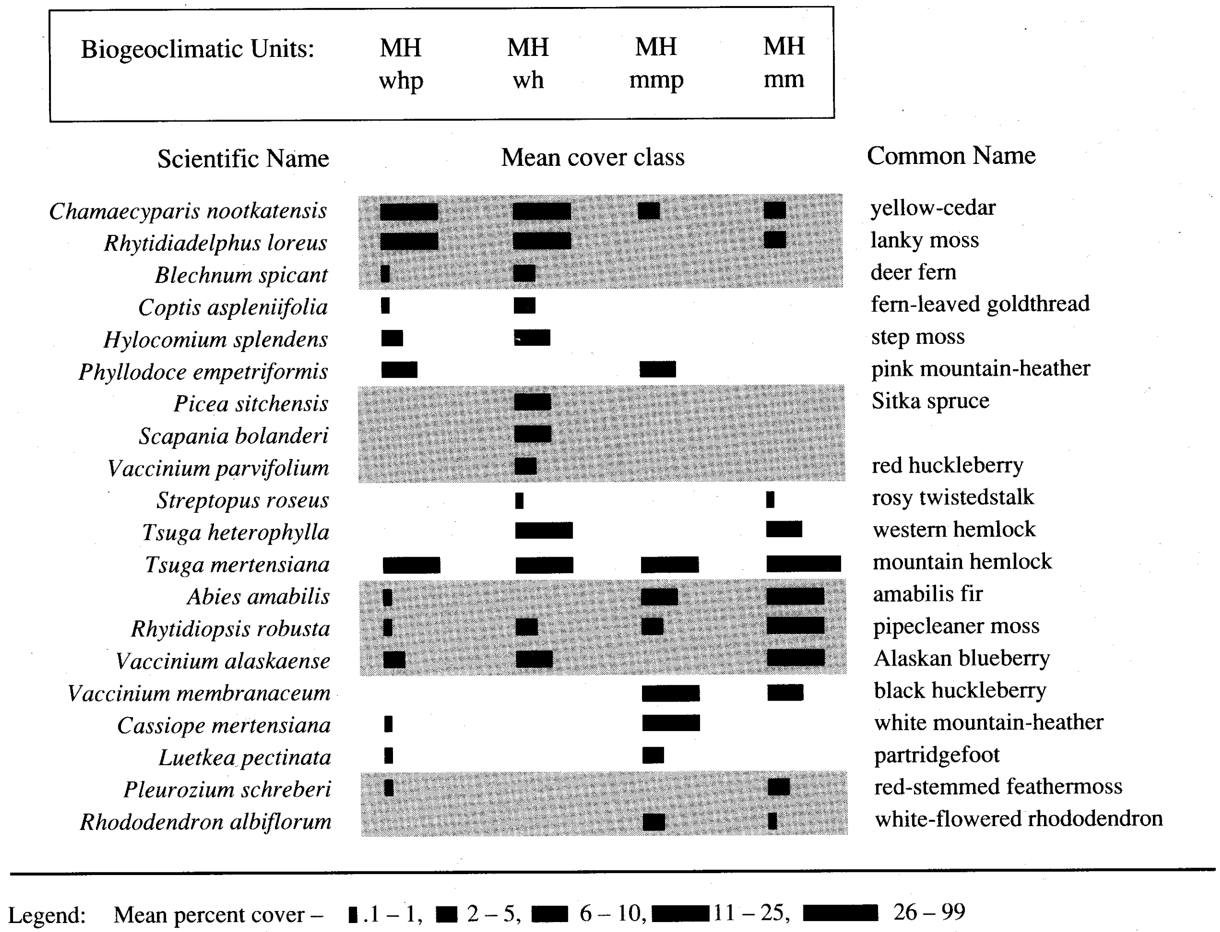
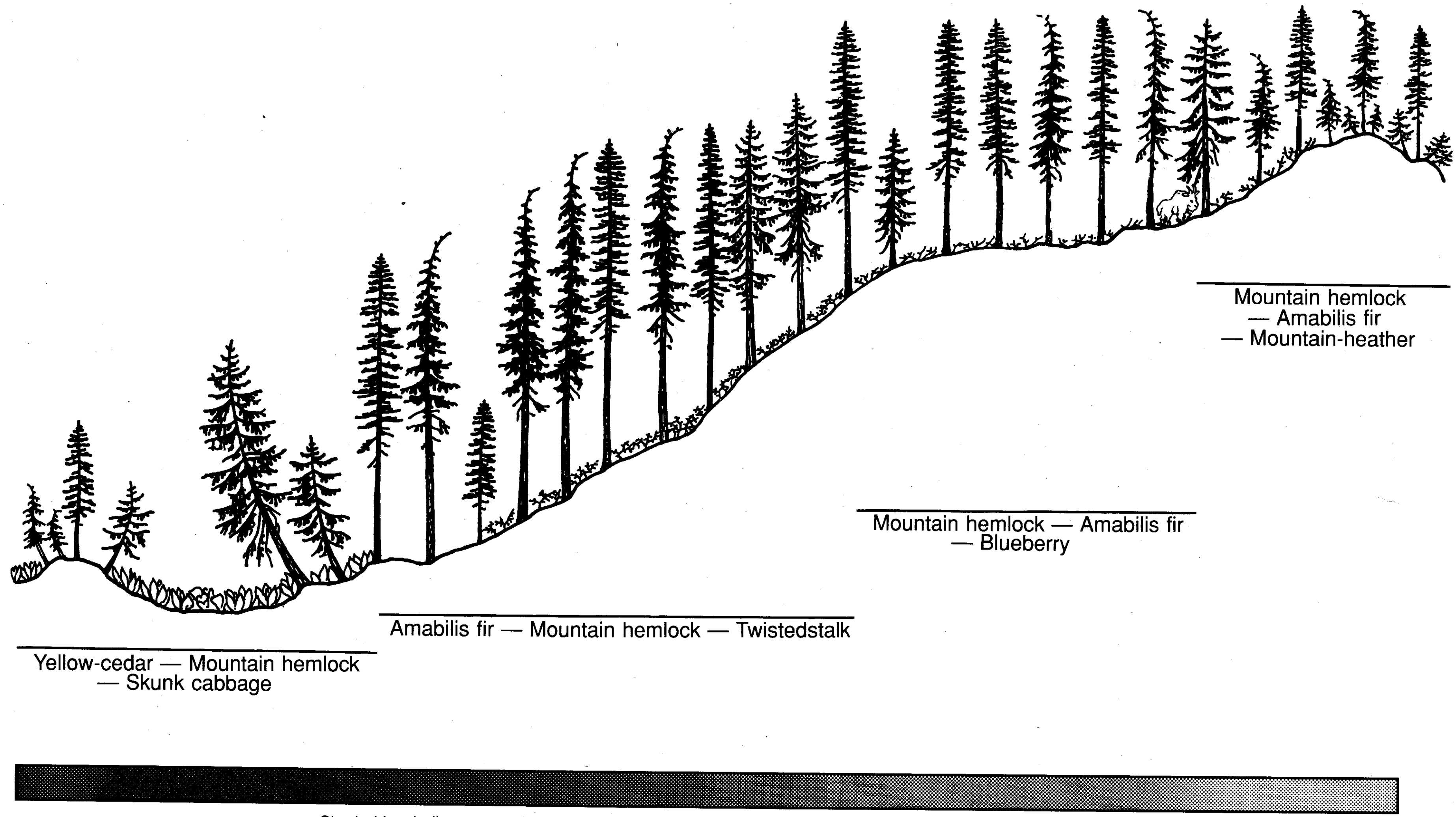


FIGURE 24. Zonal vegetation of subzones of the Mountain Hemlock zone.



Shaded bar indicates growing-season soil moisture; darker shading symbolizes increasing moisture.

FIGURE 25. Simplified schematic diagram of topographic relationships among four common site associations in a forested, maritime subzone of the Mountain Hemlock zone.

Vaccinium alaskaense (Alaskan blueberry) and advance tree regeneration (mostly of amabilis fir and mountain hemlock) dominate the very well-developed shrub layer. *Vaccinium membranaceum*, *V. ovalifolium*, and *Menziesia ferruginea* are also typical species.

Rubus pedatus (five-leaved bramble) and *Clintonia uniflora* (queen's cup) characterize the poorly developed herb layer.

The well-developed moss layer is dominated by *Rhytidiopsis robusta* (pipecleaner moss), *Rhytidiadelphus loreus*, *Dicranum scoparium* (broom moss), and *D. fuscescens* (curly heron's-bill moss).

Mountain hemlock — Amabilis fir — Mountain-heather

This association represents slightly dry and nutrient-very poor to -medium sites that occur on and around rock outcrops of ridges and upper slopes, or on upper to lower slopes where bedrock is close to the surface. Soils are shallow and stony and range from Folisols to Podzols. Organic accumulations are thick, often greasy, and have a high water-holding capacity — a significant feature of these exposed sites. Relative to other sites, the Mountain hemlock — Amabilis fir — Mountain-heather association includes the driest of all forested sites in the subzone, and has the most open tree canopy and the densest shrub layer.

Mountain hemlock dominates the uneven, open canopy; yellow-cedar and amabilis fir are subordinate tree species.

Cladothamnus pyrolaeflorus, *Vaccinium alaskaense*, and *V. membranaceum* dominate the shrub layer. *Menziesia ferruginea*, *Rhododendron albiflorum*, and *Vaccinium ovalifolium* are also frequent. Stunted yellow-cedar often adds to the cover of the shrub layer.

Phyllodoce empetriformis (pink mountain-heather), *Rubus pedatus*, *Gaultheria humifusa* (alpine-wintergreen), *Lycopodium sitchense* (Alaska clubmoss), and *Goodyera oblongifolia* (rattlesnake-plantain) characterize the poorly developed herb layer.

Rhytidiopsis robusta, *Dicranum scoparium*, and *D. fuscescens* are the dominant bryophytes.

Amabilis fir — Mountain hemlock — Twistedstalk

This association represents moist and nutrient-rich to -very rich sites. These sites are usually located on middle to lower slopes affected by temporary or permanent seepage. Soils are deep and include Brunisols, Podzols, Regosols, and Folisols. Well-defined Ae horizons are uncommon in soils of this site association, unlike those of zonal ecosystems. Humus forms are fairly thick and typically are Moders.

The well-developed tree layer is dominated by amabilis fir and mountain hemlock. Yellow-cedar and western hemlock can also be frequent. The deep soils, and ample moisture and nutrient supply of the Amabilis fir — Mountain hemlock — Twistedstalk site association promote excellent tree growth. Amabilis fir and yellow-cedar attain their optimum development in the MH on these sites, and the association itself is the most productive in the zone.

Vaccinium alaskaense and tree regeneration dominate the moderately developed shrub layer. *Vaccinium membranaceum* and *Menziesia ferruginea* are also common.

The herb layer is moderately well developed, generally much more so than in the zonal ecosystem. *Streptopus roseus* (rosy twistedstalk), *Rubus pedatus*, and *Clintonia uniflora* are the most abundant herbs. Other frequent species include *Streptopus streptopoides* (small twistedstalk), *Blechnum spicant*, *Tiarella unifoliata* (one-leaved foamflower), *T. trifoliata* (three-leaved foamflower), and *Gymnocarpium dryopteris* (oak fern).

Rhytidiopsis robusta dominates the moderately developed moss layer, and is often joined by *Rhizomnium nudum* (especially in depressions), *Dicranum scoparium*, and *Rhytidiadelphus loreus*.

Yellow-cedar — Mountain hemlock — Skunk cabbage

This association includes wet and nutrient-medium to -very rich sites found only in the lower portion of the subzone, usually on lower slopes below the Amabilis fir — Mountain hemlock — Twistedstalk or Yellow-cedar — Mountain hemlock — Hellebore site associations. Major environmental influences are abundant permanent seepage near the soil surface (seepage that can stagnate in depressions), impeded drainage, poor soil aeration, and thick accumulations of black, mucky or pitchy, acid organic materials. Soils are Gleysols and organics (Humisols and Mesisols). Surface organic accumulations average 50 cm thick and Histomoders or Saprimulls are the prevailing humus forms. As a result of these influences, the vegetation often has a boggy appearance with many of the tree species confined to drier, raised hummocks.

The forest canopy is typically open and irregular. Yellow-cedar and mountain hemlock are the dominant species, and they contribute most of the volume in large diameter classes. Amabilis fir, western hemlock, and western redcedar are less important trees.

Vaccinium alaskaense is the only constant dominant shrub, but is restricted to drier prominences.

Lysichiton americanum (skunk cabbage), *Veratrum viride*, and the bryophytes *Rhizomnium nudum*, *Sphagnum squarrosum*, and *Conocephalum conicum* are concentrated in wet depressions. *Rubus pedatus*, *Clintonia uniflora*, *Cornus canadensis* (bunchberry), *Streptopus streptopoides*, *Orthilia secunda* (one-sided wintergreen), and the mosses *Rhytidiadelphus loreus*, *Rhytidiopsis robusta*, and *Dicranum fuscescens* are abundant on drier mounds.

WILDLIFE HABITATS

The factors that most influence the assemblage of wildlife species in this zone (Table 16) are the long, cool, wet winters with heavy snow cover, steep rugged granitic landforms, and the zone's frequent interruptions by large glaciers. The MH has fewer wildlife species, and these species are less frequent than in other zones. Most large mammal use is in special edaphic units such as avalanche tracks and south-facing rock outcrops, or in the subalpine parklands. There are probably no reptiles and only a few amphibians in this zone.

TABLE 16. Selected wildlife habitats and species in the Mountain Hemlock zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth and mature coniferous forests	Extensive	Black-tailed Deer, Cougar, Black Bear, Snowshoe Hare, Northern Flying Squirrel, Douglas Squirrel, Heather Vole, Southern Red-backed Vole, Columbian Mouse Greated Horned Owl, Great Gray Owl, Blue Grouse, Northern Flicker, Pileated Woodpecker, Hairy Woodpecker, Clark's Nutcracker, Common Raven, Chestnut-backed Chickadee, Red-breasted Nuthatch, Golden-Crowned Kinglet, Townsend's Warbler	♦ Grizzly Bear, Mountain Beaver, Shrew-mole, Pacific Jumping Mouse
Wetlands and streams	Limited areal extent	Black-tailed Deer, Black Bear, Water Vole	♦ Pacific Giant Salamander, Tailed Frog
Subalpine meadows and forest openings	Common, limited areal extent	Roosevelt Elk, Black-tailed Deer, Black Bear Golden Eagle, Willow Ptarmigan, White-tailed Ptarmigan	∇ Vancouver Island Marmot ♦ Grizzly Bear, Mountain Beaver
Rugged south aspects, rock outcrops, and talus	Extensive	Mountain Goat, Common Pika Blue Grouse, White-tailed Ptarmigan	
Avalanche tracks and seepage sites	Common	Mountain Goat, Roosevelt Elk, Black-tailed Deer, Black Bear	♦ Grizzly Bear

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

The climatic climax or old-growth forests provide habitat for birds that eat bark or wood-boring insects, conifer seeds, or other birds and small mammals. Such species are the Great Horned Owl, Great Gray Owl, Clark's Nutcracker, Raven, Common Flicker, Pileated Woodpecker, Hairy Woodpecker, Chestnut-backed Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, and Townsend's Warbler.

The Vancouver Island Marmot is found in moist, parkland or herb meadow habitat only on Vancouver Island. Willow Ptarmigan occur in subalpine meadows in the Kitimat and Boundary Ranges. In late summer and early fall, Blue Grouse often migrate up to these subalpine forests from lower elevation breeding ranges, paradoxically to spend the winter. Some populations of Mountain Goat remain on south-facing, forested, rock outcrops all winter, but most migrate to lower elevation winter ranges. Coastal Grizzly Bear often select the forests of this zone for winter denning.

RESOURCE VALUES

The MH has a low capability for forestry. A short growing season is the major factor limiting forest productivity and operability. Only a few types of ecosystems in the forested subzones are suitable for forestry, if appropriate silvicultural regimes are used. Other ecosystems are more suitable for recreation and watershed use.

The MH includes many hiking and skiing trails and ski resorts, and several major provincial parks.

Severe climate and physiography of the MH preclude agricultural use.

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Chapter 8: Bunchgrass Zone

by

A. Nicholson, E. Hamilton, W.L. Harper, and B.M. Wikeem

LOCATION AND DISTRIBUTION

The Bunchgrass zone (BG) comprises the grasslands that dominate the lower elevations of the major southern interior valleys of British Columbia (Figure 26). Specifically, the zone occurs from valley bottoms up to elevations between approximately 700 and 1000 m in the following locations: the Okanagan Valley from the United States border to Summerland; the Similkameen River Valley around Keremeos; the Thompson River Valley from Spences Bridge to Kamloops; the Nicola River Valley; and the middle Fraser and lower Chilcotin River valleys from the Farwell Canyon area to Big Bar. South of the border, both the Okanagan and Similkameen valley systems open into the Columbia Basin, a large region of steppe and shrub-steppe described by Franklin and Dyrness (1973).

The BG generally occurs at elevations below the Ponderosa Pine zone, but grades directly into the Interior Douglas-fir zone in several areas.

ECOLOGICAL CONDITIONS

The climatic processes of southern British Columbia reflect physiography. For example, on the southern Interior Plateau the degree of aridity corresponds to the intensity of the Coast Mountains' rainshadow. The rainshadow is most intense and therefore the climate driest in the deeper valleys. In addition, temperature tends to increase with decreasing elevation. In the most deeply incised valleys, drought restricts tree establishment and grasslands predominate.

The climate of the BG is characterized by warm to hot, dry summers and moderately cold winters with relatively little snowfall (Figure 27 and Table 4). The distribution of precipitation is bimodal (Schaefer 1978; Williams 1983). Typically December and January are the wettest months, while a second precipitation peak occurs in June. The driest months are usually March and April, although in the southern Okanagan, September and October tend to be the driest months. The range between mean monthly temperatures is high (23-27°C), and winters become progressively colder as one moves north and west within the zone. Because spring is normally dry and summer precipitation evaporates before it can contribute to recharging soil moisture, plant growth depends mainly on winter moisture (Williams 1983). Soil moisture depletion begins with the start of the growing season; the plants become increasingly stressed as the summer progresses. Summer drought, exacerbated by warm temperatures, is the primary factor promoting the development of graminoid vegetation.

Floristically the grasslands are characterized by widely spaced bunchgrasses and a well-developed cryptogam crust. A cover of 10-15% shrubs, 60% bunchgrasses, and 25-35% cryptogams is typical of climax conditions. *Agropyron spicatum* (bluebunch wheatgrass) is the characteristic climatic climax grass. *Artemisia tridentata* (big sagebrush) is characteristic of several ecosystems.

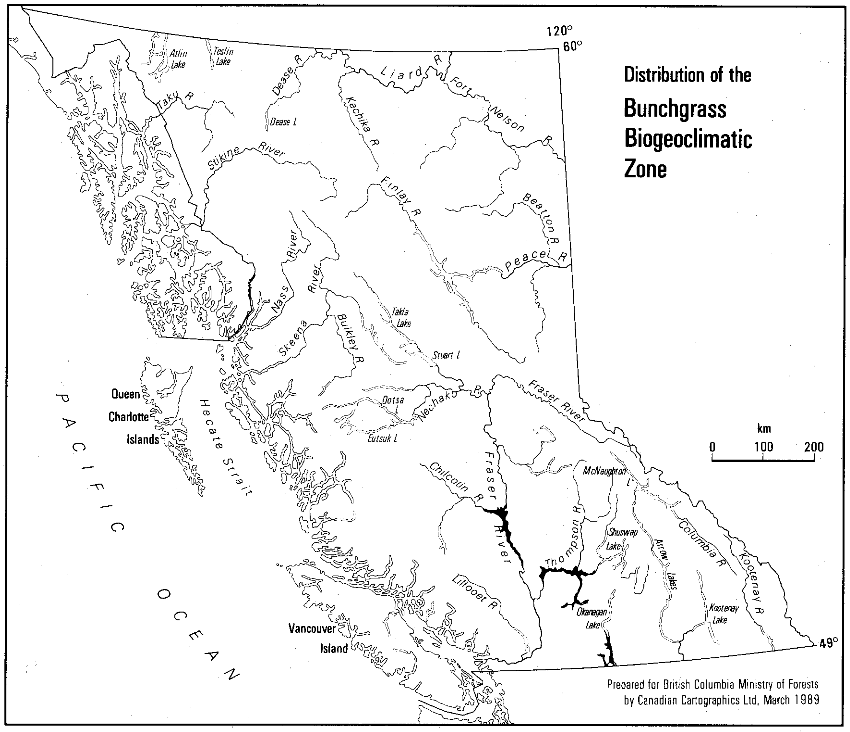

FIGURE 26. Bunchgrass zone.

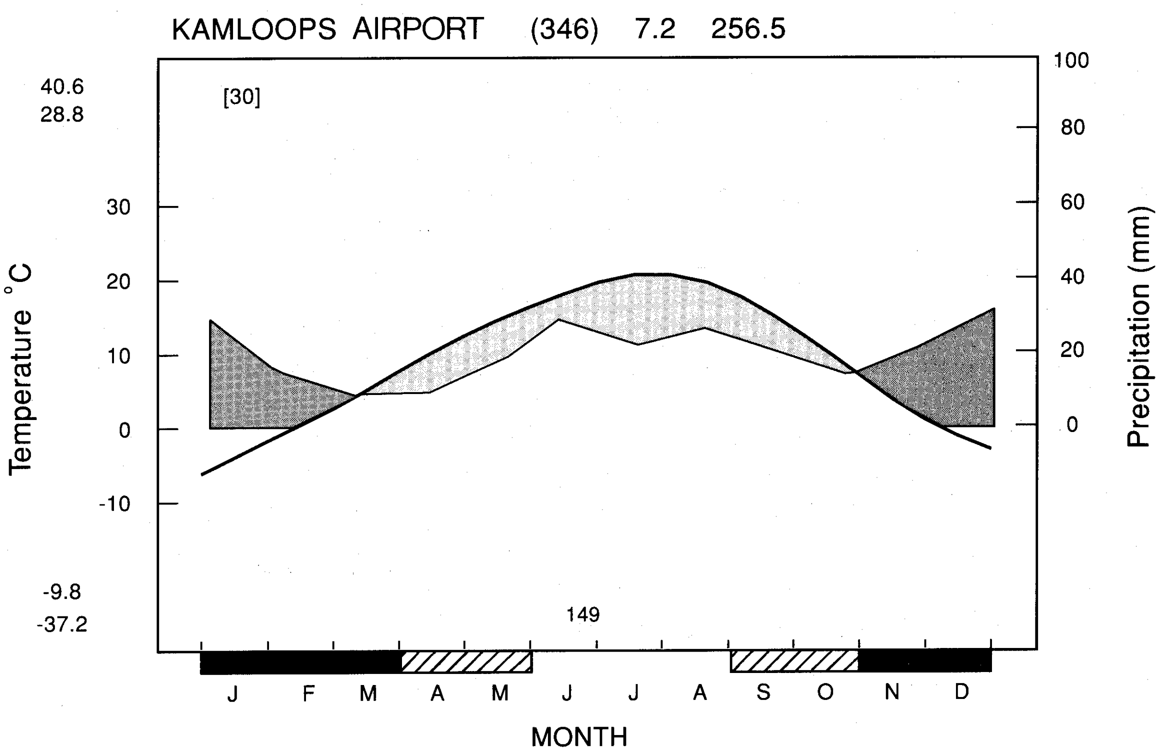

FIGURE 27. Representative climatic diagram for the Bunchgrass zone.

The vegetation of the BG reflects minor changes in topography, aspect, and drainage. Patterns of plant communities are poorly understood because of dramatic alterations in vegetation structure and composition caused by ubiquitous livestock overgrazing. In general, overgrazing results in an increase in abundance of unpalatable or weedy vascular species at the expense of bunchgrasses, particularly *Agropyron spicatum*. For example, sites in fair to poor range condition often have more *Artemisia tridentata*, *Antennaria dimorpha* (low pussytoes), *Stipa comata* (needle-and-thread grass), *Opuntia fragilis* (brittle prickly-pear cactus), and *Bromus tectorum* (cheatgrass).

In the BG, drier sites with sandy, nutrient-poor soils support vegetation dominated by *Stipa comata* and *Sporobolus cryptandrus* (sand dropseed). *Purshia tridentata* (antelope-brush) is also common on these drier sites in the southern Okanagan. Scattered *Stipa hymenoides* (Indian-ricegrass) plants occur on sand dunes. Rock outcrops and sites with shallow soils over bedrock are usually characterized by *Selaginella densa* (compact selaginella). Ponderosa pine and Douglas-fir often grow on steep rocky slopes, on the coarser-textured soils of outwash plains and colluvial fans, and in moist draws. Communities dominated by *Elymus cinereus* (giant wildrye) occur sporadically throughout the zone, generally as patches in seepage areas and along streambanks. In the southern half of the zone, *Festuca scabrella* (rough fescue) or *F. idahoensis* (Idaho fescue) often dominate on steep slopes with a north or east aspect.

Towards the zone's upper elevations, moist depressions (swales) are often dominated by *Poa pratensis* (Kentucky bluegrass) and, in the north, *Stipa spartea* (porcupinegrass) is common. Small groves of trembling aspen can occur on wetter sites at the higher elevations (above approximately 750 m). The aspen is commonly associated with *Symphoricarpos occidentalis* (western snowberry), *Poa pratensis*, *Galium boreale* (northern bedstraw), *Vicia americana* (American vetch), *Agropyron repens* (quackgrass), and *Smilacina stellata* (star-flowered false Solomon's-seal). This community type is heavily used by cattle, so in all likelihood the understory vegetation has been considerably altered from the climax condition.

Wetlands are common throughout the zone and include shrub-dominated riparian habitats with *Betula occidentalis* (water birch), *Typha latifolia* (cattail) marshes with shallow open water, and saline meadows with *Distichlis stricta* (alkali saltgrass). Alluvial black cottonwood stands occur to a limited extent on floodplains of rivers. Bunchgrass zone soils are characterized by a thick Ah horizon, developed through the accumulation of organic material released by the decomposition of fine grass roots. Soils belong to the Brown, Dark Brown, Black, and Dark Gray great groups of the Chernozem Order. Humus forms are typically very thin Xerorhizomulls with characteristics of moders (Pawluk and Sanborn 1989).

NOTES ON CLASSIFICATION

In the original biogeoclimatic classification of Krajina (1965, 1969), those grassland areas below 750 m elevation were included in the Ponderosa Pine — Bunchgrass zone (PPBG). The remaining southern Interior grasslands were placed within the Interior Douglas-fir (IDF) and the Cariboo Aspen — Lodgepole Pine (CALP) zones. However, recent analysis of grassland classification indicated that, to be consistent with the philosophy of the classification system, the grasslands below approximately 900 m elevation should be treated as a separate Bunchgrass zone. Indeed, although relatively small in areal extent, they represent the northern limits of large grasslands to the south. The grassland areas above 900-1000 m elevation were incorporated into the IDF zone.

SUBZONES

Two subzones are recognized in the BG (Table 17 and Figure 28) and correspond to two distinct elevational bands of grassland. Historically they have been referred to as the lower and middle grasslands (Spilsbury and Tisdale 1947; van Ryswyk *et al*. 1966; McLean 1969). The BGxh (Very Dry Hot subzone) or lower grassland occurs in the hottest and driest environment of the valley bottoms to approximately 700 m elevation. The hot, dry climate has resulted in fragile ecosystems with limited plant productivity and soil development. Floristically the BGxh is characterized by widely spaced clumps of *Agropyron spicatum*, *Artemisia tridentata*, and many lichen species that encrust the soil surface. Soils are typically silty clay loam to sandy loam Brown Chernozems or Regosols developed from fluvial or lacustrine deposits.

The BGxw (Very Dry Warm subzone) or middle grassland occurs above the BGxh between approximately 700 and 1000 m elevation. It is generally characterized by the absence of big sagebrush. In the somewhat cooler, moister climate, the bluebunch wheatgrass is more closely spaced than in the BGxh. The diversity of forbs, however, is slightly higher and the diversity of lichens is lower. Furthermore, the soils are more deeply developed Dark Brown Chernozems, developed predominantly from compacted gravelly tills.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following three site associations describe a typical sequence of ecosystems in the BGxw (see Figure 29).

Bluebunch wheatgrass — Selaginella

The Bluebunch wheatgrass — Selaginella association is common on very dry, rock outcrop sites throughout the BG. Soils are predominantly Regosols and humus forms are Xerorhizomulls.

The occasional ponderosa pine or Douglas-fir may be present. Scattered *Artemisia frigida* (pasture sage), *A. tridentata*, and *Chrysothamnus nauseosus* (rabbit-brush) often occur in the shrub layer. *Selaginella densa* (compact selaginella) dominates the herb layer. *Agropyron spicatum* and *Poa sandbergii* (Sandberg's bluegrass) are common grasses and *Lomatium macrocarpum* (large-fruited desert-parsley), *Erigeron linearis* (line-leaved fleabane), and *Antennaria dimorpha* are common herbs. A diverse "lichen" layer, including *Cladonia* spp. and *Diploschistes scruposus*, is typical.

TABLE 17. Synopsis of subzones in the Bunchgrass zone (BG)

Subzone	Code	Old code
Very Dry Hot	BGxh	(BGa,g/PPBGa,g)
Very Dry Warm	BGxw	(BGm,e/PPBGm,e)

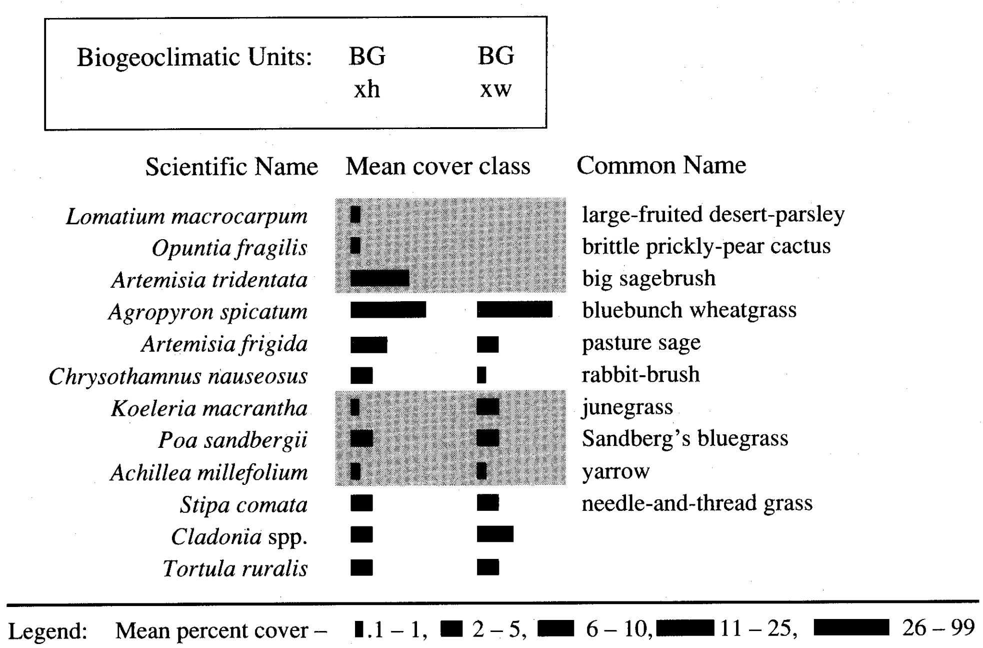

FIGURE 28. Zonal vegetation of subzones of the Bunchgrass zone.

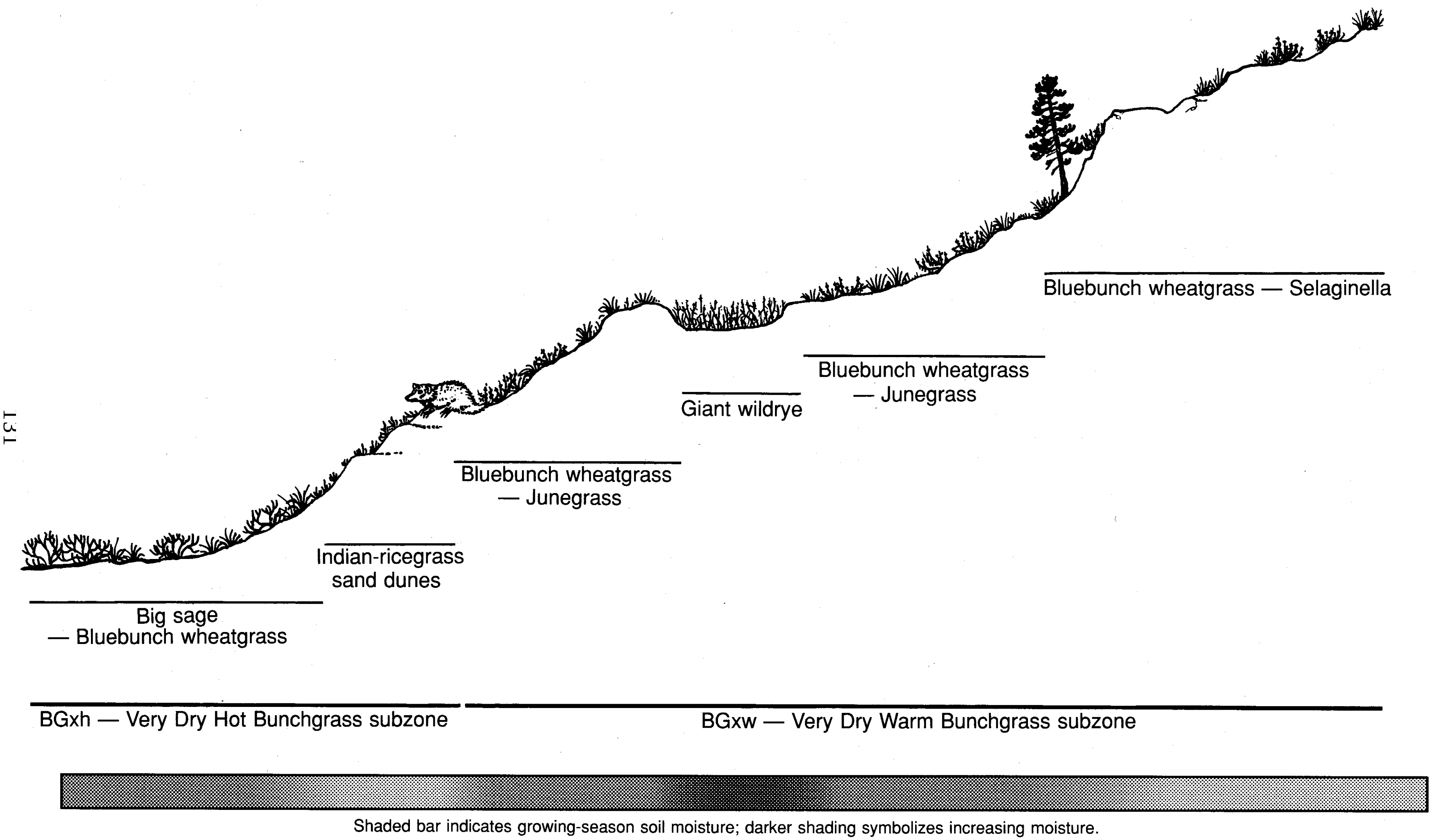

FIGURE 29. Simplified schematic diagram of topographic relationships among common site associations of the Bunchgrass zone.

Bluebunch wheatgrass — Junegrass

The Bluebunch wheatgrass — Junegrass association occupies zonal to slightly drier sites in the BGxm. It most frequently occurs on aeolian-capped till, although it is found on other types of terrain, including glaciofluvial terraces and colluvial-capped till. The till soils are typically loamy-skeletal Orthic Dark Brown Chernozems. The humus forms are Xerorhizomulls.

Undisturbed sites are characterized by well-spaced bunches of *Agropyron spicatum* and a crust of blue-green algae and lichen species. Mosses tend to increase on overgrazed sites while lichen cover declines. *Stipa comata* often increases with overgrazing until extreme disturbance results in invasion by weedy species such as *Bromus tectorum* and *Centaurea* spp. (knapweeds).

In the shrub layer, common species include *Artemisia frigida* and *Chrysothamnus nauseosus*. Both *Poa sandbergii* and *Koeleria macrantha* (junegrass) are common grasses. Common or locally abundant herbs include *Achillea millefolium* (yarrow), *Tragopogon dubius* (yellow salsify), *Antennaria dimorpha, Stipa comata, Lomatium macrocarpum*, *Crepis atrabarba* (slender hawksbeard), *Opuntia fragilis, Linum lewisii* (wild blue flax), *Festuca scabrella*, and *Balsamorhiza sagittata* (arrow-leaved balsamroot). Lichen and moss species frequently include *Cladonia* spp., *Tortula ruralis, Ceratadon purpureus, Diploschistes scruposus*, and *Bryum caespiticium*.

Giant wildrye

The Giant wildrye association is found on localized moist seepage sites. Soils are Dark Brown Chernozems. They are often alkaline and can be slightly saline as a result of restricted drainage and high surface evaporation. Humus forms are Rhizomulls. *Elymus cinereus* dominates these ecosystems. *Juncus arcticus* (arctic rush), *Carex praegracilis* (field sedge), *Poa pratensis*, and *Rosa woodsii* (Wood's rose) can be minor components. *Bryum caespiticium* is typical of the sparse moss layer.

WILDLIFE HABITATS

Although it is one of the smallest zones in British Columbia, the Bunchgrass zone supports a tremendous diversity and density of wildlife (Table 18). This is partly due to the wide range of habitats created by the juxtaposition of grasslands, shrub-steppe, riparian areas, and forest. Perhaps more importantly, this zone represents an extension of the intermontane steppe of the western Great Basin from the south into the northern forests. As a result of this strategic location, both southern and northern species frequent this zone. For example, southern species such as the Pallid Bat, Burrowing Owl, and Short-horned Lizard reach their northern breeding limit in this zone. On the other hand, northern species that rarely move further south, such as the Snowy Owl and Gyrfalcon, can be found on open rangelands in winter.

TABLE 18. Selected wildlife habitats and species in the Bunchgrass zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Bunchgrass grasslands	Extensive	Rocky Mountain Elk, Coyote, Badger, Northern Pocket Gopher Golden Eagle, Red-tailed Hawk, American Kestrel, Snowy Owl, Turkey Vulture, Sharp-tailed Grouse, Long-billed Curlew, Sandhill Crane, Black-billed Magpie, Horned Lark, Western Meadowlark, Mountain Bluebird, Bank Swallow, Grasshopper Sparrow Western Yellow-bellied Racer, Great Basin Spadefoot Toad	∇ Burrowing Owl, Prairie Falcon, Common Poorwill, White-tailed Jackrabbit, Short-horned Lizard ♦ California Bighorn Sheep, Great Basin Pocket Mouse, Montane Vole, Grasshopper Sparrow, Western Rattlesnake, Gopher Snake
Shrub-steppe	Extensive	Mule Deer, White-tailed Deer, Coyote, Badger, Northern Pocket Gopher American Kestrel, Western Meadowlark, Horned Lark, Vesper Sparrow, Lark Sparrow Western Yellow-bellied Racer, Great Basin Spadefoot Toad	∇ White-tailed Jackrabbit, Pallid Bat, Burrowing Owl, Short-horned Lizard, Tiger Salamander ♦ California Bighorn Sheep, Great Basin Pocket Mouse, Nuttall's Cottontail, Sage Thrasher, Western Bluebird, Lewis' Woodpecker, Brewer's Sparrow, Western Rattlesnake, Gopher Snake
Rocky cliffs and talus	Limited areal extent	Yellow-bellied Marmot, Western Big-eared Bat, Western Long-eared Myotis Golden Eagle, Common Raven, Rock Wren, Violet-green Swallow	∇ Spotted Bat, Pallid Bat, Fringed Myotis, Western Small-footed Myotis, Anatum Peregrine Falcon, Prairie Falcon, Canyon Wren ♦ California Bighorn Sheep, Western Rattlesnake, Night Snake, Gopher Snake, White-throated Swift
Ponderosa pine parkland	Limited areal extent	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Coyote, Badger, Hoary Bat, Northern Pocket Gopher, Golden-mantled Ground Squirrel, Deer Mouse American Kestrel, Blue Grouse, Hairy Woodpecker, Common Nighthawk, Black-billed Magpie, Brewer's Blackbird, Clark's Nutcracker, White-breasted Nuthatch, Pygmy Nuthatch, Dusky Flycatcher, Rufous Hummingbird, Black-chinned Hummingbird Western Yellow-bellied Racer, Rubber Boa	∇ Townsend's Big-eared Bat, Spotted Bat, Fringed Myotis, Flammulated Owl, Common Poorwill ♦ Lewis' Woodpecker, White-headed Woodpecker, Gray Flycatcher, Western Rattlesnake, Gopher Snake
Agricultural areas	Common	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Coyote, Northern Pocket Gopher, Meadow Vole American Kestrel, Canada Goose, Western Meadowlark, Barn Swallow, Black-billed Magpie, Bohemian Waxwing Great Basin Spadefoot Toad	♦ Lewis' Woodpecker, Western Rattlesnake, Gopher Snake

TABLE 18. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Riparian areas, wetlands, meadows, and floodplains	Limited areal extent	Mule Deer, White-tailed Deer, Long-tailed Weasel, Western Long-eared Myotis, Western Jumping Mouse Osprey, Long-eared Owl, Screech Owl, American Bittern, Virginia Rail, Sora, Canada Goose, Tundra Swan, Eared Grebe, Wood Duck, Red-winged Blackbird, Black-headed Grosbeak, Bobolink, Northern Oriole, Marsh Wren, Common Yellowthroat, Gray Catbird, Veery Western Skink, Common Garter Snake, Rubber Boa, Painted Turtle, Pacific Treefrog, Western Toad	∇ Spotted Bat, Fringed Myotis, Western Small-footed Myotis, Tiger Salamander ♦ Southern Red Bat, Nuttall's Cottontail, Western Harvest Mouse, Bald Eagle, Great Blue Heron, Black-crowned Night Heron, Yellow-breasted Chat, Yellow-headed Blackbird, Western Bluebird, Western Rattlesnake
Lakes and streams	Common	Muskrat, Beaver Canada Goose, Mallard, American Wigeon, Northern Shoveller, Redhead, Wood Duck, American Coot, American Dipper Painted Turtle, Spotted Frog, Great Basin Spadefoot Toad	∇ Tiger Salamander ♦ Western Grebe, Great Blue Heron, Black-crowned Night Heron

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

A large number of wildlife species in the BG are of provincial or national significance because of their rarity or uniqueness. Many are restricted to the southern half of the Okanagan Valley; for example, the Great Basin Pocket Mouse, Pallid Bat, Spotted Bat, Canyon Wren, White-Throated Swift, Burrowing Owl, Great Basin Spadefoot Toad, and Tiger Salamander.

Grassland ecosystems provide habitat for Rocky Mountain Elk, California Bighorn Sheep, and a host of small mammals, birds, and reptiles. Wildlife dependent on this habitat have been adversely affected by overgrazing by cattle and introduction of noxious weeds. Furthermore, much habitat has been lost through extensive conversion of the grasslands to agricultural and residential developments. As a result, there are a large number of species from this habitat that are at risk in British Columbia (Table 18).

Wildlife species of the shrub-steppe ecosystems are similar to those of the grasslands; a few species are lost, such as the Grasshopper Sparrow, but several others are added including Mule and White-tailed Deer, Sage Thrasher, and Brewer's Sparrow.

Rocky cliffs and talus provide breeding habitat for many animals whose existence in British Columbia is considered at risk. These species include the rare Spotted Bat and Pallid Bat, Anatum Peregrine Falcon, Canyon Wren, White-throated Swift, Western Rattlesnake, Night Snake, and Gopher Snake.

Small pockets of trees can occur within the Bunchgrass zone, producing a completely different wildlife habitat from the adjacent dry open steppe. These are very productive areas, supporting numerous wildlife species. Where ponderosa pine occurs in moist, shady draws and on coarser textured soils, habitat is provided for species such as the White-headed Woodpecker, Clark's Nutcracker, Lewis' Woodpecker, Townsend's Big-eared Bat, and Yellow-pine Chipmunk. Riparian woodlands of mountain alder, black cottonwood, trembling aspen, and willows, also support a rich fauna, including the Wood Duck, American Kestrel, California Myotis, Western Harvest Mouse, Water Shrew, and Western Skink.

Lakes and streams in the BG either remain open year-round or are the first to thaw in the spring. As such they provide important staging areas for migrating waterfowl in spring. Along the margins of large lakes and streams, hard-stem bulrushes and cattails provide habitat for Marsh Wren, Red-wing Blackbird, Sora, American Bittern, Muskrat, and many reptiles and amphibians.

The BG contains several non-native wildlife species. The California Quail, Ring-necked Pheasant, and Chukar were introduced directly. The Gray Partridge invaded from introductions in Washington State. Rock Doves occur in this zone as a result of accidental escapes from captivity. The European Starling and House Sparrow invaded from introductions in the eastern United States.

The Sage Grouse, which occurred in the BG, is the only native species known to have been extirpated from British Columbia. The Burrowing Owl was extirpated, but considerable effort is now underway to re-introduce this species in the South Okanagan. The Burrowing Owl's status should be considered tentative at this time. The White-tailed Jackrabbit and the Short-horned Lizard may also be near extirpation.

RESOURCE USES

The BG has high agricultural capability. With irrigation the land supports orchards, vineyards, and alfalfa production.

Grasslands are critical to the livestock industry in British Columbia. The native vegetation is used for early spring, late fall, and winter livestock range. *Agropyron spicatum* is the most productive and important forage species throughout the zone.

The occurrence of other forage species is somewhat variable, depending on the subzone and the past grazing history of the area, but can include *Koeleria macrantha*, *Aristida longiseta* (red three-awn), *Balsamorhiza sagittata*, *Eriogonum heracleoides* (parsnip-flowered buckwheat), and numerous other forbs (Tisdale 1947; McLean and Marchand 1968). *Amelanchier alnifolia* (saskatoon), *Prunus virginiana* (choke cherry), and *Purshia tridentata* can be important browse species. However, the dominant shrubs in this zone, *Artemisia tridentata* and *Chrysothamnus nauseosus*, have little grazing value for domestic livestock.

Water sports, wildlife viewing, and hiking are popular in the BG because of the warm, dry climate and the water courses and lakes in the major valleys.

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Chapter 9: Ponderosa Pine Zone

by

G.D. Hope, D.A. Lloyd, W.R. Mitchell, W.R. Erickson, W.L. Harper, and B.M.Wikeem

LOCATION AND DISTRIBUTION

The Ponderosa Pine zone (PP) occurs at low elevations along the very dry valleys of the southern Interior Plateau of British Columbia (Figure 30). The PP occurs as a thin band in the bottoms and/or on lower sidewalls of the valleys of the Fraser River in the Lytton-Lillooet area, the lower Thompson, Nicola, Similkameen and lower Kettle rivers, Okanagan Lake, and the southern Rocky Mountain Trench. Elevations range from 335 to 900 m. The zone is located between 49 and 51°N latitude in British Columbia, and extends south of the border into eastern Washington and Oregon. The PP in British Columbia represents the northern limits of a zone that is much more extensive in the western USA.

Typically, the PP's elevation falls between that of the Bunchgrass (BG) and Interior Douglas-fir (IDF) zones.

ECOLOGICAL CONDITIONS

The PP is the driest and, in summer, the warmest forested zone in British Columbia (Figure 31 and Table 4). Mean annual temperature ranges from 4.8 to 10°C. Mean monthly temperature is above 10°C for 5-6 months and below 0°C for 2-5 months. The pronounced rainshadow cast by the Coast Mountains over the southern Interior Plateau is strongly expressed in the PP. Mean annual precipitation is 280-500 mm, with 15-40% as snowfall. Summers are very warm; mean July temperature is 17-22°C. The hot, dry summers result in large moisture deficits during the growing season. Winters are cool with light snow cover.

The forests of the PP landscape are dominated by ponderosa pine. Stands are often very open and parklike with a ponderosa pine canopy and an understory dominated by *Agropyron spicatum* (bluebunch wheatgrass). In fact, the vegetation often consists of a mosaic of forest and grassland. Ponderosa pine is well adapted to fire, and fires have played an important role in the ecology of the zone. Douglas-fir is most common on moist and very moist sites associated with gullies, draws, and streams, but it also occurs as a minor component of drier sites in the northern part of the zone. Trembling aspen is a dominant component of the dense stands that occur on riparian or seepage sites throughout the zone. Water birch (*Betula occidentalis*) and paper birch are found locally in moisture-receiving sites. Black cottonwood occurs on floodplains.

The dominant soils throughout the zone are Dark Brown Chernozems and Orthic or Eluviated Eutric Brunisols. The "wettest" forested sites in the zone have imperfectly drained soils, but Gleysols are uncommon. There is local formation of saline, or alkaline, soils in depressions or basins with restricted drainage. Humus forms typically are Rhizomulls on zonal and drier sites, and Moders on zonal and wetter sites.

Grasslands occur throughout the PP. They are thought to have developed as a result of a combination of edaphic and topographic conditions, together with fire

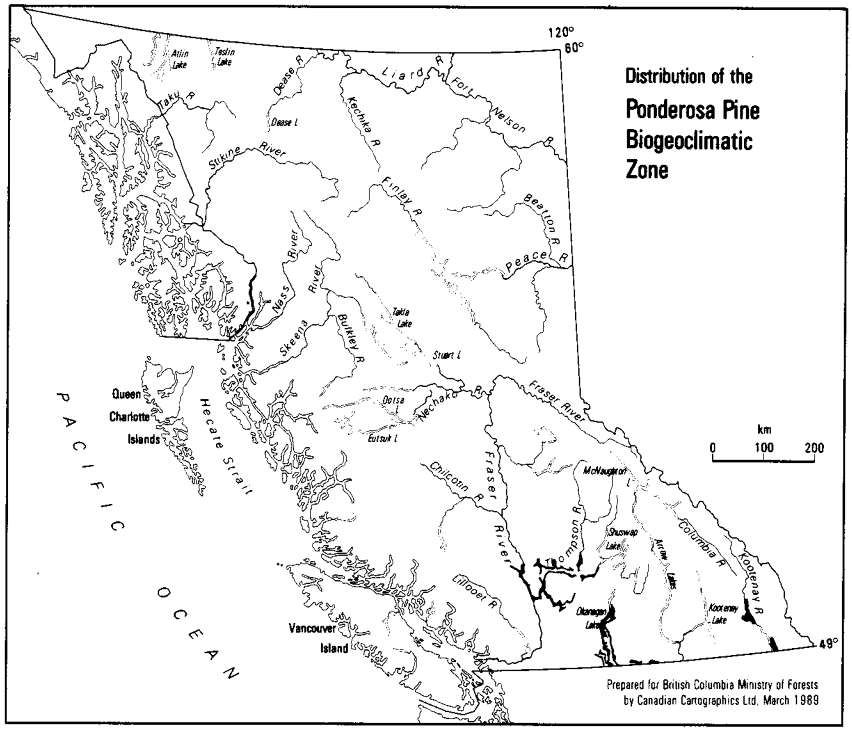

FIGURE 30. Ponderosa Pine zone.

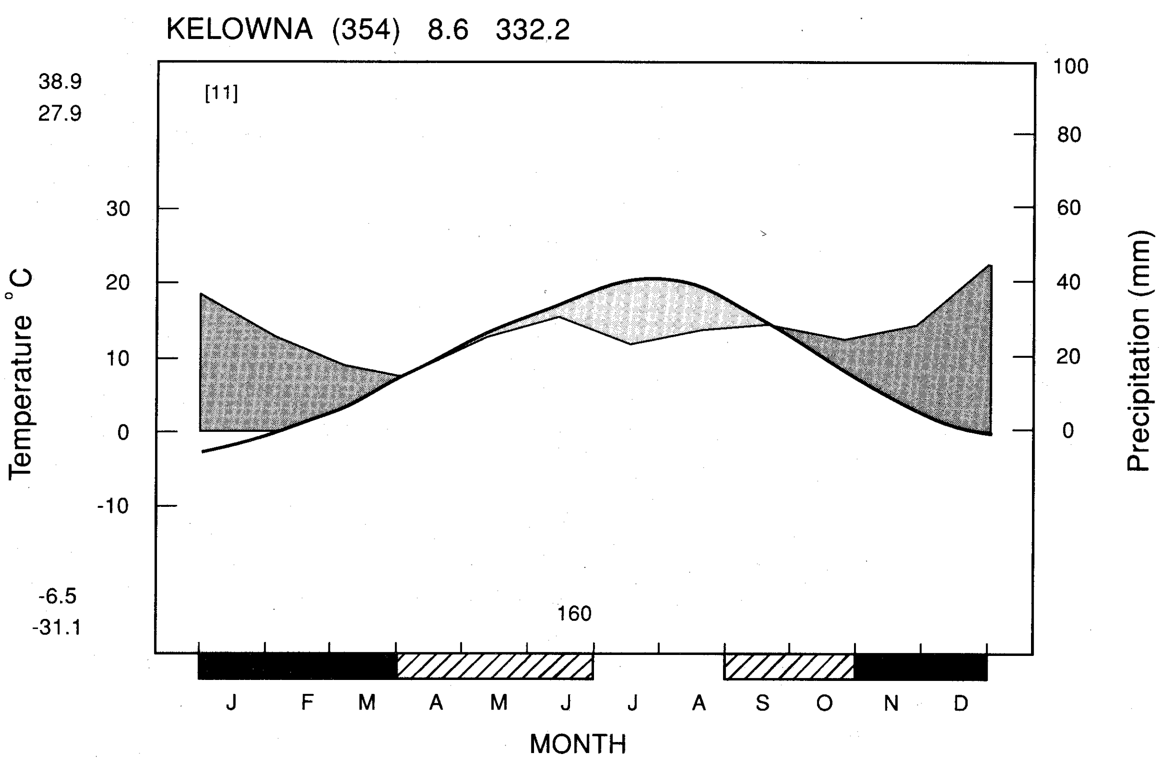

FIGURE 31. Representative climatic diagram for the Ponderosa Pine zone.

history. Dominant species in ecosystems in good range condition are *Agropyron spicatum* and *Artemisia tridentata* (big sagebrush), as well as *Festuca* spp. (fescues). Overgrazed sites in fair to poor range condition have less *Agropyron spicatum* and *Festuca* spp. and more *Artemisia tridentata* and *Poa sandbergii* (Sandberg's bluegrass), along with the invaders *Bromus tectorum* (cheatgrass) and *Centaurea* spp. (knapweeds). Many of the extensive grassland areas adjacent to the PP are included in the Bunchgrass zone.

Alkaline ponds can occur in depressions or basins with restricted drainage. These ponds dry out toward the end of summer and are fringed by wetlands which include several concentrically arranged plant communities. Common species in these communities include *Distichlis stricta* (alkali saltgrass), *Scirpus* spp. (bulrushes), and *Juncus* spp. (rushes).

NOTES ON CLASSIFICATION

Krajina (1965, 1969) grouped the lower and middle grassland areas and the lower and middle elevation dry forests into the Ponderosa Pine — Bunchgrass zone (PPBG), a zone where either ponderosa pine or bluebunch wheatgrass, or both, dominated climatic climax ecosystems. Since then, Ministry of Forests ecologists have divided the PPBG, classifying it into separate BG and PP zones, although small azonal grassland ecosystems occur within the PP. Recently, an area of the East Kootenays classified as IDFg2, has been added to the PP.

SUBZONES

Two subzones have been recognized in the PP (Table 19). Zonal vegetation in both subzones (Figure 32) is dominated by ponderosa pine and *Agropyron spicatum*. Other species in common are *Balsamorhiza sagittata* (arrow-leaved balsamroot), *Amelanchier alnifolia* (saskatoon), and *Achillea millefolium* (yarrow). The Very Dry Hot PP subzone (PPxh) is differentiated from the Dry Hot PP (PPdh) in having more *Festuca saximontana* (Rocky Mountain fescue), *Festuca idahoensis* (Idaho fescue), *Crepis atrabarba* (slender hawksbeard), and *Astragalus miser* (timber milk-vetch). The PPdh has *Lupinus sericeus* (silky lupine), *Arnica fulgens* (orange arnica), and greater abundance of *Antennaria microphylla* (rosy pussytoes), *Koeleria macrantha* (junegrass), and *Bromus tectorum* (cheatgrass).

The driest subzone (PPxh) occurs in valley bottoms from Lytton to north of Lillooet, and west along the Yalakom River and east along the Nicola River. It also occurs as an elevational band between the BG and IDF zones along the Thompson River from Lytton to east and north of Kamloops, and in the Okanagan valley from south of Vernon to the U.S. border.

The dry, hot subzone (PPdh) occurs in the southern Kettle River valley around both Midway and Grand Forks. Further east, the PPdh occupies the bottom of the Rocky Mountain Trench, both north of Cranbrook and on the southeast side of Koocanusa Reservoir.

TABLE 19. Synopsis of subzones in the Ponderosa Pine zone (PP)

Subzone	Code	Old code
Very Dry Hot PP	PPxh	(PPd/PPBGd)
Dry Hot PP	PPdh	(PPc/PPBGc/IDFg2)

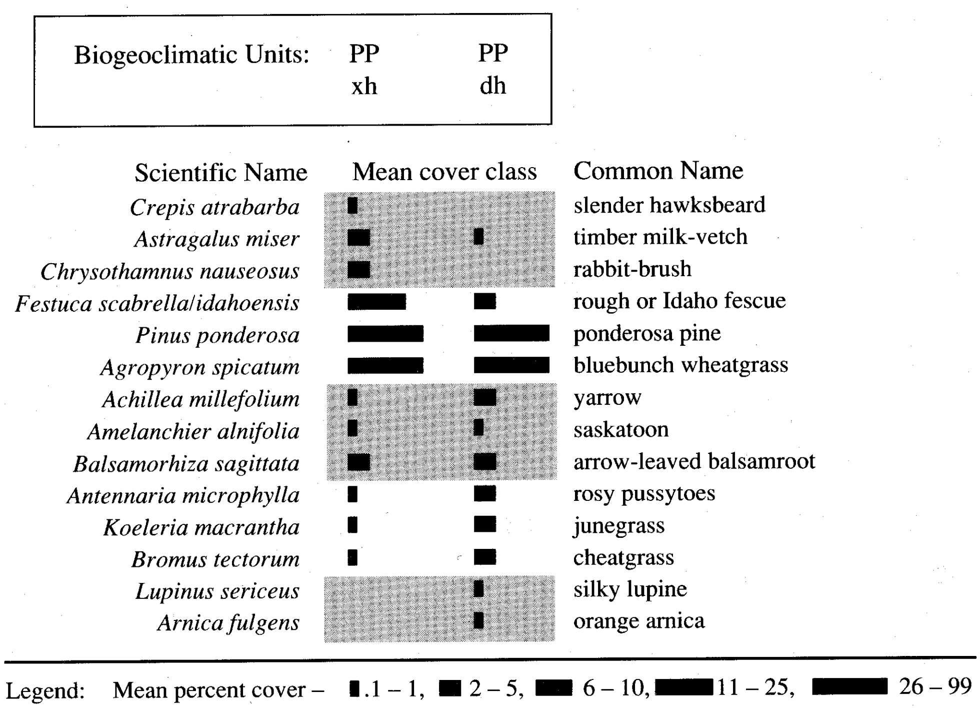

FIGURE 32. Zonal vegetation of subzones of the Ponderosa Pine zone.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following site associations occur commonly in the PP. They form a typical sequence of ecosystems in the PPxh in the Okanagan Valley (Figure 33).

Ponderosa pine — Bluebunch wheatgrass — Fescue

This is the zonal association in the PPxh subzone, and it is commonly found on loamy, moderately well-drained soils developed from morainal and glaciofluvial deposits. Soils are Orthic Eutric Brunisols and Brown Chernozems. Humus forms include Mullmoders and Rhizomulls.

Mature forest stands have very open canopies of ponderosa pine, with some Douglas-fir in the north of the subzone. Regeneration in the understory is uncommon.

Agropyron spicatum (bluebunch wheatgrass) and *Festuca* spp. (*F. idahoensis* in the south, *F. scabrella* in the north) dominate the understory. There are lesser amounts of *Achillea millefolium*, *Astragalus miser*, and *Balsamorhiza sagittata*. The zonal association in the dry subzone is similar, but lacks fescues (*Festuca* spp.).

The shrub layer is open or absent. *Chrysothamnus nauseosus* (rabbit-brush) can occur in northern areas. The moss layer is generally absent.

Ponderosa pine — Red three-awn

This is the driest site association in the PPxh. It is found on south-facing rock outcrops and steep glaciofluvial escarpments. Soils are Brown Chernozems and humus forms are loose, dry Xerorhizomulls.

The open tree canopy is dominated by ponderosa pine, with some Douglas-fir occurring in the north.

The shrub layer, if present, is poorly developed. Tree regeneration is uncommon.

The herb layer is well developed and contains *Selaginella densa* (compact selaginella), *Agropyron spicatum*, *Achillea millefolium*, and *Aristida longiseta* (red three-awn).

The moss layer is generally poorly developed, and exposed mineral soil is common. Some lichens are usually present.

Big sage — Bluebunch wheatgrass

This shrub-steppe association occurs on gently sloping, extremely dry sites throughout the PP. The Big sage — Bluebunch wheatgrass association is very similar to the zonal association of the driest BG subzone. In the PP, these sites are considered to represent disclimaxes or topoedaphic climaxes. Parent materials are generally medium- to fine-textured morainal blankets. Soils are typically Orthic Dark Brown and Brown Chernozems. Rhizomulls are the most common humus form.

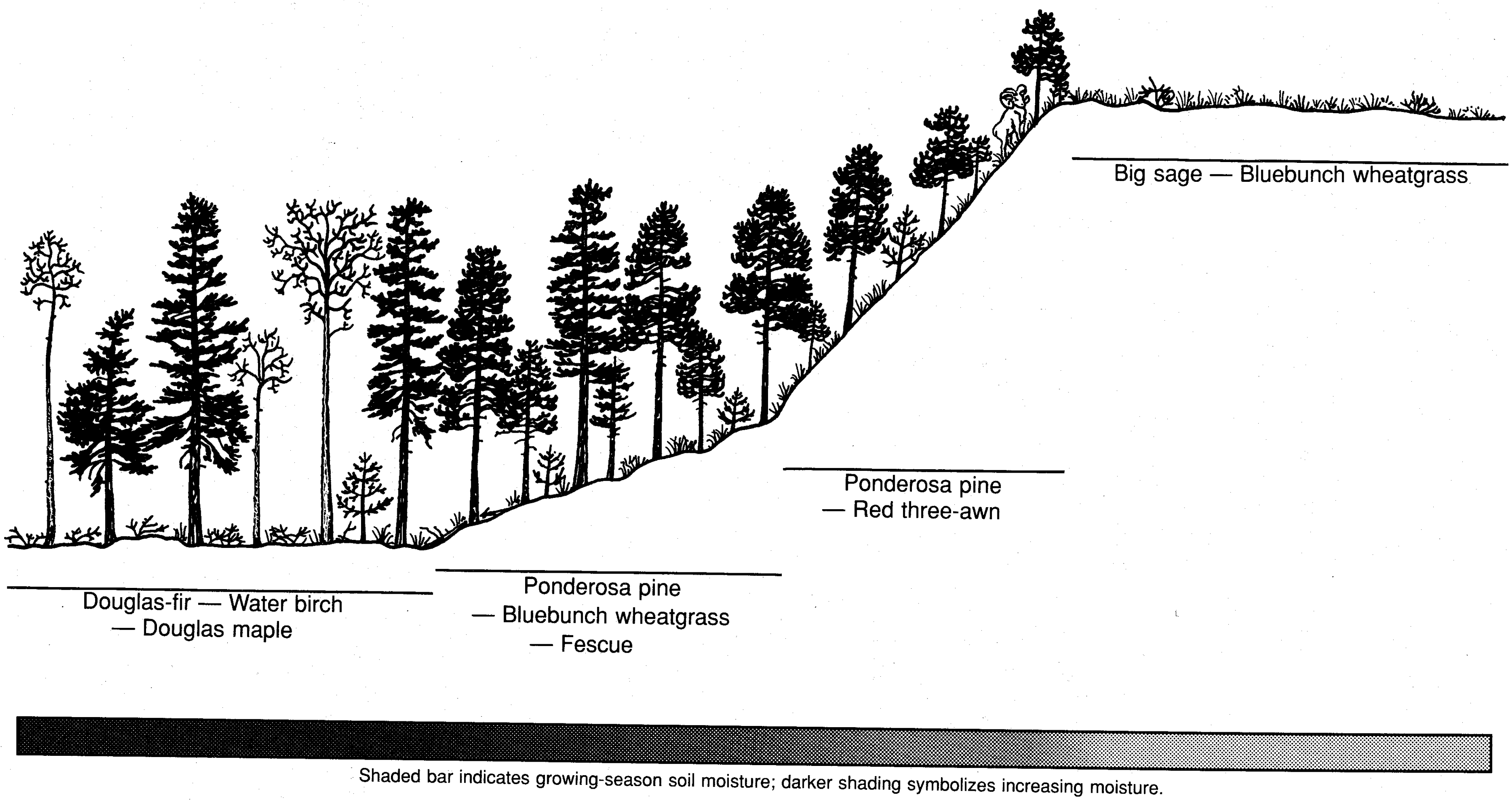

FIGURE 33. Simplified schematic diagram of topographic relationships among four common site associations of a very dry, hot subzone of the Ponderosa Pine zone.

In undisturbed stands, the shrub layer is dominated by well-spaced *Artemisia tridentata* (big sagebrush). There can be a low cover of *Artemisia frigida* (pasture sage).

The herb layer is dominated by *Agropyron spicatum* (bluebunch wheatgrass), with lesser amounts of *Poa sandbergii* and *Achillea millefolium*.

The very sparse moss layer consists mainly of *Cladonia* and *Peltigera* lichens and the moss *Tortula ruralis*.

Increased grazing of these sites results in increased cover of *Artemisia tridentata*, *Chrysothamnus nauseosus*, *Poa* spp. (bluegrasses), and *Antennaria* spp. (pussytoes). *Bromus tectorum* invades or increases in severely overgrazed ecosystems.

Douglas-fir — Water birch — Douglas maple

This association occurs on very moist to wet, nutrient-medium to very rich sites throughout the PP. Such sites are often on floodplains and along streams. Soils are medium- and fine-textured Melanic or Eutric Brunisols, or occasionally Regosols. The soils can be gleyed. Humus forms include Leptomoders, Mormoders, and Vermimulls.

Mature seral or young climax stands are very dense; they contain Douglas-fir and trembling aspen or black cottonwood. Ponderosa pine and paper birch are minor components in some stands.

The shrubby understory contains *Betula occidentalis* (water birch), *Symphoricarpos albus* (common snowberry), *Rosa* spp. (roses), *Cornus stolonifera* (red-osier dogwood), *Acer glabrum* (Douglas maple), and *Mahonia aquifolium* (tall Oregon-grape).

The well-developed herb layer is dominated by *Poa* spp., but also contains *Smilacina stellata* (star-flowered false Solomon's-seal) and *Viola canadensis* (Canada violet).

The moss layer is poorly developed.

WILDLIFE HABITATS

The three factors that most influence the assemblage of wildlife species in this zone (Table 20) are short winters with low snowfall, a strategic location between the Great Basin to the south and the boreal forests to the north, and a great diversity of vegetation types. The short, largely snow-free winters attract many animals during the winter months. Mule Deer, White-tailed Deer, Bighorn Sheep, and Rocky Mountain Elk can migrate long distances (up to 80 km) to winter in this zone. Flocks of passerine birds that have descended from higher elevations are also found during the winter months.

The strategic location between the boreal forests and western Great Basin contributes to the high diversity of wildlife species. Some northern species (e.g., Snowy

Owl and Gyrfalcon) are near the southern limit of their range, and some southern species (e.g., Canyon Wren and Spotted Bat) are near the northern limit of their range. Wildlife habitats in this zone are also diverse. A rich and varied collection of habitat niches results from the mosaic of grasslands and dry forest, the juxtaposition of wetlands and dry shrub-steppe, and the abundance of rugged cliffs and broken rock.

Ponderosa pine parklands provide habitat for species that forage on large conifer seeds (e.g., Clark's Nutcracker, Pygmy Nuthatch, and Yellow-pine Chipmunk), bark insects (e.g., Northern Flicker and White-headed Woodpecker), or flying insects (e.g., Common Poorwill). The open forest canopy passes sufficient light for the production of shrubs (e.g., *Ceanothus* spp. and *Amelanchier alnifolia*) palatable to wintering ungulates. Denser stands of Douglas-fir and ponderosa pine provide thermal cover for wintering ungulates and an abundant seed and insect source for a variety of birds and small mammals.

TABLE 20. Selected wildlife habitats and species in the Ponderosa Pine zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Ponderosa pine parkland	Extensive	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Coyote, Badger, Big Brown Bat, Hoary Bat, Yuma Myotis, Little Brown Myotis, Northern Pocket Gopher, Golden-mantled Ground Squirrel, Deer Mouse American Kestrel, Blue Grouse, Hairy Woodpecker, Common Nighthawk, Black-billed Magpie, Brewer's Blackbird, Clark's Nutcracker, White-breasted Nuthatch, Pygmy Nuthatch, Dusky Flycatcher, Rufous Hummingbird, Black-chinned Hummingbird Western Yellow-bellied Racer, Rubber Boa, Great Basin Spadefoot Toad	∇ Townsend's Big-eared Bat, Spotted Bat, Fringed Myotis, Western Small-footed Myotis, Flammulated Owl, Common Poorwill ♦ Lewis' Woodpecker, White-headed Woodpecker, Gray Flycatcher, Western Rattlesnake, Gopher Snake
Shrub-steppe	Common	Mule Deer, Coyote, Badger American Kestrel, Western Meadowlark, Horned Lark, Vesper Sparrow Western Yellow-bellied Racer	∇ White-tailed Jackrabbit, Pallid Bat, Burrowing Owl, Short-horned Lizard, Tiger Salamander ♦ California Bighorn Sheep, Nuttall's Cottontail, Great Basin Pocket Mouse, Lewis' Woodpecker, Sage Thrasher, Western Bluebird, Brewer's Sparrow, Western Rattlesnake, Gopher Snake
Rocky cliffs and talus	Limited areal extent	Yellow-bellied Marmot Golden Eagle, Common Raven, Rock Wren, Cliff Swallow	∇ Spotted Bat, Pallid Bat, Fringed Myotis, Western Small-footed Myotis, Anatum Peregrine Falcon, Canyon Wren, White-throated Swift ♦ California Bighorn Sheep, Western Rattlesnake, Night Snake, Gopher Snake

TABLE 20. Continued

Habitat	**Habitat distribution**	**Representative wildlife species**	**Wildlife species at risk**[a]
Ponderosa pine and Douglas-fir forests	Extensive	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Cougar, Coyote, Black Bear, Big Brown Bat, Little Brown Myotis, California Myotis, Red Squirrel, Northwestern Chipmunk, Long-tailed Vole Great Horned Owl, Northern Pygmy Owl, Northern Saw-whet Owl, Pileated Woodpecker, Hairy Woodpecker, Northern Flicker, Clark's Nutcracker, Hammond's Flycatcher, Dusky Flycatcher, Steller's Jay, Mountain Chickadee, Red-breasted Nuthatch, Townsend's Solitaire, Swainson's Thrush, Solitary Vireo, Yellow-rumped Warbler, Western Tanager, Chipping Sparrow, Cassin's Finch, Red Crossbill Western Yellow-bellied Racer	∇ Flammulated Owl ♦ California Bighorn Sheep, Lewis' Woodpecker, Western Rattlesnake, Gopher Snake
Agricultural areas	Common	Rocky Mountain Elk, White-tailed Deer, Coyote, Northern Pocket Gopher, Meadow Vole American Kestrel, Canada Goose, Western Meadowlark, Barn Swallow, Black-billed Magpie, Bohemian Waxwing Great Basin Spadefoot Toad	♦ Western Rattlesnake, Gopher Snake
Riparian areas, wetlands, meadows, and floodplains	Limited areal extent	Mule Deer, White-tailed Deer, Long-tailed Weasel, Big Brown Bat, Little Brown Myotis, Western Jumping Mouse, Water Shrew Osprey, Long-eared Owl, Screech Owl, American Bittern, Virginia Rail, Sora, Canada Goose, Tundra Swan, Eared Grebe, Wood Duck, Red-winged Blackbird, Black-headed Grosbeak, Bobolink, Northern Oriole, Marsh Wren, Common Yellow-throat, Gray Catbird, Veery Common Garter Snake, Rubber Boa, Northern Leopard Frog	∇ Spotted Bat, Fringed Myotis, Western Small-footed Myotis, Western Long-eared Myotis, Tiger Salamander ♦ Southern Red Bat, Western Harvest Mouse, Bald Eagle, Great Blue Heron, Yellow-breasted Chat, Yellow-headed Blackbird, Western Bluebird, Western Rattlesnake
Lakes and streams	Common	Yuma Myotis, Little Brown Myotis, Muskrat, Beaver Canada Goose, Mallard, American Wigeon, Northern Shoveller, Redhead, American Coot, American Dipper Painted Turtle, Great Basin Spadefoot Toad	∇ Tiger Salamander ♦ Western Grebe, Black-crowned Night Heron, Great Blue Heron

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Rugged cliffs and talus are relatively common in this zone. They provide breeding habitat for several rare bat species (e.g., Spotted Bat, Pallid Bat) as well as some of the less abundant bird and reptile species such as the Canyon Wren and Western Rattlesnake. When adjacent grassy forage areas are present, Bighorn Sheep will use these low elevation cliff habitats as lambing grounds.

Shrub-steppe habitats contain the same wildlife species as do similar habitats in the Bunchgrass zone. These areas provide winter and spring grass forage for California Bighorn Sheep and Rocky Mountain Elk, shrub forage for Mule and White-tailed deer, and breeding habitat for big sagebrush-adapted birds such as the Sage Thrasher and Brewer's Sparrow.

Wetland meadows and moist, shady draws harbour reptiles and amphibians such as the Common Garter Snake, Tiger Salamander, and Northern Leopard Frog — species that are poorly adapted to the dry forests that dominate this zone. Lakes and potholes are breeding grounds for the Canada Goose and various dabbling and diving ducks, and provide year-round habitat for the Painted Turtle and Tiger Salamander.

Agriculture is restricted to lower elevation valleys and riparian areas, habitats historically used by ungulates as winter range. Species such as Coyote, Rocky Mountain Elk, Mule Deer, and White-tailed Deer are now often considered pests because of crop depredations. Some species of wildlife benefit from the change in vegetation associated with agriculture, for example, the Coyote, American Kestrel, Mountain Bluebird, and Lewis' Woodpecker.

The PP contains several non-native bird species. The California Quail, Ring-necked Pheasant, Chukar, Gray Partridge, Rock Dove, European Starling, and House Sparrow all occur in this zone as a result of direct or indirect introductions from elsewhere.

Sage Grouse once occurred in this zone, but are now considered extirpated in British Columbia. The White-tailed Jackrabbit, Nuttall's Cottontail, and Short-horned Lizard could also belong in this category.

RESOURCE VALUES

The Ponderosa Pine zone is of limited commercial value for forestry. Productivity of ponderosa pine and Douglas-fir is low to poor on all sites except the relatively uncommon moist and very moist sites.

The primary agricultural use of the PP is for cattle grazing. The zone provides important early spring and late fall forage for domestic livestock. Grassland areas, although chronically overgrazed in the past, are now better managed and provide valuable grazing. Flat areas, especially on fluvial or lacustrine terraces, are irrigated for hay production.

On range in excellent condition, *Agropyron spicatum* is the primary forage species, although *Festuca scabrella* and *F. idahoensis* are also important. Other forage plants can include *Stipa comata* (needle-and-thread grass), *Koeleria macrantha*, *Balsamorhiza sagittata*, and numerous other forbs. *Poa pratensis* (Kentucky bluegrass) can be an important forage for livestock on wetter sites and on sites below climax condition. Some browse species, such as *Amelanchier alnifolia*, *Prunus virginiana* (choke cherry), *Symphoricarpos albus*, and *Rosa* spp. are often available to livestock, but are usually limited in their distribution (McLean and Marchand 1968).

In the Okanagan Valley, favourable soil types (fluvial and lacustrine deposits) are used, when irrigated, for orchards and vineyards.

Recreational use of the PP includes some spring, fall, and winter hiking and cycling, horseback riding, nature study, and some hunting, fishing, and motorcycle (dirt bike) riding. Major tourist use occurs along the beaches of some of the main lakes.

The zone itself makes a very small contribution to early spring run-off and sustained yield watershed flows. However, significant municipal, domestic, and agricultural water consumption occurs in the zone.

Major land use conflicts are common in the Ponderosa Pine zone as a result of the demands made on the available land base for agricultural use, for major transportation corridors, for urban, rural, and industrial developments, for recreational uses, and for wildlife wintering areas. Consequently, these areas represent a challenge in integrated land use planning and important gains have been made through this approach.

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Chapter 10: Interior Douglas-fir Zone

by

G.D. Hope, W.R. Mitchell, D.A. Lloyd, W.R. Erickson, W.L. Harper, and B.M.Wikeem

LOCATION AND DISTRIBUTION

The Interior Douglas-fir zone (IDF) dominates the low- to mid-elevation landscape of south-central interior British Columbia (Figure 34), between 49° and 52° 30′N latitude. The zone also extends south into Washington, Oregon, Idaho, and Montana, and east into Alberta. In British Columbia, the IDF occupies the rolling and valley terrain of the southern Interior Plateau and southern Rocky Mountain Trench, and also fingers into the lee side of the Coast Mountains. Lowest elevations of the zone are between 350 (in some valleys) and 600 m; upper elevations are at 900-1450 m.

Typically, the IDF occurs at elevations below the Montane Spruce zone and, where the valleys are deep enough, above the Ponderosa Pine zone. In the northern portions of the IDF, the zone is surrounded by the Sub-Boreal Pine — Spruce and Sub-Boreal Spruce zones, and the Bunchgrass zone is found below the IDF along the Fraser and Chilcotin rivers. In the coast transition areas, the IDF occurs below the Coastal Western Hemlock zone.

ECOLOGICAL CONDITIONS

The IDF has a continental climate characterized by warm, dry summers, a fairly long growing season, and cool winters (Figure 35; Table 4). The main factor controlling the climate is the rainshadow created in the lee of topographic barriers (the Coast, Cascade, and Columbia mountains) to the prevailing easterly flowing air. Mean annual temperature is 1.6-9.5°C. The average temperature is below 0°C for 2-5 months, and above 10°C for 3-5 months. Mean annual precipitation ranges from 300 to 750 mm, except in the wettest areas where precipitation exceeds 1000 mm. Twenty to 50% of the precipitation falls as snow. Substantial growing season moisture deficits are common and frosts can occur at any time.

Open to closed, mature forests containing Douglas-fir cover much of the IDF landscape. Pure Douglas-fir climax stands are common, and often have an open canopy, because ground fires were common historically, and survival of mature trees with thick bark was favoured. Where crown fires have commonly occurred in the past, there are extensive mixed stands of Douglas-fir and lodgepole pine, often with scattered large Douglas-fir veterans. Ponderosa pine occurs at lower elevations south of Clinton and Little Fort. In very dry parts of the zone, it forms early seral stands on zonal sites, but is eventually replaced by Douglas-fir. Ponderosa pine persists as a climax species on drier sites, and even in the moister subzones it occurs on dry, south-facing slopes. Hybrid white spruce (*Picea engelmannii* x *glauca*) occurs on moister sites and is most common at higher elevations transitional to the Montane Spruce zone. Western redcedar sometimes occurs in mature forests on zonal and wetter sites in the moister areas transitional to the Coastal Western Hemlock or Interior Cedar — Hemlock zones. Lodgepole pine is more widespread at higher elevations where it is a common successional species. Trembling aspen is also a widely distributed seral species throughout the zone. Grand fir is restricted to the southwestern, wettest part of the

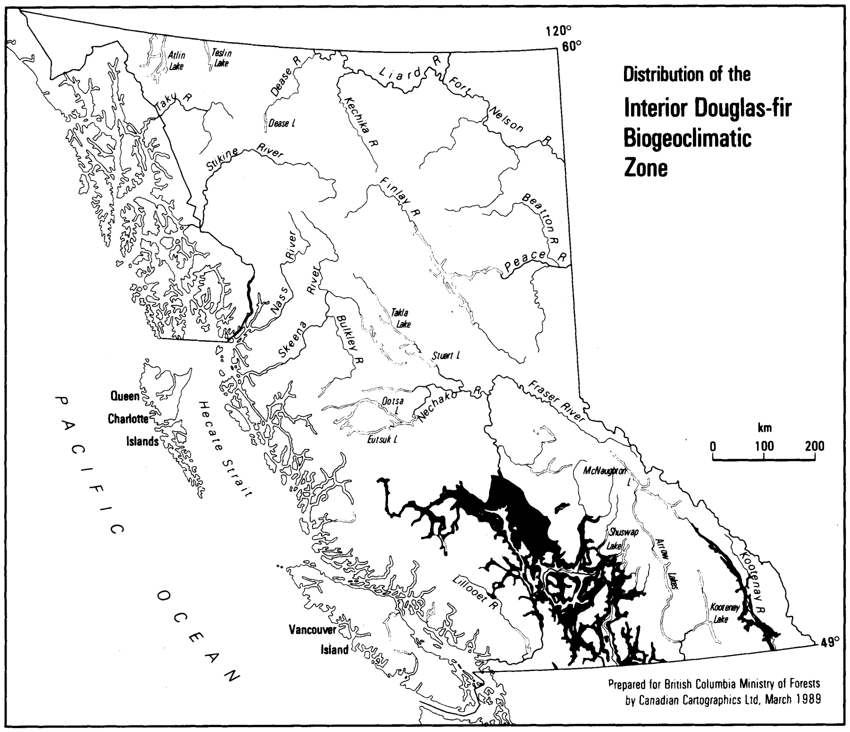

FIGURE 34. Interior Douglas-fir zone.

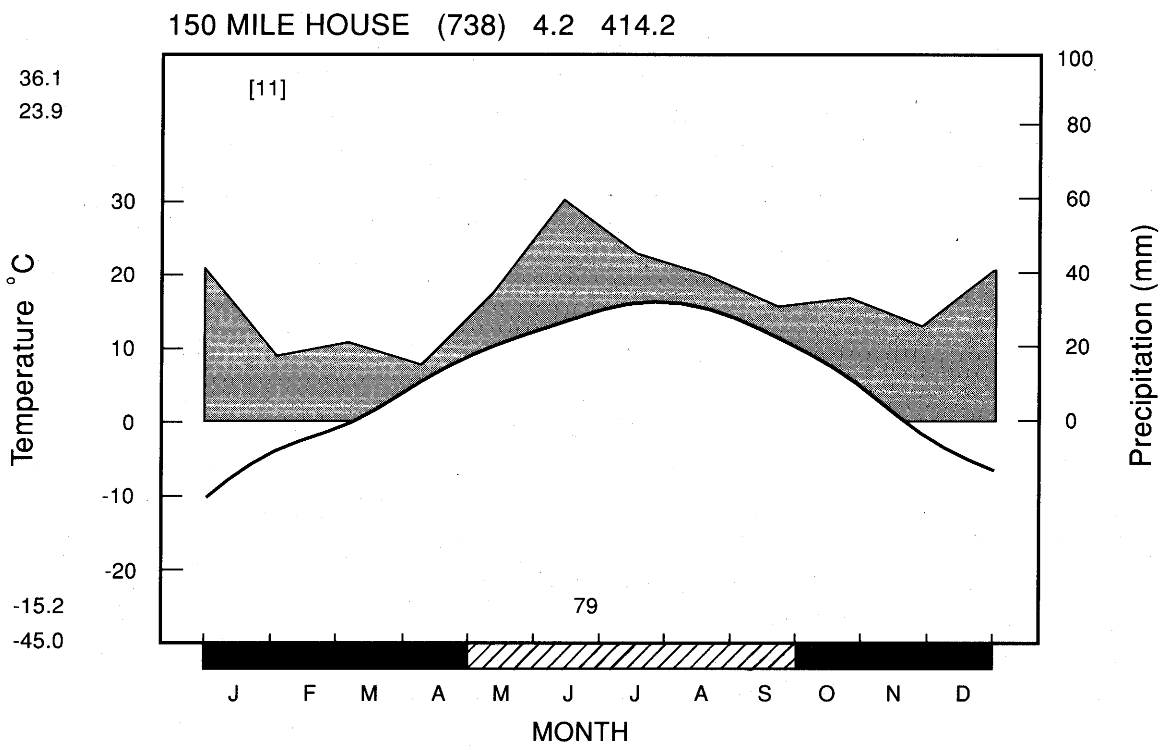

FIGURE 35. Representative climatic diagram for the Interior Douglas-fir zone.

IDF. Paper birch is common on moist sites and in the wettest subzones. Western larch is restricted to the southeastern part of the zone, where it frequently occurs after fire. *Juniperus scopulorum* (Rocky Mountain juniper) is found occasionally at lower elevations, usually on dry sites.

A combination of edaphic and topographic conditions and fire history has led to the development of large grassland communities in parts of the IDF. These grasslands have been modified by grazing of domestic livestock and influenced by reduced fire frequency since the turn of the century. Grassland in good to excellent range condition is dominated by *Agropyron spicatum* (bluebunch wheatgrass), together with *Festuca idahoensis* (Idaho fescue) in the south, *F. scabrella* (rough fescue) in the central parts of the zone, and *Stipa richardsonii* (spreading needlegrass) and *Festuca saximontana* (Rocky Mountain fescue) in the northern, Chilcotin grasslands. *Artemisia frigida* (pasture sage), *Koeleria macrantha* (junegrass), and *Poa pratensis* (Kentucky bluegrass) are also common and increase in abundance under grazing pressure. Past overgrazing has also shifted dominance from the bunchgrasses (fescues and bluebunch wheatgrass) toward other less palatable “increaser” species such as *Lupinus sericeus* (silky lupine), *Astragalus miser* (timber milk-vetch), and *Achillea millefolium* (yarrow), and weedy invaders such as *Bromus tectorum* (cheatgrass), *Erigeron compositus* (cut-leaved daisy), and *Tragopogon* spp. (salsifies). Soils of the IDF grasslands are mainly Orthic Dark Brown Chernozems at lower elevations and Orthic Black and Dark Grey Chernozems higher in the zone. Where large areas of grassland ecosystems occur, they have been mapped as grassland phases of IDF subzones.

Zonal ecosystems in the IDF occur on well- to moderately well-drained upland sites on morainal deposits derived from basic volcanic bedrock. Soils are typically Orthic or Dark Gray Luvisols, and Eutric or Dystric Brunisols. Generally soils in the zone have medium to rich nutrient status, because of the predominance of base-rich bedrock and the low rates of leaching in the dry climates. Humus form development usually results in Moders, with occasional Mors and Mullmoders. Leptomoders are common on lower elevation zonal ecosystems, whereas Mormoders and Hemimors are most common at upper elevations. The Mormoders are most prevalent where there is a grassy ground cover.

Non-forested wetlands are common in the IDF. These range from *Typha latifolia* (cattail) and *Scirpus lacustris* (great bulrush) marshes in shallow depressions and around open water, to sedge fens of *Carex aquatilis* (water sedge), *C. rostrata* (beaked sedge), and *C. lasiocarpa* (slender sedge), to saline meadows dominated by *Distichlis stricta* (alkali saltgrass), *Puccinellia nuttalliana* (Nuttall’s alkaligrass), and *Hordeum jubatum* (foxtail barley). Many of the fens include a tall or low shrub canopy of willows (*Salix* spp.) and sometimes *Betula glandulosa* (scrub birch) or *B. pumila* (swamp birch). Shrub-carrs dominated by scrub birch occur at the drier edges of many fens, especially in the northern areas. Tall willow swamps often follow small streams and drainage channels. Bogs are uncommon in the IDF.

NOTES ON CLASSIFICATION

The northern portion of the IDF in the Cariboo-Chilcotin area was classified by Krajina (1965, 1969) as a southern subzone of his Cariboo — Aspen — Lodgepole Pine zone (CALP), a zone the Ministry of Forests no longer recognizes. Large grassland areas within the IDF are classified as grassland phases of the zone. Part of the IDF in the East Kootenays is now in the Ponderosa Pine zone.

SUBZONES

Seven subzones have been recognized in the IDF (Table 21). The very dry subzones lack lodgepole pine, *Linnaea borealis* (twinflower), *Paxistima myrsinites* (falsebox), and *Chimaphila umbellata* (prince's pine), and commonly have ponderosa pine (Figure 36). The two moist and wet subzones have some western redcedar, paper birch as a seral species, low cover of *Calamagrostis rubescens* (pinegrass), but no *Arctostaphylos uva-ursi* (kinnikinnick). Generally, with increasing effective moisture (whether as a result of greater precipitation or cooler temperatures) there is a trend from open forest with grassy ground cover to closed forest with more shrubs and mixed forb-grass-moss ground cover.

TABLE 21. Synopsis of subzones in the Interior Douglas-fir zone (IDF)

Subzone	Code	Old code
Very Dry Hot IDF	IDFxh	(IDFa1/a3)
Very Dry Warm IDF	IDFxw	(IDFa2)
Very Dry Mild IDF	IDFxm	(IDFa4)
Dry Mild IDF	IDFdm	(IDFf/g3)
Dry Cool IDF	IDFdk	(IDFb/d)
Moist Warm IDF	IDFmw	(IDFj)
Wet Warm IDF	IDFww	(IDFe)

The very dry subzones occupy some of the major valleys of the southern Interior Plateau. The IDFxh occurs in the lower elevations of the Okanagan valley south of Enderby, along the Similkameen valley, along the North and South Thompson rivers from north and east of Kamloops west to the Fraser River, and in the Fraser River valley and its tributaries in the Lytton-Lillooet area. The IDFxw occupies lower elevations of major valleys in the Clinton-Cache Creek area and midslopes of the Fraser River valley west of Clinton. The IDFxm occupies lower elevations of the Chilcotin and Fraser river valleys from south of Alexandria to west of Clinton.

The dry IDF subzones occur at moderate elevations on the lee side of the Coast, Cascade, and Purcell mountains. The IDFdk, the "modal" IDF subzone, occupies lower to middle elevations of the southern Interior Plateau in the lee of the Coast and Cascade mountains, extending east from the Tatla Lake area to north of Williams

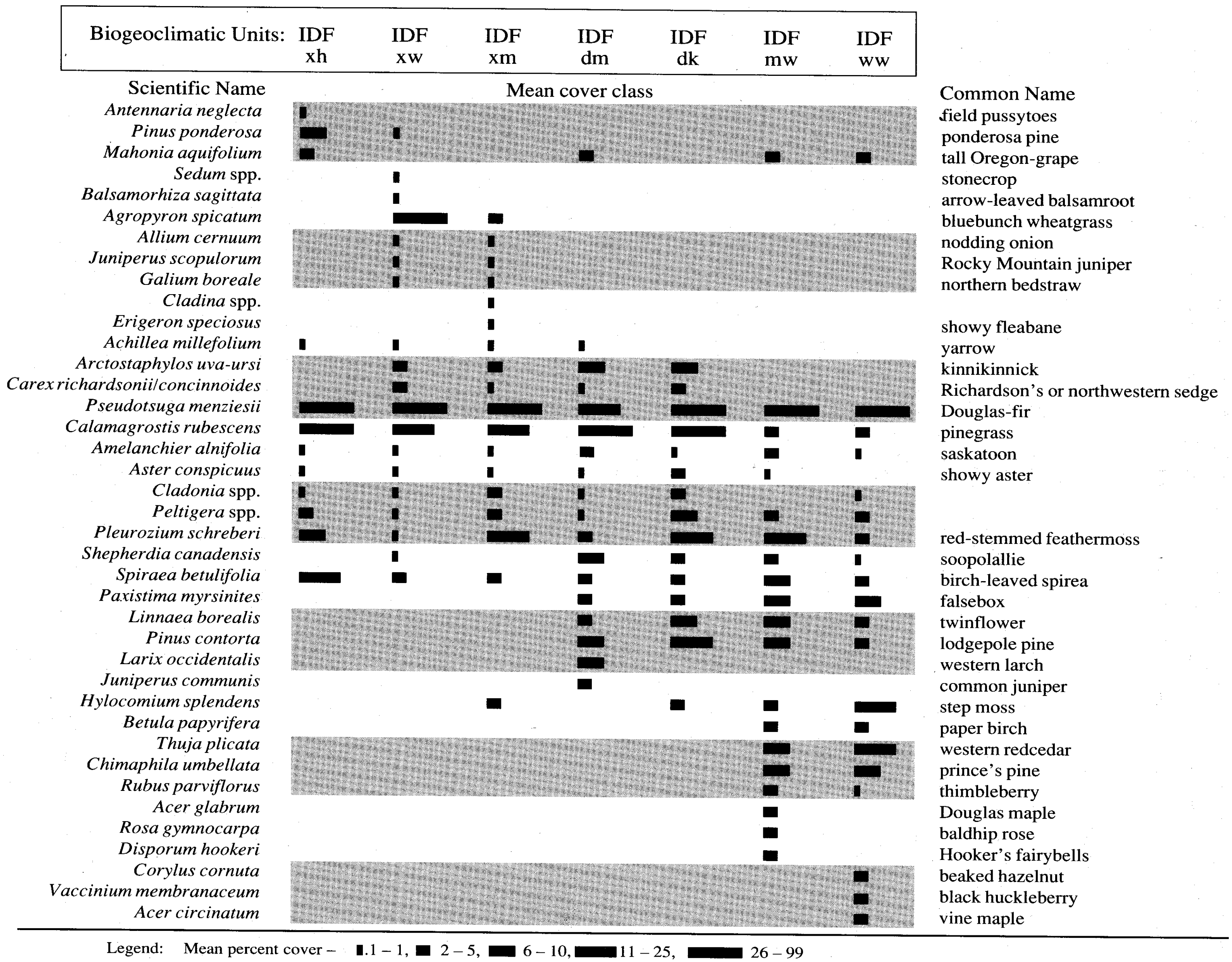

FIGURE 36. Zonal vegetation of subzones of the Interior Douglas-fir zone.

Lake and then south, to southeast of Princeton. The IDFdm occurs in the Okanagan Highlands and along the Kettle River drainage, north of Grand Forks, and in the valley bottoms and on lower slopes of the Rocky Mountain Trench and its major tributaries south of the Blaeberry River. This subzone is distinguished by the presence of western larch.

The moister IDFmw occurs in a narrow band transitional to the Interior "wet belt" from east of Peachland to Salmon Arm, and then northwest to the North Thompson River and its tributaries near Clearwater. The IDFww subzone occurs on the lee side of the Coast Mountains along the eastern end of the Klinaklini and Atnarko river valleys, along the Lillooet River valley east of Pemberton, and in the Fraser River valley around Boston Bar.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The four site associations described below are common in the IDF. They form a typical sequence of ecosystems in the IDFdk on the southern Interior Plateau (Figure 37).

Douglas-fir — Lodgepole pine — Pinegrass — Feathermoss

This association is common in the dry subzones. It is the zonal association in the IDFdk and is similar to associations that occur on sites with "drier" relative soil moisture regimes in the moist and wet subzones. It occurs primarily on moderately well- and well-drained, loamy, morainal deposits derived from basic volcanic bedrock. Soils are predominantly Eutric and Dystric Brunisols and Gray Luvisols. The most common humus forms are Hemimors and Mormoders. The zonal association in the IDFdm subzone is similar to this one, but differs in that western larch and *Juniperus communis* (common juniper) are found in the IDFdm association.

Mature stands consist of Douglas-fir and lodgepole pine; climax stands can contain only Douglas-fir. The understory contains varying amounts of Douglas-fir regeneration.

The moderately developed shrub layer contains *Spiraea betulifolia* (birch-leaved spirea) and *Shepherdia canadensis* (soopolallie). *Paxistima myrsinites* can occur in moister parts of the subzone and *Rosa acicularis* (prickly rose) in northern areas.

The herb layer has considerable cover of *Calamagrostis rubescens* (pinegrass) and lesser amounts of *Linnaea borealis*, *Arctostaphylos uva-ursi*, *Arnica cordifolia* (heart-leaved arnica), and *Aster conspicuus* (showy aster).

Mosses are infrequent; *Pleurozium schreberi* (red-stemmed feathermoss) is the most common. *Peltigera* spp. and *Dicranum polysetum* (wavy-leaved moss) are often present.

Douglas-fir — Snowberry — Bluebunch wheatgrass

This association occurs on very dry, nutrient-poor to -medium sites, generally on upper, south-facing slopes in the dry and moist subzones. Soils are often shallow and

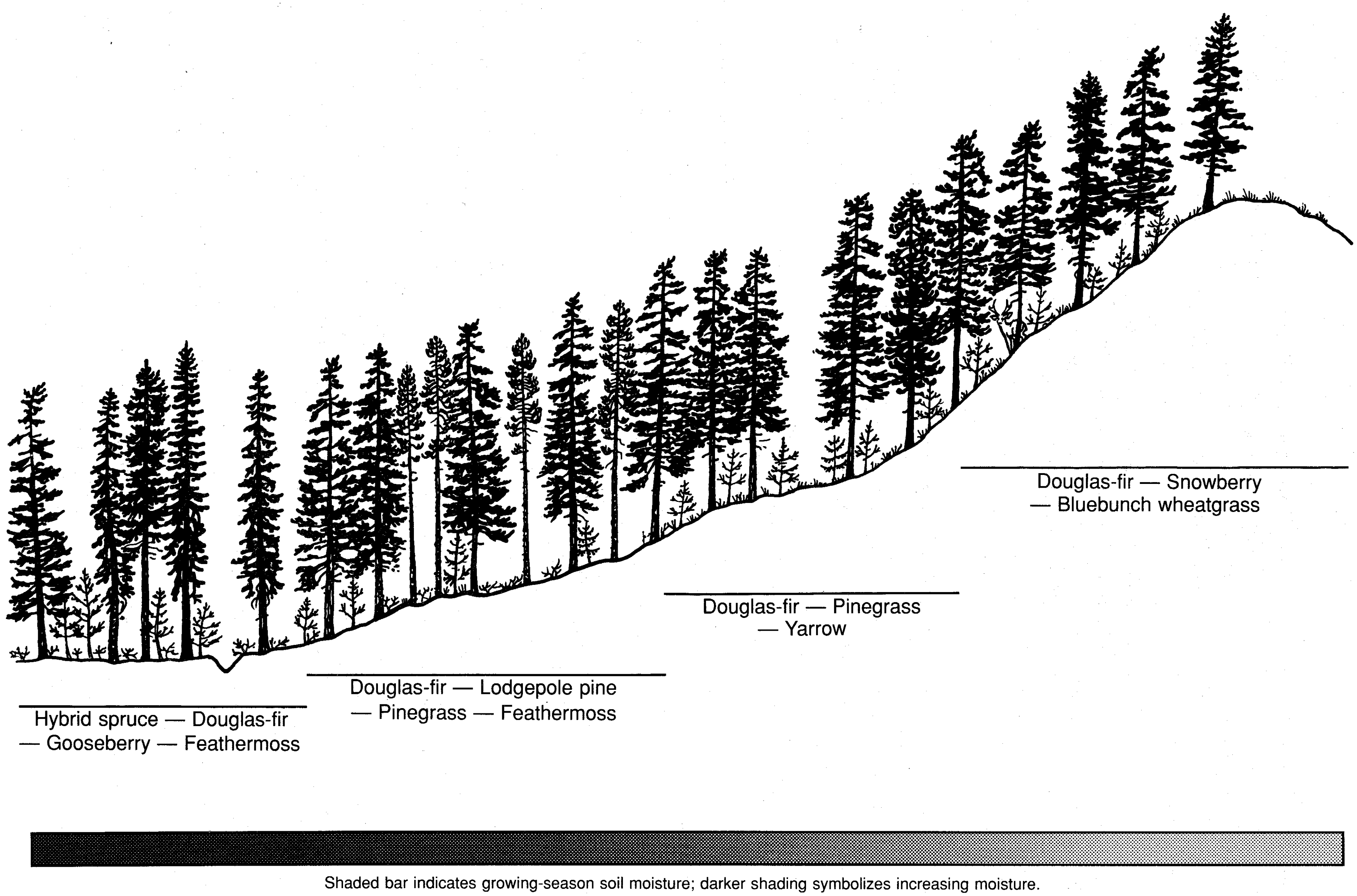

FIGURE 37. Simplified schematic diagram of topographic relationships among four common site associations of a dry, cool subzone of the Interior Douglas-fir zone.

derived from colluvial or morainal deposits. Soils are predominantly Orthic Melanic and Orthic Eutric Brunisols. Humus forms include thin Leptomoders and Mullmoders.

Mature stands have an open tree canopy of Douglas-fir. Similar associations at lower elevations contain ponderosa pine as a seral species.

The shrub layer is dominated by a moderate cover of *Symphoricarpos albus* (common snowberry) and/or *Spiraea betulifolia*. *Amelanchier alnifolia* (saskatoon), and *Juniperus communis* can also occur, and *Ceanothus velutinus* (snowbrush) is common in the south.

The herb layer is moderately well developed and is dominated by *Agropyron spicatum* (bluebunch wheatgrass). There can be a low cover of *Calamagrostis rubescens*. The moss layer is patchy.

Douglas-fir — Pinegrass — Yarrow

This association typically occupies moderately dry, poor to rich sites in middle to upper slope positions in the dry subzones of the IDF. A similar association, but containing ponderosa pine, is the zonal association in the IDFxh subzone. Soils are predominately Eutric and Dystric Brunisols and Gray Luvisols. The most common humus forms are Hemimors and Mormoders.

Mature stands have a moderately open canopy of Douglas-fir. The understory has scattered clumps of Douglas-fir of various ages.

The sparse shrub layer consists of *Spiraea betulifolia* and *Shepherdia canadensis*. *Rosa acicularis* is more common in the north of the subzone.

The herb layer is well developed and dominated by *Calamagrostis rubescens*. There are lesser amounts of *Aster conspicuus* and *Arctostaphylos uva-ursi* and *Achillea millefolium* (yarrow). The moderately developed moss layer contains *Pleurozium schreberi*. In dense, older stands the moss layer can be continuous.

Hybrid spruce — Douglas-fir — Gooseberry — Feathermoss

This association occurs on moist and very moist, nutrient-medium to very rich sites throughout the very dry and dry subzones. It is most extensive along floodplains where the IDF occupies large valley floors; it also occurs as small pockets in depressions, often adjacent to streams. Soils are orthic and gleyed subgroups of Brunisols and Gray Luvisols. Humus forms are Hemihumimors and Hemimors.

Mature stands in this association contain a mix of hybrid white spruce and Douglas-fir, both in the canopy and the understory. A small amount of lodgepole pine is occasionally present.

The understory is diverse. Common shrubs include *Ribes lacustre* (black gooseberry), *Lonicera involucrata* (black twinberry), *Cornus stolonifera* (red-osier dogwood), and *Rosa acicularis*. *Symphoricarpos albus* and *Acer glabrum* (Douglas maple) occur in some areas.

The well-developed herb layer contains *Linnaea borealis*, *Cornus canadensis* (bunchberry), *Calamagrostis rubescens*, and *Osmorhiza chilensis* (mountain sweet-cicely).

Pleurozium schreberi (red-stemmed feathermoss) is consistently present in the poorly to moderately developed moss layer. In northern areas of the subzone the moss layer becomes continuous.

WILDLIFE HABITATS

The factors that most influence the assemblage of species in this zone (Table 22) are the relatively short, cool winters and extensive Douglas-fir forests with variable canopy closure. Low elevation, south-facing aspects attract many animals during winter. Mule Deer, White-tailed Deer, Bighorn Sheep, and Rocky Mountain Elk can migrate long distances (up to 80 km) to winter in this zone. Non-migratory passerine birds descend from higher elevations to form mixed species flocks during the winter months.

This zone has a wide range of habitat niches for wildlife, as a result of the topographic variety and great diversity of overstory and understory vegetation. Douglas-fir forests serve as winter range for many ungulates. In the northern parts of the IDF, Mule Deer require old-growth Douglas-fir stands for forage (litter-fall) and snow interception. In the southern parts of the zone, south aspect forests and dry Douglas-fir and ponderosa pine forests provide winter habitat for Rocky Mountain Elk, Mule Deer, White-tailed Deer, and Bighorn Sheep.

These forests also support a diverse complement of birds that feed on conifer seeds, bark-insects, and small mammals. Some of these forest birds are largely insectivorous, such as the Pileated Woodpecker, Northern Flicker, and Red-breasted Nuthatch. Others, such as Clark's Nutcracker and Red Cross-bill, depend more on conifer seeds. The rare Flammulated Owl nests in old ponderosa pine and Douglas-fir trees in the south Okanagan and Kamloops areas.

Edaphic bunchgrass grasslands support a different group of wildlife species. California and Rocky Mountain bighorn sheep occur where suitable rugged escape terrain is nearby. Mule and White-tailed deer graze these areas in early spring; Golden Eagle and Red-tailed Hawk hunt the grasslands for mice, voles, and ground squirrels. Species more common at lower elevations, such as Badger, Great Basin Pocketmouse, Western Rattlesnake, Gopher Snake, and Great Basin Spadefoot Toad, often occur on the IDF grasslands. Small lakes and potholes within the grasslands serve as breeding grounds for various dabbling and diving ducks such as Northern Pintail, American Wigeon, Mallard, Blue-winged Teal, Lesser Scaup, and American Coot, as well as for the Painted Turtle. Larger lakes and marshes are important staging and breeding areas for a great variety of waterbirds.

TABLE 22. Selected wildlife habitats and species in the Interior Douglas-fir zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth and mature coniferous forest	Extensive	Rocky Mountain Elk, Black-tailed Deer, Mule Deer, White-tailed Deer, Black Bear, Cougar, Bobcat, Coyote, Big Brown Bat, Hoary Bat, Red Squirrel, Southern Red-backed Vole Northern Pygmy-Owl, Blue Grouse, Pileated Woodpecker, Clark's Nutcracker, Red-naped Sapsucker, Red-breasted Nuthatch Rubber Boa, Pacific Treefrog	∇ Flammulated Owl ♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Williamson's Sapsucker
Young seral forest	Extensive	Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Cougar, Coyote, Badger, Northern Pocket Gopher Ruffed Grouse	
South aspect Douglas-fir and ponderosa pine parkland	Common	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Cougar, Coyote, Badger, Big Brown Bat, Northern Pocket Gopher, Golden-mantled Ground Squirrel Swainson's Hawk, Blue Grouse, White-breasted Nuthatch Western Yellow-bellied Racer, Rubber Boa	∇ Townsend's Big-eared Bat, Flammulated Owl, Common Poorwill ♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, White-headed Woodpecker, Western Rattlesnake, Gopher Snake
Bunchgrass grassland	Common in some areas	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Cougar, Coyote, Badger, Yellow-bellied Marmot, Golden-mantled Ground Squirrel Golden Eagle, Red-tailed Hawk, Turkey Vulture, Short-eared Owl, Sharp-tailed Grouse, Long-billed Curlew, Sandhill Crane, Black-billed Magpie, Mountain Bluebird Western Yellow-bellied Racer, Great Basin Spadefoot Toad	∇ Burrowing Owl, Prairie Falcon, Common Poorwill ♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Great Basin Pocket Mouse, Lewis' Woodpecker, Western Rattlesnake, Gopher Snake
Rocky cliffs and talus	Limited areal extent	Mountain Goat, Common Pika, Yellow-bellied Marmot, Yellow-pine Chipmunk, Western Long-eared Myotis Turkey Vulture, White-throated Swift Western Yellow-bellied Racer	♦ Western Rattlesnake, Gopher Snake
Agricultural areas	Limited areal extent	Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Coyote, Ermine, Columbian Ground Squirrel, Deer Mouse American Kestrel, Canada Goose, Mountain Bluebird	♦ Lewis' Woodpecker

TABLE 22. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Riparian areas, wetlands, meadows and floodplains	Common, limited areal extent	Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Lynx, Mink, Big Brown Bat American Kestrel, Blue Grouse, Ruffed Grouse, Sharp-tailed Grouse, Mountain Bluebird, Le Conte's Sparrow Rubber Boa, Northern Alligator Lizard, Western Skink, Western Toad, Wood Frog, Northern Leopard Frog, Great Basin Spadefoot Toad	∇ Tiger Salamander ♦ Grizzly Bear, Great Blue Heron, Yellow-headed Blackbird
Lakes and streams	Common	Black Bear, Mink, Little Brown Myotis, California Myotis, Beaver, Muskrat Bald Eagle, Osprey, Canada Goose, Trumpeter Swan, Canada Goose, Sandhill Crane, Virginia Rail, Eared Grebe, Wood Duck, Bufflehead, Common Goldeneye, Barrow's Goldeneye, American Avocet, Black Tern, Ring-billed Gull, Bonaparte's Gull Painted Turtle, Spotted Frog, Long-toed Salamander, Great Basin Spadefoot Toad	∇ Tiger Salamander ♦ California Gull, Great Blue Heron

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Riparian areas, because of their high vegetative productivity and structural heterogeneity, support a rich diversity of breeding birds and small mammals. In addition, these habitats are often selected by Moose and Mule Deer as calving areas. Wetland meadows and shady draws provide habitat for the Western Terrestrial Garter Snake, Northern Leopard Frog, and Tiger Salamander — species that are poorly adapted to the dry forests that dominate this zone.

Rocky cliffs and talus provide security cover and breeding habitat for Mountain Goat, Yellow-bellied Marmot, Common Pika, Western Rattlesnake, and Townsend's Big-eared Bat.

Agriculture is restricted to lower elevation valleys and riparian areas, sites that often were historically used by ungulates as winter range. Species such as Coyote, Rocky Mountain Elk, Mule Deer, and White-tailed Deer are often considered pests because they sometimes feed on domestic animals or crops. The change in vegetation associated with agriculture benefits some species of wildlife; for example, the Coyote, American Kestrel, Mountain Bluebird, and Lewis' Woodpecker.

RESOURCE VALUES

Forestry is one of several important resource uses in the IDF. Sawlog and pulpwood production are management options for many sites.

The primary agricultural use of the Interior Douglas-fir zone is cattle grazing. The zone provides most of the forested summer ranges for cattle in the province, and also contains spring and fall ranges and wintering areas, particularly in the grasslands. *Calamagrostis rubescens* is the principal forest understory species over much of the IDF. Secondary forage species on forested sites can include *Bromus* spp. (bromegrass), *Carex concinnoides* (northwestern sedge), *Arnica cordifolia*, *Lathyrus ochroleucus* (creamy peavine), and *Vicia* spp. (vetches) (Tisdale 1950; Tisdale and McLean 1957). The principal forage in dry, open forests and grasslands includes *Agropyron spicatum* and *Festuca scabrella* or *F. idahoensis*. *Poa pratensis*, *Stipa occidentalis* (stiff needlegrass), and *Balsamorhiza sagittata* (arrow-leaved balsamroot) can also be important, depending on the ecosystem and grazing history. Browse can be provided by *Amelanchier alnifolia*, *Rosa* spp. (roses), and *Purshia tridentata* (antelope-brush) in some areas. Hay for winter feeding is often produced in the lower parts of the zone.

Fur harvesting is another important resource activity in this zone.

The annual contribution made by the zone to sustained yield watershed flows is fairly limited, although the IDF does contribute significantly to early spring run-off. Significant municipal, domestic, and agricultural water use occurs within the zone.

The IDF is also important for recreation. Many valuable fishing lakes and hunting areas lie within the zone. It is also admirably suited to hiking and horseback riding. Cross-country skiing is a very popular winter activity in the IDF.

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Chapter 11: Interior Cedar — Hemlock Zone

by

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LOCATION AND DISTRIBUTION

The Interior Cedar — Hemlock zone (ICH) occurs at lower to middle elevations (400-1500 m) of southeastern British Columbia, ranging from 49° to 54° 15′N latitude (Figure 38). The zone also extends south into eastern Washington, Idaho, and western Montana. In southeastern British Columbia, the ICH occupies the lower slopes of the Columbia Mountains (where commonly called the Interior Wet Belt), the windward or western side of the continental divide along the Rocky Mountains, and much of the Shuswap and Quesnel highlands.

The ICH also occurs just east of the Coast Mountains in the Nass Basin and adjacent parts of the Hazelton and Skeena mountains of west central British Columbia. In this area the zone extends from 54° 45′ to 57° 30′N latitude, and ranges from 100 to 1000 m in elevation, occupying lower and middle elevations in the central to upper Skeena and Nass River drainages, and central portions of the Iskut and Stikine rivers. The Engelmann Spruce — Subalpine Fir zone (ESSF) is the subalpine zone above the ICH.

ECOLOGICAL CONDITIONS

The ICH has an interior, continental climate dominated by easterly moving air masses that produce cool wet winters and warm dry summers (Figure 39; Table 4). The zone is one of the wettest in the interior of the province; parts of the ESSF are wetter. Periodic inundation by dry, high-pressure, continental air masses results in a few very cold winter days and a few very hot summer days. Mean annual temperature ranges from 2 to 8.7°C, a range that reflects the wide latitudinal extent of the ICH. The temperature averages below 0°C for 2-5 months, and above 10°C for 3-5 months of the year. The mean annual precipitation is 500-1200 mm, 25-50% of which falls as snow.

Mean annual precipitation is significantly lower in the ICH than in most of the Coastal Western Hemlock zone (CWH). Greater snow melt in the ICH contributes considerably to the hydrologic regime, thereby minimizing summer soil moisture deficits. As a consequence, the two zones share many ecological features. Indeed, the ICH is the most productive forest zone in the interior of British Columbia, and second only to the CWH in all of Canada.

As in most British Columbia zones, upland coniferous forests dominate the ICH landscape. However, the ICH has the highest diversity of tree species of any zone in the province. Western redcedar and western hemlock dominate mature climax forests. Grand fir is a common component of climax stands in the extreme southern reaches of the zone. White spruce, Engelmann spruce, their hybrids, and subalpine fir are common and can form a part of climax stands with either western hemlock or redcedar, especially in areas of cold air drainage and ponding or of higher elevations. In northwestern British Columbia, an apparent white x Sitka spruce hybrid, also known as Roche spruce (*Picea* x *lutzii*), joins subalpine fir, western hemlock, and sometimes redcedar in many climax stands.

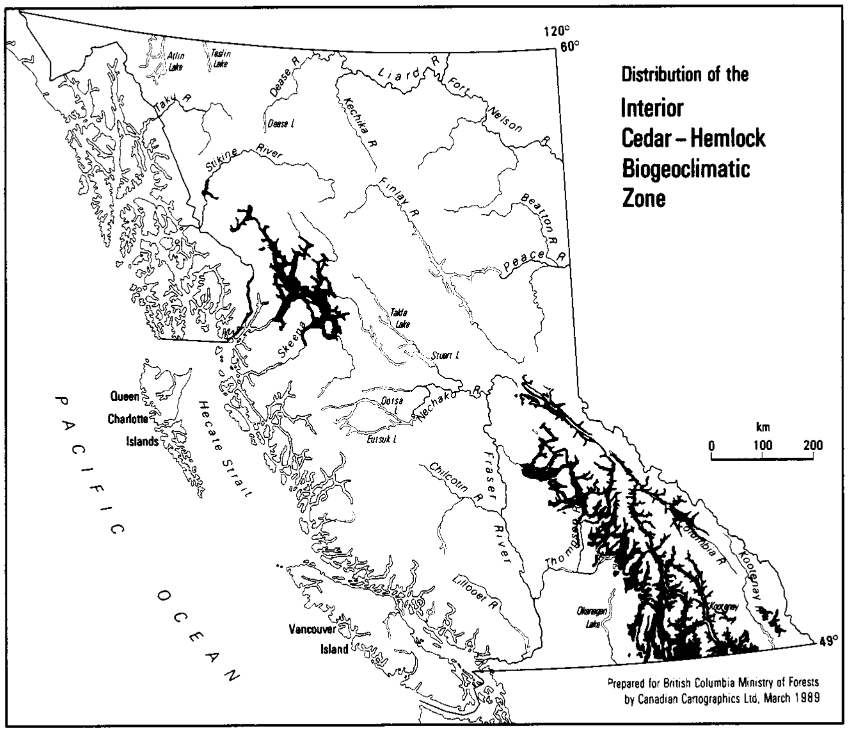


FIGURE 38. Interior Cedar — Hemlock zone.

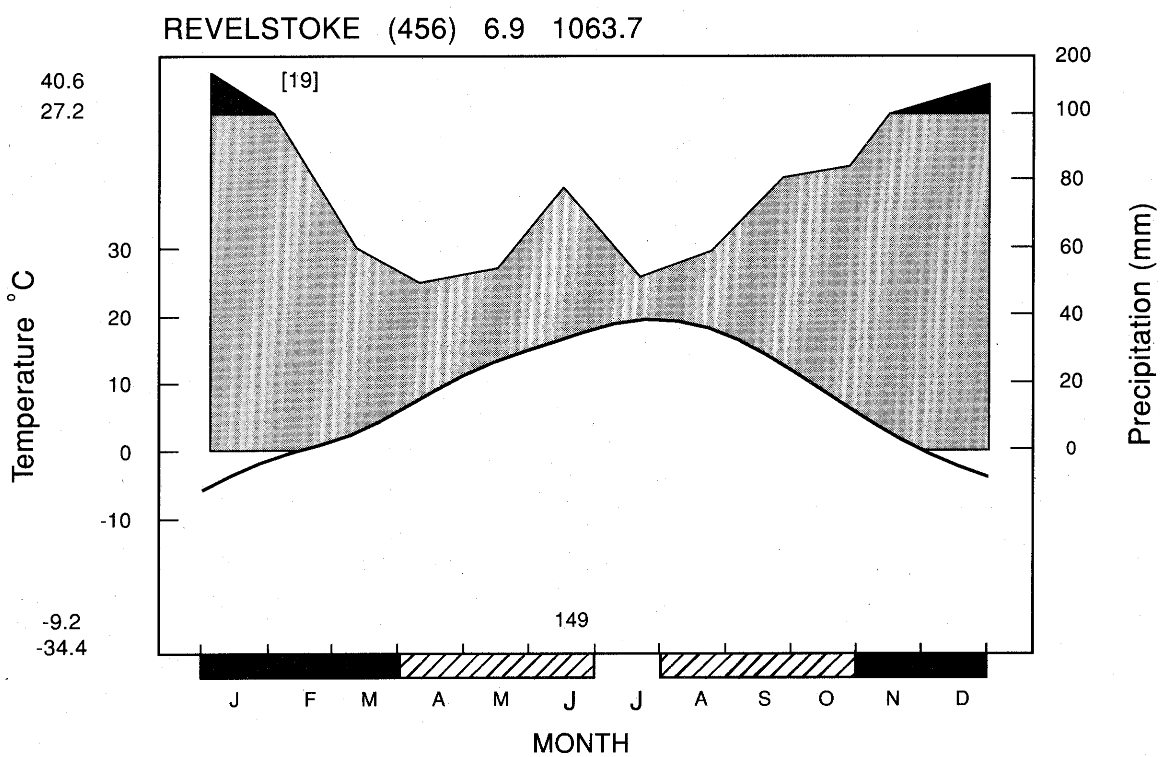


FIGURE 39. Representative climatic diagram for the Interior Cedar — Hemlock zone.

Throughout the ICH, tree species of successional stages and edaphic climaxes vary with geographic location and habitat. Western larch, Douglas-fir, and western white pine are common seral species in the central and southern portions of the zone, usually on mesic and drier sites. Ponderosa pine occurs on dry, warm slopes in some parts of the southern ICH. Engelmann spruce, white spruce, various spruce hybrids, subalpine fir, and black cottonwood are often edaphic climax species in moist to wet ecosystems. Lodgepole pine, trembling aspen, and paper birch are common seral species virtually throughout the zone, although in wetter parts of the ICH wildfires have been infrequent and large areas are dominated by very old climax stands. Forest fires play an important role in drier parts of the ICH, and successional stands are commonly interspersed with climax stands, particularly in climatically and edaphically drier parts of the zone.

Extensive wetlands are infrequent in the ICH due primarily to the steeply sloping mountainous terrain of much of the zone. Wetlands are usually restricted to small transitional bogs and fens, and to skunk cabbage swamps. However, associated with the many lakes, reservoirs, and waterways are abundant riparian and lakeshore marshes. The bogs and fens are generally non-forested or have only a few stunted lodgepole pine, western hemlock, hybrid white spruce, or black spruce. Characteristic understory species include *Carex* spp. (sedges), *Salix* spp. (willows), *Ledum groenlandicum* (Labrador tea), *Kalmia microphylla* (bog-laurel), *Betula glandulosa* (scrub birch), *Menyanthes trifoliata* (buckbean), *Oxycoccus oxycoccos* (bog cranberry), *Sphagnum* spp. (sphagnum mosses), *Tomenthypnum nitens* (golden fuzzy fen moss), and *Aulacomnium palustre* (glow moss). Skunk cabbage swamps are found along small drainage channels. Dominant vegetation includes western redcedar, western hemlock, hybrid white spruce, *Oplopanax horridus* (devil's club), *Lysichiton americanum* (skunk cabbage), *Athyrium filix-femina* (lady fern), *Gymnocarpium dryopteris* (oak fern), *Equisetum arvense* (common horsetail), *Mnium*, *Rhizomnium* and *Plagiomnium* spp. (leafy mosses), and *Sphagnum* spp.

Humo-Ferric Podzols represent the dominant soil development in zonal ecosystems. Brunisolic or Orthic Gray Luvisols are also common on mesic sites with finer textured parent materials. Ferro-Humic Podzols can be found in zonal ecosystems in wetter portions of the ICH. Drier sites in drier parts of the zone usually have brunisolic development, whereas with increasing soil moisture in the form of seepage or groundwater, there is a gradation from gleyed subgroups of Brunisols and Podzols, through Gleysols, to Organic soils on poorly and very poorly drained sites. Soil development usually extends to about 1 m in most ecosystems. Humus forms tend to be Hemimors and Mormoders.

NOTES ON CLASSIFICATION

Krajina (1969) originally called this zone the Interior Western Hemlock zone. Ministry of Forests ecologists changed the name to Interior Cedar — Hemlock to better reflect the areas that climax in western redcedar, but lack hemlock. The "outlier" of the ICH in northwestern British Columbia was classified by Krajina (1973) as a transitional part of the Coastal Western Hemlock zone. Ministry of Forests ecologists, however, have placed the area in the ICH because of its floristic characteristics and because the regional climate (which is a transitional cordilleran type, neither typically coastal nor interior) seems to fit best in the interior zone.

A subzone from the Montane Spruce zone (MSmm, MSe, or MSb3) was recently added to the ICHdm because of its similarity to this subzone.

SUBZONES

Eleven subzones are found in the ICH (Table 23). The vegetation on zonal ecosystems (Figure 40) shows considerable variation from the driest through to the wettest subzones. Douglas-fir, *Lonicera utahensis* (Utah honeysuckle), *Mahonia aquifolium* (tall Oregon-grape), and *Linnaea borealis* (twinflower) are common in the drier subzones; *Gymnocarpium dryopteris*, *Oplopanax horridus*, *Streptopus roseus* (rosy twistedstalk), *Dryopteris expansa* (spiny wood fern), and *Mnium* spp. are common in the wetter subzones. All zonal ecosystems have western redcedar, western hemlock, or both species as a major component of the mature forest. Hybrid white spruce, Roche spruce, grand fir, and subalpine fir can be significant components of zonal ecosystems in certain subzones.

The ICHxw is the only subzone considered to be "very dry." This subzone occurs in a few areas in extreme southeastern British Columbia, the largest area being in the Creston Valley. Several species are more abundant here (on zonal sites) than in any other ICH subzone — for example, *Corylus cornuta* (beaked hazelnut), *Physocarpus malvaceus* (mallow ninebark), and *Philadelphus lewisii* (mock-orange).

TABLE 23. Synopsis of subzones in the Interior Cedar — Hemlock zone (ICH)

Subzone	Code	Old code
Very Dry Warm ICH	ICHxw	(ICHd)
Dry Warm ICH	ICHdw	(ICHal)
Dry Cool ICH	ICHdk	(ICHe3)
Moist Warm ICH	ICHmw	(ICHa2/m1/m2)
Moist Mild ICH	ICHmm	(ICHj)
Moist Cool ICH	ICHmk	(ICHe1/e2/c/MSe)
Moist Cold ICH	ICHmc	(ICHg1/g2/g3)
Wet Cool ICH	ICHwk	(ICHw/h1/h2/k/b)
Very Wet Cool ICH	ICHvk	(ICHb/v/f)
Very Wet Cold ICH	ICHvc	(ICHg4/g5)

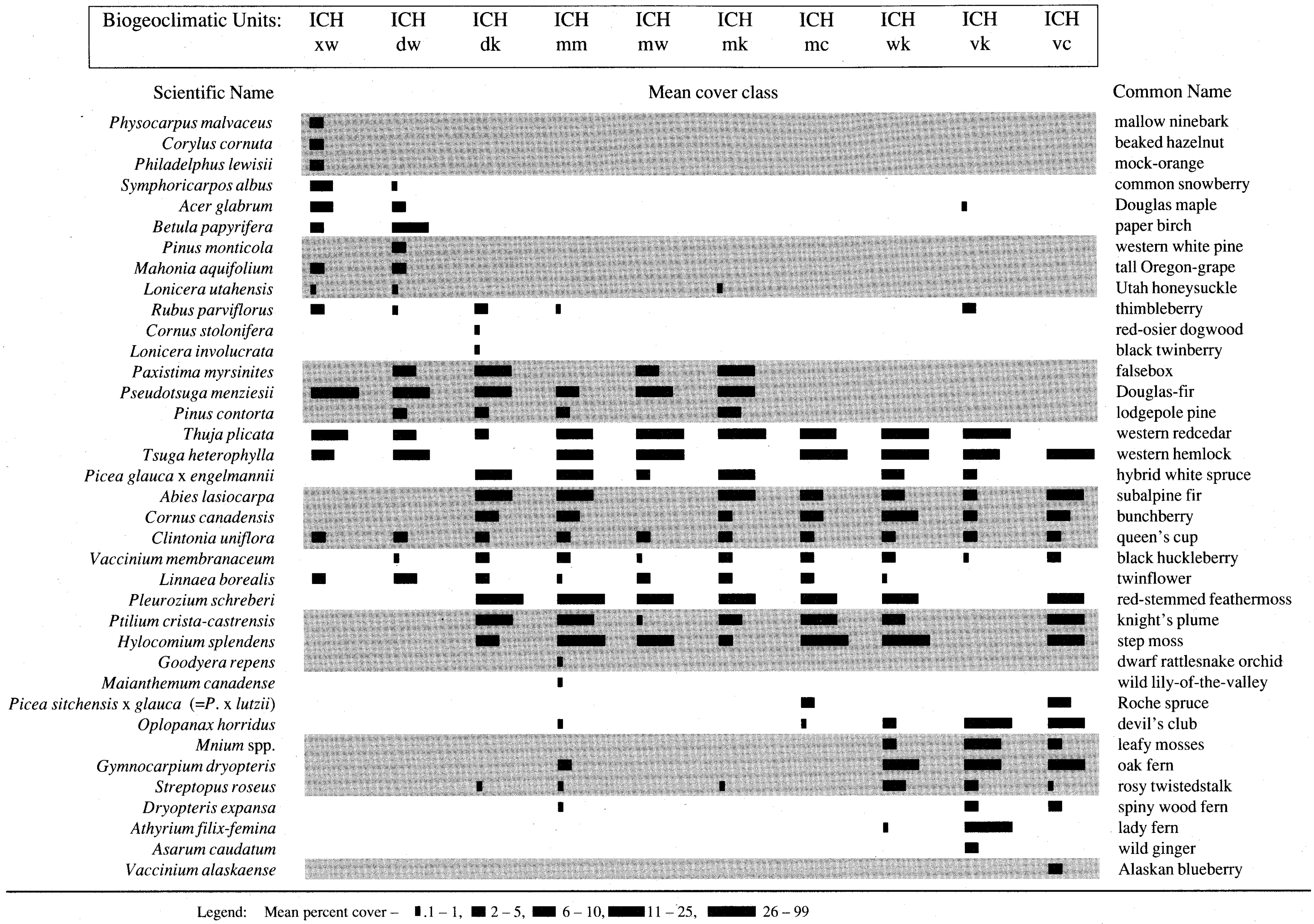


FIGURE 40. Zonal vegetation of subzones of the Interior Cedar — Hemlock zone.

The two dry subzones are scattered throughout the zone in south-central and southeastern British Columbia. The ICHdw is found in the valley bottoms and lower slopes of the upper Granby River, Lower Arrow Lake, Columbia River, Slocan and Kootenay river valleys, and the Goat and southern Moyie rivers. The ICHdk, one of the subzones that lacks hemlock, occurs near Canim Lake.

Four moist subzones occur in the zone; from the extreme southeast to the northwest, they vary from "warm" to "cold" climates, respectively. The ICHmw covers a large geographic area from the valleys of the southern Monashee, Selkirk, Purcell, and Rocky mountains, to the Shuswap Lake-Thompson River area. The ICHmm is located in the Rocky Mountain Trench from Hugh Allen Creek to McBride. The ICHmk occurs in the Rocky Mountains in the lower Bull and Elk river valleys, in the Golden area, in many valleys of the southern Purcell and Monashee mountains, and around the upper Shuswap — lower Quesnel highlands from near the North Thompson River to about Quesnel Lake. This is another subzone that lacks hemlock. The northernmost moist subzone is the ICHmc, located in northwestern British Columbia from near Hazelton to Meziadin Lake. Roche spruce is present here and western hemlock is particularly abundant.

The wet, cool ICHwk is found in the Columbia and Rocky mountains and Quesnel Highland from the Fraser River near Dome Creek, south through the Quesnel Lakes — upper Cariboo River areas to the North Thompson River — upper Adams Lake region and southeast to the lower Revelstoke Reservoir — upper Arrow Lake area.

Two "very wet" subzones are found in the ICH. The ICHvk is common in the Blue River — Mica Creek area and in the Rocky Mountain Trench near Dome Creek. The ICHvc is in the northwest along the Bell-Irving and middle Iskut and Stikine rivers. Both subzones are characterized by "devil's club" zonal associations, but the ICHvc has Roche spruce, rather than hybrid white spruce, more feathermosses, and no western redcedar. The absence of western redcedar in the ICHvc is perhaps a result of the lack of heat in the summer months. Subalpine fir is very productive here.

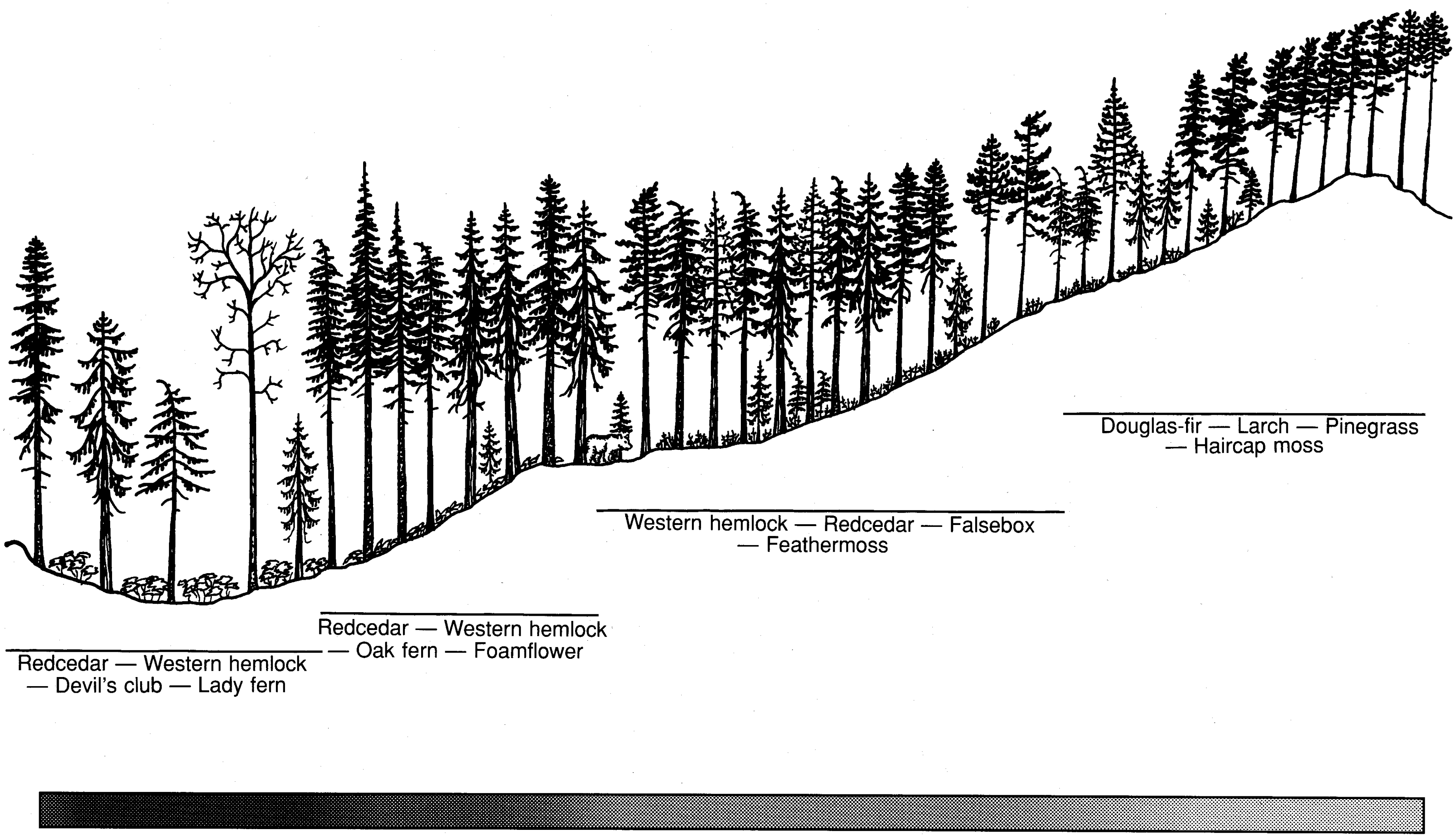
SOME REPRESENTATIVE SITE ASSOCIATIONS

Four common site associations in the ICH are described below. They form a typical sequence in the ICHmw (Figure 41).

Western hemlock — Redcedar — Falsebox — Feathermoss

The Western hemlock — Redcedar — Falsebox — Feathermoss association occurs on zonal sites throughout the ICHmw and on some drier than zonal sites in the ICHwk and vk. At climax, western hemlock and, to a lesser extent, western redcedar dominate these ecosystems and usually form a closed canopy. Douglas-fir and western white pine are common seral associates.

The climax understory has poorly to moderately developed shrub and herb layers. Typical shrubs are *Paxistima myrsinites* (falsebox), *Vaccinium membranaceum* (black



Shaded bar indicates growing-season soil moisture; darker shading symbolizes increasing moisture.

FIGURE 41. Simplified schematic diagram of topographic relationships among four common site associations of a moist, warm subzone of the Interior Cedar — Hemlock zone.

huckleberry), and *Taxus brevifolia* (western yew). Common herbs are *Cornus canadensis* (bunchberry), *Clintonia uniflora* (queen's cup), *Linnaea borealis*, *Chimaphila umbellata* (prince's pine), *Viola orbiculata* (round-leaved violet), *Tiarella unifoliata* (one-leaved foamflower), *Goodyera oblongifolia* (rattlesnake-plantain), and *Orthilia secunda* (one-sided wintergreen).

The very well-developed and continuous moss layer is characteristically dominated by *Pleurozium schreberi* (red-stemmed feathermoss) and usually contains *Hylocomium splendens* (step moss) and *Rhytidiopsis robusta* (pipecleaner moss). Soils are generally Orthic Humo-Ferric Podzols occurring on a wide variety of parent materials. Dystric Brunisols are occasionally found. Humus form is typically an Orthimormoder between 4 and 8 cm thick.

Douglas-fir — Larch — Pinegrass — Haircap moss

This site association is found on very dry, nutrient-very poor to -medium sites in the ICHmw. These sites occur around bedrock outcrops, on steep colluvial slopes, or on coarse-textured, excessively drained, glaciofluvial landforms. Dystric Brunisols are the most common soils, although Eutric, Melanic, and Sombric Brunisols also occur, depending largely on parent materials and the cover of grasses.

Douglas-fir, lodgepole pine, western larch, and western white pine usually occur with some poorly growing western redcedar and western hemlock. Forest stands are often open and have a poorly developed understory.

Characteristic shrubs are *Paxistima myrsinites*, *Penstemon fruticosus* (shrubby penstemon), *Juniperus communis* (common juniper), *Amelanchier alnifolia* (saskatoon), and *Spiraea betulifolia* (birch-leaved spirea).

The herb layer usually includes *Arctostaphylos uva-ursi* (kinnikinnick), *Achillea millefolium* (yarrow), and *Calamagrostis rubescens* (pinegrass).

Cladonia, *Cladina*, and *Peltigera* lichens are the most constant species in the poorly developed moss layer. Some mosses occasionally occur in abundance, such as *Pleurozium schreberi*, *Polytrichum* (haircap mosses), and *Rhacomitrium* species.

Redcedar — Western hemlock — Oak fern — Foamflower

The Redcedar — Western hemlock — Oak fern — Foamflower site association is found on fresh, nutrient-poor to -rich sites in the southern ICH — typically in the ICHmw and vk. Stands are dominated by western redcedar and western hemlock with a component of spruce (Engelmann and white x Engelmann hybrids) and subalpine fir.

The moderately developed shrub layer typically includes *Paxistima myrsinites*, *Lonicera utahensis*, *Taxus brevifolia*, *Vaccinium ovalifolium* (oval-leaved blueberry), and some *Oplopanax horridus*.

Gymnocarpium dryopteris (oak fern), *Clintonia uniflora*, *Cornus canadensis*, *Smilacina racemosa* (false Solomon's-seal), *Tiarella unifoliata* (one-leaved foamflower), *Rubus pedatus* (five-leaved bramble), *Streptopus roseus*, *S. amplexifolius* (clasping-leaved twistedstalk), and *Athyrium filix-femina* form much of the moderately to well-developed herb layer.

The moss layer is usually well developed, ranging from a carpet of *Rhytidiopsis robusta* and *Pleurozium schreberi* with minor amounts of *Hylocomium splendens* and *Ptilium crista-castrensis* (knight's plume), to patchier mixtures of these four species with clumps of *Mnium* spp. (including *Plagiomnium* and *Rhizomnium* spp.) and *Brachythecium* spp.

Soils are most commonly gleyed subgroups of Humo-Ferric Podzols and Dystric Brunisols on a variety of parent materials. Temporary seepage characterizes these sites. Mormoders are the most common humus form and are generally 6-12 cm thick.

Redcedar — Western hemlock — Devil's club — Lady fern

This site association occurs on moist sites, generally in moisture-receiving positions at the bases of slopes or along rivers and streams. This is a common site association throughout the ICH, with the exception of the ICHxw, dm, dk, and vc. In the ICHvk, this association occurs on zonal sites as well as on lower slopes.

Stands are generally dominated by western redcedar with some western hemlock. Spruce (Engelmann and hybrids), subalpine fir, and occasionally black cottonwood can also be abundant, depending on the amount of cold air drainage to, and periodic flooding of, the site. Individual trees are often large but widely spaced so the tree canopy is typically irregular and open. Hence, the shrub layer is well developed and often very dense. *Oplopanax horridus* (devil's club) is the dominant shrub, often with minor amounts of *Ribes lacustre* (black gooseberry), *Acer glabrum* (Douglas maple), *Rubus parviflorus* (thimbleberry), and *Cornus stolonifera* (red-osier dogwood).

The herb layer is moderately to well developed, depending on the density of the overlying shrub layer. Characteristic herbs include *Athyrium filix-femina* (lady fern), *Gymnocarpium dryopteris*, *Streptopus roseus*, *Tiarella unifoliata*, *Dryopteris expansa*, *Clintonia uniflora*, *Circaea alpina* (enchanter's nightshade), and *Viola glabella* (stream violet).

The moss layer is moderately to well developed and can consist only of patches of *Mnium* spp. (including *Plagiomnium* and *Rhizomnium* spp.) or of a more complete moss cover including *Ptilium crista-castrensis*, *Hylocomium splendens*, and *Rhytidiadelphus triquetrus* (electrified cat's-tail).

Soils can be Gleysols, gleyed subgroups of Podzols and Brunisols, or Regosols.

WILDLIFE HABITATS

Important ecological factors that influence the wildlife species in this zone (Table 24) are the cool, long, snowy winters and the warm, dry summers, the dense conifer forests of primarily western hemlock and/or western redcedar, and — except for the Nass Basin — the narrow, deep valleys. Except for the ICHxw subzone in extreme southeastern British Columbia, most forests quickly regenerate after forest fire or clearcut logging.

TABLE 24. Selected wildlife habitats and species in the Interior Cedar — Hemlock zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth and mature coniferous forests	Common, dwindling	Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Wolverine, Marten, Red Squirrel, Southern Red-backed Vole Barred Owl, Boreal Owl, Great Gray Owl, Great Horned Owl, Northern Pygmy Owl, Long-eared Owl, Saw-whet Owl, Pileated Woodpecker, Steller's Jay, Gray Jay, Varied Thrush, Golden-crowned Kinglet, Townsend's Warbler, Bohemian Waxwing, Red Crossbill, Winter Wren, Mountain Chickadee	♦ Caribou, Grizzly Bear, Red-tailed Chipmunk, Northern Long-eared Myotis ∇ Townsend's Big-eared Bat
South aspect forests	Common	Moose, Mule Deer, White-tailed Deer, Rocky Mountain Elk, Mountain Goat, Black Bear, Cougar, Yellow-bellied Marmot, Golden-mantled Ground Squirrel Golden Eagle, Ruffed Grouse, Great Horned Owl Rubber Boa	♦ Grizzly Bear
Young seral forests	Extensive	Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Cougar, Coyote Ruffed Grouse, Downy Woodpecker, Steller's Jay, American Robin, Dusky Flycatcher	♦ Northern Long-eared Myotis
Clearcuts and burns	Limited areal extent	Moose, Mule Deer, White-tailed Deer, Rocky Mountain Elk, Cougar Golden Eagle, Ruffed Grouse, Black-backed Woodpecker, Three-toed Woodpecker, Olive-sided Flycatcher, Western Bluebird, Townsend's Solitaire	♦ Lewis' Woodpecker, Northern Long-eared Myotis
Riparian areas, wetlands, meadows, and floodplains	Common, not extensive	Moose, Caribou, Mule Deer, Grizzly Bear, Black Bear, Gray Wolf, Lynx, Badger, Beaver, Muskrat, Columbian Ground Squirrel American Kestrel, Blue Grouse, Ruffed Grouse, Mountain Bluebird Western Terrestrial Garter Snake, Northern Alligator Lizard, Rubber Boa, Western Skink, Western Toad, Pacific Treefrog, Spotted Frog, Wood Frog	∇ Forster's Tern ♦ Caribou, Grizzly Bear, Northern Long-eared Myotis, Great Blue Heron, Coeur d'Alene Salamander
Lakes and streams	Common	Moose, Beaver, Muskrat, Little Brown Myotis, Water Shrew Bald Eagle, Tundra Swan, Canada Goose, Common Loon, Bonaparte's Gull, Red-necked Grebe, Eared Grebe, American Avocet Painted Turtle, Spotted Frog, Wood Frog	∇ Forster's Tern ♦ Northern Long-eared Myotis, Great Blue Heron, Western Grebe, Coeur d'Alene Salamander, Tailed Frog

TABLE 24. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Avalanche tracks	Common in mountains	Rocky Mountain Elk, Black Bear, Badger, Columbian Ground Squirrel	♦ Grizzly Bear, Caribou
Rocky cliffs and talus	Limited areal extent	Mountain Goat, Yellow-bellied Marmot, Golden-mantled Ground Squirrel, Columbian Ground Squirrel, Common Pika	♦ Red-tailed Chipmunk
Agricultural areas	Limited areal extent	Mule Deer, White-tailed Deer, Rocky Mountain Elk, Black Bear, Columbian Ground Squirrel Northern Harrier, Red-tailed Hawk, American Kestrel, Sandhill Crane, Eastern Kingbird, Western Kingbird, Mountain Bluebird	♦ Grizzly Bear

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Wildlife that inhabit this zone are adapted either to survive or avoid the deep snows of winter. Grizzly Bear and Black Bear are the most common large mammals, and the ICH as well as the ESSF are the most productive zones in the interior of British Columbia for these species. Bears are well adapted to survive the long winters with deep snow. Their hibernation period of 5-7 months means that they can avoid most of the winter period. In the Columbia Mountains, the ICH provides the necessary high-protein and high-energy diet for the bears' growth, in the form of lush herbaceous vegetation and abundant huckleberry and blueberry patches. In the Nass Basin, lush vegetation, huckleberries, blueberries, and spawning salmon are summer and fall bear foods.

Large ungulates such as Mule Deer, White-tailed Deer, and Rocky Mountain Elk occur in the drier subzones in the southern portion of the province. Where possible these species only use this zone during the summer and fall and migrate to the adjacent Interior Douglas-fir zone for the winter. Caribou, while never very common, occur throughout much of the ICH in the late summer and early fall before they move up in winter to ESSF forests with a deeper, denser snowpack. Moose are scattered throughout this zone in the winter, but are only common in the Nass Basin, Fraser River section of the Rocky Mountain Trench, Shuswap Highland, and Quesnel Highland. They are able to tolerate the deep snows because of the protection that the forest canopy provides and the abundant supply of browse.

Many species of birds rely on conifer seeds, bark-inhabiting insects, or other birds, for food. Pileated Woodpecker inhabit mature and old-growth forests, while Lewis' Woodpecker and Black-backed Three-toed Woodpecker are more abundant in the burned-over forests and clearcuts with remnant snags. Some wood-boring birds, such as Yellow-bellied Sapsucker, Hairy Woodpecker, and Downy Woodpecker, prefer the mixed coniferous/deciduous forests. Other bird species that inhabit the mature conifer forests are the Great Horned Owl, Northern Pygmy Owl, Long-eared Owl, Saw-whet Owl, Gray Jay, Steller's Jay, Winter Wren, Varied Thrush, Golden-crowned Kinglet, Bohemian Waxwing, Townsend's Warbler, and Red Crossbill.

Mature forests with mixed deciduous and coniferous species offer a variety of insects and seeds for breeding populations of Western Wood-Pewee, Gray Jay, Black-capped Chickadee, Red-breasted Nuthatch, House Wren, Veery, Yellow-rumped Warbler, Evening Grosbeak, Pine Grosbeak, Pine Siskin, and White-winged Crossbill.

Burned-over patches and clearcuts with standing snags and stumps are the preferred breeding habitats of the Olive-sided Flycatcher, Western Bluebird, and Townsend's Solitaire.

Wetlands, especially in the Nass Basin, provide excellent habitat for waterbird production, including sandpipers, dabbling and diving ducks, and loons. The Kootenay River floodplain in the Creston Valley produces substantial numbers of diving and dabbling ducks, Western Grebe, Red-necked Grebe, Great Blue Heron, and Forster's Tern. The Creston Valley wetlands are also an important migratory staging area for the Canada Goose, Tundra Swan, and other waterfowl.

Most of the amphibian and reptile species occur in the warmer valley bottoms, commonly adjacent to riparian areas, but they often spend long periods in damp forest litter or moist forest clearings. In the Columbia Mountains and adjacent highlands are found the Long-toed Salamander, Western Toad, Pacific Treefrog, and Spotted Frog, but in the Nass Basin only the Spotted Frog, Wood Frog, and Western Toad are found. Reptile distribution is even more restricted in this zone. Only the Common Garter Snake is widespread, in riparian areas and damp forest litter in the major valleys. The Western Terrestrial Garter Snake is found only in wetlands and riparian areas in the southern portion of the Columbia Mountains and Okanagan Highland. The Western Skink, Northern Alligator Lizard, Rubber Boa, and Painted Turtle are found along the valley bottoms in the southernmost portion of the ICH.

Agricultural areas are limited in extent, and restricted to lower elevations and riparian areas in the southern portion of this zone. Introduced species such as Ring-necked Pheasant and Wild Turkey are adapted to these modified habitats. However, large mammals such as Grizzly Bear, Black Bear, Rocky Mountain Elk, Mule Deer, and White-tailed Deer are considered pests in agricultural areas. Some species of birds, such as the Eastern Kingbird, Western Kingbird, and Mountain Bluebird, benefit from the opening of the forest canopy and the increase in the number of insects.

RESOURCE VALUES

Forestry is the primary economic activity in this zone. The tree species diversity of the ICH has allowed it to weather some insect infestations and diseases better than adjoining zones, although both western hemlock and western redcedar are prone to heart rot throughout the zone (after about age 90-100, where studied).

The ICH is the most productive zone in the interior of the province for fibre production. In southern subzones, site indices at 100 years for western white pine on slightly dry to moist sites are around 38 m. Western larch and Douglas-fir site indices are only slightly less than those of white pine on most sites. The best growth is in rich alluvial ecosystems where site indices at 100 years can be over 40 m for both spruce and white pine. In northern subzones, Douglas-fir, hybrid white spruce, and subalpine fir are the most productive species.

Most areas of the zone have a low potential for agriculture because of topographic constraints. One major exception is the Creston Valley, which has favourable climate, topography, and soils for agriculture. Some of the most productive and accessible agricultural, wildlife, and forestry land has been flooded by hydro-electric reservoirs.

Because of the lack of suitable forage in most ICH forests, range use is restricted to cutblocks and road right-of-ways. Range use is common in the drier subzones; however, it is much less than in the Interior Douglas-fir, Montane Spruce, and Ponderosa Pine zones. Administrative decisions also have an impact on range use. For example, the Kamloops Forest region seeds cutblocks in many ICH subzones to provide summer forage; the same subzones in adjacent Regions are not used to the same extent. Orchardgrass (*Dactylis glomerata*), timothy (*Phleum pratense*), and clovers (*Trifolium* spp.) are commonly seeded. Native forage and browse include *Calamagrostis rubescens*, *Carex* spp., *Epilobium angustifolium* (fireweed), *Amelanchier alnifolia*, *Vaccinium* spp., and *Salix* spp.

This zone is also important for fur harvesting.

Recreational activities include hiking, skiing, fishing, and hunting. Abundant lakes, pondages, and waterways provide ample boating and fishing opportunities.

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Chapter 12: Montane Spruce Zone

by

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LOCATION AND DISTRIBUTION

The Montane Spruce zone (MS) occurs in British Columbia at middle elevations between 53° and 49°N latitude (Figure 42). The zone extends from the northern limits of the Fraser Plateau to the U.S. border, specifically on: 1) the Southern Interior Plateau, 2) the lee side of the Coast and Cascade mountains, and 3) the southern Rocky Mountains and Rocky Mountain Trench. The MS also extends south into Washington, Idaho, and Montana. Elevations range from 1100 to 1500 m in wetter parts of the zone, and from 1250 to 1700 m in drier areas.

The MS is found elevationally above the Interior Douglas-fir (IDF) or Sub-Boreal Pine — Spruce (SBPS) zones, over most of their ranges, and below the Engelmann Spruce — Subalpine Fir zone (ESSF).

ECOLOGICAL CONDITIONS

The MS has a cool, continental climate characterized by cold winters and moderately short, warm summers (Figure 43). The climate of the zone is between that of the ESSF and the IDF (or SBPS). As well, it has similarities to that of the Sub-Boreal Spruce zone (Table 4). Mean annual temperature is 0.5-4.7°C. The average temperature is below 0°C for 5 months of the year and above 10°C for 2-4 months. Mean annual precipitation ranges from 380 to 900 mm; the growing season is sufficiently warm and dry that moisture deficits can occur, particularly in the drier subzones.

The MS was included in the ESSF of Krajina (1969). It has strong floristic affinities with the ESSF, such as climax stands of spruce and subalpine fir, and prominence of *Vaccinium membranaceum* (black huckleberry) in zonal ecosystems, as well as some affinity with the IDF as indicated by the abundance of *Calamagrostis rubescens* (pinegrass), *Paxistima myrsinites* (falsebox), and occasionally Douglas-fir in zonal ecosystems. However, the MS lacks many species characteristic of the IDF and ESSF. Thus, even though the MS is characterized as a transitional zone, it does have its own unique combination of species because of its intermediate nature. Hybrid white spruce is common, rather than Engelmann spruce. Characteristic understory species are *Lonicera utahensis* (Utah honeysuckle) and *Vaccinium scoparium* (grouseberry), in addition to those listed above.

One of the most distinctive features of the MS landscape is the extensive, young and maturing seral stands of lodgepole pine that have formed following wildfire. In wetter subzones, and on wet sites in all areas, maturing seral stands contain mixtures of lodgepole pine, hybrid white spruce, and subalpine fir. Hybrid white spruce and subalpine fir are the dominant, shade-tolerant, climax trees; however, lodgepole pine's frost tolerance, resistance to drought, and serotinous cones all favour its establishment after fire. Under the lodgepole pine canopy, frost and surface drying are reduced, and hybrid white spruce and subalpine fir can regenerate.

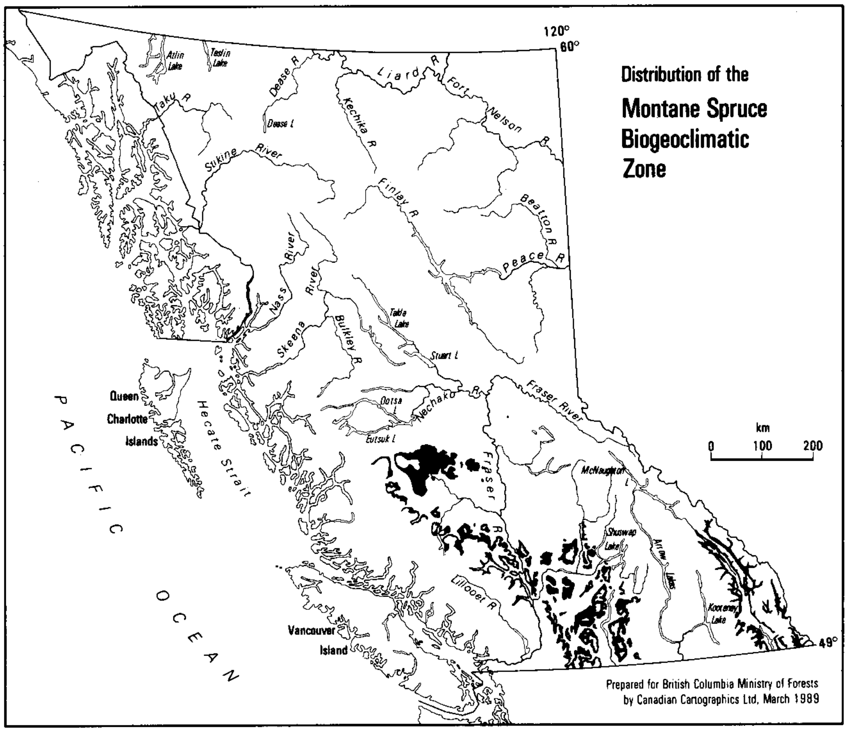

FIGURE 42. Montane Spruce zone.

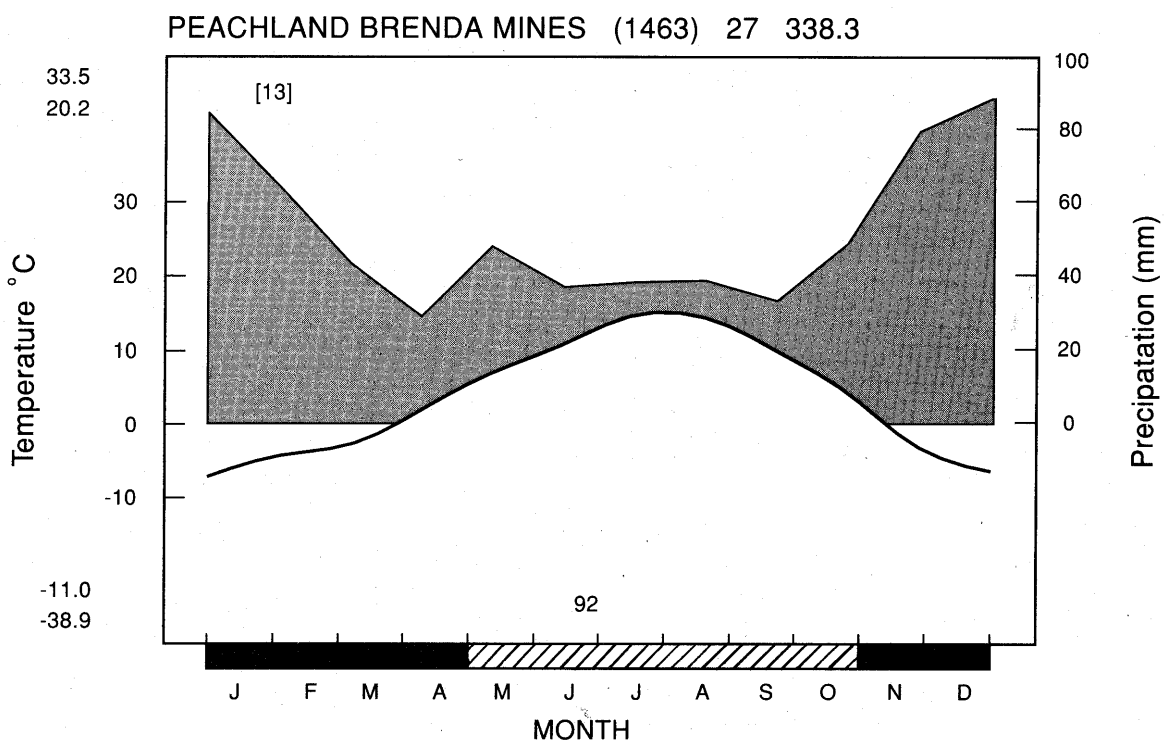

FIGURE 43. Representative climatic diagram for the Montane Spruce zone.

Douglas-fir is an important seral species in zonal ecosystems, and is a climax species on warm, south-facing slopes in the driest ecosystems. Western larch is confined to the eastern part of the zone, where it frequently occurs as a seral species after fire. Western redcedar occurs in the wetter parts of the zone, transitional to the Interior Cedar — Hemlock zone. Trembling aspen is a common seral species throughout the zone. Black cottonwood occurs on some wet sites.

On the extensive loamy to clayey morainal deposits (derived largely from volcanic bedrock), zonal and drier ecosystems have soils that are dominantly Brunisolic or Orthic Gray Luvisols and Eutric Brunisols. Humo-Ferric Podzols and Dystric Brunisols develop on coarser-textured deposits or in wetter parts of the zone. Humus forms in zonal ecosystems are commonly Hemimors and Hemihumimors, ranging from 3 to 10 cm in thickness.

Grassland ecosystems are uncommon in the MS, occurring only on south-facing upper slopes and ridges in the driest subzones. Vegetation on these sites is dominated by grasses such as *Agropyron spicatum* (bluebunch wheatgrass) and *Festuca idahoensis* (Idaho fescue).

In the mountainous topography typical of the MS, wetlands are uncommon. Where terrain is more subdued, wetlands occur more frequently. The most common wetland type consists of a fen community of *Salix* spp. (willows), *Carex* spp. (sedges), and *Aulacomnium palustre* (glow moss).

NOTES ON CLASSIFICATION

The Ministry of Forests has designated the MS as a new zone, previously included by Krajina (1969) as a southern, lower elevation part of the ESSF. The MS is closely related to several vegetation zones described by other authors in British Columbia (McLean 1970) and the adjacent U.S.A. (Franklin and Dyrness 1973; Pfister *et al.* 1977).

SUBZONES

Five subzones have been recognized in the MS (Table 25). *Vaccinium scoparium* and *Linnaea borealis* (twinflower) are characteristic of all subzones except the MSdc (Figure 44). All subzones have lodgepole pine, hybrid white spruce, *Orthilia secunda* (one-sided wintergreen), and a moderate to high cover of *Pleurozium schreberi* (red-stemmed feathermoss). Common species include *Lonicera utahensis*, *Paxistima myrsinites*, *Vaccinium membranaceum*, *Goodyera oblongifolia* (rattlesnake-plantain), *Calamagrostis rubescens*, *Arnica cordifolia* (heart-leaved arnica), *Cornus canadensis* (bunchberry), and *Chimaphila umbellata* (prince's pine).

The two coldest MS subzones occur on the lee side of the Coast Mountains. The MSxv occurs at middle to upper elevations on the western Fraser Plateau and at middle elevations on the eastern slopes of the Coast Mountains. This subzone lacks many of the common species of other MS subzones and has several species not found on zonal sites in the others, specifically *Juniperus communis* (common juniper), *Empetrum nigrum* (crowberry), and *Cladina* lichens. The MSdc subzone occurs northwest and west of Lillooet in the Coast Mountains. It is very species-poor on zonal ecosystems, relative to other subzones.

TABLE 25. Synopsis of subzones in the Montane Spruce zone (MS)

Subzone	Code	Old code
Very Dry Very Cold MS	MSxv	(MSd)
Very Dry Cool MS	MSxk	(MSc)
Dry Cold MS	MSdc	(MSb4)
Dry Cool MS	MSdk	(MSa)
Dry Mild MS	MSdm	(MSb1/b2)

On the southern Interior Plateau, there are two subzones. The MSxk subzone occurs at mid-elevations in the central part of the Thompson Plateau and southern edge of the Fraser Plateau, from the U.S. border north to Clinton — Bonaparte Lake. The MSdm occurs on the lee side of the Cascade Mountains from Lytton to the U.S. border, on the east and south sides of the Thompson Plateau from Little Fort to northeast of Princeton, and east of Okanagan Lake in the Okanagan Highland from Lumby to the U.S. border.

In the southeast of the province, from Golden to the U.S. border, the MSdk occurs on midslopes of the Rocky Mountain Trench and in valley bottoms and lower valley slopes of the eastern Purcell and Rocky mountains.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The four site associations described here are common in the MS. They form a typical sequence in the MSdm (Figure 45).

Hybrid spruce — Falsebox — Feathermoss

This zonal association is common in the MSdm.

Soils are typically well-drained Orthic and Eluviated Dystric Brunisols, Orthic Humo-Ferric Podzols, or Brunisolic Gray Luvisols, developed on thick morainal deposits composed primarily of volcanic materials. Humus forms are moderately thick (5-10 cm) Hemimors or Hemihumimors.

Lodgepole pine, hybrid white spruce, and subalpine fir form mixed, maturing seral stands. Douglas-fir can be a component of these stands.

The shrub layer is moderately well developed, consisting primarily of *Paxistima myrsinites* (falsebox), *Vaccinium membranaceum*, and a low cover of *Lonicera utahensis*. Both hybrid white spruce and subalpine fir are regenerating conifers.

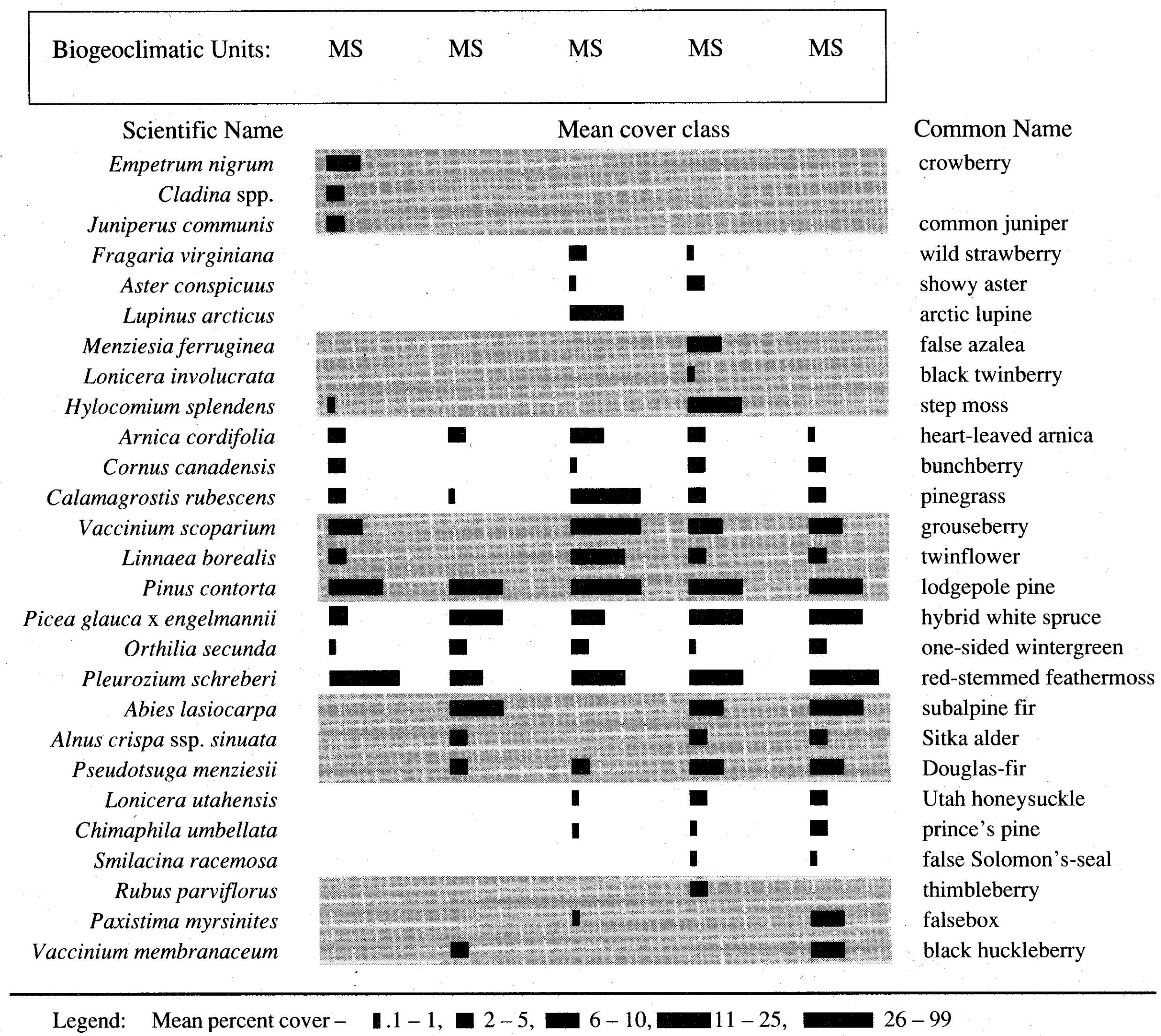

FIGURE 44. Zonal vegetation of subzones of the Montane Spruce zone.

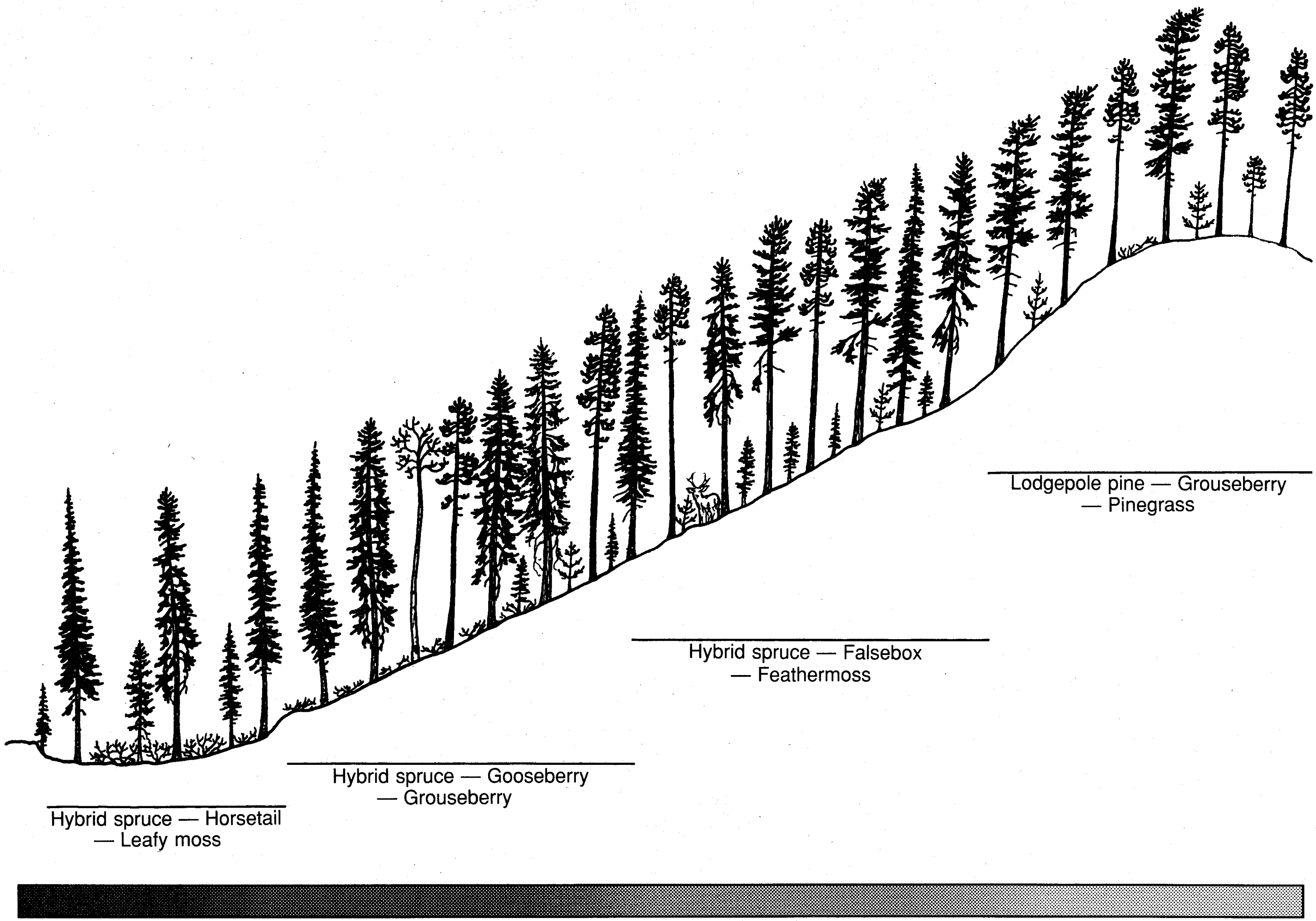

FIGURE 45. Simplified schematic diagram of topographic relationships among four common site associations of a dry, mild subzone of the Montane Spruce zone.

Common species in the herb layer are *Vaccinium scoparium*, *Linnaea borealis*, *Orthilia secunda*, *Goodyera oblongifolia*, *Chimaphila umbellata*, and *Cornus canadensis*.

A well-developed moss layer is the dominant feature of the understory. It is composed primarily of *Pleurozium schreberi* (red-stemmed feathermoss), with lesser amounts of *Ptilium crista-castrensis* (knight's plume) and other mosses and lichens.

Lodgepole pine — Grouseberry— Pinegrass

The Lodgepole pine — Grouseberry — Pinegrass association, and other similar pinegrass-dominated site associations, are found on very dry sites in all the MS subzones except the MSxv. Soils are generally Orthic Dystric and Eutric Brunisols and Brunisolic Gray Luvisols. Humus forms are typically thin (2-4 cm) Hemimors and Hemihumimors.

These sites are characterized by open, mature seral stands of lodgepole pine, with regenerating hybrid white spruce and subalpine fir. Douglas-fir is often a component of these stands, especially on south-facing slopes.

The shrub layer is poorly developed. It contains *Lonicera utahensis*, *Paxistima myrsinites*, *Spiraea betulifolia* (birch-leaved spirea), and occasionally *Vaccinium membranaceum* and *Shepherdia canadensis* (soopolallie).

The herb layer, which dominates the understory, contains *Calamagrostis rubescens* (pinegrass), *Vaccinium scoparium* (grouseberry), and *Linnaea borealis*. *Arctostaphylos uva-ursi* (kinnikinnick) is often present.

The moss layer is poorly developed, but *Pleurozium schreberi* is usually present.

Hybrid spruce — Gooseberry — Grouseberry

This association occurs on moist and very moist, nutrient-poor to -rich sites in the MSdm and MSxk. A similar association occurs on these sites in the MSdc, but lacks *Vaccinium scoparium*. Soils are usually gleyed subgroups of Brunisols, Gray Luvisols, or Humo-Ferric Podzols. Humus forms include Hemihumimors, Mormoders, and Hemimors.

These sites support mature seral and maturing climax stands of hybrid white spruce, subalpine fir, and lodgepole pine, occasionally with scattered Douglas-fir.

The shrub layer is dominated by Ribes lacustre (black gooseberry), and also contains *Lonicera involucrata* (black twinberry), *L. utahensis*, and *Vaccinium membranaceum*. *Alnus crispa* ssp. *sinuata* (Sitka alder) and *Rubus parviflorus* (thimbleberry) can be present.

The herb layer is moderately developed and contains *Vaccinium scoparium* (grouseberry), *Orthilia secunda*, *Cornus canadensis*, *Tiarella unifoliata* (one-leaved foamflower), *Linnaea borealis*, *Rubus pedatus* (five-leaved bramble), and *Arnica cordifolia*.

The moss layer is moderately well developed with *Pleurozium schreberi* dominant.

Hybrid spruce — Horsetail — Leafy moss

This association occurs on wet, nutrient-medium to -very rich sites in most MS subzones. It generally occurs in wet depressions and receiving sites adjacent to swamps, and along streams. Soils are usually gleyed subgroups of Brunisols and Humo-Ferric Podzols; Gleysols also occur. Humus forms include Hydromoders, Humimors, and occasional Mulls.

Stands are open and dominated by hybrid white spruce, with lesser amounts of subalpine fir. The shrub layer is moderately well developed and dominated by *Ribes lacustre* and *Lonicera involucrata*.

The well-developed herb layer is dominated by *Equisetum arvense* (common horsetail), but also contains *Vaccinium scoparium*, *Cornus canadensis*, *Rubus pedatus*, and *Streptopus amplexifolius* (clasping-leaved twistedstalk).

The well-developed moss layer is dominated by *Aulacomnium palustre* and *Mnium*, *Rhizomnium*, and *Plagiomnium* spp. (leafy mosses).

WILDLIFE HABITATS

The main ecological factors affecting the fauna of this zone (Table 26) are the cold, snowy winters, short, warm summers, extensive lodgepole pine forests, and sloping mountainous topography. Wildlife that inhabit this zone are adapted to either survive or avoid the deep snows of winter. With the exception of Caribou and occasionally Moose, most ungulates migrate to lower elevations during winter to escape deep snow.

The extensive seral stands of lodgepole pine provide summer and fall range for Moose and Mule Deer, with good thermal and hiding cover in the dense regeneration thickets. Birds, such as the Three-toed Woodpecker and Black-backed Woodpecker, that forage on bark-inhabiting insects are common in the pine forests. The northern parts of the MSxv, in the western Chilcotin, contain extensive dry lodgepole pine forests with a substantial terrestrial lichen ground cover, and provide important winter habitat for Caribou.

In the mature coniferous forests of hybrid white spruce and subalpine fir, many species occur that also inhabit similar, more extensive habitats in the adjacent ESSF. Fisher, Marten, Red Squirrel, Southern Red-backed Vole, Great Gray Owl, and Red Crossbill are some examples. Moose and Mule Deer probably select these habitats because of higher forage production compared to dense seral stands of lodgepole pine.

Steep south-facing grassland slopes, though not extensive in the MS, are locally important as foraging areas for California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Mule Deer, Golden-mantled Ground Squirrel, Golden Eagle, and Mountain Bluebird. Avalanche tracks, with their lush forage production, are feeding habitats for Grizzly Bear, Black Bear, Mountain Goat, Rocky Mountain Elk, and Moose. Rocky cliffs provide escape cover for Mountain Goat, California Bighorn Sheep, and Rocky Mountain Bighorn Sheep, and talus provides denning areas for Common Pika and Golden-mantled Ground Squirrel.

TABLE 26. Selected wildlife habitats and species in the Montane Spruce zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Young seral forests	Extensive	Moose, Mule Deer, Black Bear, Lynx, Coyote, Little Brown Myotis, Snowshoe Hare, Porcupine, Heather Vole, Deer Mouse, Masked Shrew Northern Goshawk, Northern Hawk Owl, Northern Pygmy-Owl, Ruffed Grouse, Three-toed Woodpecker, Black-backed Woodpecker, Wilson's Warbler, Rufous Hummingbird, Pine Grosbeak, Western Tanager, Dark-eyed Junco, Yellow-rumped Warbler	♦ Grizzly Bear
Mature coniferous forests	Extensive	Moose, Mule Deer, Cougar, Lynx, Coyote, Black Bear, Fisher, Marten, Red Squirrel, Snowshoe Hare, Silver-haired Bat, Little Brown Myotis, Long-legged Myotis, Southern Red-backed Vole, Deer Mouse, Masked Shrew Barred Owl, Great Gray Owl, Spruce Grouse, Pileated Woodpecker, Black-backed Woodpecker, Three-toed Woodpecker, Steller's Jay, Clark's Nutcracker, Varied Thrush, Red Crossbill, Golden-crowned Kinglet, Mountain Chickadee, Red-breasted Nuthatch Long-toed Salamander	♦ Caribou, Grizzly Bear
Steep, south aspect grasslands	Limited areal extent	Rocky Mountain Elk, Mule Deer, Cougar, Golden-mantled Ground Squirrel Golden Eagle, Blue Grouse, Mountain Bluebird	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Grizzly Bear
Avalanche tracks	Limited areal extent	Mountain Goat, Moose, Rocky Mountain Elk, Mule Deer, Black Bear	♦ Grizzly Bear
Rocky cliffs and talus	Limited areal extent	Mountain Goat, Common Pika, Golden-mantled Ground Squirrel Golden Eagle	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep
Riparian areas, wetlands, meadows, floodplains, lakes, and streams	Common, limited areal extent	Moose, Mule Deer, Black Bear, Coyote, Long-tailed Weasel, Little Brown Myotis, Water Vole, Deer Mouse, Western Jumping Mouse, Meadow Jumping Mouse Ruffed Grouse, Harlequin Duck, American Dipper Western Toad, Spotted Frog, Long-toed Salamander	♦ Caribou, Grizzly Bear, Tailed Frog

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Riparian areas and waterbodies are very important summer habitats for a variety of mammals, birds, and amphibians because they are, in a sense, wet islands in a matrix of fairly dry forest. Moose and Mule Deer often select these habitats in the summer to drop and rear their calves and fawns, because of the abundant forage and dense security cover. The American Dipper and Harlequin Duck can be observed foraging in fast-moving streams. Amphibians in this zone, such as the Spotted Frog, Western Toad, and Long-toed Salamander, are usually not far from a pond or stream.

RESOURCE VALUES

Forest harvesting, both for sawlogs and pulpwood, is very active in the MS. Mountain pine beetle (*Dendroctonus ponderosae*) has caused widespread mortality in mature pine stands and, during the 1980's, much of the logging in the MS concentrated on removing beetle-affected timber.

The primary agricultural use of the MS is cattle grazing. It is the second most important zone in the province, after the IDF, in providing forested summer range for cattle. Temporary forage production after fires and logging, both of seeded and native species, and forage produced by grass-sedge meadows are important. Zonal and drier ecosystems with seral stands of lodgepole pine provide some grasses (mainly *Calamagrostis rubescens*) and forbs, but forage production increases markedly after logging. Cutblocks, skid trails, and logging roads are often seeded with a variety of domestic species, notably orchardgrass (*Dactylis glomerata*) and clovers (*Trifolium* spp.).

Fur harvesting is an important resource use of this zone.

The MS is also important for recreation. Many valuable fishing, camping, and hunting areas lie within the zone. The zone is popular for other activities, such as hiking and horseback riding in summer, and cross-country skiing and snowmobiling in winter.

The zone makes an important contribution to spring and early summer runoff. In the dry Thompson Plateau and Okanagan Highland, the contribution of this runoff to overall watershed flow is important, although the early snow melt in the MS means that middle and late summer contributions are low.

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Chapter 13: Sub-Boreal Pine — Spruce Zone

by

O. Steen and D.A. Demarchi

LOCATION AND DISTRIBUTION

The Sub-Boreal Pine — Spruce zone (SBPS) is a montane zone that occurs on the high plateau in the west central interior of British Columbia (Figure 46). It lies south and west of the Sub-Boreal Spruce zone (SBS) in the rainshadow of the Coast Mountains. It is mostly within the area known as the Chilcotin.

The SBPS occupies the gently rolling landscape of the Fraser Plateau and the southern-most portions of the Nechako Plateau. These are high elevation plateaus. Elevations in the northern part of the zone are mostly 850-1300 m, while in the southern and western parts, near the Coast Mountains, elevations range from 1100 to 1500 m. The SBPS generally occurs at elevations above the Interior Douglas-fir zone (IDF) and below the Montane Spruce, Sub-Boreal Spruce, and Engelmann Spruce — Subalpine Fir zones on the Fraser Plateau. The Sub-Boreal Pine — Spruce zone is drained primarily by the Chilcotin, West Road (Blackwater), Dean, and Entiako rivers.

ECOLOGICAL CONDITIONS

Climate of the SBPS is continental and characterized by cold, dry winters and cool, dry summers (Figure 47). Compared to the SBS, the SBPS is drier and has similar mean daily temperatures in winter, but cooler mean daily temperatures in summer. The number of growing degree days above 5°C in the SBPS is significantly less than in either the SBS or the Boreal White and Black Spruce zones (Table 4). The cool, dry growing seasons of the SBPS result in large part from its position in the strong rainshadow of the Coast Mountains and its relatively high elevations. The low precipitation, dry air, and clear skies created by the rainshadow effect result in significant night-time radiation cooling and low overnight temperatures. Night-time frosts are common in all months. Mean annual temperatures in the SBPS range from 0.3 to 2.7°C with a mean of 1.9°C. As in the SBS, mean monthly temperatures are below 0°C for 4-5 months of the year but, unlike in the SBS, are above 10°C for only 1-3 months of the year. Mean annual precipitation ranges from 335 to 580 mm, of which 30-50% falls as snow. Peak snowpack is only 50-60 cm.

Upland coniferous forests dominate the SBPS landscape. Lodgepole pine is by far the most common tree species and, in fact, large areas of the forest contain no tree species other than lodgepole pine. Owing to an extensive fire history, the pine trees are generally young, even-aged, and often dense. Productivity of the forest is severely limited by the harsh climate.

In addition to lodgepole pine, the only common tree species of the SBPS are white spruce and trembling aspen. White spruce is common in the understory and is occasionally present in the canopy of mature pine stands on zonal sites, especially in the wetter northern and eastern parts of the zone. In the very dry, southwestern part of the zone, spruce is uncommon even in the understory of pine stands. White spruce-dominated forests occur on many of the moist sites throughout the SBPS, but these

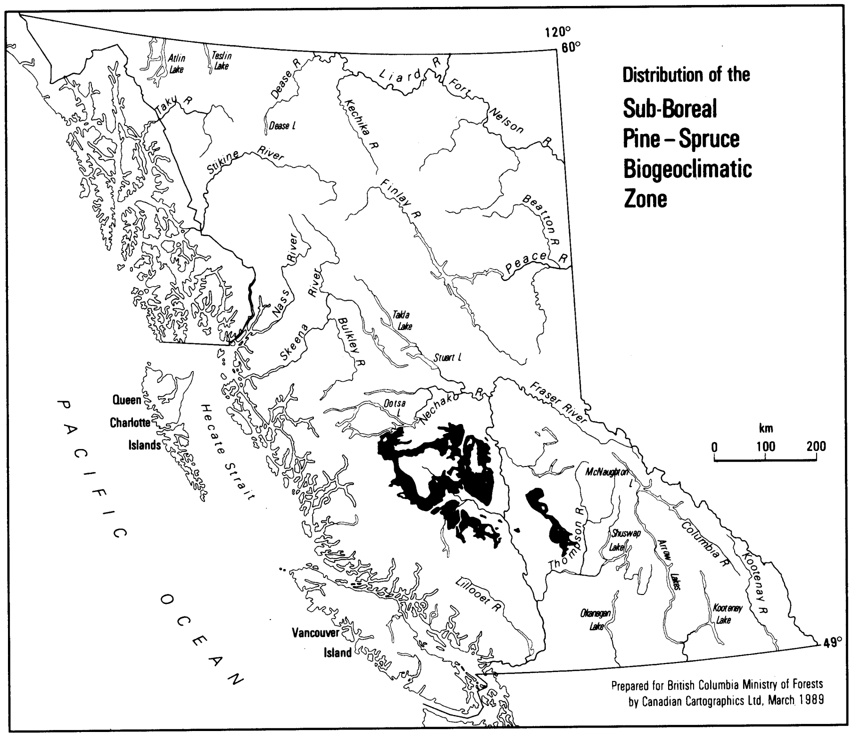

FIGURE 46. Sub-Boreal Pine — Spruce zone.

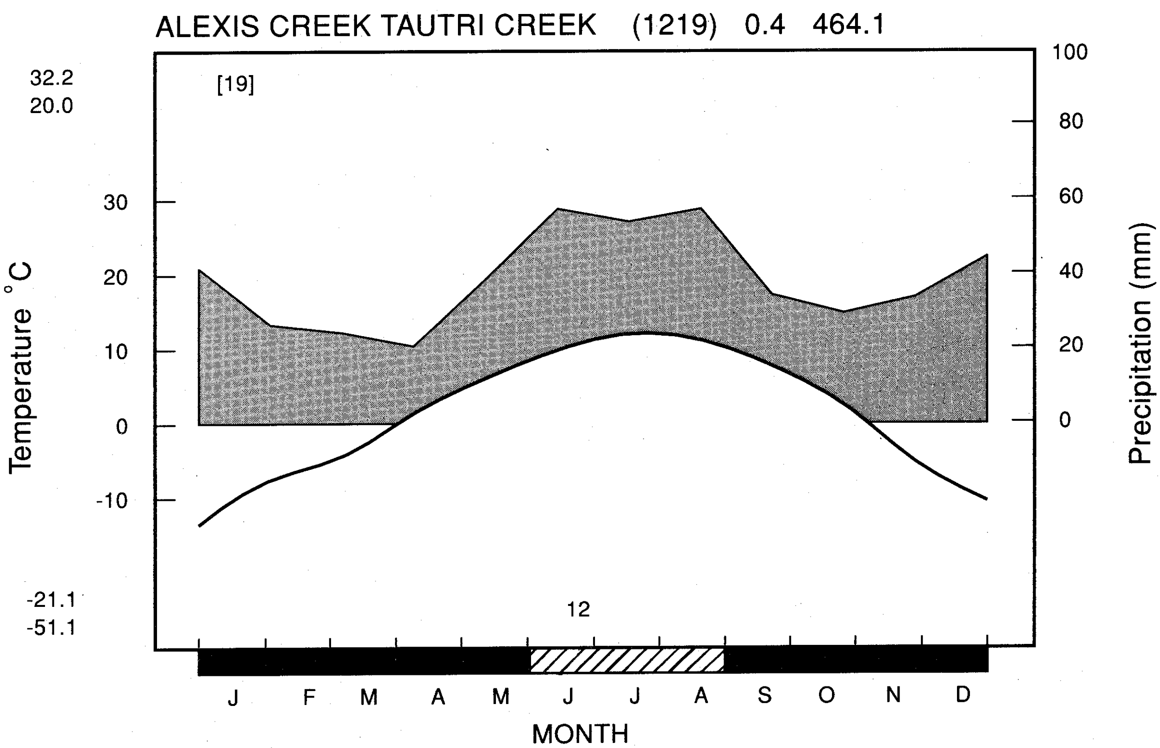

FIGURE 47. Representative climatic diagram for the Sub-Boreal Pine — Spruce zone.

spruce stands are usually small and they often ring the perimeter of non-forested wetlands. Trembling aspen is a common seral species throughout the zone but the stands it dominates are usually small.

Other tree species that occur occasionally in the SBPS are Douglas-fir, subalpine fir, black spruce, and black cottonwood. Douglas-fir occurs on some warm south-facing slopes, especially in the eastern part of the zone and near the boundary with the IDF. Subalpine fir is absent west of the Fraser River but occurs infrequently in the understory of stands east of the river. Black spruce occurs in some cold valley bottoms and in wetlands in the northern part of the zone. Black cottonwood occurs locally on the floodplains of the principal rivers, but is not common.

White spruce is the theoretical climatic climax tree species over most of the SBPS. In the very dry southwestern part of the zone, however, the abundance of pine regeneration and the virtual absence of spruce regeneration on zonal sites suggest that lodgepole pine is the climatic climax tree species. In the remainder of the zone, the dominance of pine on zonal sites has been maintained by recurrent wildfires, and pine is considered a persistent fire-climax species. In the absence of fire, succession to spruce dominance would be very slow.

Undergrowth vegetation of pine forests on zonal sites is generally low-growing and dominated by dwarf shrubs, grasses, lichens, and mosses. Lichens dominate the moss layer in the very dry southwestern part of the zone, while mosses dominate elsewhere.

Soil development in the SBPS is relatively weak and soils on zonal sites are members primarily of the Brunisol and Luvisol orders. Brunisolic Gray Luvisols and Orthic Dystric Brunisols are the most common soils on the dominant morainal deposits. The surface organic layer (humus form) is typically very thin (less than 4 cm) and has very slow rates of decomposition. On imperfectly and poorly drained sites, common soils are gleyed subgroups of Brunisolic and Luvisolic soils or Gleysols. Zonal humus forms are thin Xeromors and Hemimors.

Non-forested wetlands are abundant on the SBPS landscape as a result of the poorly developed drainage patterns on the plateau surface. Many of these wetlands are managed for hay production or grazing. Common wetland community types include shrub-carrs dominated by *Betula glandulosa* (scrub birch) and *Salix* (willow) spp., shrub fens with various *Salix* and *Carex* (sedge) species, and several types of sedge fens. Grass or sedge-dominated meadows, which are only seasonally wet, are common around the periphery of wetter types and in some better-drained but cold depressions. Acidic bogs are uncommon.

Small natural grasslands occur occasionally in the SBPS, especially on dry, south-facing slopes of glaciofluvial landforms.

The Sub-Boreal Pine — Spruce zone has a history of frequent wildfires. Effects of these fires are evident in the patchwork of different aged stands and the small number of stands more than 120 years old. A recent mountain pine beetle epidemic has resulted in extensive mortality of pine trees in the SBPS, especially in the southwest.

NOTES ON CLASSIFICATION

The area of the Sub-Boreal Pine — Spruce zone was originally (Krajina 1965) included in the northwestern portion of the Cariboo Aspen — Lodgepole Pine zone. More recently (Annas and Coupé 1979), it was reclassified as part of the Sub-Boreal Spruce zone. However, it is now considered a zone distinct from the SBS because of its colder, drier climate; its distinctive forest undergrowth with relatively abundant lichens, *Calamagrostis rubescens* (pinegrass), and *Arctostaphylos uva-ursi* (kinnikinnick); and the climax or persistent-seral status of lodgepole pine on zonal sites.

SUBZONES

Four subzones are included within the SBPS (Table 27). The driest subzone, the SBPSxc, occurs in the southwest part of the zone in an arc along the inside of the Coast Mountains as far north as the Rainbow Range. On zonal sites in this subzone (Figure 48), white spruce is poorly represented, *Arctostaphylos uva-ursi* and *Calamagrostis rubescens* dominate the herb layer, and lichens dominate the moss layer. A slightly more moist subzone, the SBPSdc, occurs in the northeast quarter of the zone. Compared to the very dry subzone, white spruce is more common, a greater number of species are well represented in the herb layer, and mosses (especially *Pleurozium schreberi* [red-stemmed feathermoss]) dominate the moss layer. An even more moist but cold subzone, the SBPSmc, occurs in the northwest corner of the zone, generally north and west of the Ilgachuz Range. Spruce is relatively well represented and mosses dominate the forest undergrowth on zonal sites. Unlike other areas of the SBPS, *Calamagrostis rubescens* is uncommon on zonal sites. This subzone is transitional to cold, dry subzones of the SBS zone. The fourth subzone, the SBPSmk, occurs in the eastern-most part of the zone, largely east of the Fraser River. It is the warmest subzone of the SBPS and includes the greatest amount of Douglas-fir. *Calamagrostis rubescens* and mosses dominate the undergrowth on zonal sites.

TABLE 27. Synopsis of subzones in the Sub-Boreal Pine — Spruce zone (SBPS)

Subzone	Code	Old code
Very Dry Cold SBPS	SBPSxc	(SBSa1)
Dry Cold SBPS	SBPSdc	(SBSa3)
Moist Cool SBPS	SBPSmk	(SBSb)
Moist Cold SBPS	SBPSmc	(SBSa2)

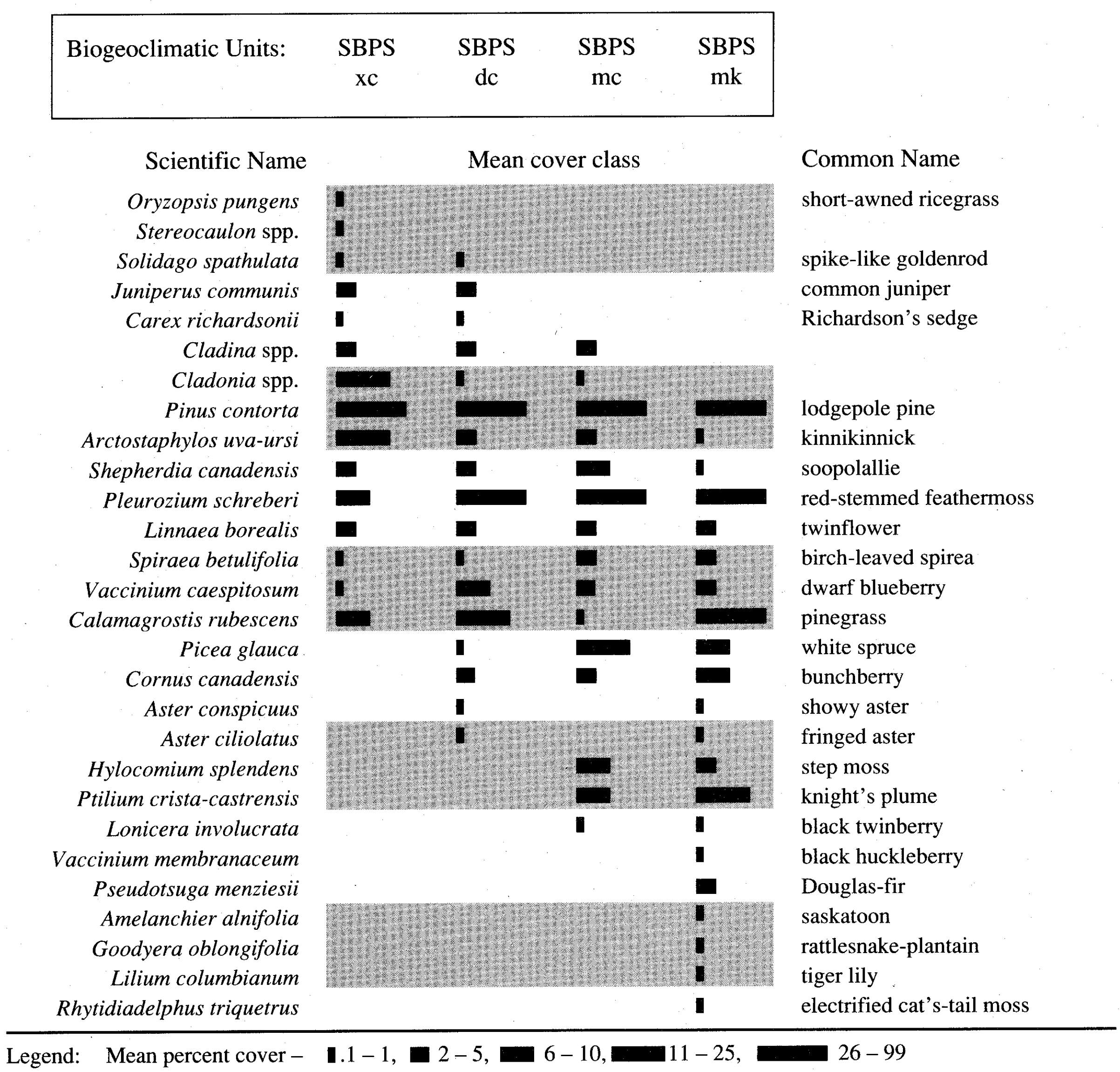

FIGURE 48. Zonal vegetation subzones of the Sub-Boreal Pine — Spruce zone.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following four site associations are common on the SBPS landscape and form a sequence of ecosystems from dry to wet in the SBPSdc (see Figure 49).

Lodgepole pine — Juniper — Feathermoss

This is the zonal and most common association of the SBPSdc. It is extensive on well and moderately well-drained morainal deposits and also occurs on finer-textured glaciofluvial deposits. Soils are mostly Brunisolic Gray Luvisols or, less often, Orthic Gray Luvisols and have a thin (3-4 cm) Hemimor humus form.

Even-aged stands of lodgepole pine with a moderately closed canopy dominate the vegetation. White spruce is seldom present in the canopy, although it occurs in the understory of most stands. Trembling aspen is sometimes present in the tree canopy, especially in young seral stands.

The shrub layer in most stands has low to moderate cover and is usually dominated by *Juniperus communis* (common juniper), *Shepherdia canadensis* (soopolallie), and *Rosa acicularis* (prickly rose). A very well-developed cover of *Juniperus communis* is present in some relatively old stands. Lodgepole pine regeneration is consistently present but usually patchy.

The herb layer is moderately well developed and dominated by *Calamagrostis rubescens* and *Arctostaphylos uva-ursi*. Other common species are *Vaccinium caespitosum* (dwarf blueberry), *Cornus canadensis* (bunchberry), *Linnaea borealis* (twinflower), *Epilobium angustifolium* (fireweed), and *Fragaria virginiana* (wild strawberry).

A well-developed cover of mosses, primarily *Pleurozium schreberi* (red-stemmed feathermoss), is present on most sites. Lichens are also consistently present but less abundant than on drier sites. Lichen species are mainly *Cladonia* spp., *Cladina* spp., *Peltigera* spp., and *Stereocaulon* spp.

Lodgepole pine — Kinnikinnick — Cladonia

This site association is very common in the two driest SBPS subzones, the SBPSxc and SBPSdc. In the SBPSdc, it includes all forested sites drier than the zonal site; in the very dry SBPSxc, it includes the zonal as well as drier sites. In the wetter climate of the SBPSmc, it includes only the driest forested sites. Thus, this association occurs on the driest sites of the SBPS zone, encompassing a broad range of site features.

Such sites are most common on well and rapidly drained morainal deposits, but are also present on sandy glaciofluvial deposits and on thin soils over bedrock. Soils are predominantly Dystric Brunisols or weakly developed Brunisolic Gray Luvisols. The humus form is most often a very thin (less than 3 cm) Xeromor or Hemimor.

The vegetation is characterized by open stands of lodgepole pine with only occasional scattered white spruce. Lodgepole pine, sometimes with a few trembling aspen, dominates the young seral stands.

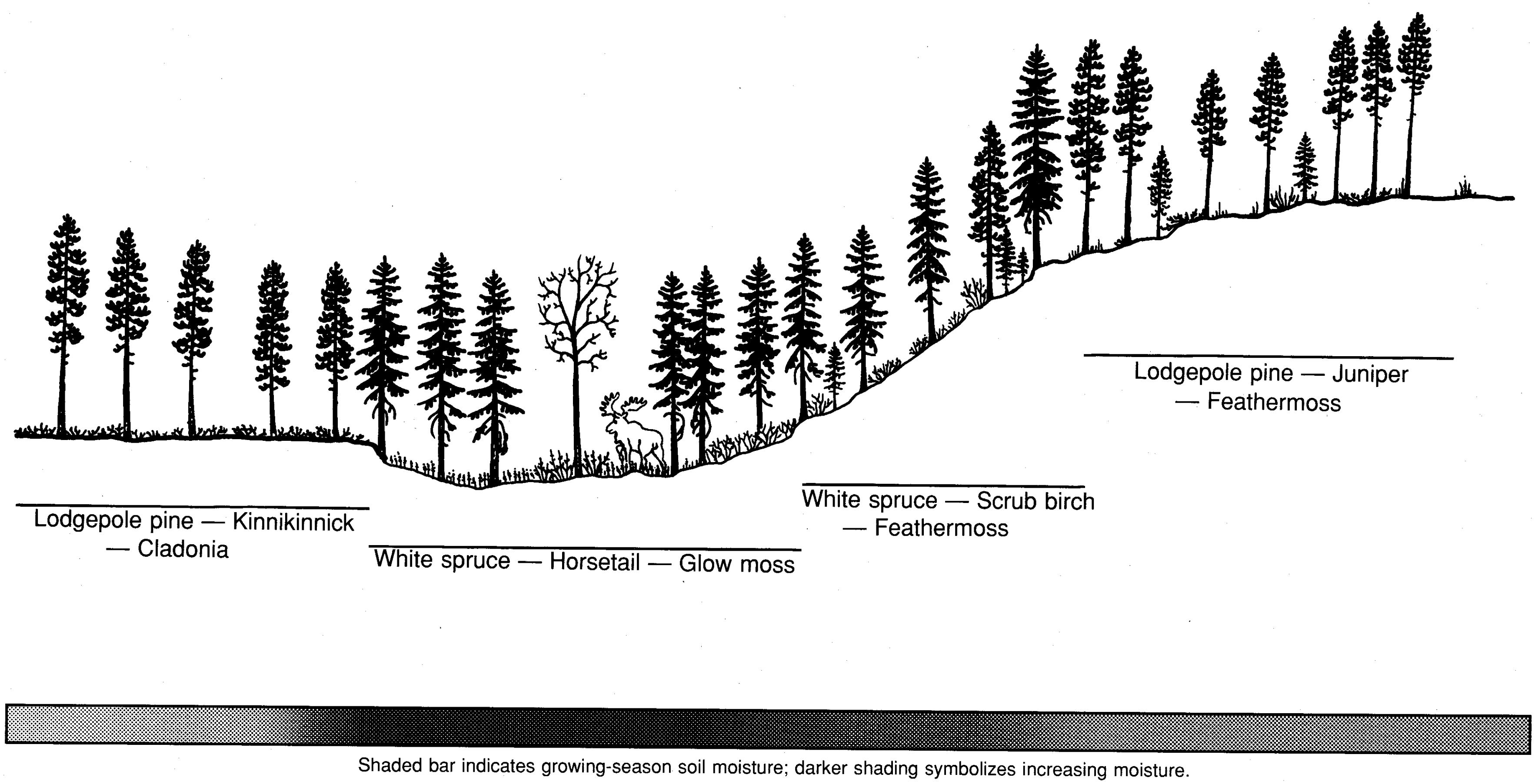

FIGURE 49. Simplified schematic diagram of topographic relationships among four common site associations of a dry subzone of the Sub-Boreal Pine — Spruce zone.

In the undergrowth, low shrubs 0.5-1 m tall cover 5-30% of the surface. *Juniperus communis* and *Shepherdia canadensis* are most abundant, but *Spiraea betulifolia* (birch-leaved spirea) and *Rosa acicularis* are also common. Lodgepole pine regeneration, 0.5 and 2.0 m tall, is often well represented but clumped. A few white spruce seedlings can be present.

The herb layer is dominated by dwarf shrubs, especially *Arctostaphylos uva-ursi* (kinnikinnick), and by a relatively small number of low herbaceous species. Common species are *Linnaea borealis*, *Solidago spathulata* (spike-like goldenrod), *Carex richardsonii* (Richardson's sedge), *Oryzopsis pungens* (short-awned ricegrass), and *Calamagrostis rubescens*.

The moss layer is dominated by lichens; species are similar to those in the Lodgepole pine — Juniper — Feathermoss association. Principal mosses are *Pleurozium schreberi*, *Dicranum polysetum* (wavy-leaved moss), and *Polytrichum juniperinum* (juniper haircap moss). A large proportion of the soil surface can lack vegetation cover over the pine needle litter.

White spruce — Scrub birch — Feathermoss

This is a common site association of moist lower slopes in the SBPSxc, SBPSdc, and SBPSmc. It occurs primarily on moderately well to imperfectly drained morainal deposits and less commonly on fluvial or lacustrine deposits. Soils are mostly Brunisolic Gray Luvisols and gleyed subgroups of Dystric Brunisols and Gray Luvisols. Humus forms are thicker (mostly 4-10 cm) than on the drier sites and are mostly Humimors, Hemimors, and Mormoders. As a result of the greater supply of moisture and nutrients, these are relatively productive sites for trees and other vegetation in the western SBPS.

Stands are dominated by white spruce with some lodepole pine.

The shrub layer is generally better developed and contains a larger number of species than in the drier site associations. Common species are *Rosa acicularis*, *Shepherdia canadensis*, *Lonicera involucrata* (black twinberry), *Juniperus communis*, *Salix glauca* (grey-leaved willow), and *Betula glandulosa* (scrub birch). Tree regeneration is predominantly white spruce.

The herb layer is relatively sparse but contains several low-growing species. Common species include *Petasites frigidus* var. *palmatus* (palmate coltsfoot), *Linnaea borealis*, *Epilobium angustifolium*, *Fragaria virginiana*, *Cornus canadensis*, and *Achillea millefolium* (yarrow).

The moss layer is moderately well developed and dominated by feathermosses, especially *Pleurozium schreberi* (red-stemmed feathermoss) and *Hylocomium splendens* (step moss). *Aulacomnium palustre* (glow moss), a moist-site moss, is usually present. Lichens are consistently present and include *Peltigera aphthosa*, *Cladonia* spp., and *Cladina* spp.

White spruce — Horsetail — Glow moss

The White Spruce — Horsetail — Glow moss association includes the wettest sites with a closed forest canopy in the SBPS. It is common in all SBPS subzones on imperfectly and poorly drained morainal or fluvial deposits, primarily at the toe of slopes and in small depressions. A water table is commonly present near the soil surface for a significant part of the growing season. Soils are primarily Gleysols but also include gleyed subgroups of Brunisols and Luvisols on the imperfectly drained sites. Humus forms include Hydromors, Histomors, and Hydromoders.

The forest canopy of mature stands is dominated by white spruce or hybrid white (Engelmann x white) spruce and only occasionally includes other species such as lodgepole pine or trembling aspen. The canopy tends to be relatively open and the trees clumped.

The shrub layer is moderately to well developed and often dominated by *Lonicera involucrata*. Other common species include *Salix* spp., *Ribes* spp. (gooseberries and currants), *Rosa acicularis*, *Cornus stolonifera* (red-osier dogwood), *Alnus tenuifolia* (mountain alder), and *Viburnum edule* (highbush-cranberry). White spruce, hybrid spruce, or occasionally black spruce are the principal species of tree regeneration. On poorly drained sites, tree seedlings establish primarily on raised microsites.

The herb layer includes many species, most of which are low-growing forbs. *Equisetum arvense* (common horsetail) is consistently present and often dominant. Other common species include *Rubus pubescens* (trailing raspberry), *Linnaea borealis*, *Petasites frigidus* var. *palmatus*, *Cornus canadensis*, *Calamagrostis canadensis* (bluejoint), and *Carex disperma* (soft-leaved sedge).

Hylocomium splendens and Mniaceae mosses (mostly leafy mosses) commonly dominate the moderately well-developed moss layer. Other common species are *Aulacomnium palustre*, *Pleurozium schreberi*, *Ptilium crista-castrensis* (knight's plume), and *Tomenthypnum nitens* (golden fuzzy fen moss).

WILDLIFE HABITATS

The factors that most influence the assemblage of wildlife species in this zone (Table 28) are its cold, dry winters and cool, dry summers; its occurrence on high elevation plateaus; and its position, in the centre of the province, leeward of the Pacific, Chilcotin, and Kitimat ranges. Wildlife that inhabit this zone are those that are adapted to either survive or avoid the long, cold winters. Moose can survive on the riparian shrubs, Caribou seek out terrestrial lichen patches in open pine forests, Black Bear spend the winter in hibernation, and most insect-eating birds migrate to warmer climates.

Wetlands are common and provide excellent habitat for the production of waterbirds, including Sandhill Cranes, sandpipers, dabbling and diving ducks, Canada Geese, and loons. The only nesting colony of White Pelican in the province occurs on Stum Lake within this zone. The wetland vegetation provides year-round forage for

TABLE 28. Selected wildlife habitats and species in the Sub-Boreal Pine — Spruce zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Lodgepole pine forests	Extensive	Moose, Black Bear, Cougar, Lynx, Marten, Gray Wolf, Snowshoe Hare, Porcupine, Red Squirrel, Yellow-pine Chipmunk, Deer Mouse, Masked Shrew Northern Goshawk, Great Horned Owl, Northern Hawk-Owl, Barred Owl, Ruffed Grouse, Spruce Grouse, Pileated Woodpecker, Hairy Woodpecker, Gray Jay, Red Crossbill, Mountain Chickadee, Red-breasted Nuthatch, Brown Creeper	♦ Caribou
Riparian areas, wetlands, meadows, floodplains, lakes, and streams	Common	Moose, Mule Deer, Black Bear, Red Fox, Beaver, Muskrat, Meadow Jumping Mouse, Pygmy Shrew Bald Eagle, Ruffed Grouse, Trumpeter Swan, Canada Goose, Sandhill Crane, Herring Gull, Ring-billed Gull, Spotted Sandpiper, Black Tern, Eared Grebe, Common Loon, Barrow's Goldeneye, Harlequin Duck, Rusty Blackbird, Eastern Kingbird, Dusky Flycatcher, Marsh Wren, Catbird Common Garter Snake, Western Toad, Wood Frog, Spotted Frog, Long-toed Salamander	∇ American White Pelican ♦ Caribou, Grizzly Bear, Western Grebe
Spruce forests	Limited areal extent	Moose, Black Bear, Gray Wolf, Lynx, Fisher, Marten, Little Brown Myotis, Northern Flying Squirrel, Southern Red-backed Vole Great Gray Owl, Boreal Owl, Three-toed Woodpecker, Gray Jay, Magnolia Warbler, Yellow-rumped Warbler, Red-breasted Nuthatch	♦ Caribou
Open aspen forests and grasslands	Limited areal extent	Moose, Mule Deer, Black Bear, Coyote, Red Fox, Badger, Woodchuck, Yellow Pine Chipmunk, Deer Mouse, Pygmy Shrew American Kestrel, Pygmy Owl, Sharp-tailed Grouse, Northern Flicker, Yellow-bellied Sapsucker, Downy Woodpecker, Steller's Jay, Mountain Bluebird, Vaux's Swift, Boreal Chickadee Common Garter Snake, Western Toad	♦ Grizzly Bear

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species ''sensitive'' and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Moose, Beaver, and Muskrat. Black Bear and the occasional Grizzly Bear also forage on vegetation here during the summer months, and some of the larger streams support spawning salmon, another food source for bears. Many birds, such as the Eastern Kingbird, Dusky Flycatcher, Marsh Wren, and Catbird, are attracted by the myriad insects that swarm over these wetlands.

The extensive pine forests provide habitat for seed-eating animals such as Red Squirrel; bark insect-eating birds such as Pileated Woodpecker, Hairy Woodpecker, Mountain Chickadee, Red-breasted Nuthatch, Brown Creeper, Hermit Thrush; and predatory animals such as Marten, Fisher, Goshawk, Great Horned Owl, and Barred Owl that feed on the insect and seed-eating animals. A few animals, such as the Spruce Grouse and Porcupine, thrive on the needles, buds, and bark of the pine trees. With the exception of terrestrial lichens for Caribou, these upland forests provide very poor forage for ungulates.

While not common, mature spruce forests provide cover for Moose, Mule Deer, and Black Bear, and the arboreal lichens provide winter forage for Caribou. Many of the seed and insect-eating birds are the same ones that occur in the pine forests, although here the snags are larger and last longer, providing better habitat opportunities for cavity-nesting birds and mammals.

Open grassland and aspen habitats are used by a variety of birds feeding on insects or succulent herbs. Birds include Sharp-tailed Grouse, Northern Pygmy-Owl, Vaux's Swift, Northern Flicker, Yellow-bellied Sapsucker, Downy Woodpecker, Steller's Jay, and Boreal Chickadee. Moose, Mule Deer, Black Bear, Grizzly Bear, and Snowshoe Hare also forage in these herbaceous-rich habitats. Large predatory mammals in these habitats include the Gray Wolf, Coyote, Red Fox, and Lynx.

RESOURCE VALUES

Timber productivity in the SBPS is low. However, the gentle terrain and small, relatively uniform size of trees allows for efficient mechanized harvesting. In recent years, timber harvesting has greatly increased in the SBPS, stimulated primarily by attempts to reduce losses of merchantable timber killed by epidemics of mountain pine beetle.

The SBPS has very low capability for agriculture. However, the numerous nonforested wetlands in the zone are extensively used for hay production and, to a lesser extent, cattle grazing. Water levels in many of the wetlands are manipulated for hay production. The abundance of *Calamagrostis rubescens* in the understory of upland forests of the eastern parts of the zone contributes to the range value of the SBPS.

Fur harvest from this zone is among the highest in the province.

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Chapter 14: Sub-Boreal Spruce Zone

by

D. Meidinger, J. Pojar, and W.L. Harper

LOCATION AND DISTRIBUTION

The Sub-Boreal Spruce zone (SBS) is the montane zone dominating the landscape of the central interior of British Columbia (Figure 50). It occupies the gently rolling terrain of the Nechako and Fraser plateaus and the Fraser Basin and fingers into more mountainous areas along its western, northern, and eastern boundaries. The SBS is found over a wide latitudinal range, from 51° 30′ to 59°N latitude. The zone generally occurs from the valley bottoms to 1100-1300 m elevation.

The SBS adjoins the Boreal White and Black Spruce zone in the north, the Interior Cedar — Hemlock zone in the wetter areas to the northwest and east, the Sub-Boreal Pine — Spruce zone in the dry southwest, and the Interior Douglas-fir zone in the south. The Engelmann Spruce — Subalpine Fir zone is the subalpine zone above the SBS.

ECOLOGICAL CONDITIONS

The climate of the SBS is continental, and is characterized by seasonal extremes of temperature; severe, snowy winters; relatively warm, moist, and short summers; and moderate annual precipitation (Figure 51 and Table 4). In contrast to the boreal, sub-boreal climate is slightly less continental, thus slightly warmer in January and cooler in July (Table 4). Sub-boreal winters are shorter and the vegetative season slightly longer with, in some cases, lower evapotranspiration. Mean annual temperature of the SBS ranges from 1.7 to 5°C. Average temperature is below 0°C for 4-5 months of the year, and above 10°C for 2-5 months. Mean annual precipitation data from long-term stations ranges from 440-900 mm, of which perhaps 25-50% is snow. Short-term data indicate that mean annual precipitation can range from 415 to 1650 mm in the SBS.

The SBS is part of the Canadian Boreal Forest Region (Krajina 1965). Krajina’s original concept of the SBS was expanded southward following the work of Annas and Coupé (1979). Recently, a new zone, the Sub-Boreal Pine — Spruce zone (SBPS), was recognized in the driest, coldest parts of the former SBS in the south and southwest. We now consider the forests of the SBS as broadly transitional between the true montane forests of Douglas-fir to the south; the drier, colder pine — spruce forests to the southwest; boreal forests to the north; and subalpine forests at higher elevations.

Upland coniferous forests dominate the sub-boreal landscape. Hybrid white spruce (*Picea engelmannii* x *glauca*) and subalpine fir are the dominant climax tree species. Lodgepole pine, a seral species in the SBS, is common in mature forests in the drier parts of the zone and both lodgepole pine and trembling aspen pioneer the extensive seral stands. Paper birch is another pioneer tree, often on moist, rich sites. Douglas-fir is usually a long-lived seral species in the SBS, occurring abundantly on dry, warm, rich sites and as a consistent, although small, component of many mesic forests, especially in the southeastern part of the zone. Black spruce also occurs occasionally in climax upland forest.

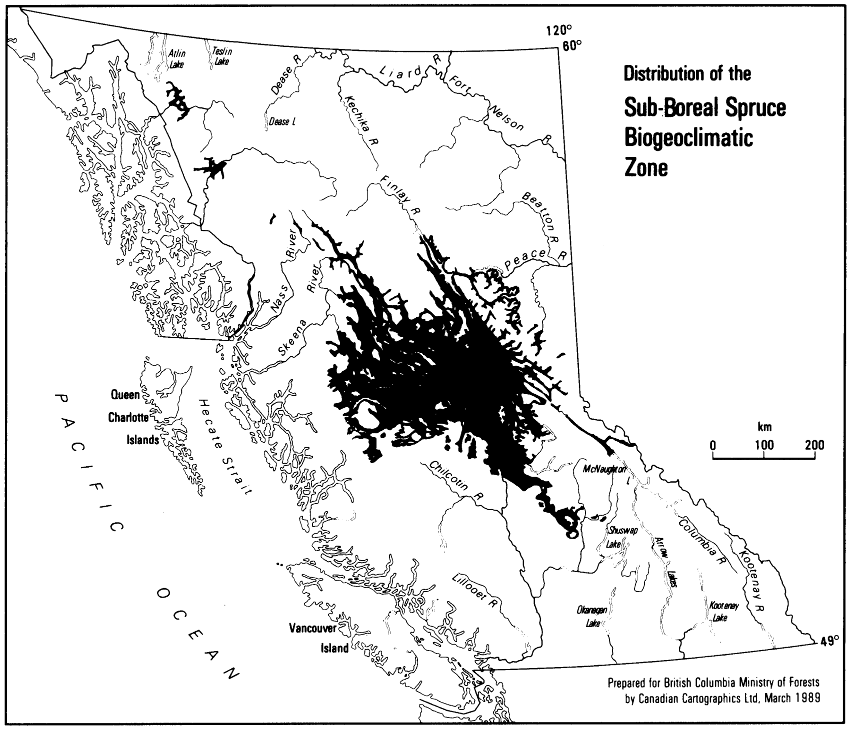

FIGURE 50. Sub-Boreal Spruce zone.

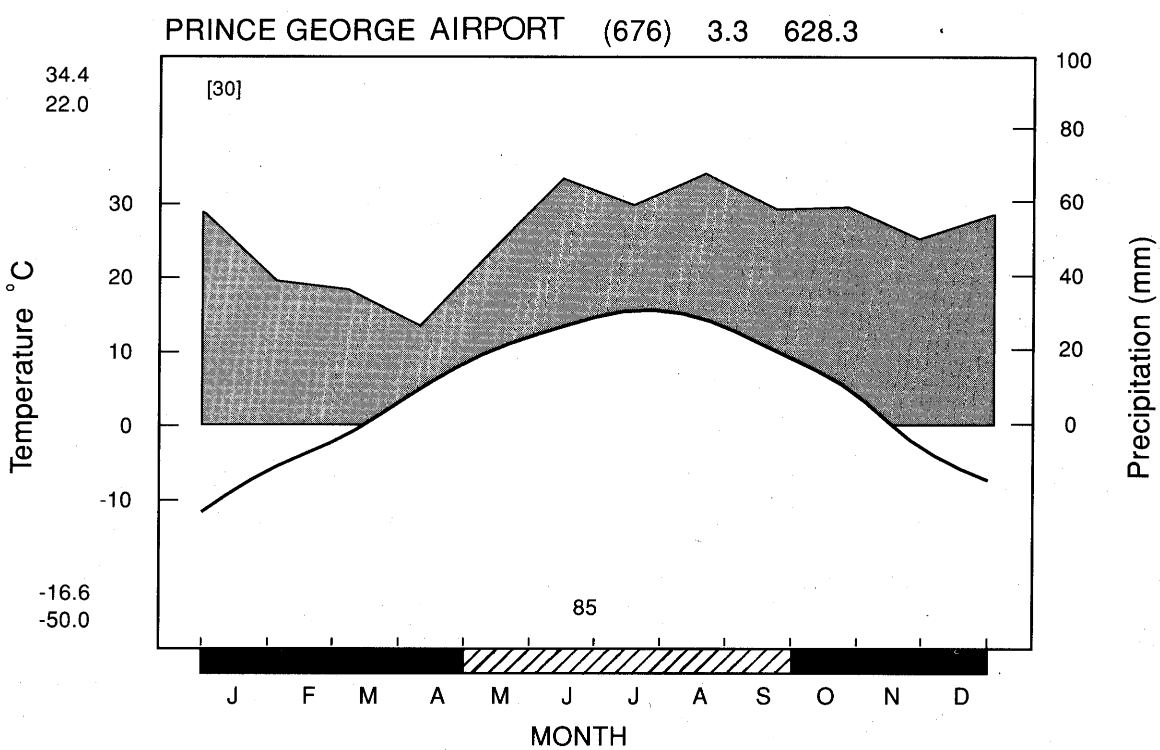

FIGURE 51. Representative climatic diagram for the Sub-Boreal Spruce zone.

Upland soils are primarily from the Luvisolic, Podzolic, and Brunisolic soil orders. Podzols and Brunisolic and Orthic Gray Luvisols are the most common soils found on the abundant morainal deposits. Imperfectly to poorly drained sites in the SBS typically have Gleysols or gleyed subgroups of Luvisols, Podzols, or Brunisols.

Alluvial forests of black cottonwood, often with a minor component of spruce, occur to a limited extent on active floodplains of the major streams and rivers.

Wetlands are common and dot the landscape in poorly drained, postglacial depressions or river ox-bows. Wetland community types include *Carex* (sedge) marshes, shrub fens of *Betula glandulosa* (scrub birch), *B. pumila* (swamp birch), and *Salix* spp. (willows), treed fens and swamps with black and hybrid white spruce, and black spruce — *Sphagnum* bogs. Acidic, nutrient-poor bogs are less common than the richer wetland types (marshes, fens, and swamps). Tamarack is a rare species in the SBS and occurs in only a few fens and swamps of the Nechako, Chilako, and Blackwater drainages.

Natural grassland and shrub-steppe are uncommon in the SBS, occurring on some warm, dry sites scattered in the major valleys.

NOTES ON CLASSIFICATION

Krajina (1965) classified much of the southern SBS as a northern subzone of his Cariboo Aspen — Lodgepole Pine zone (CALP), a zone the Ministry of Forests no longer recognizes. The dry, cold areas recognized as part of the SBS before 1988 (i.e., SBSa and SBSb) are now part of the Sub-Boreal Pine — Spruce zone.

SUBZONES

Ten subzones are recognized in the SBS (Table 29). Species characteristic of the warmer, drier subzones include Douglas-fir, *Shepherdia canadensis* (soopolallie), *Calamagrostis rubescens* (pinegrass), and *Oryzopsis asperifolia* (rough-leaved ricegrass) (Figure 52). The moister, cooler subzones typically have subalpine fir, *Rubus pedatus* (five-leaved bramble), *Petasites frigidus* var. *palmatus* (palmate coltsfoot), *Streptopus amplexifolius* (clasping-leaved twistedstalk), and *Gymnocarpium dryopteris* (oak fern).

Two of the three dry subzones occur on the Interior Plateau. The SBSdw is found in a long northwest to southeast band from about Stuart Lake to Canim Lake. The SBSdk is centred around Francois Lake and extends, at lower elevations, from Trembleur Lake in the north, to Ootsa Lake in the south. The third, the SBSdh, is found in the Rocky Mountain Trench and Fraser River valley near Valemount.

The moist subzones are found throughout the SBS zone. The SBSmh is in the Fraser and Quesnel River valleys from Alexandria and Hydraulic to Prince George.

The SBSmw is mainly in the Quesnel Highland and the SBSmm is near Clearwater. The "typical" SBS subzone is the SBSmk, ranging from Prince George — Fort St. James to Nation Lakes — Williston Reservoir. The somewhat colder SBSmc occurs at middle elevations from the Blackwater — Ootsa Lake area to Babine Lake and River.

TABLE 29. Synopsis of subzones in the Sub-Boreal Spruce zone (SBS)

Subzone	Code	Old code
Dry Hot SBS	SBSdh	(SBSh)
Dry Warm SBS	SBSdw	(SBSk)
Dry Cool SBS	SBSdk	(SBSd)
Moist Hot SBS	SBSmh	(SBSl)
Moist Warm SBS	SBSmw	(SBSc)
Moist Mild SBS	SBSmm	(SBSm1)
Moist Cool SBS	SBSmk	(SBSe2/o)
Moist Cold SBS	SBSmc	(SBSm2/e1/e/i)
Wet Cool SBS	SBSwk	(SBSj/n)
Very Wet Cool SBS	SBSvk	(SBSf)

The wetter subzones are found in the northern and eastern parts of the SBS. Part of the SBSwk occurs around Takla Lake, with the majority occurring in the east from the Peace Arm of Williston Reservoir south to the upper Quesnel River. The SBSvk occurs in mountainous terrain from the Bowron River to north of Mackenzie.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following four site associations are common on the SBS landscape. They form a typical sequence of ecosystems in the SBSmk (Figure 53).

Hybrid spruce — Huckleberry — Highbush-cranberry

The Hybrid spruce — Huckleberry — Highbush-cranberry association is common in the SBS moist and wet subzones. This association is the zonal association in the SBSmk, and occurs on "drier" sites in the SBSwk. It is mostly found on moderately well-drained sites on morainal deposits, although it can also be found on glaciofluvial deposits. Soils are a mixture of Brunisolic Gray Luvisols, Orthic Humo-Ferric Podzols, Orthic and Eluviated Dystric Brunisols, and Orthic Gray Luvisols. Hemimors are the most common humus forms.

Mature stands are usually well stocked with hybrid white spruce, lodgepole pine, and subalpine fir. Trembling aspen and paper birch are frequent components of seral stands.

The shrub layer is moderately developed with species such as *Vaccinium membranaceum* (black huckleberry), *Rubus parviflorus* (thimbleberry), *Viburnum edule* (highbush-cranberry), and *Alnus crispa* ssp. *sinuata* (Sitka alder). Advance regeneration of subalpine fir and some spruce is a consistent feature.

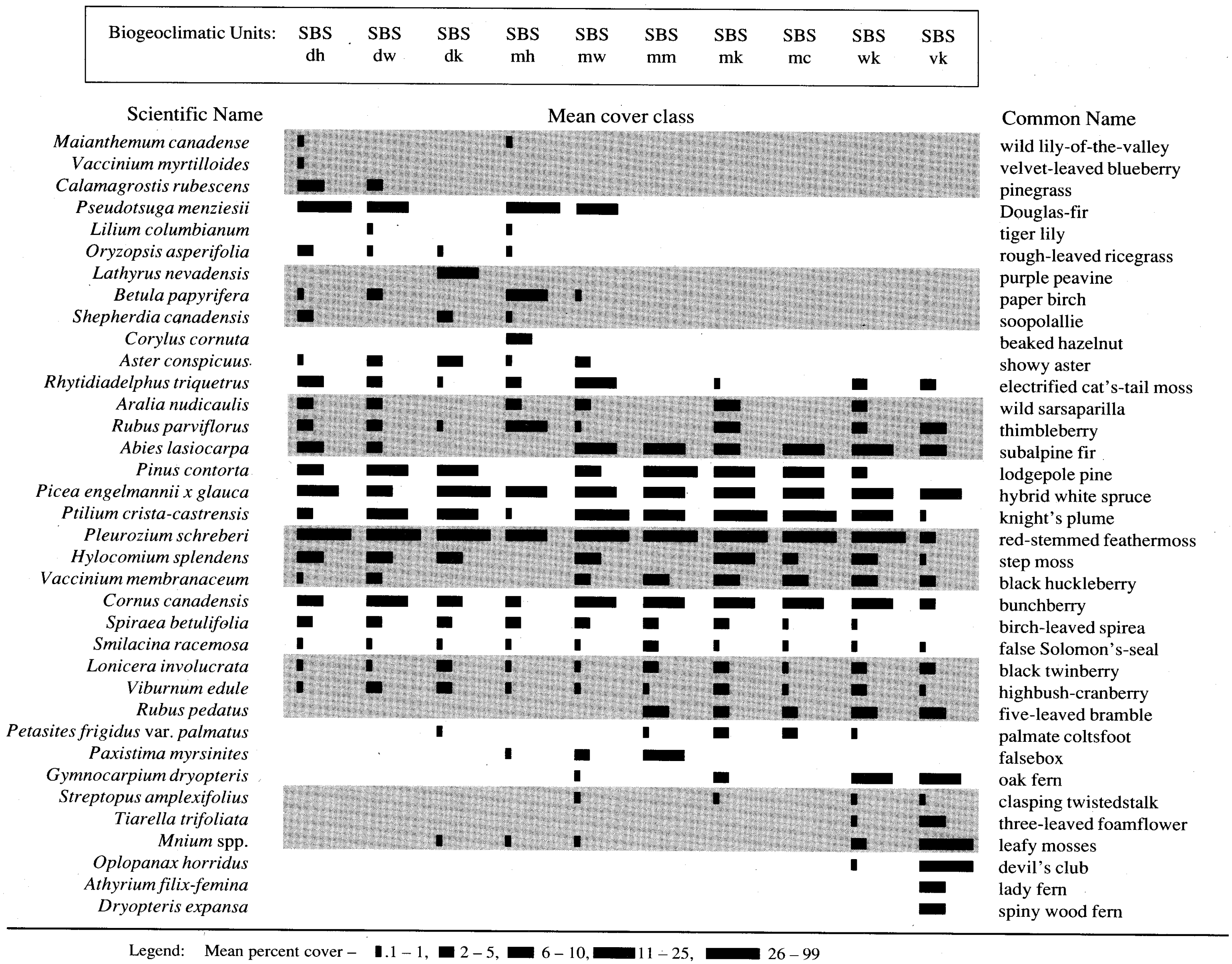

FIGURE 52. Zonal vegetation of subzones of the Sub-Boreal Spruce zone.

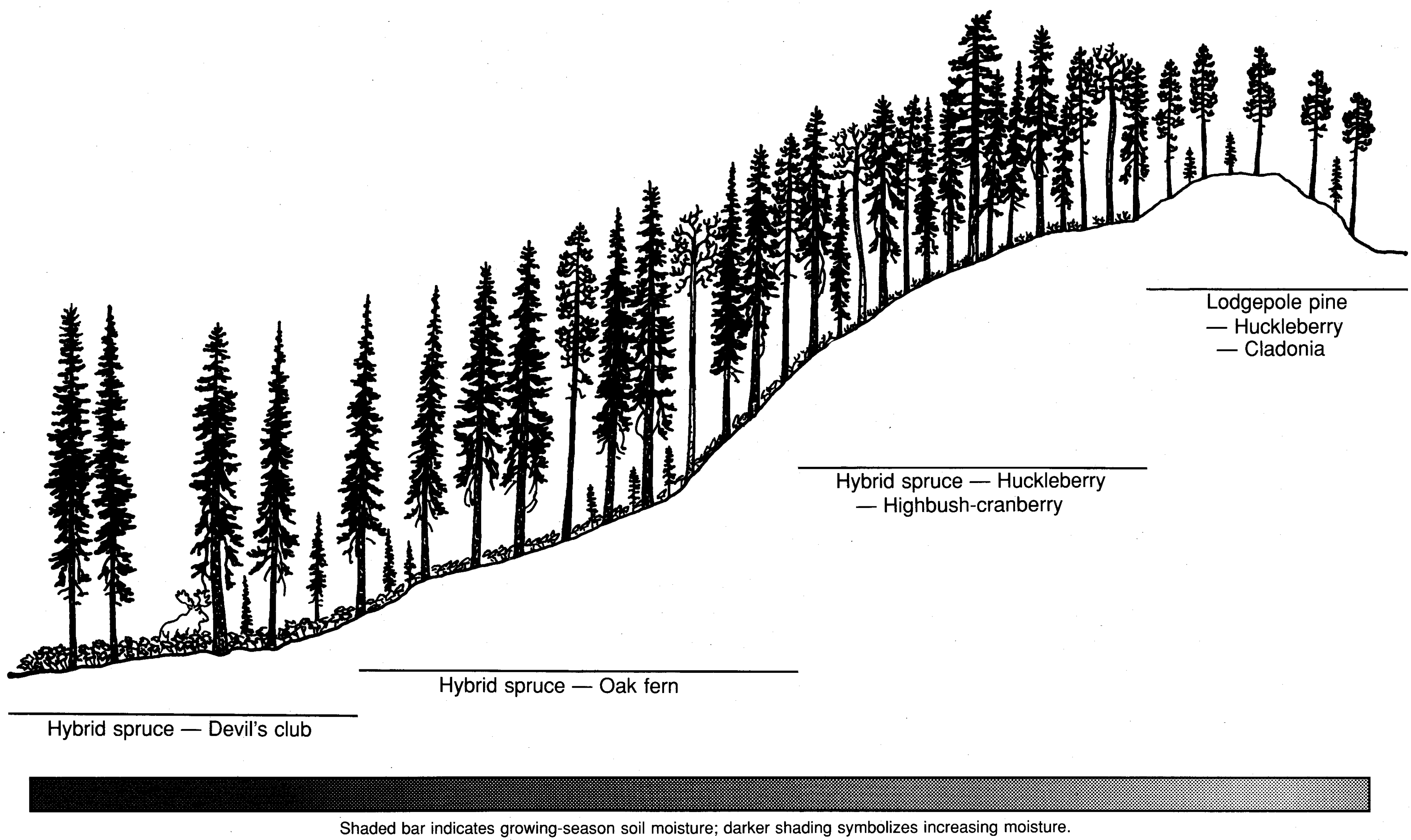

FIGURE 53. Simplified schematic diagram of topographic relationships among four common site associations of a moist, cool subzone of the Sub-Boreal Spruce zone.

Common herbs include *Cornus canadensis* (bunchberry), *Clintonia uniflora* (queen's cup), *Orthilia secunda* (one-sided wintergreen), *Linnaea borealis* (twinflower), *Smilacina racemosa* (false Solomon's-seal), *Lycopodium annotinum* (stiff clubmoss), and *Rubus pedatus*.

The well-developed moss layer is primarily composed of the mosses *Pleurozium schreberi* (red-stemmed feathermoss), *Ptilium crista-castrensis* (knight's plume), and *Hylocomium splendens* (step moss), and the lichen *Peltigera aphthosa*.

Lodgepole pine — Huckleberry — Cladonia

The Lodgepole pine — Huckleberry — Cladonia association is found on dry, nutrient-poor to -medium sites that generally occur on rapidly drained glaciofluvial, colluvial, or eolian materials in the moist, cool, and cold SBS subzones. Soils are predominantly Orthic Humo-Ferric Podzols and Eluviated and Orthic Dystric Brunisols. Typical humus forms are thin, crusty Xeromors.

These ecosystems are characterized by open stands of lodgepole pine with poorly developed shrub and herb layers, and a well-developed "moss" layer dominated by lichens.

Tree regeneration is sparse and consists of lodgepole pine with some subalpine fir and hybrid white spruce. The dominant shrub is generally *Vaccinium membranaceum* (black huckleberry) of poor vigour; *Vaccinium myrtilloides* (velvet-leaved blueberry) can be abundant in the SBSmk.

Arctostaphylos uva-ursi (kinnikinnick) is the dominant species in the herb layer.

The "moss" layer is dominated by lichens of the genera *Cladina*, *Cladonia*, *Peltigera*, and *Stereocaulon*. The most common mosses are *Polytrichum juniperinum* (juniper haircap moss) and *P. piliferum* (awned haircap moss).

Hybrid spruce — Oak fern

The Hybrid spruce — Oak fern site association is found on fresh, nutrient-poor to -rich sites throughout the moist to very wet subzones. This is the zonal association in the SBSwk. Soils are usually gleyed subgroups of Humo-Ferric Podzols, Brunisols, Gray Luvisols, or Brunisolic Gray Luvisols. Humus forms include Mormoders, Leptomoders, and Hemimors.

Subalpine fir and hybrid white spruce are the climax tree species. *Viburnum edule*, *Lonicera involucrata* (black twinberry), *Vaccinium membranaceum*, *Ribes lacustre* (black gooseberry), and *Rubus parviflorus* are common in the moderately developed shrub layer.

The well-developed herb layer is dominated by *Gymnocarpium dryopteris* (oak fern); *Cornus canadensis, Rubus parviflorus*, and *Clintonia uniflora* are also frequent.

The moss layer is dominated by *Pleurozium schreberi, Ptilium crista-castrensis, Hylocomium splendens, Bracythecium hylotapetum*, and *Mnium* spp. (leafy mosses; mostly *Plagiomnium* and *Rhizomnium* spp.).

Hybrid spruce — Devil's club

The Hybrid spruce — Devil's club site association occurs on moist, nutrient-poor to -very rich sites in the moist to very wet subzones. Such moist, rich habitats typically are found on or at the base of long, steep slopes, in ravines and gullies, and along streams. However, the Hybrid spruce — Devil's club association occurs on zonal sites in the SBSvk. Soils are generally gleyed subgroups of Gray Luvisols, Brunisols, or Humo-Ferric Podzols; Gleysols also occur. Humus forms can be Hemimors, Humimors, or Mormoders.

The tree layer comprises large but widely spaced hybrid white spruce and subalpine fir. The favourable habitat is reflected in excellent tree growth.

The dominant shrubs are *Oplopanax horridus* (devil's club), *Rubus parviflorus*, and *Lonicera involucrata*. The common herbs are *Gymnocarpium dryopteris*, *Athyrium filix-femina* (lady fern), *Tiarella trifoliata* (three-leaved foamflower), *Cornus canadensis*, and *Streptopus amplexifolius*.

The Mniaceae mosses (mostly *Plagiomnium*, *Rhizomnium*, and *Mnium*) are the most common in the moss layer along with *Brachythecium* spp., *Pleurozium schreberi*, and *Ptilium crista-castrensis*.

WILDLIFE HABITATS

Important ecological factors for wildlife in this zone are the long snowy winters, the dominance of dense spruce — subalpine fir and pine forests on gently rolling terrain, and the abundant wetlands. Wildlife that inhabit this zone (Table 30) are adapted to either survive or avoid the severe winters. Moose are the most common large ungulate; in fact, the Sub-Boreal Spruce zone represents the centre of abundance of Moose in British Columbia. Moose are well adapted to survive the severe winters of much of the SBS. Their long legs reduce the energetic costs of locomotion in deep snow and their large body generates and maintains heat efficiently.

Smaller mammals survive the winter by constructing burrows under the snow (e.g., Deer Mouse) or by travelling on top of the snow (e.g., Snowshoe Hare). Most birds migrate south in winter, but some such as the Pine Grosbeak and Red Crossbill remain year-round.

Old-growth coniferous forests in this zone provide thermal and hiding cover for Moose, as well as early winter habitat for Caribou when it is adjacent to the higher elevation Engelmann Spruce — Subalpine Fir zone. These forests also provide abundant habitat and prey for several predators such as the Gray Wolf, Fisher, Marten, and Ermine. Marten are very abundant in this zone, feeding primarily on Southern Red-backed Voles. Other common rodents include Red Squirrel, Northern Flying Squirrel, Woodchuck, and Deer Mouse.

Mature coniferous forest meets the habitat requirements of different birds for a variety of reasons. Pine Siskin, Magnolia Warbler, and Yellow-rumped Warbler all prefer coniferous trees for nesting, while the Golden-crowned Kinglet feeds on foliage

TABLE 30. Selected wildlife habitats and species in the Sub-Boreal Spruce zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth spruce and subalpine fir forests	Extensive, dwindling	Moose, Mule Deer, Black Bear, Gray Wolf, Lynx, Red Fox, Fisher, Marten, Ermine, Big Brown Bat, Little Brown Myotis, Snowshoe Hare, Woodchuck, Red Squirrel, Northern Flying Squirrel, Southern Red-backed Vole, Deer Mouse, Pygmy Shrew Great Gray Owl, Boreal Owl, Three-toed Woodpecker, Black-backed Woodpecker, Gray Jay, Magnolia Warbler, Yellow-rumped Warbler, Pine Siskin, Ruby-crowned Kinglet, Golden-crowned Kinglet, Pine Grosbeak, White-winged Crossbill, Red-breasted Nuthatch	♦ Caribou
Riparian areas, wetlands, meadows, and floodplains	Common	Moose, Mule Deer, Black Bear, Beaver, Meadow Jumping Mouse Bald Eagle, Ruffed Grouse, Trumpeter Swan, Canada Goose, Herring Gull, Ring-billed Gull, Black Tern, Eared Grebe, Common Loon, Barrow's Goldeneye, Harlequin Duck, Rusty Blackbird Common Garter Snake, Western Toad, Spotted Frog, Wood Frog	♦ Caribou, Grizzly Bear, Western Grebe
Seral pine forests	Extensive	Moose, Mule Deer, Black Bear, Lynx, Snowshoe Hare, Porcupine, Yellow Pine Chipmunk, Deer Mouse, Southern Red-backed Vole, Deer Mouse Northern Goshawk, Great Horned Owl, Northern Hawk-owl, Ruffed Grouse, Spruce Grouse, Red Crossbill, Black-capped Chickadee	
Mixed deciduous and coniferous forests	Extensive	Moose, Mule Deer, Black Bear, Gray Wolf, Lynx, Marten, Ermine, Red Squirrel, Porcupine, Snowshow Hare, Deer Mouse Northern Goshawk, Northern Hawk-owl, Great Horned Owl, Common Raven, Northern Flicker, Downy Woodpecker, Yellow-bellied Sapsucker, Pine Siskin, Yellow Warbler, Dark-eyed Junco, Black-capped Chickadee, Chipping Sparrow	♦ Caribou, Northern Long-eared Myotis, Black-throated Green Warbler, Canada Warbler
Agricultural areas	Limited areal extent	Moose, Mule Deer, Black Bear, Coyote, Deer Mouse American Kestrel, Sandhill Crane, Canada Goose, Mountain Bluebird	
Grasslands and shrub-steppe	Limited areal extent	Rocky Mountain Elk, Mule Deer, Gray Wolf, Coyote, Black Bear American Kestrel, Ruffed Grouse	♦ Grizzly Bear

TABLE 30. Continued

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

insects, including the spruce budworm. Seeds from cones provide food for birds such as the Pine Siskin and Pine Grosbeak, and predatory birds like the Great Gray Owl and Boreal Owl feed on the rodent populations.

Young seral forests are created through removal of the forest canopy by logging or burning. These changes to the structure of wildlife habitat change the distribution and abundance of wildlife species. Logging prevails in this zone, so there are abundant young seral forest habitats in various stages of succession.

Some wildlife species benefit from the early successional scrub that develops after disturbance. Moose and Mule Deer will browse available forage in these shrublands, given adjacent thermal and hiding cover. Voles and mice are common, and avian predators that prefer to hunt open areas (e.g., Northern Hawk-owl and Great Horned Owl) do well in this successional stage.

Other animal species become more abundant as natural succession proceeds to lodgepole pine and aspen forests. Snowshoe Hare support an abundant Lynx population in the young seral forests. Species such as Porcupine, Red Crossbill, and Spruce Grouse occur in this type because their habitat requirements include pine.

Next to coniferous and mixed forests, the second most abundant wildlife habitat type in the SBS includes riparian areas, wetlands, meadows, floodplains, lakes, and streams. Moose forage on aquatic vegetation in shallow lakes and swamps, and on the early successional shrubs of active floodplains. Dense deciduous vegetation in riparian areas provides thermal and hiding cover for Moose. The omnivorous Grizzly Bear forages on roots, shoots, and small mammals, in a variety of wetland and riparian habitats.

The wetlands common in this zone provide excellent habitat for waterfowl. There are high breeding concentrations of Eared Grebe, Herring Gull, and Black Tern. These wetlands are the most important breeding centre in the world for Barrow's Goldeneye.

Amphibians and reptiles are poorly adapted to cold temperatures and deep snows; hence, only three amphibian and one reptile species occur in this zone. The Western Toad, Wood Frog, Spotted Frog, and Common Garter Snake are found in riparian and wetland habitats, as well as in the adjacent forests.

Agricultural areas also provide habitat for some wildlife species in the SBS. Field crops often supply forage for Moose, Mule Deer, and Canada Goose. Coyotes feed on abundant vole and mouse populations, and both the Mountain Bluebird and American Kestrel hawk insects. These man-made habitats also provide staging areas for migrating Sandhill Crane.

Natural grasslands and shrub-steppe, although scattered and uncommon, support many wildlife species. Rocky Mountain Elk are of particular note, because they are not found in any abundance elsewhere in this zone.

RESOURCE VALUES

Forest harvesting is very active in the SBS. Slightly dry and fresh sites generally have moderate capability for producing spruce and lodgepole pine; moderately dry sites have low capability for lodgepole pine; moist sites have high capability for spruce and subalpine fir growth. The SBS landscape provides large tracts of moderately productive forests and offers excellent potential for increasing fibre yields through intensive silviculture.

Most of the SBS has low capability for agriculture because of adverse climate, topography, bedrock, stoniness, or poor drainage. Lacustrine soils at the lower elevations have moderate capability, with limitations from poor soil structure and poor drainage. Alluvial deposits at lower elevations along the major rivers have the best capability for agriculture. Throughout most of the SBS, present agricultural activity is forage-based to support both cattle and dairy operations. On some of the more favourable sites, field crops and cereal grains are produced. Early seral and open mature forests, especially in the drier subzones, are used for seasonal grazing of livestock. Important range can be provided by seeding clearcuts and landings.

Fur harvest from this zone is among the highest in the province.

Recreational pursuits in the SBS include fishing, hunting, camping, studying natural history, cross-country skiing, and snowmobiling.

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Chapter 15: Engelmann Spruce — Subalpine Fir Zone

by

R. Coupé, A.C. Stewart, and B.M. Wikeem

LOCATION AND DISTRIBUTION

The Engelmann Spruce — Subalpine Fir zone (ESSF) is the uppermost forested zone in the southern three-quarters of the interior of British Columbia (Figure 54). It lies below the alpine tundra in the Rocky Mountains, Columbia Mountains, the eastern (leeward) side of the Coast Mountains, and the southern portions of the Skeena and Omineca mountains. It is also found on the highest elevations of the Interior Plateau, south of 57°N latitude. Outside of British Columbia, the ESSF occurs in Alberta as well as in the Pacific Northwest and Rocky Mountain states. In British Columbia, it occurs at elevations of 1200-2100 m in the southwest, from 1500 to 2300 m in the southeast, and from 900 to 1700 m in the northern part of the zone.

The ESSF occurs predominantly in mountainous terrain which is often steep and rugged. However, it also occurs on some dissected high plateaus, such as the Quesnel and Shuswap highlands. The ESSF typically occurs above the Interior Cedar — Hemlock, Montane Spruce, or Sub-Boreal Spruce zones. Smaller areas are found above the southern-most portions of the Boreal White and Black Spruce zone and the subcontinental portions of the Coastal Western Hemlock zone. The Spruce — Willow — Birch zone is the subalpine zone that adjoins the ESSF along its northern boundary, and the Mountain Hemlock zone is on its western boundary. In southern British Columbia, many of the lowest elevation portions of the original ESSF (Krajina 1965) are now included in the Montane Spruce zone.

ECOLOGICAL CONDITIONS

The ESSF has a relatively cold, moist, and snowy continental climate (Figure 55). Growing seasons are cool and short while winters are long and cold. According to available data (Table 4), mostly from southeastern British Columbia, mean annual temperatures range from -2 to +2°C. Mean monthly temperatures are below 0°C for 5-7 months, and above 10°C for 0 to only 2 months. Mean annual precipitation is highly variable within the zone. Relatively dry portions of the zone receive only 400-500 mm of precipitation while wetter areas receive up to 2200 mm. Most (50-70%) of the precipitation falls as snow and maximum snowpack ranges from about 1 to nearly 4 m. Soils are commonly frozen in winter, especially in areas with relatively light snowfall where freezing occurs before there is significant snow cover.

The ESSF includes continuous forest at its lower and middle elevations and subalpine parkland at its upper elevations. In the subalpine parkland, clumps of trees occur together with areas of heath, meadow, and grassland. The clumps of trees occur primarily in microsites that accumulate snow and thus provide protection from winter winds as well as a supply of growing-season moisture.

Engelmann spruce and subalpine fir are the dominant climax tree species in the ESSF. Spruce, which is typically the longer-lived species, usually dominates the canopy of mature stands; subalpine fir is most abundant in the understory. However, at high elevations of the zone and in some wetter areas, subalpine fir frequently dominates the forest canopy.

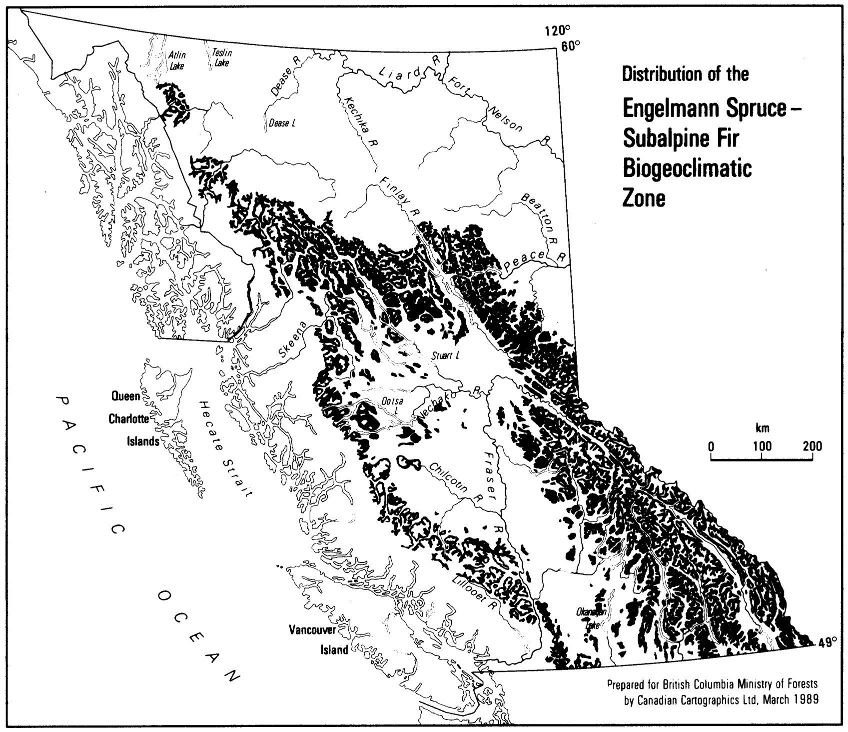

FIGURE 54. Engelmann Spruce — Subalpine Fir zone.

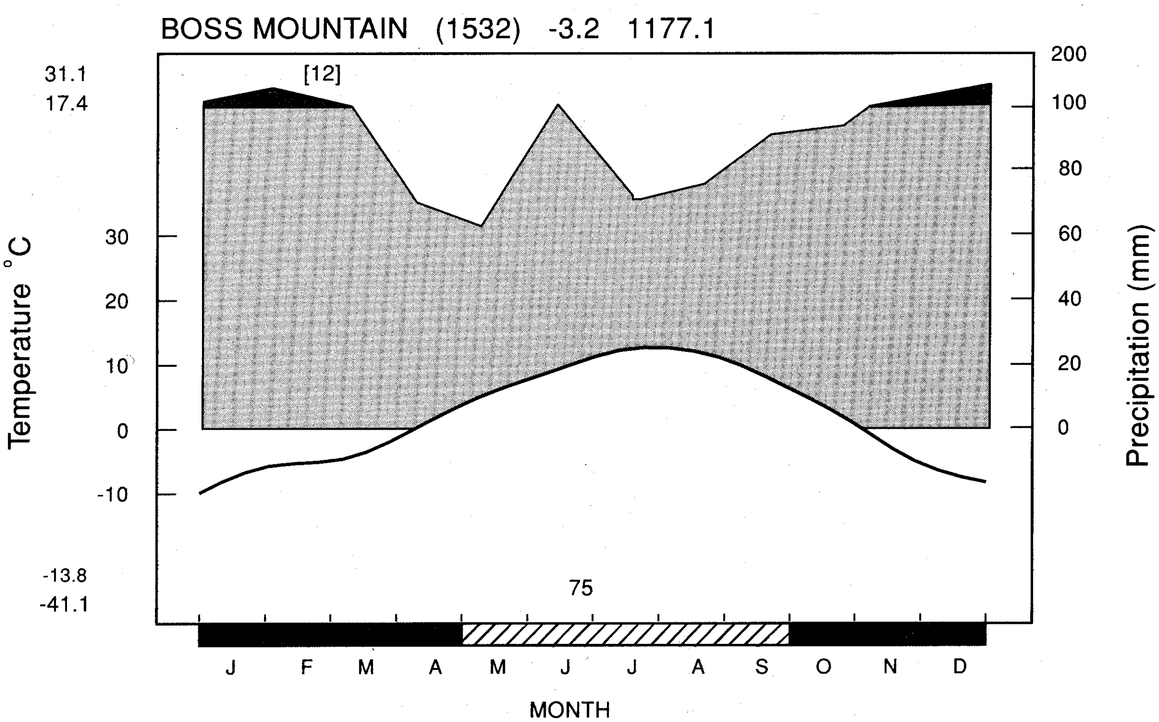

FIGURE 55. Representative climatic diagram for the Engelmann Spruce — Subalpine Fir zone.

Lodgepole pine is a widespread seral species after fire. In the driest regions of the zone, lodgepole pine forests frequently dominate the landscape. Whitebark pine, limber pine, and alpine larch also occur in this zone, usually in drier regions and on dry sites. Whitebark pine ranges north to about McBride in the east, and to the Skeena River in the west, while limber pine and alpine larch are restricted mainly to southeastern British Columbia. Mountain hemlock occurs infrequently in areas of heavy snowfall where the early snowpack probably prevents the soil from freezing. Amabilis fir occurs in areas adjacent to the Coast Mountains. Other tree species that occur commonly in lower elevation zones but occasionally in the ESSF are western white pine, Douglas-fir, western hemlock, and western redcedar. Deciduous trees are uncommon in the ESSF.

Subalpine heath that occurs at high elevations of the ESSF is closely related floristically to the heath communities of yet higher elevations in the Alpine Tundra zone. One or more of *Cassiope mertensiana* (white mountain-heather), *C. tetragona* (four-angled mountain-heather), *Phyllodoce empetriformis* (pink mountain-heather), and *P. glanduliflora* (yellow mountain-heather) dominates the heath. This heath vegetation usually develops in areas of late-lying snow.

Subalpine meadows contain a large variety of herbaceous species, often with showy flowers. Typical species throughout the ESSF include *Valeriana sitchensis* (Sitka valerian), *Veratrum viride* (Indian hellebore), *Senecio triangularis* (arrow-leaved groundsel), *Thalictrum occidentale* (western meadowrue), *Erigeron peregrinus* (subalpine daisy), *Lupinus arcticus* (arctic lupine), *Pedicularis bracteosa* (bracted lousewort), and *Castilleja miniata* (common red paintbrush). Meadows occur in open areas that are not highly exposed to winds and where the soil remains moist throughout the growing season.

Subalpine grassland is a conspicuous feature of the drier, mostly southern parts of the ESSF. These grasslands typically occur on steep, south-facing slopes in areas of base-rich bedrock. Fescue bunchgrasses are the most characteristic dominants and they include *Festuca scabrella*, *F. viridula*, or *F. altaica*, depending on the geographical area.

Snow avalanche tracks are very common in high-snowfall, mountainous portions of the ESSF. These tracks are usually occupied by a distinctive vegetation that is a tangle of tall shrub and herbaceous species. Sitka or slide alder (*Alnus crispa* ssp. *sinuata)* is the dominant shrub while *Senecio triangularis*, *Veratrum viride*, *Heracleum lanatum* (cow-parsnip), *Athyrium filix-femina* (lady fern), *Thalictrum occidentale*, *Urtica dioica* (stinging nettle), and *Carex* spp. (sedges) are common herbs.

Rapidly to moderately well-drained parent materials in the ESSF have podzolic soil development and are classified as Humo-Ferric Podzols. Humus forms are generally Mors (Hemimors, Hemihumimors, and Humimors).

SUBZONES

Fifteen forested subzones are currently recognized in the ESSF (Table 31 and Figure 56). This large number is due to the very broad latitudinal and elevational range of the zone and to the variability in climate, especially precipitation. The 15 subzones can be grouped into three broad climatic types: dry, moist, and wet.

The four dry climate subzones (ESSFxc, ESSFdc, ESSFdk, ESSFdv) occur in the southern third of the province in the rainshadow of the Coast and Columbia mountains. They occur primarily above the Montane Spruce zone and are characterized by abundant *Vaccinium scoparium* (grouseberry) and sparse herb cover in the undergrowth.

TABLE 31. Synopsis of subzones in the Engelmann Spruce — Subalpine Fir zone (ESSF)[a]

Subzone	Code	Old code
Very Dry Cold ESSF	ESSFxc	(ESSFd)
Dry Cool ESSF	ESSFdk	(ESSFa)
Dry Cold ESSF	ESSFdc	(ESSFel/e2)
Dry Very Cold ESSF	ESSFdv	(ESSFe3)
Moist Warm ESSF	ESSFmw	(ESSFf)
Moist Mild ESSF	ESSFmm	(ESSFo)
Moist Cool ESSF	ESSFmk	(ESSFl)
Moist Cold ESSF	ESSFmc	(ESSFk)
Moist Very Cold ESSF	ESSFmv	(ESSFv/n)
Wet Mild ESSF	ESSFwm	(ESSFc)
Wet Cool ESSF	ESSFwk	(ESSFh1/h3)
Wet Cold ESSF	ESSFwc	(ESSFc/m/b/h2/h3)
Wet Very Cold ESSF	ESSFwv	(ESSFi)
Very Wet Cold ESSF	ESSFvc	(ESSFb/w)
Very Wet Very Cold ESSF	ESSFvv	(ESSFu)

[a] Parkland subzones occur above each of the forested subzones. They are designated by the letter ‘p’ appended to the code (e.g., ESSFxcp is the Very Dry Cold Parkland ESSF subzone).

The moist climate group includes three Interior subzones (ESSFmv, ESSFmc, ESSFmm) and two subcontinental subzones (ESSFmk and ESSFmw). They are characterized by an ericaceous shrub layer, a sparse cover of herbs, and a relatively dense moss layer. The Interior subzones are distinguished by the presence of *Ptilium crista-castrensis* (knight’s plume), *Cornus canadensis* (bunchberry), and *Arnica cordifolia* (heart-leaved arnica). The subcontinental subzones occur immediately leeward of the Coast Mountains from the Bulkley Ranges south to the U.S. border. They are distinguished by a poorly developed herb layer and the frequent occurrence of mountain hemlock and amabilis fir.

The six subzones in the wet climate group have a moderately dense ericaceous shrub layer and a very productive, luxuriant herbaceous layer on zonal sites. Characteristic species of these subzones are *Vaccinium ovalifolium* (oval-leaved blueberry), *Gymnocarpium dryopteris* (oak fern), *Tiarella unifoliata* (one-leaved foamflower), *Streptopus roseus* (rosy twistedstalk), and *Valeriana sitchensis*. Five of

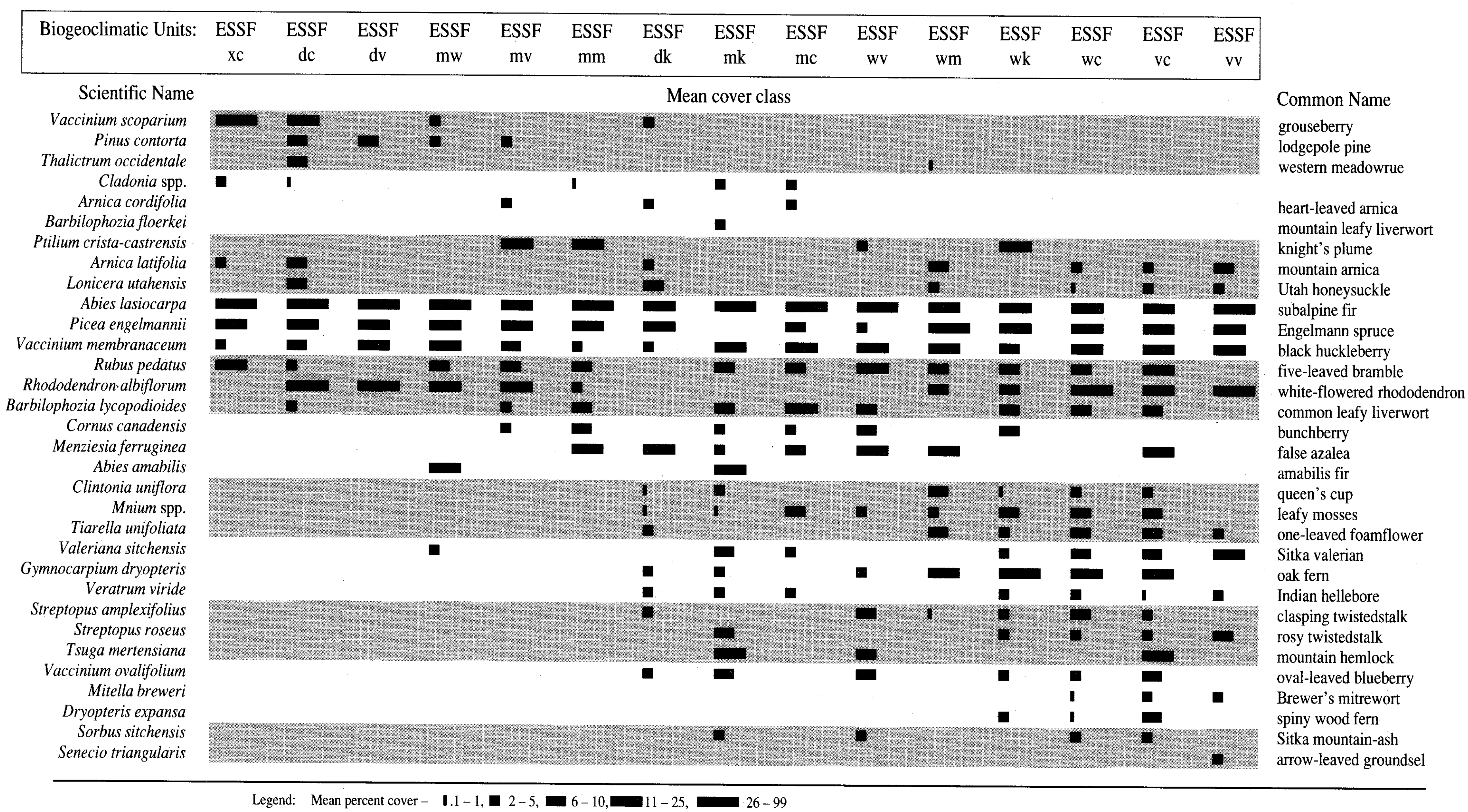

FIGURE 56. Zonal vegetation of forested subzones of the Engelmann Spruce — Subalpine fir zone.

these subzones (ESSFwm, ESSFwk, ESSFwc, ESSFvc, ESSFvv) occur in the high-snowfall areas of the Columbia and Rocky mountains of eastern British Columbia. The sixth subzone (ESSFwv) occurs in the northwestern part of the province (north of the Skeena River) on the eastern flanks of the Coast Mountains.

Fifteen parkland subzones are also recognized in the ESSF. Each forested subzone has areas of parkland above it. These areas are transitional to true alpine and are classed as separate subzones.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The four site associations described below are common in the moist and wet groups of subzones and form a typical sequence of ecosystems in the ESSFwk (Figure 57).

Subalpine fir — Oak fern — Knight's plume

The Subalpine fir — Oak fern — Knight's plume site association is the zonal association in the ESSFwk. It occurs on fresh, moderately well-drained morainal and colluvial materials with a coarse loamy texture. Soils are typically Orthic Humo-Ferric Podzols with an Orthihemimor or Mycohemimor humus form.

The tree layer is most often dominated by Engelmann spruce but occasionally by subalpine fir. Lodgepole pine is an infrequent seral species.

The shrub layer is moderately well developed and dominated primarily by *Vaccinium membranaceum* (black huckleberry), *V. ovalifolium*, *Rhododendron albiflorum* (white-flowered rhododendron), and *Ribes lacustre* (black gooseberry). Small amounts of *Oplopanax horridus* (devil's club), *Lonicera involucrata* (black twinberry), and *Rubus parviflorus* (thimbleberry) are often present, especially at lower elevations. Subalpine fir regeneration is typically abundant.

The moderately well-developed herb layer is dominated by *Streptopus roseus*, *Rubus pedatus* (five-leaved bramble), *Gymnocarpium dryopteris* (oak fern), and *Valeriana sitchensis*. Species that are usually present but in lesser amounts are *Veratrum viride, Athyrium filix-femina, Lycopodium annotinum* (stiff clubmoss), *Tiarella unifoliata*, *Clintonia uniflora* (queen's cup), and *Listera cordata* (heart-leaved twayblade).

The moss layer includes *Pleurozium schreberi* (red-stemmed feathermoss), *Rhizomnium nudum*, *Ptilium crista-castrensis* (knight's plume), *Brachythecium* spp., *Rhytidiopsis robusta* (pipecleaner moss), and *Peltigera aphthosa*.

Subalpine fir — Huckleberry — Feathermoss

This association includes the driest forested sites of the ESSFwk. It occurs on slightly to moderately dry sites on ridge crests, bedrock outcrops, and on upper, south-facing slopes. Most sites are on coarse-textured morainal or colluvial materials. Soils

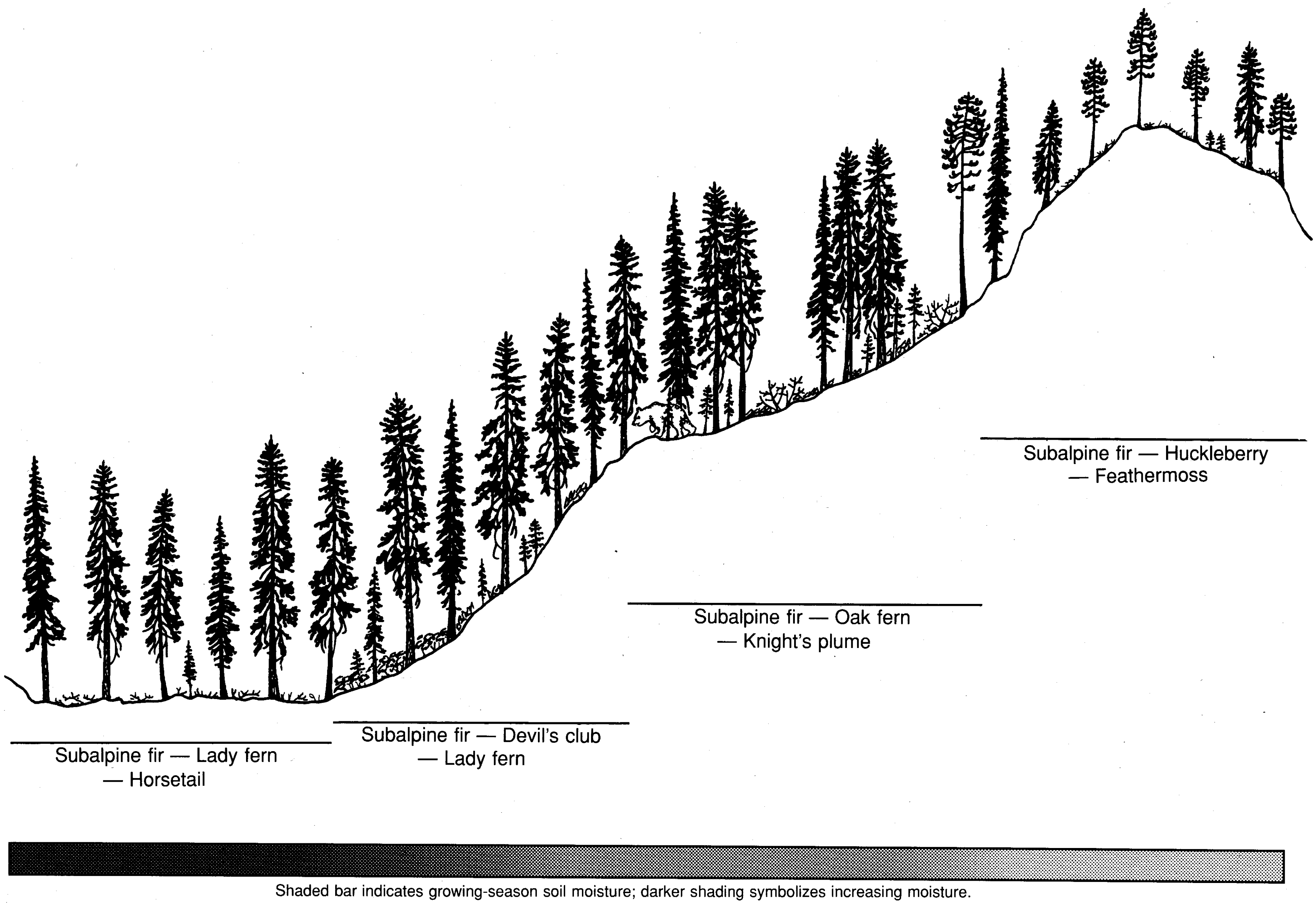

FIGURE 57. Simplified schematic diagram of topographic relationships among four common site associations of a wetter subzone of the Engelmann Spruce — Subalpine fir zone.

are typically thin, lithic phases of Humo-Ferric Podzols and Dystric Brunisols. Surface organic layers are thin, desiccated, and derived from coniferous needles, lichens, and mosses. Humus forms include Hemimors, Xeromors, and Xeromoders.

These sites are frequently occupied by long-lived seral stands of lodgepole pine. Engelmann spruce and subalpine fir are usually present in the understory.

The shrub layer is poorly to moderately well developed and typically includes *Amelanchier alnifolia* (saskatoon), *Juniperus communis* (common juniper), and *Vaccinium membranaceum* (black huckleberry). Subalpine fir and Engelmann spruce regeneration is relatively sparse.

The sparse herbaceous layer includes *Cornus canadensis*, *Hieracium albiflorum* (white-flowered hawkweed), *Linnaea borealis* (twinflower), *Clintonia uniflora*, and *Epilobium angustifolium* (fireweed).

The moss layer is usually continuous and dominated by *Pleurozium schreberi* (red-stemmed feathermoss), *Ptilium crista-castrensis*, *Dicranum* spp., and *Polytrichum juniperinum* (juniper haircap moss). Fruticose lichens, especially species of *Stereocaulon*, *Cladonia*, and *Cladina*, are usually abundant.

Subalpine fir — Devil's club — Lady fern

The Subalpine fir — Devil's club — Lady fern site association occurs on moist, moderately well to imperfectly drained, middle and lower slope positions in the ESSFmk, ESSFmm, and ESSFwv. Soils are primarily Orthic Humo-Ferric Podzols but also include Gleyed and Sombric Humo-Ferric Podzols.

Engelmann spruce and subalpine fir are the dominant tree species. Spruce is most often dominant in the moist subzones, while subalpine fir is most often dominant in the wet subzone. Western hemlock is frequently present in the ESSFwv.

The dense shrub layer is dominated by *Oplopanax horridus* (devil's club). Other common species are *Vaccinium membranaceum*, *Menziesia ferruginea* (false azalea), and *Ribes lacustre*.

Ferns, especially *Athyrium filix-femina* (lady fern), *Gymnocarpium dryopteris*, and *Dryopteris expansa* (spiny wood fern), are abundant. Other common herbs are *Streptopus roseus*, *Rubus pedatus*, *Tiarella unifoliata*, and *Veratrum viride*.

A moderate cover of mosses is present and most often includes *Brachythecium hylotapetum*, *Ptilium crista-castrensis*, *Mnium* spp. (includes *Plagiomnium* and *Rhizomnium* spp.; leafy mosses), and *Pleurozium schreberi*.

Subalpine fir — Lady fern — Horsetail

This site association occurs on very moist to wet, imperfectly to poorly drained sites on lower slopes and in depressions. Soils are Humic Gleysols or Orthic Gleysols and are typically wet throughout the growing season.

These ecosystems have relatively open forest canopies dominated by Engelmann spruce and subalpine fir. Trees occur primarily on raised microsites.

The shrub layer is poorly to moderately developed. *Ribes lacustre*, *Vaccinium ovalifolium*, *Rubus parviflorus*, and *Lonicera involucrata* are often present.

The herb layer is relatively well developed and dominated by *Equisetum arvense* (common horsetail), *Athyrium filix-femina*, *Senecio triangularis*, *Thalictrum occidentale*, *Gymnocarpium dryopteris*, and *Valeriana sitchensis*. Common but less abundant species include *Heracleum lanatum* (cow-parsnip), *Platanthera dilatata* (white bog-orchid), and *Tiarella unifoliata*.

A moderate cover of mosses is present. Principal species are *Ptilium crista-castrensis* and *Brachythecium* spp.

WILDLIFE HABITATS

The factors that most influence the assemblage of wildlife species in the ESSF (Table 32) are the wet, cool summers, long cold snowy winters, and steep topography. Ungulates such as Moose, Mountain Goat, Caribou, and Mule Deer are found throughout while Rocky Mountain Elk, Bighorn Sheep, White-tailed Deer, and Stone Sheep are more restricted in distribution. Moose can occasionally winter in some of the drier regions of the ESSF, but normally leave during winter to escape the deep snowfall. Mountain Goat and Caribou are best adapted to these conditions and frequently winter in the ESSF. The ESSF is one of the most productive zones for Grizzly Bear. Few reptiles occur in this zone and the only amphibians expected to be found are the Western Toad, Spotted Frog, Cascades Frog, Tailed Frog, and Long-toed Salamander.

Conifer forests make up the most common habitat in the ESSF and are important for furbearers such as Marten, Fisher, Red Squirrel, and Wolverine, as well as for a variety of seed-eating birds such as the Red Crossbill, White-winged Crossbill, Pine Siskin, and Clark's Nutcracker. In heavy snow areas, Caribou rely exclusively during the winter on arboreal lichens, which are abundant in mature conifer forests in the ESSF, particularly those adjacent to the Interior Cedar — Hemlock zone. Wildlife managers have long been concerned with the impacts of timber harvesting on Caribou in this zone because of the lichen component in old-growth forests. Other species found in old-growth habitats include the Varied Thrush, Three-toed Woodpecker, Spruce Grouse, Golden-crowned Kinglet, Red-breasted Nuthatch, Mountain Chickadee, Winter Wren, Orange-crowned Warbler, Steller's Jay, Cassin's Finch, and Hammond's Flycatcher.

Avalanche tracks are a common feature of the ESSF. These habitats are important summer range for ungulates because of the abundant, lush forage. For the same reason, avalanche tracks are also important spring and summer habitats for Grizzly Bear and Black Bear.

Young seral forests, resulting from logging and wildfire, provide habitat for a wide variety of wildlife. Many species of ungulates, and the Snowshoe Hare, select young

TABLE 32. Selected wildlife habitats and species in the Engelmann Spruce — Subalpine Fir zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Old-growth and mature coniferous forests	Extensive	Moose, Mule Deer, Cougar, Lynx, Gray Wolf, Coyote, Black Bear, Wolverine, Fisher, Marten, Red Squirrel, Northern Flying Squirrel, Snowshoe Hare, Silver-haired Bat, Little Brown Myotis, Long-legged Myotis, Southern Red-backed Vole, Deer Mouse, Masked Shrew Barred Owl, Great Gray Owl, Blue Grouse, Spruce Grouse, Black-backed Woodpecker, Three-toed Woodpecker, Steller's Jay, Clark's Nutcracker, Varied Thrush, Red Crossbill, White-winged Crossbill, Pine Siskin, Hammond's Flycatcher, Cassin's Finch, Golden-crowned Kinglet, Mountain Chickadee, Red-breasted Nuthatch, Winter Wren Long-toed Salamander	∇ Spotted Owl ♦ Caribou, Grizzly Bear, Tailed Frog
Subalpine parkland meadows	Limited areal extent	Mountain Goat, Moose, Mule Deer, Rocky Mountain Elk, Black Bear, Coyote, Badger, Long-tailed Weasel, Porcupine, Hoary Marmot, Columbian Ground Squirrel, Golden-mantled Ground Squirrel Blue Grouse, Golden-crowned Sparrow, Fox Sparrow, American Robin, Rufous Hummingbird	∇ Cascade Mantled Ground Squirrel ♦ Caribou, California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Grizzly Bear, Red-tailed Chipmunk
Young seral forests	Extensive	Moose, Mule Deer, Black Bear, Lynx, Coyote, Little Brown Myotis, Snowshoe Hare, Porcupine, Heather Vole, Deer Mouse, Masked Shrew Northern Goshawk, Northern Hawk Owl, Northern Pygmy-Owl, Three-toed Woodpecker, Black-backed Woodpecker, Wilson's Warbler, Rufous Hummingbird, Pine Grosbeak, Western Tanager, Dark-eyed Junco, Yellow-rumped Warbler, Bohemian Waxwing	♦ Grizzly Bear
Steep, rugged, south aspect grasslands	Limited areal extent	Mountain Goat, Cougar, Hoary Marmot, Golden-mantled Ground Squirrel Golden Eagle, Blue Grouse	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep
Avalanche tracks	Common in mountains	Mountain Goat, Moose, Rocky Mountain Elk, Mule Deer, Black Bear	♦ Grizzly Bear
Rocky cliffs, talus, and sparsely vegetated rocks	Common in mountains	Mountain Goat, Common Pika, Columbian Ground Squirrel, Golden-mantled Ground Squirrel Golden Eagle	∇ Cascade Mantled Ground Squirrel, Anatum Peregrine Falcon ♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep

TABLE 32. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Riparian areas, wetlands, meadows, floodplains, lakes, and streams	Common	Moose, Mule Deer, Black Bear, Coyote, Long-tailed Weasel, Little Brown Myotis, Beaver, Water Vole, Deer Mouse, Western Jumping Mouse, Meadow Jumping Mouse Ruffed Grouse, Harlequin Duck, American Dipper Western Toad, Spotted Frog, Cascades Frog, Long-toed Salamander	♦ Caribou, Grizzly Bear, Mountain Beaver, Tailed Frog, Cascades Frog

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

forests during summer for the abundant forbs and shrubs. During fall, Black Bear and Grizzly Bear seek out blueberries and huckleberries, which can be very abundant in open stands. Breeding birds commonly found in the young seral forests include the Northern Pygmy-Owl, Northern Goshawk, Wilson's Warbler, Rufous Hummingbird, Pine Grosbeak, Western Tanager, Dark-eyed Junco, Yellow-rumped Warbler, Three-toed Woodpecker, Black-backed Woodpecker, and Bohemian Waxwing.

Wetlands and riparian habitats in the ESSF are frequently not as productive as equivalent areas in adjacent lower elevation zones, and have lower species diversity. Moose, Grizzly Bear, and Black Bear are commonly associated with such habitats. Swift-flowing streams are important habitats for Harlequin Duck, American Dipper, and the Tailed Frog (in extreme southeastern British Columbia).

Subalpine parkland is a common habitat at the upper elevations of the ESSF. The parkland forests of southeastern British Columbia have abundant arboreal lichens and are important for Caribou, which move up from lower elevations in late winter after the deep snows have settled. The associated meadows provide valuable summer range for many large mammals including Mule Deer, Rocky Mountain Elk, Mountain Goat, Caribou, Moose, Bighorn Sheep, Grizzly Bear, and Black Bear. Commonly observed small mammals include the Hoary Marmot, Columbian Ground Squirrel, and Porcupine. The Golden-crowned Sparrow, Fox Sparrow, American Robin, and Rufous Hummingbird are common birds of ESSF parkland.

In this zone, Mountain Goat frequently inhabit rugged south-facing terrain on a year-round basis. Mountain Sheep, which have much less tolerance to deep snow, are usually found in such subalpine habitat only in summer and fall. Blue Grouse are also associated with these habitats, especially during winter. Golden Eagle select south-facing cliffs for nest sites (aeries), particularly where large rodents such as the Hoary Marmot and Columbian Ground Squirrel are abundant.

RESOURCE VALUES

Timber harvesting is very active in the accessible parts of the ESSF. The most productive ecosystems are those with fresh to moist moisture regimes at lower elevations of the zone. Best growth occurs in rich alluvial ecosystems and on lower slope sites which receive nutrient-laden seepage waters from upslope. Such ecosystems are highly productive for Engelmann spruce and subalpine fir.

The ESSF has very low capability for agriculture because of the adverse climate and topography. Domestic livestock grazing during the brief summer season is the only significant agricultural use. Although the zone is extensive, grazing is limited to wetlands and forest openings (McLean *et al*. 1963), mainly in drier subzones. Clearcuts can serve as transitional range and can be highly productive when seeded to domestic forages. Forage species are poorly documented, but common native forages include *Carex* spp., *Calamagrostis rubescens*, *Phleum alpinum*, *Danthonia intermedia*, and *Arnica cordifolia*, and *Vaccinium* spp. browse (McLean *et al*. 1971).

Fur harvest from this zone is among the highest in the province.

Recreational pursuits in the ESSF include skiing, hiking, mountaineering, hunting, and camping. Many of British Columbia's provincial and national parks include ruggedly scenic parts of the ESSF.

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Chapter 16: Boreal White and Black Spruce Zone

by

C. DeLong, R.M. Annas, and A.C. Stewart

LOCATION AND DISTRIBUTION

Most of the Boreal White and Black Spruce zone (BWBS) in British Columbia occurs on an extension of the Great Plains (the Alberta Plateau) into the northeastern corner of the province (Figure 58). This corner makes up about 10% of the total land area of British Columbia. The zone also occupies the lower elevations of the main valleys west of the northern Rocky Mountains (Figure 58). In northeastern British Columbia, this lowland to montane zone occurs north of roughly 54°N latitude and at elevations ranging from 230 to approximately 1300 m. In northwestern British Columbia, it occurs north of 56° from the valley bottoms to 1000-1100 m elevation. The vast majority of the zone occurs above 600 m; the main exceptions are the Fort Nelson Lowland (± 450 m) and some deeply incised valleys (e.g., Peace, Stikine, Liard, Ft. Nelson, Petitot).

The Spruce — Willow — Birch zone is the subalpine zone above the BWBS over most of its range in the province, but in the southern part of the BWBS, the Engelmann Spruce — Subalpine Fir zone occurs above it.

The BWBS is the most widespread zone in Canada, occurring from the Yukon Territory across all the provinces to Newfoundland.

ECOLOGICAL CONDITIONS

The northern continental climate, with its frequent outbreaks of arctic air masses, features long, very cold winters and short growing seasons (Figure 59; Table 4). The mean annual temperature for long-term climatic stations within the zone is -2.9 to 2°C. The daily maximum temperature can be quite high in mid-summer, but monthly averages remain below 0°C for 5-7 months of the year, and above 10°C for only 2-4 months. Annual precipitation averages between 330 and 570 mm, with 35-55% of this falling as snow. The ground freezes deeply for a large part of the year, and discontinuous permafrost is common in the northeastern parts of the zone.

White spruce, trembling aspen, lodgepole pine, black spruce, balsam poplar, tamarack, subalpine fir, common paper birch, and Alaska paper birch are the major tree species in the forested sections of the BWBS. Forest fires are frequent throughout the zone, maintaining most of the forests in various successional stages.

Forests predominate in the better-drained plateau, foothill, and cordilleran sections of the zone, where mixed trembling aspen — white spruce forests on Gray Luvisols dominate the landscape.

Relatively open pine — lichen forests occur on the driest sites, which are usually on rapidly drained outwash deposits. Mixed pine and black spruce stands are common on level or gently sloping, north-facing sites on compacted morainal or lacustrine soils. Dense black spruce — moss communities develop on imperfectly drained sites.

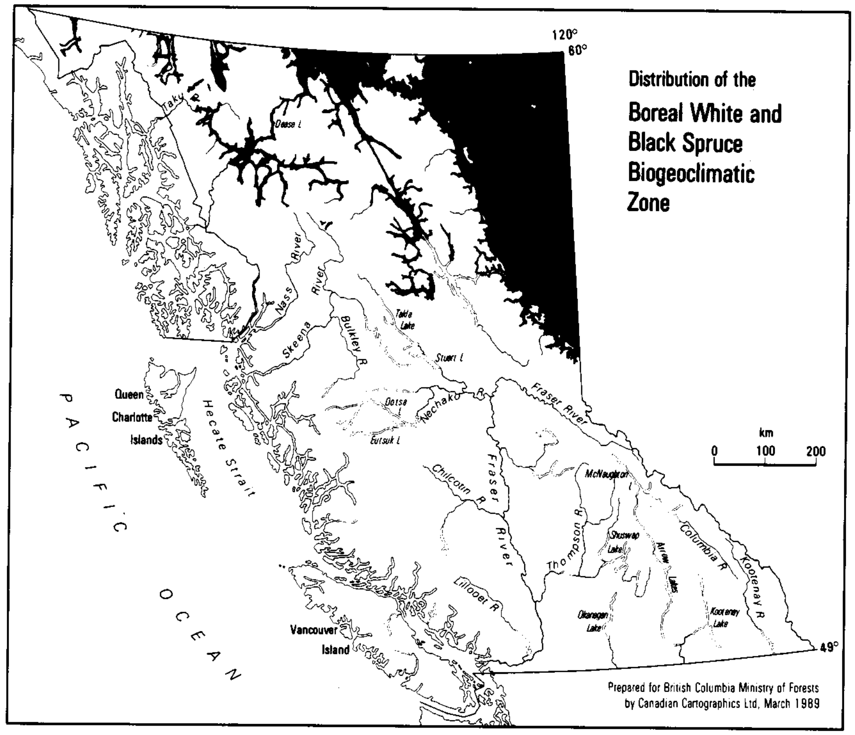

FIGURE 58. Boreal White and Black Spruce zone.

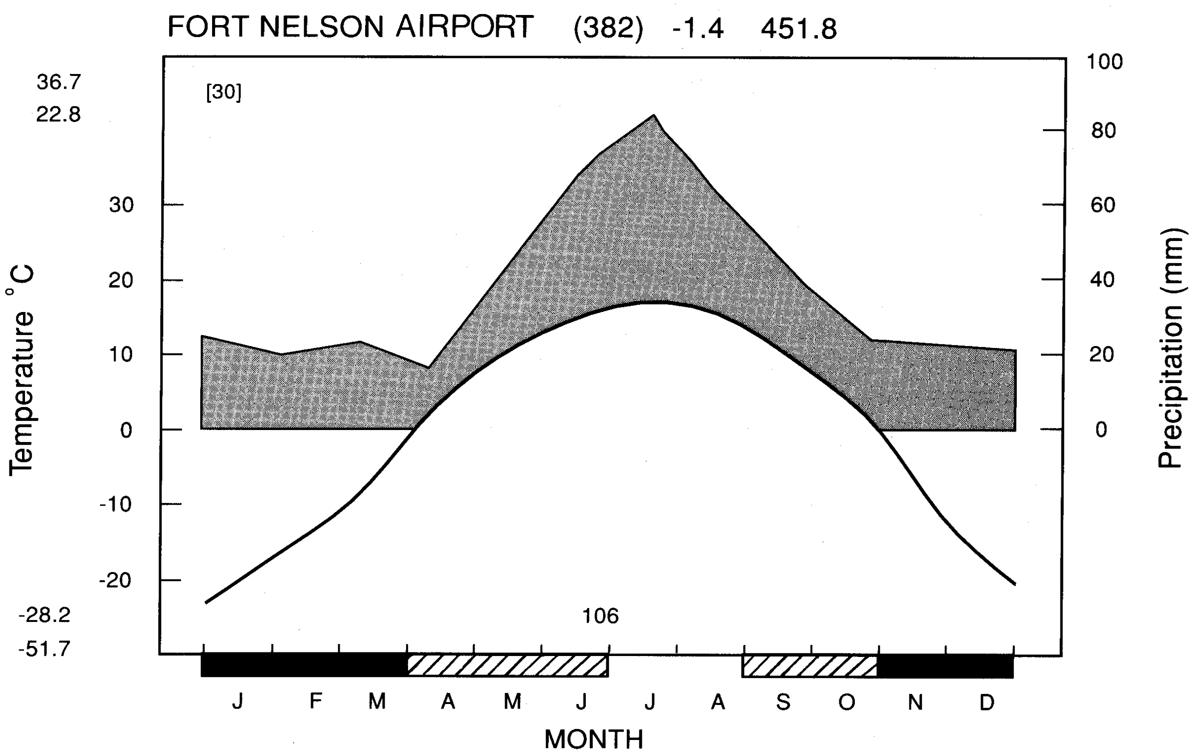

FIGURE 59. Representative climatic diagram for the Boreal White and Black Spruce zone.

The most productive forests and agricultural lands of this zone occur on rich, well-drained alluvial sites. White spruce and balsam poplar can reach heights of over 50 m, and productivity can exceed 7 m^3/ha per year. Soils are typically Cumulic Regosols on these floodplains.

The poorly drained lowlands (especially the Fort Nelson Lowland) are a mosaic of forest and wetland ecosystems. Here, Organic Cryosols, Luvic Gleysols, and Organics are the most common soils. The build-up of organic matter from bog vegetation tends to insulate frozen ground, resulting in lenses of permafrost. Black spruce and occasionally tamarack are the main trees on organic terrain. They are, however, much reduced in size compared to their stature on upland sites.

Tamarack forms pure stands only in nutritionally rich (minerotrophic) fens and swamps, and occurs mainly north and east of the Rockies (basically on the Alberta Plateau and the Liard Plain). Common species of these fens are *Carex* spp. (sedges), *Betula glandulosa* (scrub birch), *Betula pumila* (swamp birch), *Chamaedaphne calyculata* (leatherleaf), *Myrica gale* (sweet gale), *Andromeda polifolia* (bog-rosemary), *Ledum groenlandicum* (Labrador tea), *Menyanthes trifoliata* (buckbean), *Drosera rotundifolia* (round-leaved sundew), *Oxycoccus oxycoccos* (bog cranberry), and the mosses *Aulacomnium palustre* (glow moss), *Tomenthypnum nitens* (golden fuzzy fen moss), and *Sphagnum* spp. (sphagnum mosses).

Grassland and scrub communities occur (usually in small pockets) on steep, south-facing slopes above many of the major rivers such as the Peace and the Stikine. Chernozemic, Chernozem-like, and Brunisolic soils occur in these ecosystems. Common shrubs include *Rosa acicularis* (prickly rose), *Rosa woodsii* (Wood's rose), *Amelanchier alnifolia* (saskatoon), *Symphoricarpos occidentalis* (western snowberry), and trembling aspen. Herbs and grasses include *Artemisia frigida* (pasture sage), *A. campestris* (northern wormwood), *Agropyron smithii* (western wheatgrass), *Achillea millefolium* (yarrow), *Koeleria macrantha* (junegrass), *Stipa comata* (needle-and-thread grass), *Galium boreale* (northern bedstraw), and *Antennaria microphylla* (rosy pussytoes).

Humus forms in mature conifer stands are mostly Hemimors with some Hemihumimors, Velomors, and Humimors. Mixedwood and aspen stands have humus forms that are usually Hemimors and Hemihumimors, but are thinner than in conifer stands. Mormoders are also found in aspen ecosystems.

Important agricultural land exists in the BWBS around Dawson Creek and Fort St. John. Many of these soils have developed on lacustrine clays over marine shales and show Solonetzic development.

SUBZONES

Three subzones are recognized in the BWBS (Table 33 and Figure 60) in British Columbia. Distinguishing species for the dry, cool BWBSdk include *Shepherdia canadensis* (soopolallie) and *Geocaulon lividum* (bastard toad-flax). The moist, warm BWBSmw typically has *Lathyrus ochroleucus* (creamy peavine), *Mertensia paniculata* (tall bluebells), *Galium boreale,* and *Mitella nuda* (common mitrewort). *Abies lasiocarpa* (subalpine fir) and *Vaccinium membranaceum* (black huckleberry) help differentiate the wet, cool BWBSwk from the other two boreal subzones.

TABLE 33. Synopsis of subzones in the Boreal White and Black Spruce zone (BWBS)

Subzone	Code	Old code
Dry Cool BWBS	BWBSdk	(BWBSe/a2)
Moist Warm BWBS	BWBSmw	(BWBSc1/c2/a1)
Wet Cool BWBS	BWBSwk	(BWBSd1/d2/b)

The BWBSdk is found primarily west of the Rocky Mountains except where it follows the Liard River as it slices east through the mountains. It is located below the Spruce — Willow — Birch (SWB) and in some cases the Engelmann Spruce — Subalpine Fir (ESSF) zones. The regional climate is drier and cooler with a shorter growing season than that of the BWBSmw. The forests are dominated by white spruce or lodgepole pine.

The BWBSmw covers the rolling topography from the Red Willow River, near where the 120°W longitude (i.e., Alberta border) intercepts the Rocky Mountains, north to the Yukon and Northwest Territories borders. Elevation ranges from 600 to 1050 m in the south and 350 to 1100 m in the north. The regional climate is relatively moist and warm with a longer growing season than the higher elevation BWBSwk. The forests are dominated by white spruce or aspen.

The BWBSwk is found in the foothills and on lower to middle slopes of the Rocky Mountains, from the Alberta border north to the Yukon. The BWBSwk is widespread at its southern extent; in the north it is reduced to isolated pockets. It is located between the BWBSmw and either the ESSF or SWB at elevations of 900-1300 m, depending on latitude and topography. The climate is wetter and cooler with a shorter growing season than the BWBSmw. The forests are dominated by white spruce or lodgepole pine.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following four site associations are common in the BWBS landscape. They form a typical sequence of ecosystems in the southern portion of the BWBSmw (Figure 61).

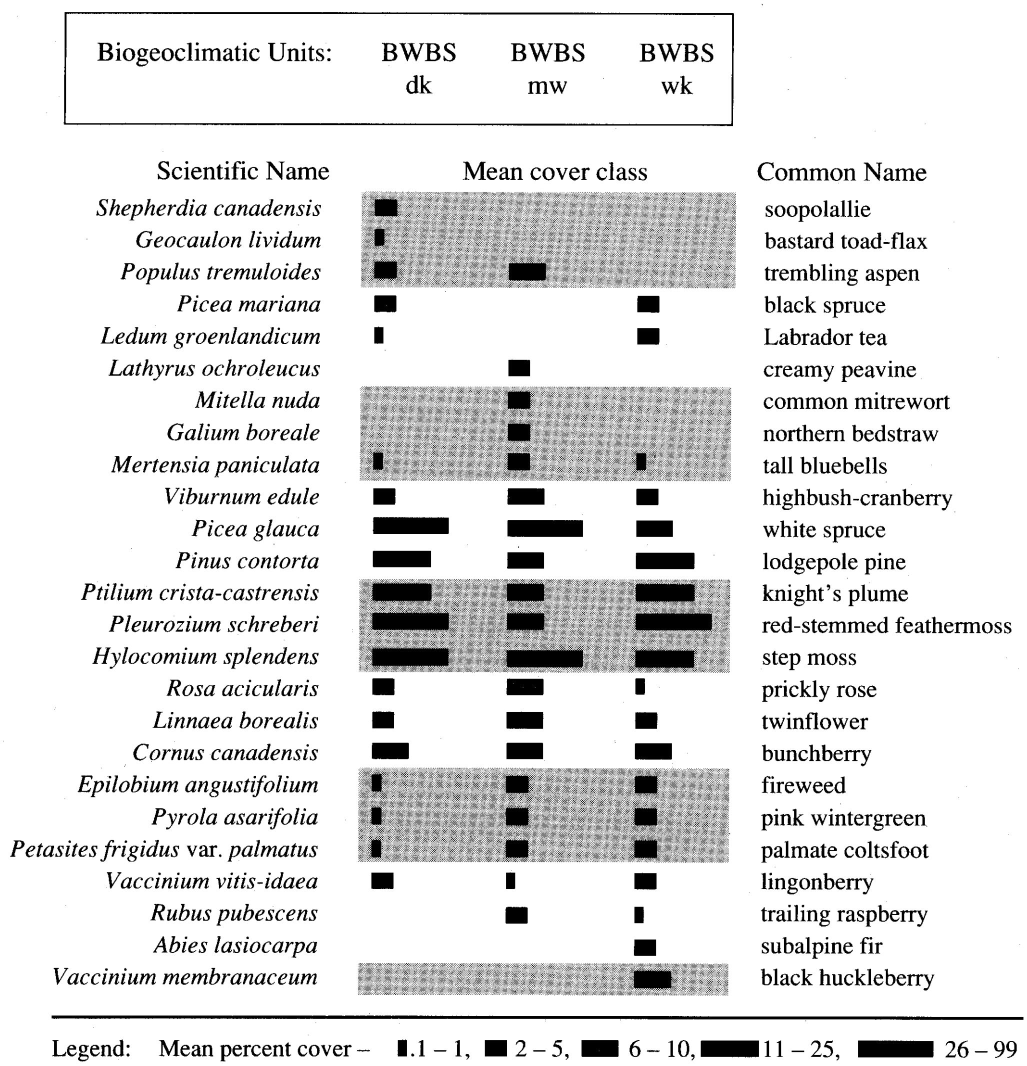

FIGURE 60. Zonal vegetation of subzones of the Boreal White and Black Spruce zone.

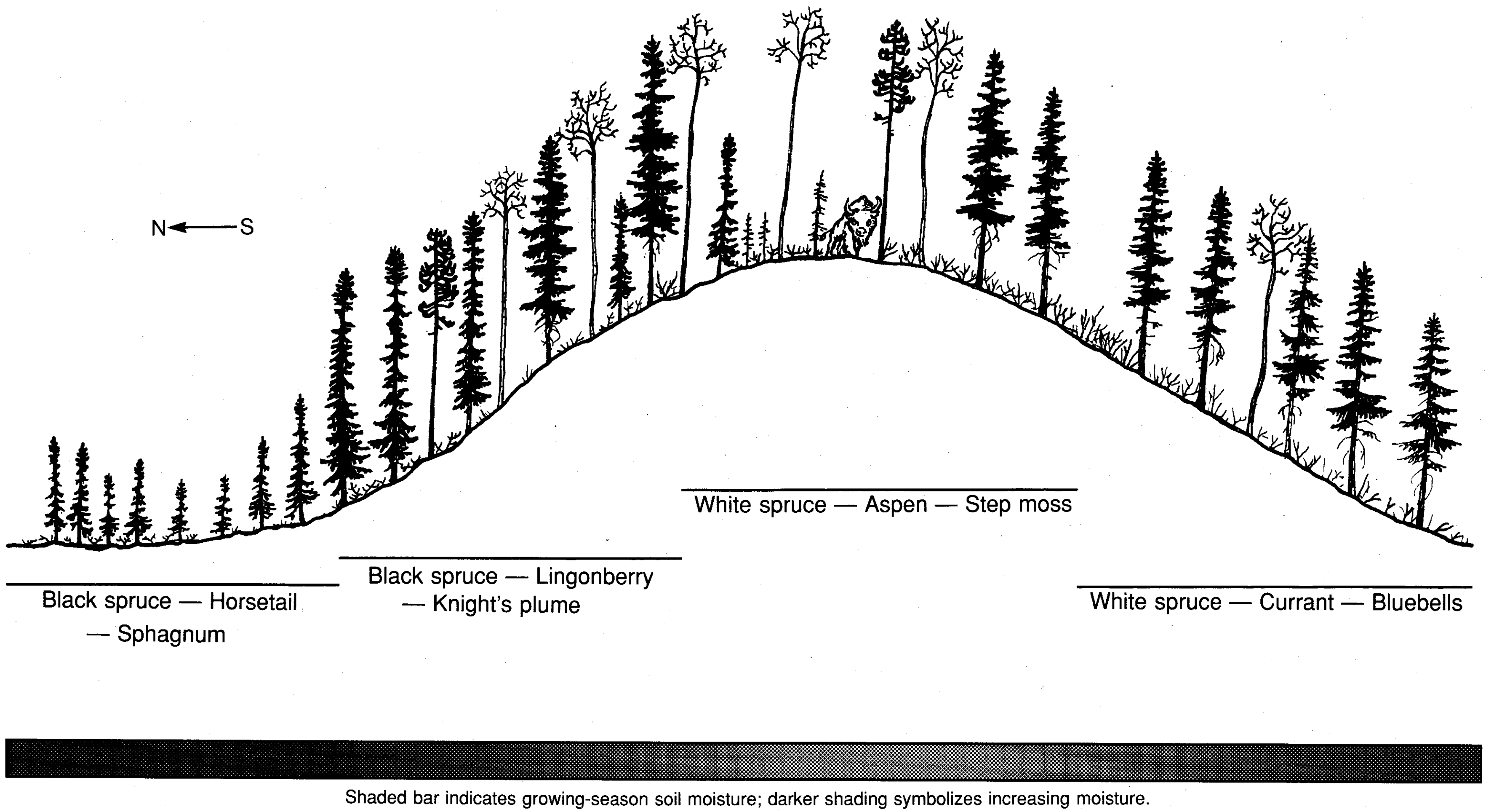

FIGURE 61. Simplified schematic diagram of topographic relationships among four common site associations of the Boreal White and Black Spruce zone.

White spruce — Aspen — Step moss

The White spruce — Aspen — Step moss association is very common east of the Rocky Mountains. It is the zonal association in the BWBSmw and is mostly found on moderately well-drained, fresh to slightly dry sites in the uplands. Soils are primarily fine-textured Gray Luvisols with some Brunisols. Hemimors and Mormoders are the most common humus forms.

Mature stands are usually well stocked with white spruce. Seral stands are dominated by trembling aspen with occasional components of balsam poplar and lodgepole pine.

The shrub layer is well developed and dominated by *Viburnum edule* (highbush-cranberry) and *Rosa acicularis*. Advance regeneration of white spruce is a consistent feature.

Common herbs include *Linnaea borealis* (twinflower), *Rubus pubescens* (trailing raspberry), *Mertensia paniculata*, *Petasites frigidus* var. *palmatus* (palmate coltsfoot), *Pyrola asarifolia* (pink wintergreen), and *Cornus canadensis* (bunchberry).

The moss layer is usually dominated by *Hylocomium splendens* (step moss), *Pleurozium schreberi* (red-stemmed feathermoss), and *Ptilium crista-castrensis* (knight's plume).

Black spruce — Lingonberry — Knight's plume

The Black spruce — Lingonberry — Knight's plume association occurs on moist to wet, nutrient-very poor to -poor sites on level to gently sloping north-facing slopes throughout the zone. Soils are usually medium- to fine-textured Dystric Brunisols or Grey Luvisols. Hemimors are the most common humus forms.

Lodgepole pine and black spruce dominate mature stands; trembling aspen or lodgepole pine dominate seral stands.

The most common shrubs are *Rosa acicularis* and *Ledum groenlandicum*; *Alnus crispa* ssp. *crispa* (green alder) is sometimes present.

Cornus canadensis, *Linnaea borealis*, *Vaccinium vitis-idaea* (lingonberry), *Epilobium angustifolium* (fireweed), *Petasites frigidus* var. *palmatus*, and *Vaccinium caespitosum* (dwarf blueberry) generally dominate the herb layer.

The well-developed moss layer is primarily composed of the mosses *Pleurozium schreberi*, *Hylocomium splendens* and *Ptilium crista-castrensis* (knight's plume), and the lichen *Peltigera aphthosa*.

White spruce — Currant — Bluebells

The White spruce — Currant — Bluebells association is found on moist, nutrient-medium to -rich sites generally in moisture-receiving topographic positions in the BWBSmw and wk. Soils are usually Gray Luvisols or Luvic Gleysols. Hemimors and Mormoders are the most common humus forms.

The shrub layer is usually dominated by *Viburnum edule*, *Rosa acicularis*, *Ribes triste* (red swamp currant), and *Lonicera involucrata* (black twinberry).

Cornus canadensis, *Epilobium angustifolium*, *Linnaea borealis*, *Rubus pubescens*, *Mertensia paniculata* (tall bluebells), *Petasites frigidus* var. *palmatus*, and *Mitella nuda* usually dominate the herb layer. As well, *Calamagrostis canadensis* (bluejoint) is often a dominant component of this layer, especially after any disturbance to the stand.

The moss layer is dominated by *Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*.

Black spruce — Horsetail — Sphagnum

The Black spruce — Horsetail — Sphagnum association contains vegetation characteristic of plateau bogs in the Dawson Creek/Fort St. John area. These plateau bogs are very common on poorly drained organic soils. On the nutrient-poorer sites the humus forms are Hydromors or Histomors and on the nutrient-richer sites they are Hydromoders or Histomoders.

Growth of trees is very poor in these bogs; black spruce is dominant, with tamarack forming a minor component of the stunted stands.

Characteristic shrubs include *Ledum groenlandicum* and *Salix myrtillifolia* (bilberry willow).

The herb layer is usually dominated by *Vaccinium vitis-idaea*, *Equisetum* spp. (*scirpoides* [dwarf scouring-rush], *sylvaticum* [wood horsetail], *arvense* [common horsetail]), and *Petasites frigidus* var. *palmatus*.

The moss layer is dominated by *Hylocomium splendens*, *Pleurozium schreberi*, *Aulacomnium palustre*, and *Sphagnum* spp.

WILDLIFE HABITATS

Despite a harsh climate, this zone is surprisingly rich in wildlife (Table 34). The BWBS has the least snowfall of all the northern zones and consequently is very important for wintering ungulates. Moose, Caribou and, to a lesser degree, Mule Deer are distributed throughout, while Rocky Mountain Elk, White-tailed Deer, and Wood Bison are found primarily east of the Rocky Mountains. Stone Sheep, Dall Sheep, and Mountain Goat occur sporadically, wherever suitable rugged terrain exists. The largest known population of "canyon dwelling" Mountain Goat in Canada occurs in the Grand Canyon of the Stikine. Large carnivores such as Black Bear and Gray Wolf are widespread and abundant, while Grizzly Bear are common in the mountainous regions of the BWBS.

Frequent forest fires have formed a mosaic of upland forests of different ages in the BWBS. Conifers are often slow to re-establish after fire and deciduous forests of aspen and willow are commonplace and persistent. These deciduous forests are very productive habitats for ungulates, a wide selection of birds (including many of the warblers, thrushes, vireos, and flycatchers), and a variety of small mammals.

Some birds, such as the Black-throated Green Warbler, White-throated Sparrow, Rose-breasted Grosbeak, Broad-winged Hawk, and Blue Jay, are not commonly found in other zones.

TABLE 34. Selected wildlife habitats and species in the Boreal White and Black Spruce zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Mixed deciduous and coniferous forests	Extensive	Moose, Rocky Mountain Elk, Mule Deer, White-tailed Deer, Black Bear, Gray Wolf, Lynx, Marten, Ermine, Red Squirrel, Porcupine, Snowshoe Hare, Deer Mouse Northern Goshawk, Broad-winged Hawk, Northern Hawk-owl, Great Horned Owl, Sharp-tailed Grouse, Ruffed Grouse, Common Raven, Gray Jay, Blue Jay, Downy Woodpecker, Yellow-bellied Sapsucker, Hermit Thrush, Least Flycatcher, Yellow Warbler, Dark-eyed Junco, Red-eyed Vireo, Black-capped Chickadee, Purple Finch, White-throated Sparrow, Rose-breasted Grosbeak	♦ Caribou, Northern Long-eared Myotis, Black-throated Green Warbler, Canada Warbler
Mature coniferous forests	Extensive	Moose, Gray Wolf, Coyote, Lynx, Wolverine, Marten, Red Squirrel, Least Chipmunk, Northern Red-backed Vole Northern Goshawk, Boreal Owl, Great Gray Owl, Spruce Grouse, Northern Shrike, Red-breasted Nuthatch, Boreal Chickadee	♦ Caribou, Gray-cheeked Thrush
Peatlands or muskeg	Extensive on plains and lowlands	Moose, Meadow Jumping Mouse, Western Jumping Mouse, Northern Bog Lemming, Water Vole, Arctic Shrew Northern Harrier, Great Gray Owl, Boreal Owl, Sharp-tailed Grouse, Solitary Sandpiper, Lesser Yellowlegs, Le Conte's Sparrow, Swamp Sparrow, Blackpoll Warbler, Palm Warbler, Yellow-bellied Flycatcher, Olive-sided Flycatcher, Marsh Wren Striped Chorus Frog, Wood Frog	∇ Wood Bison ♦ Grizzly Bear, Black-throated Green Warbler, Connecticut Warbler
Wetlands, shallow lakes, and streams	Common	Moose, Beaver, Muskrat, Mink, Water Shrew Trumpeter Swan, Red-throated Loon, Sora, Mallard, Northern Pintail, Blue-winged Teal, Northern Shoveller, Barrow's Goldeneye, Bufflehead, Ring-necked Duck, Oldsquaw, White-winged Scoter, Horned Grebe, Bonaparte's Gull, Herring Gull, Franklin's Gull, Mew Gull, Black Tern, Semipalmated Plover, Common Snipe, Semipalmated Sandpiper, White-rumped Sandpiper, Wilson's Phalarope, Red-winged Blackbird, Tree Swallow Wood Frog, Striped Chorus Frog, Spotted Frog	♦ Pacific Loon, Arctic Loon, Ring-billed Gull, Least Sandpiper, Short-billed Dowitcher, Wandering Tattler, Arctic Tern, Yellow-headed Blackbird, Purple Martin

TABLE 34. Continued

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Riparian areas and floodplains	Common, not extensive	Moose, Black Bear, Gray Wolf, Beaver, Muskrat, Meadow Jumping Mouse, Western Jumping Mouse, Meadow Vole, Arctic Shrew Bald Eagle, Canada Goose, Ruffed Grouse, Eastern Phoebe, Northern Waterthrush, American Redstart Common Garter Snake, Western Garter Snake, Western Toad, Long-toed Salamander	♦ Grizzly Bear, Mourning Warbler
South aspect grassland and scrub in the Alberta Plateau	Limited areal extent	Moose, Rocky Mountain Elk, Mule Deer, Black Bear, Gray Wolf American Kestrel, Common Raven, Common Crow, Black-billed Magpie, Alder Flycatcher	♦ Grizzly Bear, Mourning Warbler
South aspect grassland and scrub in the mountains	Limited areal extent	Stone Sheep, Mountain Goat, Moose, Rocky Mountain Elk, Mule Deer, Black Bear, Gray Wolf Golden Eagle, Merlin, American Kestrel, Common Raven, Common Crow, Black-billed Magpie, Alder Flycatcher	♦ Dall Sheep, Grizzly Bear
Agricultural areas	Limited areal extent	Mule Deer, White-tailed Deer, Black Bear, Coyote, Ermine, Meadow Vole Northern Harrier, American Kestrel, Rough-legged Hawk, Snowy Owl, Short-eared Owl, Northern Shrike, Sharp-tailed Grouse, Tundra Swan, Sandhill Crane, Upland Sandpiper, White-fronted Goose, Common Raven, Common Crow, Black-billed Magpie, Brewer's Blackbird, Common Nighthawk, Lapland Longspur, Barn Swallow, Snow Bunting	♦ Purple Martin

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Most reptiles and amphibians are ill adapted to a northern climate and consequently only 7 of the 39 species found in British Columbia occur in the BWBS. The Western Garter Snake and Common Garter Snake are the only two reptiles and are found in the "warmer" main valleys and lower elevations of the Peace River region. Amphibians such as the Wood Frog, Spotted Frog, and Western Toad are widely distributed throughout the many wetland and moist upland habitats. The Long-toed

Salamander has been reported in the Stikine and Peace river valleys, but is secretive and seldom observed. The Striped Chorus Frog is restricted to the BWBS in British Columbia, inhabiting wetland areas of the Alberta Plateau.

Mixed forests of trembling aspen, lodgepole pine, and white spruce are the most characteristic and widespread upland habitat in the BWBS. Moose, Caribou, Mule Deer, Gray Wolf, and Black Bear are common large mammals. Smaller mammals include the Lynx, Red Squirrel, Ermine, Snowshoe Hare, and Deer Mouse. Birds such as the Northern Goshawk, Great Horned Owl, Ruffed Grouse, Common Raven, Gray Jay, Downy Woodpecker, and Black-capped Chickadee are characteristic residents. Other birds such as the Yellow-bellied Sapsucker, Hermit Thrush, Yellow-rumped Warbler, Purple Finch, and Dark-eyed Junco are commonly found in these areas in summer.

Bogs and fens, intermixed with forest, make up one of the most common habitats in the BWBS. Often referred to as "muskeg," these peatlands are particularly extensive in the northeastern corner of the province. Moose, Caribou, and Black Bear are the most common large mammals of muskeg habitats. Wood Bison historically inhabited much of this extensive muskeg and are still occasionally observed in the Fort Nelson area. The Great Gray Owl and Sharp-tailed Grouse are characteristic year-round residents, while migratory species such as the Solitary Sandpiper, Lesser Yellowlegs, Palm Warbler, Tennessee Warbler, Swamp Sparrow, and Blackpoll Warbler select these areas for breeding during summer.

Marsh and shallow lake habitats are dispersed throughout the BWBS, but are most abundant in the Alberta Plateau portion. These very productive wetlands are important for a wide variety of wildlife and account for the greatest diversity of bird species in the BWBS. Mallard, Northern Pintail, Blue-winged Teal, Northern Shoveller, Barrow's Goldeneye, Bufflehead, and Ring-necked Duck are characteristic waterfowl. Other birds commonly associated with BWBS wetlands include the Red-winged Blackbird, Horned Grebe, Common Snipe, Marsh Wren, Black Tern, Wilson's Phalarope, Tree Swallow, and Sora. Moose, Caribou, Beaver, Muskrat, Mink, Arctic Shrew, and Meadow Vole also frequent these habitats. The Wood Frog, Spotted Frog, and Striped Chorus Frog are usually found in or adjacent to marshes and lakes.

The agricultural areas of the Peace River district have several associated species such as the Sharp-tailed Grouse, Black-billed Magpie, Upland Sandpiper, Common Crow, Barn Swallow, Common Nighthawk, American Kestrel, Short-eared Owl, and Northern Harrier. Introduced species such as the European Starling and House Sparrow have become well established. Migrating species such as the Tundra Swan, Sandhill Crane, Rough-legged Hawk, White-fronted Goose, Northern Shrike, and Lapland Longspur stop over briefly in the spring and fall. Other birds such as the Snowy Owl, Common Raven, and Snow Bunting move into the agricultural areas during winter. Mule Deer, White-tailed Deer, Black Bear, Coyote, Ermine, and Meadow Vole are common mammals. Although wildlife are often more readily observed in these man-made habitats, they have less species diversity than the original native habitats.

The floodplain and riparian areas found throughout the BWBS are vital wildlife habitats, as in other biogeoclimatic zones. In winter, Moose rely on these alluvial habitats for the abundant browse (especially red-osier dogwood [*Cornus stolonifera*]), and during spring, Moose and Mule Deer use the dense cover while calving. The largest balsam poplar grow on these sites and provide nest trees for the Bald Eagle.

Steep, south-facing grass/shrub communities found along the major valleys and in the Rocky Mountain foothills provide critical wintering habitats for several ungulate species. Though relatively minor in extent, these habitats have low snow depths and provide winter range for Mule Deer and Rocky Mountain Elk, and in some areas for Stone Sheep and Mountain Goat. Kinnikinnick and saskatoon berries attract Black Bear to these slopes in the autumn.

RESOURCE VALUES

Fresh to moist sites in this zone have moderate capability for producing white spruce and trembling aspen. South-facing, slightly dry sites have moderate capability for producing lodgepole pine. All other sites generally have low capability for producing any commercial species.

Forest harvesting in the BWBS is relatively active and will continue to grow with the increased use of trembling aspen and balsam poplar. There are still large areas which are not much good for logging because of an abundance of poorly drained, non-productive wetlands.

Fresh to moist sites have moderate capability for agriculture if topography is not limiting. These sites are common in the southern portion of the BWBS east of the Rocky Mountains, and this is where most of the agricultural activity is concentrated, especially around Dawson Creek and Fort St. John. Fine-textured, stone-free lacustrine soils and large floodplains associated with the Peace River and major tributaries, in combination with a favourable climate, have resulted in some of the most productive agricultural land in British Columbia. Elsewhere, agriculture is largely inappropriate because of adverse climate and poorly drained organic soils.

Range use in the BWBS occurs primarily east of the Rocky Mountains. Most of the range is in successional forests; for example, about half the range resource in the Peace River area occurs in aspen ecosystems. Principal forages include *Calamagrostis canadensis*, *Elymus innovatus*, *Agropyron trachycaulum* (slender wheatgrass), *Lathyrus ochroleucus*, *Astragalus* spp. (milk-vetches), *Vicia* spp. (vetches), *Rosa* spp. (roses), *Amelanchier alnifolia*, *Cornus stolonifera* (red-osier dogwood), and *Salix* spp. (willows). Cattle are grazed throughout the growing season.

Hunting and fishing are the main recreational activities in the BWBS. Fur harvest from this zone is among the highest in the province.

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Chapter 17: Spruce — Willow — Birch Zone

by

J. Pojar and A.C. Stewart

LOCATION AND DISTRIBUTION

The Spruce — Willow — Birch zone (SWB) is the most northerly subalpine zone in British Columbia (Figure 62). It extends north from 56.5-57°N latitude, well into the Yukon Territory and the Mackenzie District of the Northwest Territories, where it reaches 60-70°N latitude. In British Columbia, the SWB occupies the middle elevations of the northern Rocky Mountains; the Cassiar and northernmost Omineca and Skeena mountains; that part of the St. Elias Mountains that extends into the Haines Triangle; and much of the Stikine, Yukon, and Liard plateaus. Elevations of the SWB in northern British Columbia range between 1000 and 1700 m in the southern portion of the zone, and between 900 and 1500 m in the north. The SWB is usually the subalpine zone above the Boreal White and Black Spruce zone (BWBS) in northern British Columbia, occupying a position comparable to that of the Engelmann Spruce — Subalpine Fir zone above the lower elevation zones further south.

ECOLOGICAL CONDITIONS

The climate of the Spruce — Willow — Birch zone is evidently an interior subalpine type, although long-term climatic data (see Table 4) are available from only two stations, Cassiar (Figure 63) and Muncho Lake. Cassiar is more representative of the zone as a whole, whereas Muncho Lake represents the drier, eastern portion of the zone fairly well. Mean annual temperature is about -0.7 to -3°C. Temperature averages above 10°C for probably just 1 month, although up to 3 months is possible at some medium elevations like Muncho Lake. Mean annual precipitation is 460-700 mm, with 35-60% as snowfall. Winters are long and cold, summers brief and cool. Moist Pacific air from the west frequently causes sudden, often violent, local storms during summer. A more stable air mass usually prevails in the winter, but cold spells can be broken by chinook winds.

Lower elevations of the SWB are generally forested, mainly by white spruce and subalpine fir. Indeed, in British Columbia the zone could well be called the spruce — fir — willow — birch zone, in view of the abundance of subalpine fir. A general pattern apparent in many valleys is of intermittent to closed forest cover of white spruce plus variable amounts of pine and aspen in the valley bottoms and on lower slopes. Higher on the slopes subalpine fir dominates, especially on northern and eastern exposures, where it often forms nearly pure stands. Black spruce, lodgepole pine, and trembling aspen are relatively minor species, although all can be locally abundant. However, none of these three minor species is nearly as common and widespread in the SWB as they are in the BWBS. It appears that wildfires have been less frequent and extensive in the SWB than in the adjacent BWBS, and extensive seral stands of lodgepole pine are uncommon though they do occur, as in the upper Jennings — Little Rancheria rivers. Balsam poplar is uncommon, and Engelmann spruce, paper birch, and tamarack are absent from the SWB.

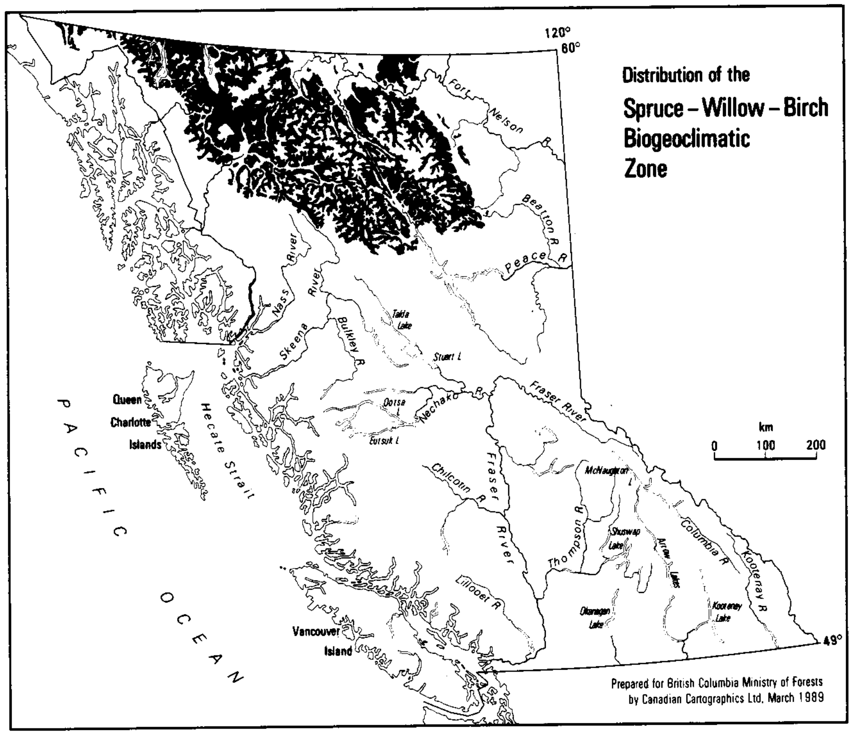

FIGURE 62. Spruce — Willow — Birch zone.

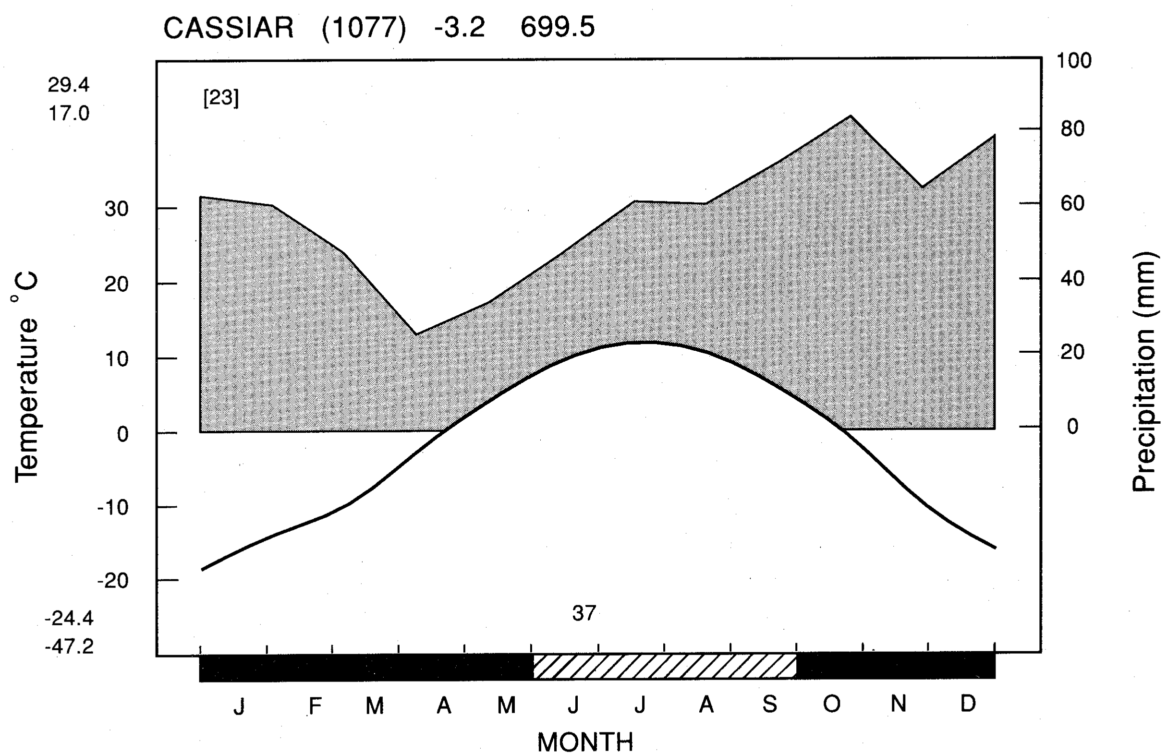

FIGURE 63. Representative climatic diagram for the Spruce — Willow — Birch zone.

Upper elevations of the SWB (essentially a scrub/parkland subzone) are dominated by fairly tall (1-4 m high) deciduous shrubs, mainly *Betula glandulosa* (scrub birch) and several willows, including *Salix glauca* (grey-leaved willow), *S. barclayi* (Barclay's willow), *S. planifolia* (tea-leaved willow), *S. barrattiana* (Barratt's willow), *S. alaxensis* (Alaska willow), and *S. lanata* (woolly willow). Scrub birch appears to dominate habitats with nutrient-medium or poorer status, whereas the willows seem to prefer more favourable nutrient regimes. Groves of stunted aspen and balsam poplar occur at timberline in some areas, usually on steep south slopes. It has been hypothesized that the long summer days and short, warm, frostless summer nights promote the dominance of deciduous shrubs in this zone, because the shrubs, after capitalizing on the short but intense growing season, shed their leaves in late summer and thus avoid the killing autumn frosts (Krajina 1975).

In some of the high wide valleys subject to massive cold air ponding, a non-forested mosaic of shrubfields, fens, and dry to moist grassland occupies the valley floor and lowermost slopes; a skirt of forest occurs on the lower slopes; and shrubs again dominate above the intermediate forested belt. This "double treeline" phenomenon is particularly well developed and striking in the northern plateau terrain. Permafrost can be found in such valleys, especially in finer-textured materials above 1200-1400 m. Elsewhere in the SWB, permafrost is sporadic, occurring in pockets mainly on north slopes.

A Lodgepole pine — Scrub birch — Lichen woodland association occurs on some of the driest, poorest sites, usually on rapidly drained outwash deposits. Aspen stands are fairly common on drier sites along the major valleys, usually on the warmer south-facing slopes of valley bottom moraines and glaciofluvial landforms, or on steep, south-facing, colluvial slopes.

Subalpine fir commonly forms open forest and woodland on steep, moist, cold, middle slopes, with best development on northern and eastern exposures. These ecosystems can be characterized as a Subalpine fir — Scrub birch — Crowberry association on Humo-Ferric Podzols. Shrub-dominated ecosystems are widespread and range from swamps and fens to dry colluvial scrub. Some common shrubby associations are:

- *Salix barclayi — Betula glandulosa — Carex aquatilis* (water sedge) fens;
- *Salix (glauca, barclayi, planifolia) — Aulacomnium palustre* (glow moss) wet willow thickets;
- *Salix alaxensis — Epilobium latifolium* (broad-leaved willowherb) — *Drepanocladus uncinatus* (sickle moss) riparian willow thickets;
- *Betula glandulosa — Festuca altaica* (Altai fescue) — *Hylocomium splendens* (step moss) fresh to moist upland scrub;
- *Salix glauca — Betula glandulosa — Festuca altaica* slightly dry to fresh upland scrub;

- *Salix scouleriana* (Scouler's willow) — *Linnaea borealis* (twinflower) — *Festuca altaica* fresh to drier brulé scrub;
- *Juniperus communis* (common juniper) — *Arctostaphylos uva-ursi* (kinnikinnick) dry dwarf scrub.

Wetlands in the SWB are usually the richer or minerotrophic types, including white spruce and tall willow swamps, *Salix* — *Betula* — *Carex* (sedge) fens, and *Carex* marshes. Acid, nutrient-poor bogs are uncommon, and generally belong to a Black spruce — Labrador tea — Sphagnum association.

Subalpine grasslands are frequent but not too extensive in this zone, and are of two general types:

A. Dry grassland on steep, colluvial or glaciofluvial, south slopes, with shallow soils on frequently calcareous parent materials. Typical species include *Poa glauca* (glaucous bluegrass), *Calamagrostis purpurascens* (purple reedgrass), *Festuca altaica*, *Elymus innovatus* (fuzzy-spiked wildrye), *Agropyron trachycaulum* (slender wheatgrass), *Saxifraga tricuspidata* (three-toothed saxifrage), *Potentilla pensylvanica* (prairie cinquefoil), *Artemisia frigida* (pasture sage), and *A. campestris* ssp. *borealis* (northern wormwood).

B. Dry to fresh *Festuca altaica* grassland on flat to gently rolling outwash or morainal landforms; sometimes extensive as in above-mentioned, high wide valleys (e.g., upper Stikine drainage); with also typically *Aconitum delphiniifolium* (mountain monkshood), *Artemisia norvegica* ssp. *saxatilis (mountain sagewort)*, *Polemonium caeruleum* (tall Jacob's-ladder), *Potentilla diversifolia* (diverse-leaved cinquefoil), *Carex macloviana* (thick-headed sedge), *Phleum alpinum* (alpine timothy); and numerous other forbs and grasses.

SUBZONES

There has been insufficient study of the SWB in British Columbia to distinguish and characterize subzones. It is clear that there are consistently throughout the zone two elevational subzones: a lower subzone of generally open forest and an upper subzone of deciduous scrub. It also appears that the dry cold climate of the Yukon Plateau (southwestern Yukon in the lee of the St. Elias Mountains) penetrates into British Columbia in the Atlin area, and may be reflected in a drier subzone. Beyond that, the SWB appears to be fairly uniform across the northern part of the province, although the SWB in the Haines Triangle is probably different but remains something of a mystery.

Zonal soils are Humo-Ferric Podzols or Brunisols, depending on the amount of precipitation (Brunisols being more common in areas of lower rainfall). Depending on the acidity of the parent material, both Eutric (high pH) and Dystric (low pH) Brunisols can occur. On fine-textured parent materials, Gray Luvisols can be found. Hemimors and Mormoders are the most common humus forms on zonal sites.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following is a typical sequence of ecosystems in the forested SWB (Figure 64).

White spruce — Grey-leaved willow — Scrub birch

This association occurs as open forest and woodland on dry to fresh, moderately well-drained uplands in the lower subzone of the SWB. White spruce generally dominates the moderately developed tree layer. Subalpine fir can be co-dominant, while lodgepole pine and trembling aspen are usually minor in mature stands. Spruce and fir form most of the tree regeneration.

Salix glauca (grey-leaved willow) and *Betula glandulosa* (scrub birch) are the characteristic dominant species of the moderately to very well-developed shrub layer. Other shrubs that often occur include *Salix planifolia*, *S. scouleriana*, *S. bebbiana* (Bebb's willow), *Potentilla fruticosa* (shrubby cinquefoil), and *Shepherdia canadensis* (soopolallie).

The dwarf shrub/herb layer is generally moderately well developed and typically includes *Empetrum nigrum* (crowberry), *Linnaea borealis*, *Vaccinium vitis-idaea* (lingonberry), *V. caespitosum* (dwarf blueberry), *Festuca altaica*, *Epilobium angustifolium* (fireweed), *Lupinus arcticus* (arctic lupine), and *Mertensia paniculata* (tall bluebells).

The well-developed moss layer is usually dominated by *Pleurozium schreberi* (red-stemmed feathermoss) and *Hylocomium splendens* (step moss) (note that *Ptilium crista-castrensis* [knight's plume] is a minor species in the SWB), but there is a diversity of other cryptogams as well, such as *Dicranum acutifolium*, *Polytrichum juniperinum* (juniper haircap moss), and the lichens *Cladina mitis*, *C. rangiferina* (reindeer lichen), *Cladonia ecmocyna*, *C. gonecha*, *C. gracilis*, *Peltigera aphthosa*, *P. malacea*, and *Nephroma arcticum*.

Soils are primarily Humo-Ferric Podzols and (Dystric) Brunisols, with also some Gray Luvisols. Typical humus forms are Hemimors and Mormoders.

Glaucous bluegrass — Northern wormwood

The Glaucous bluegrass — Northern wormwood association represents one of several dry subalpine grassland ecosystems that occur on very steep, south-facing colluvial (sometimes glaciofluvial) slopes in the SWB. Grasses and sedges dominate the well-developed herb layer; characteristic species include *Poa glauca* (glaucous bluegrass), *Agropyron trachycaulum*, *Koeleria macrantha* (junegrass), *Festuca altaica*, *F. saximontana* (Rocky Mountain fescue), *Trisetum spicatum* (spike trisetum), *Carex supina* (spreading arctic sedge), *C. petasata* (pasture sedge), and *C. obtusata* (blunt sedge). Typical forbs are *Potentilla pensylvanica*, *Artemisia campestris* ssp. *borealis* (northern wormwood), and *Oxytropis varians* (Alaskan locoweed). The moss layer is generally sparse, but *Tortula ruralis*, *Peltigera canina* (dog lichen), *Parmelia separata*, and *Physconia muscigena* are characteristic species.

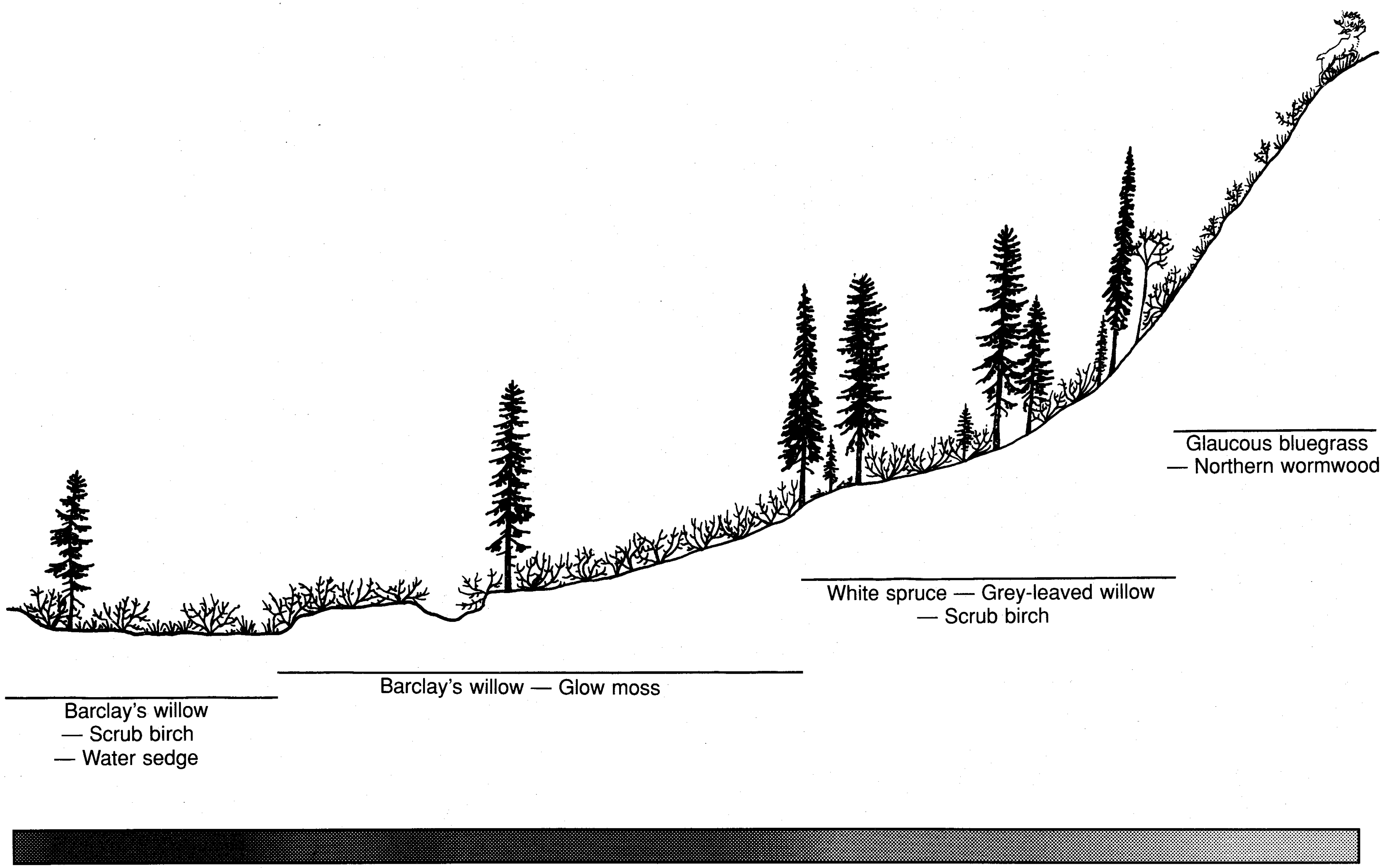

FIGURE 64. Simplified schematic diagram of topographic relationships among four common site associations of a lower, forested subzone of the Spruce — Willow — Birch zone.

Other dry grasslands of the SWB can be dominated by one or a combination of *Calamagrostis purpurascens*, *Festuca altaica*, *Elymus innovatus*, and *Agropyron trachycaulum*, but all have very similar physiognomy and are obviously closely related.

These grasslands are best developed over richer parent materials; typical soils are Eutric and Melanic Brunisols or Chernozem-like types. Humus forms are Rhizomulls.

Barclay's willow — Glow moss

Wet willow thickets, characterized by the Barclay's willow — Glow moss association, are widespread on imperfectly drained sites in the valley bottoms on fluvial fans, meander plains, lakesides, and depressions in till plains. Typical soils are Rego Humic Gleysols or Gleyed Regosols. Typical humus forms are Hydromoders.

The shrub stratum is well developed, but variable in that tall shrubs can be lacking or abundant. *Salix glauca*, *S. barclayi* (Barclay's willow), *S. planifolia* and sometimes *S. barrattiana*, *S. commutata* (variable willow), and *S. pseudomonticola* (mountain willow) are prominent willows, and *Potentilla fruticosa* is common.

The dwarf shrub/herb layer is moderately to well developed and rich in species. Common species include *Festuca altaica*, *Luzula parviflora* (small-flowered woodrush), *Poa leptocoma* (bog bluegrass), *Petasites frigidus* var. *palmatus* (palmate coltsfoot), *Salix myrtillifolia* (bilberry willow), *Rubus arcticus* (dwarf nagoonberry), *Aconitum delphiniifolium*, *Mertensia paniculata*, *Polemonium caeruleum*, *Stellaria longipes* (long-stalked starwort), *Senecio pauciflorus* (rayless alpine butterweed), *Calamagrostis canadensis* (bluejoint), and *Carex atrata* (blackened sedge).

The moss layer is moderately developed and characteristically hummocky. Prominent species are *Aulacomnium palustre* (glow moss), *Hylocomium splendens*, and *Peltigera aphthosa*. Important associates include *Polytrichum strictum*, *Drepanocladus uncinatus*, *Plagiomnium venustum*, and *Peltigera scabrosa*.

Barclay's willow — Scrub birch — Water sedge

A common wetland type of the SWB can be termed a moderately rich (weakly minerotrophic) shrubby fen. The Barclay's willow — Scrub birch — Water sedge association usually develops on Terric Mesisols or Humisols and Humic Gleysols with Hydromor or Hydromoder humus forms.

Trees are often lacking; if present, they are usually white spruce, widely scattered, stunted, and slow-growing. *Salix barclayi* (Barclay's willow), *Betula glandulosa* (scrub birch), *Salix glauca*, *S. planifolia*, *Potentilla fruticosa*, and *Ledum groenlandicum* (Labrador tea) dominate the moderately to well-developed shrub stratum.

A moderately developed to dense dwarf shrub/herb layer is always present. *Carex aquatilis* (water sedge) is usually most abundant, followed by *Salix myrtillifolia* and *Empetrum nigrum*. Common associates are *Arctostaphylos rubra* (red bearberry), *Oxycoccus oxycoccos* (bog cranberry), *Rubus chamaemorus* (cloudberry), *R. arcticus*, *Equisetum arvense* (common horsetail), *Carex disperma* (soft-leaved sedge), *C. vaginata* (sheathed sedge), and *Arctagrostis latifolia* (polargrass).

The cryptogamic layer (mainly mosses) is usually well developed and markedly hummocky. Prominent species include *Aulacomnium palustre*, *Tomenthypnum nitens* (golden fuzzy fen moss), *Paludella squarrosa*, *Drepanocladus exannulatus*, *Sphagnum capillaceum* (common red sphagnum), *S. recurvum*, *Plagiomnium ellipticum*, *Calliergon cordifolium*, and *Polytrichum strictum*.

WILDLIFE HABITATS

The SWB has the harshest climate of all the forested zones in British Columbia, second only to the non-forested Alpine Tundra zone. The climate of the SWB has a profound effect on wildlife (Table 35), an effect especially noticeable during late summer when many species, birds in particular, begin migration to avoid the abrupt early autumns and long bitter winters.

Moose and Caribou are the most abundant and widespread ungulates found in the SWB, particularly in summer. Valley bottoms provide the best winter range for both species, but much of this zone is abandoned by mid-winter because of deep snow. Mountain Goat tolerate the deep snow better than most ungulates because of the steep terrain they inhabit. They are locally abundant wherever suitable steep, rugged terrain occurs. Because of the favourable topography, Mountain Goat appear to be more numerous in the wetter regions of this zone, most notably on the lee side of the Coast Range. Stone Sheep are found where steep south-facing grasslands associated with rugged terrain occur. They are particularly abundant in the Rocky Mountain Foothills and the Kechika Mountains. Dall Sheep are found only in the extreme northwestern corner of the province and typically summer in the SWB. Rocky Mountain Elk and Mule Deer are uncommon except in the Rocky Mountain Foothills. Both Grizzly Bear and Black Bear occur in the SWB, although the former is often more common. No reptiles occur in this zone and the Western Toad, Wood Frog, and Spotted Frog are the only amphibians.

Closed to open conifer forests are the most common type of treed habitat in the SWB. Open stands of lodgepole pine, developed on coarse textured soils such as those found in upper reaches of the Turnagin and Jennings rivers, are important as Caribou winter range. Caribou paw or nuzzle through the snow on these sites for ground lichens, which are the major part of their winter diet. Large mammals such as the Moose, Grizzly Bear, and Gray Wolf are found in these areas primarily in summer. Other typical forest species include the Spruce Grouse, Common Raven, Gray Jay, Boreal Chickadee, Red-breasted Nuthatch, Three-toed Woodpecker, Ruby-crowned Kinglet, Red Squirrel, Wolverine, and Marten.

TABLE 35. Selected wildlife habitats and species in the Spruce — Willow — Birch zone (adapted from Wildlife Branch 1989)

Habitat	Habitat distribution	Representative wildlife species	Wildlife species at risk[a]
Coniferous and mixed coniferous/ deciduous forests	Extensive	Moose, Rocky Mountain Elk, Black Bear, Gray Wolf, Lynx, Wolverine, Porcupine, Snowshoe Hare, Red Squirrel, Deer Mouse, Least Weasel Northern Goshawk, Northern Hawk-owl, Spruce Grouse, Three-toed Woodpecker, Common Raven, Gray Jay, Yellow-bellied Sapsucker, Hermit Thrush, Swainson's Thrush, Dark-eyed Junco, Wilson's Warbler, Bohemian Waxwing, Ruby-crowned Kinglet, Boreal Chickadee, Red-breasted Nuthatch	♦ Caribou, Gray-cheeked Thrush
Willow — birch shrublands in valley bottoms	Extensive	Moose, Black Bear, Gray Wolf, Wolverine, Lynx, Snowshoe Hare, Arctic Ground Squirrel, Brown Lemming Golden Eagle, Northern Goshawk, Willow Ptarmigan, Northern Shrike, Wilson's Warbler, Brewer's Sparrow, Tree Sparrow, Smith's Longspur	♦ Caribou, Plains Bison, Grizzly Bear, Tundra Shrew, Hudsonian Godwit
Grasslands	Limited areal extent	Moose, Stone Sheep, Arctic Ground Squirrel Golden Eagle, Common Raven, Blue Grouse, Say's Phoebe	♦ Caribou, Dall Sheep, Plains Bison, Grizzly Bear, Gyrfalcon
Rugged and steep, open south aspects	Common	Mountain Goat, Stone Sheep, Brown Lemming Willow Ptarmigan	♦ Dall Sheep, Gyrfalcon
Wetlands, shallow lakes, and streams	Limited areal extent	Moose, Black Bear, Beaver, Muskrat, Mink, Meadow Vole, Northern Bog Lemming, Arctic Shrew, Water Shrew Northern Harrier, Red-throated Loon, Mallard, Northern Pintail, Bufflehead, California Gull, Red-necked Phalarope, Least Sandpiper, Semipalmated Plover Western Toad, Wood Frog, Spotted Frog	♦ Plains Bison, Grizzly Bear, Arctic Loon, Arctic Tern, Lesser Golden-Plover
Riparian areas and floodplains	Limited areal extent	Moose, Black Bear, Gray Wolf, Beaver, Muskrat Ruffed Grouse, American Redstart, Northern Waterthrush Western Toad, Wood Frog	♦ Caribou, Grizzly Bear, Arctic Tern

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

Open, shrubby, valley bottom habitats are a characteristic feature of the SWB. These habitats are important as summer range for Moose and Caribou, but are usually too exposed and snowy to be used as winter range. The Willow Ptarmigan, Arctic Ground Squirrel, Gyrfalcon, and Wilson's Warbler are commonly observed here in summer.

Wetlands and shallow lakes are not as abundant or productive as those found in the BWBS. Beaver are the most common furbearers associated with this habitat, with lodges occasionally observed near treeline, where willow and birch shrubs are the only available food source. Moose wade through these areas in summer to find aquatic vegetation and escape biting insects. Other representative species include the Northern Harrier, Mallard, Northern Pintail, Bufflehead, Arctic Tern, California Gull, Red-necked Phalarope, and Red-throated Loon.

Reduced snow depths on open south-facing slopes favour wintering Stone Sheep, Dall Sheep, Mountain Goat, and Moose. Less typical species such as Rocky Mountain Elk and Mule Deer winter in the Rocky Mountain foothills where there is less than average snowfall. The Golden Eagle, Gyrfalcon, Common Raven, Blue Grouse, Say's Phoebe, and Arctic Ground Squirrel are other characteristic species.

Young seral forests and shrublands are extensive and have a wide diversity of species. The Moose, Snowshoe Hare, Lynx, Porcupine, Dark-eyed Junco, American Robin, Wilson's Warbler, and Bohemian Waxwing are typical wildlife associated with these habitats.

Although not extensive, floodplain and riparian habitats are the most important areas in the SWB for Moose because of good browse production. Other species typical of these habitats include the Northern Waterthrush, American Redstart, and Ruffed Grouse.

Although not native to this zone, one of the largest populations of Plains Bison occurs in the Muskwa River area, the result of an introduction in the 1970's.

RESOURCE VALUES

There is no forestry or agriculture in the SWB, and it is unlikely there will be, at least in the near future. The main resource uses are hunting, by both residents and guided non-residents, and trapping.

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Chapter 18: Alpine Tundra Zone

by

J. Pojar and A.C. Stewart

LOCATION AND DISTRIBUTION

The Alpine Tundra zone (AT) occurs on high mountains throughout the province (Figure 65). In southeastern British Columbia, the AT occurs at elevations above approximately 2250 m; in the southwest, above 1650 m; in the northeast, above 1400 m; in the northwest, above 1000 m. The zone is concentrated along the coastal mountains and in the northern and southeastern parts of the province and occurs above all three subalpine zones. The AT extends beyond British Columbia on the high mountains to the north, east, and south.

ECOLOGICAL CONDITIONS

The harsh alpine climate is cold, windy, and snowy, and characterized by low growing season temperatures and a very short frost-free period (Table 4). British Columbia has only two long-term, alpine climate stations: Old Glory Mountain, near Trail (Figure 66) and Mt. Fidelity in Glacier National Park. Available short- and long-term data indicate that the mean annual temperature ranges from -4 to 0°C. The average temperature remains below 0°C for 7-11 months. Frost can occur at any time. The AT is the only zone in the province where the mean temperature of the warmest month is less than 10°C. Mean annual precipitation is 700-3000 mm, most of which (70-80%) falls as snow.

Alpine ecosystems in British Columbia have received relatively little attention from scientists and land managers. Furthermore, most of the studies that have been done remain unpublished and poorly available in thesis or report form (see Hamilton[12]). However, some general features of the AT can be derived from the available information.

The alpine zone is, by definition, treeless, but tree species are common at lower elevations, although in stunted or krummholz form.[13] The most common krummholz species are subalpine fir, Engelmann spruce, white spruce, mountain hemlock, and whitebark pine. Krummholz is usually not widespread, however. Alpine vegetation is dominated by shrubs, herbs, bryophytes, and lichens. Of course, much of the alpine landscape lacks vegetation and is the domain of rock, ice, and snow.

Alpine scrub or shrubfield vegetation of low deciduous shrubs often dominates lower alpine subzones, especially in the northern part of the province. Common shrubs are willows (e.g., *Salix arctica* [arctic willow], *S. barclayi* [Barclay's willow], *S. barrattiana* [Barratt's willow], *S. glauca* [grey-leaved willow], *S. planifolia* [tea-leaved willow]), and *Betula glandulosa* (scrub birch).

[12] Hamilton, E. 1983. A problem analysis of the classification of Alpine Tundra and subalpine parkland subzones within the British Columbia Ministry of Forests Ecosystem Classification program. B.C. Min. For., Res. Br., Victoria, B.C. Draft report.

[13] Some ecologists include krummholz within the subalpine zone; others, within the alpine zone.

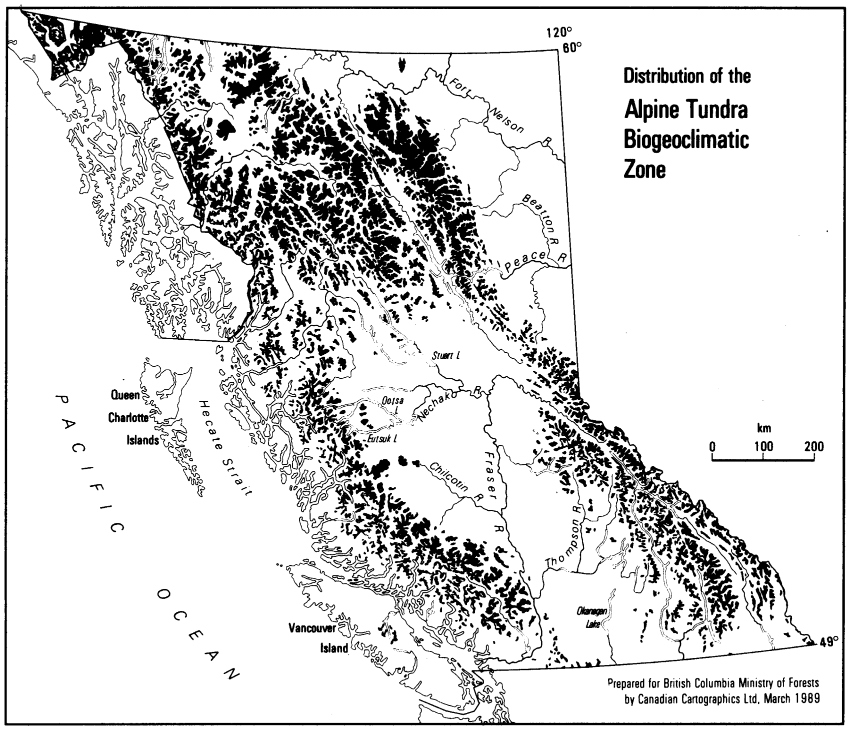

FIGURE 65. Alpine Tundra zone.

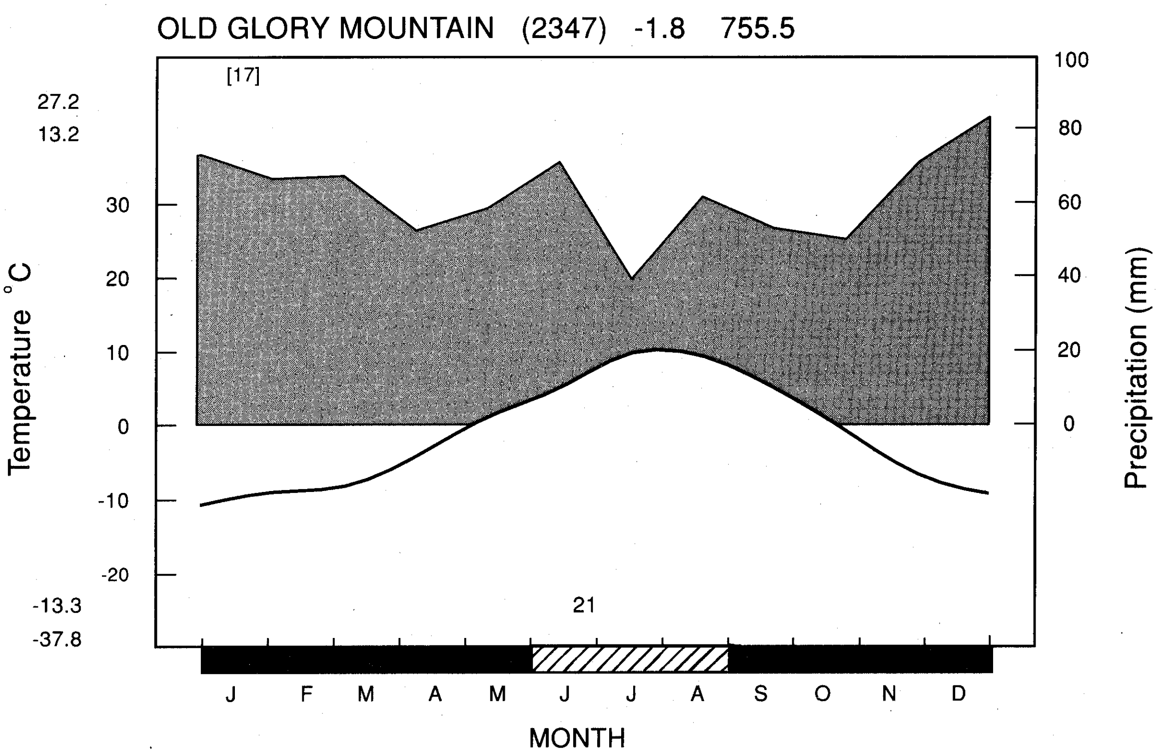

FIGURE 66. Representative climatic diagram for the Alpine Tundra zone.

A dwarf scrub of prostrate woody plants is the most common form of vegetation in the AT as a whole. Dwarf scrub generally is most abundant in the middle elevations of the zone. This scrub is especially widespread in moister, snowier regions; in drier regions it tends to be restricted to areas of snow accumulation. However, some scrub types (e.g., the *Dryas octopetala* [white mountain-avens] association) are restricted to windswept, largely snow-free ridgecrests. Important dwarf shrubs include evergreen-leaved species such as *Cassiope* spp. and *Phyllodoce* spp. (mountain-heathers), *Luetkea pectinata* (partridgefoot), *Arctostaphylos uva-ursi* (kinnikinnick), *Empetrum nigrum* (crowberry), *Vaccinium vitis-idaea* (lingonberry), *Loiseleuria procumbens* (alpine azalea), and *Dryas* spp., as well as deciduous species such as *Salix cascadensis* (Cascade willow), *S. polaris* (polar willow), *S. reticulata* (netted willow), *S. reticulata* ssp. *nivalis* (snow willow), *Vaccinium uliginosum* (bog blueberry), and *Arctostaphylos rubra* (red bearberry).

Alpine grass vegetation is also widespread. It becomes dominant in drier regions, as in higher elevations of the south central Interior, the Chilcotin district and elsewhere on the leeward slopes of the Coast Mountains, and along the leeward side of the Rocky Mountains. Elsewhere, grass vegetation tends to be more localized and often is restricted to steep south-facing slopes or convex, windswept ridges. Dominant grasses and sedges vary from south to north, but some important species of drier alpine communities are *Festuca altaica* (Altai fescue), *F. brachyphylla* (alpine fescue), *F. scabrella* (rough fescue), *F. viridula* (green fescue), *Elymus innovatus* (fuzzy-spiked wildrye), *Agropyron violaceum* (broad-glumed wheatgrass), *Poa rupicola* (timberline bluegrass), *Hierochloe alpina* (alpine sweetgrass), *Calamagrostis purpurascens* (purple reedgrass), *Danthonia intermedia* (timber oatgrass), *Carex nardina* (spikenard sedge), *C. microchaeta* (small-awned sedge), *C. phaeocephala* (dunhead sedge), *C. scirpoidea* ssp. *pseudoscirpoidea* (single-spiked sedge), and *Kobresia myosuroides* (Bellard's kobresia). Grass vegetation also dominates some seepage or snowbed ecosystems. Some common graminoid species of wetter alpine communities are *Calamagrostis lapponica* (Lapland reedgrass), *Arctagrostis latifolia* (polargrass), *Poa arctica* (arctic bluegrass), *Carex* spp. (e.g., *Carex aquatilis* [water sedge], *C. enanderi* [Enander's sedge], *C. nigricans* [black alpine sedge], *C. podocarpa* [short-stalked sedge], *C. spectabilis* [showy sedge], *C. capitata* [capitate sedge]), *Eriophorum* spp. (cotton-grasses), *Juncus drummondii* (Drummond's rush), *J. parryi* (Parry's rush), *Luzula arcuata* (curved alpine woodrush), and *L. wahlenbergii* (Wahlenberg's woodrush).

Herb meadows or herbfields dominated by broad-leaved forbs are also common in the alpine, especially at middle and lower elevations. These meadows usually develop on well-drained sites with deep soils, in seepage areas, or along alpine rivulets and streams. Important species in British Columbia include *Lupinus arcticus* (arctic lupine), *Senecio triangularis* (arrow-leaved groundsel), *Erigeron peregrinus* (subalpine daisy), *Valeriana sitchensis* (Sitka valerian), *Veratrum viride* (Indian hellebore), *Arnica* spp. (arnicas), *Pedicularis* spp. (louseworts), *Castilleja* spp. (paintbrushes), *Antennaria lanata* (woolly pussytoes), *Anemone occidentalis* (western pasqueflower), *Caltha leptosepala* (white marsh-marigold), *Heracleum lanatum* (cow-parsnip), *Erythronium grandiflorum* (glacier lily), *Ranunculus eschscholtzii* (subalpine buttercup), *R. nivalis* (snow buttercup), *Oxyria digyna* (mountain sorrel), and *Artemisia norvegica* ssp. *saxatilis* (mountain sagewort).

Few species of vascular plants (most of which are cushion- or mat-formers) have adapted to the extreme conditions in the highest parts of the alpine zone. However, a few mosses and liverworts and numerous lichens persist and even thrive at the upper limits of vegetation. Plant communities can occur over bedrock, in fellfield or boulderfield habitats, or as vegetation stripes on patterned or sorted ground. Species of the lichen genera *Cetraria*, *Alectoria*, *Umbilicaria*, *Parmelia*, *Rhizocarpon*, and *Lecanora*, as well as the lichens *Thamnolia subuliformis* and *Dactylina arctica*, and the mosses *Polytrichum piliferum* (awned haircap moss), *Rhacomitrium lanuginosum*, and *R. heterostichum*, typify the sparse, predominantly cryptogamic vegetation.

In alpine ecosystems the plants are typically small, close to the ground, and often widely separated by bare soil or rock. Unlike a forest, tundra does not modify microclimate very much, and the physical environment dictates the vegetation in the alpine zone. The terrain can be gentle or extremely rough, but in any case the effects of microenvironment are pronounced in such open and windy places. Even a few centimetres difference in microtopography makes a pronounced difference in soil temperature, depth of thaw, wind effects, snow drifting, and resultant protection to plants.

Alpine vegetation and soil typically occur in a complex mosaic of communities and polypedons. Major environmental factors are topographic exposure, wind, solar radiation, soil temperature, and the distribution of snow and its meltwater. These factors are all interrelated and also superimposed on patterns of bedrock, soil frost features, and sometimes permafrost as well.

The processes of frost shattering, colluviation, solifluction, nivation, cryoturbation, and permafrost development are all active. Soil development is often absent or weak, and is strongly affected by these processes that disrupt and dislocate horizons, displace and incorporate materials from other horizons, and mechanically sort soil particles. Such effects combine with the cold climate (which slows weathering) to greatly retard soil development.

Regosols (Orthic and Humic) are probably the most common soils overall in British Columbia's alpine zone. Constant churning of surface and subsoil particles results in poor horizon differentiation and frequent buried bands of organic-rich materials resembling former A horizons. Brunisols are also common and can dominate in drier alpine areas. Where graminoid sods have developed, organic matter incorporation in upper mineral horizons results in Melanic and Sombric Brunisols with turfy Ah horizons. Wet habitats commonly have Humic Gleysols or Organic soils. Turbic Cryosols and Organic Cryosols are common in northern regions or on north aspects where subsurface drainage is impeded. Ferro-Humic Podzols typically develop under krummholz, mountain-heather, and scrub birch vegetation.

Alpine humus forms have not been studied very much, but it appears that Rhizomulls are widespread in herb-dominated tundra ecosystems. Hemimors and Mormoders, however, may be expected beneath alpine scrub and heath vegetation.

SUBZONES

Ecologists have an incomplete understanding of the subzones of the AT in British Columbia, although they certainly appreciate the great diversity of alpine ecosystems in our extremely mountainous, climatically and edaphically complex province. There are three major divisions of the alpine zone in British Columbia:

- Maritime or Coastal
- Northern Interior (north of roughly 56° latitude)
- Southern Interior

Each of these regions can be further divided along climatic and elevational gradients, but no one has yet made ecological sense of the resulting matrix of possible subzones.

Maritime alpine tundra is dominated by alpine heath, a dwarf, evergreen scrub characterized by *Cassiope mertensiana* (white mountain-heather) and *Phyllodoce empetriformis* (pink mountain-heather). The zonal tundra of the northern Interior is characterized by dwarf willows (especially *Salix reticulata* and *S. polaris*), grasses (especially *Festuca altaica*), sedges, and lichens. Southern Interior tundra is more variable. *Dryas octopetala*, other dwarf willows (especially *Salix reticulata* ssp. *nivalis* and *S. cascadensis*), grasses, sedges, and lichens typify drier climates; alpine heath dominates in moister, snowier climates.

SOME REPRESENTATIVE SITE ASSOCIATIONS

The following descriptions pertain to a high alpine subzone studied in the rolling alplands of the Stikine Plateau, in north central British Columbia (see Figure 67).

Dwarf willow — Small-awned sedge

This association is widespread on all aspects over the exposed plateau surfaces and on the broad wind-swept ridges typical of the northern plateau terrain. Parent materials commonly have been derived from local bedrock, although thin morainal deposits also occur. Sloping sites with finer-textured parent materials tend to have solifluction lobes with Dystric and Sombric Brunisols. Cryic and Turbic Regosols are most common on flat or gently sloping sites that often have patterned ground features. The typical humus form is an alpine Rhizomull.

The tundra vegetation is dominated by dwarf willows, graminoid species, and lichens. *Salix polaris* and *S. reticulata* are the dominant dwarf willows. Prominent

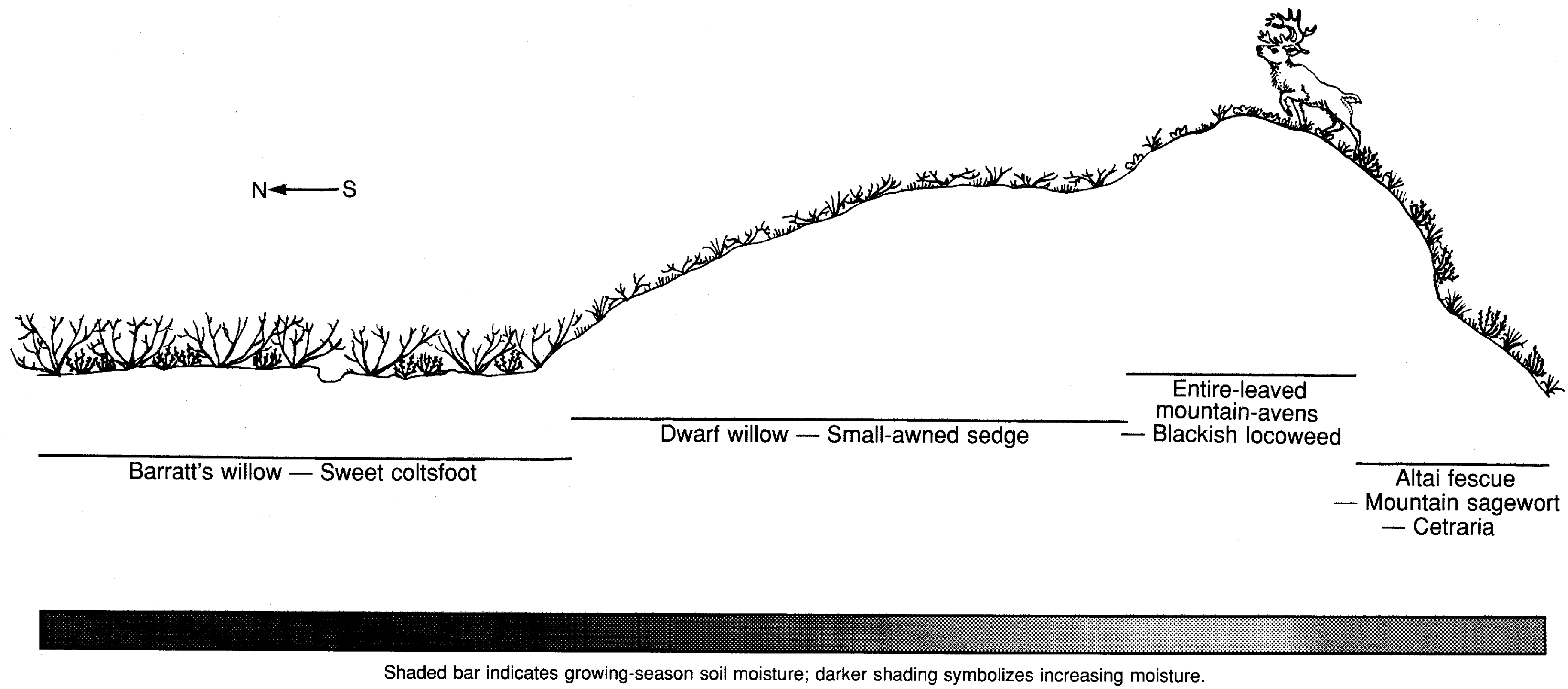

FIGURE 67. Simplified schematic diagram of topographic relationships among four common site associations of a northern subzone of the Alpine Tundra zone.

graminoid species include *Carex microchaeta* (small-awned sedge), *Hierochloe alpina*, *Festuca altaica*, *F. brachyphylla*, and *Luzula arctica* (arctic woodrush). Common forbs are *Polygonum viviparum* (alpine bistort), *Antennaria monocephala* (one-headed pussytoes), *Potentilla hyparctica* (arctic cinquefoil), *Silene acaulis* (moss campion), and *Stellaria longipes* (long-stalked starwort).

The cryptogamic layer is moderately to well developed. Important species include the lichens *Cetraria nivalis*, *C. delisei*, *C. cucullata*, *C. islandica*, *Stereocaulon paschale*, *Thamnolia subuliformis*, *Alectoria ochroleuca*, and *Dactylina arctica*, as well as the mosses *Polytrichum piliferum*, *Rhytidium rugosum*, *Distichium capillaceum*, and *Ditrichum flexicaule*.

Entire-leaved mountain-avens — Blackish locoweed

Cushion plant tundra occurs on dry, exposed, convex ridgecrests throughout northern British Columbia. These ecosystems occupy rapidly drained, gravelly or rubbly habitats. Parent materials have been derived from the local, usually somewhat calcareous, sedimentary bedrock. Stone-striping is common; there is usually much bare ground between clumps of vegetation. Soils are typically Regosols, of Orthic, Humic, and Turbic subgroups. Typical humus forms are alpine Rhizomulls.

The poorly to moderately developed dwarf shrub/herb layer is dominated by cushion- or mat-forming plants. Important species include *Dryas integrifolia* (entire-leaved mountain-avens), *Oxytropis nigrescens* (blackish locoweed), *Silene acaulis*, *Potentilla uniflora* (one-flowered cinquefoil), *Lupinus arcticus*, *Salix reticulata*, *Draba nivalis* (snow draba), *Kobresia myosuroides*, *Hierochloe alpina*, *Calamagrostis purpurascens*, and *Carex microchaeta*.

The "moss" layer is moderately developed and dominated by lichens. Prominent species are *Cetraria nivalis*, *C. cucullata*, *C. nigricans*, *C. tilesii*, *Thamnolia subuliformis*, *Alectoria ochroleuca*, *Cornicularia divergens*, *C. aculeata*, and *Lecidea* spp.

Altai fescue — Mountain sagewort — Cetraria

Dry grassy tundra is common on steep, generally south-facing colluvial slopes. These habitats are well drained and typically have light, discontinuous, winter snow cover. Typical soils are alpine Eutric Brunisols, Orthic Humic Regosols, and Black Chernozem-like types. The prevailing humus form is an alpine Rhizomull.

Festuca altaica (Altai fescue) and *Artemisia norvegica* ssp. *saxatilis* (mountain sagewort) characterize the well-developed herb layer. Common associated species include *Hierochloe alpina*, *Carex microchaeta*, *Luzula spicata* (spiked woodrush), *Gentiana glauca* (glaucous gentian), *Potentilla diversifolia* (diverse-leaved cinquefoil), *Polygonum viviparum*, *Silene acaulis*, and *Campanula lasiocarpa* (mountain harebell).

The moderately developed moss layer is dominated by *Stereocaulon paschale*, *Cetraria nivalis*, *C. cucullata*, *Cladina alpestris*, and *Polytrichum piliferum*.

Barratt's willow — Sweet coltsfoot

Low thickets of *Salix barrattiana* (Barratt's willow) are common on wet sites in alpine valleys or swales, usually along low gradient streams, on gently sloping alluvial fans, or at the base of long slopes. Soils that have developed on the poorly drained, recent alluvium or colluvium are Cumulic Regosols or Rego Humic Gleysols. Typical humus forms are Hydromoders and Saprimulls. The snowpack of these ecosystems is deep, but usually melts several weeks earlier than in typical snowbed areas. This association is also common in the Canadian Rocky Mountains.

The dense, low shrub layer is dominated by *Salix barrattiana*, which is occasionally joined by *S. alaxensis* (Alaska willow), *S. glauca*, or *S. planifolia*.

The moderately developed herb layer can have numerous species, but *Petasites frigidus* var. *frigidus* (sweet coltsfoot), *Rubus arcticus* (dwarf nagoonberry), *Polemonium caeruleum* (tall Jacob's-ladder), and *Senecio lugens* (black-tipped groundsel) are most characteristic.

Prominent in the moderately to well-developed moss layer are *Tomenthypnum nitens* (golden fuzzy fen moss), *Drepanocladus revolvens*, *Aulacomnium palustre* (glow moss), *Mnium blyttii*, *Plagiomnium venustum*, *Brachythecium* spp., and *Hylocomium splendens* (step moss).

WILDLIFE HABITATS

Climate and rugged topography are the overwhelming factors influencing the assemblage of wildlife species in the Alpine Tundra zone (Table 36). The AT has the harshest climate of all the zones found in British Columbia. Rock and ice are among the most common features of the AT, ice being particularly common in the Coast Range. These areas, bereft of vegetation, generally have low value as wildlife habitat.

Wildlife species diversity and density are low in the AT. This is partly a result of severe conditions, but the isolated and scattered nature of alpine habitats also reduces species diversity. Despite these limiting factors, there are several wildlife species that are well adapted to the harsh environment. These include Mountain Goat, Gyrfalcon, White-tailed and Willow Ptarmigan, Water Pipit, and Rosy Finch.

For wildlife habitat purposes, the wide-ranging AT can be subdivided into three distinct areas, based on the underlying subalpine zone: Mountain Hemlock (MH), Engelmann Spruce — Subalpine Fir (ESSF), or Spruce — Willow — Birch (SWB) zones. These areas correspond to the maritime, southern Interior, and northern Interior subdivisions mentioned previously. Alpine tundra above the MH along the coast has exceptionally high snowfall and extensive icefields and glaciers. The snowpack does not melt away until well into summer and vegetation is sparse and includes primarily mountain-heathers. Even Mountain Goat, which are well adapted to wintering in the AT, generally descend to lower elevations along the coast in winter. Ungulates that winter in drier alpine regions, such as Caribou, California Bighorn Sheep, and Stone Sheep, are absent from the maritime alpine in winter. In the

TABLE 36. Selected wildlife habitats and species in the Alpine Tundra zone (adapted from Wildlife Branch 1989)

Habitat	**Habitat distribution**	**Representative wildlife species**	**Wildlife species at risk**[a]
Alpine heath, grasslands, tundra, and scrub	Common	Mountain Goat, Stone Sheep, Mule Deer, Black Bear, Hoary Marmot, Arctic Ground Squirrel Golden Eagle, Red-necked Phalarope, Snow Bunting, White-tailed Ptarmigan, Rock Ptarmigan, Willow Ptarmigan, Water Pipit, Horned Lark, Rosy Finch	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Dall Sheep, Caribou, Grizzly Bear, Gyrfalcon, Least Sandpiper
Alpine meadows	Common, limited areal extent	Stone Sheep, Rocky Mountain Elk, Mule Deer, Black Bear, Hoary Marmot, Columbian Ground Squirrel, Arctic Ground Squirrel, Brown Lemming, Northern Bog Lemming, Meadow Vole, Water Vole Golden Eagle, Blue Grouse, White-tailed Ptarmigan, Willow Ptarmigan, Golden Plover, Rufous Hummingbird	∇ Vancouver Island Marmot, Cascade Mantled Ground Squirrel ♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Dall Sheep, Caribou, Grizzly Bear
Windswept and south aspect alpine	Common in drier areas	Mountain Goat, Stone Sheep, Hoary Marmot Golden Eagle, Common Raven, Smith's Longspur, Snow Bunting, White-tailed Ptarmigan, Rock Ptarmigan	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Dall Sheep, Caribou, Gyrfalcon
Krummholz	Common, limited areal extent	Mountain Goat, Stone Sheep, Mule Deer, Rocky Mountain Elk, Black Bear, Red Fox, Wolverine, Marten, Snowshoe Hare, Hoary Marmot, Golden-mantled Ground Squirrel Sharp-shinned Hawk, Blue Grouse, White-tailed Ptarmigan, Willow Ptarmigan, American Robin, Dark-eyed Junco, American Tree Sparrow, Golden-crowned Sparrow Western Toad, Wood Frog, Spotted Frog	♦ California Bighorn Sheep, Rocky Mountain Bighorn Sheep, Dall Sheep, Caribou, Grizzly Bear, Red-tailed Chipmunk
Rocky cliffs, talus, and sparsely vegetated rock	Extensive	Mountain Goat, Golden-mantled Ground Squirrel, Common Pika, Hoary Marmot, Least Chipmunk Golden Eagle, Rock Ptarmigan, Townsend's Solitaire, Say's Phoebe	∇ Vancouver Island Marmot, Cascade Mantled Ground Squirrel ♦ Collared Pika

[a] Wildlife species and subspecies at risk are those on the preliminary Red and Blue Lists proposed in the Provincial Wildlife Strategy, B.C. Ministry of Environment (October 1989 draft).

∇ Red-listed wildlife species. These are being **considered** by the Wildlife Branch for designation as endangered or threatened in British Columbia.

♦ Blue-listed wildlife species. The Wildlife Branch considers these species "sensitive" and/or deserving of management attention. Population viability is a concern for these species because of (a) major declines in population numbers; or (b) major changes in habitat that will further reduce existing distribution. Species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category, are included in this category.

summer, Roosevelt Elk, Black-tailed Deer, and Mule Deer forage in lower elevation krummholz and meadow habitats. Other species found in summer include the Golden Eagle, White-tailed Ptarmigan, Rock Ptarmigan, Wolverine, and Hoary Marmot. The endangered Vancouver Island Marmot also occurs in the Alpine Tundra zone.

The largest subdivision of Alpine Tundra occurs above the ESSF. Snow depths are variable, being least in the East Kootenays and lee of the Coast Mountains, and greatest in the Interior "wet belt." In the driest areas, Rocky Mountain Bighorn Sheep, California Bighorn Sheep, Mountain Goat, and Caribou winter on steep south-facing habitats or on windswept vegetated ridges. Some of the densest populations of Mountain Goat in North America can be found in these drier areas. In snowier areas, only Mountain Goat are expected to occur during winter. Stone Sheep occur at the southern extreme of their range near the Williston Reservoir. Mule Deer, Rocky Mountain Elk, Grizzly Bear, and Black Bear are found in krummholz and lush meadow habitats during summer and fall. Other species include the Wolverine, Hoary Marmot, Columbian Ground Squirrel, Golden-mantled Ground Squirrel, and Common Pika. Characteristic birds include the Golden Eagle, White-tailed Ptarmigan, Rock Ptarmigan, Horned Lark, Water Pipit, and Rosy Finch.

The coldest and generally driest subdivision of Alpine Tundra lies above the SWB in northern British Columbia. Stone Sheep and Caribou are found throughout, particularly in the drier portions. Stone Sheep winter on steep, windswept, south-facing terrain while Caribou prefer windswept mountain plateau habitats. Mountain Goat are found wherever suitably rugged terrain occurs and are notably abundant in the transition areas in the lee of the Coast Range. Other mammals common to this northern subdivision include the Grizzly Bear, Gray Wolf, Red Fox, Wolverine, Hoary Marmot, Arctic Ground Squirrel, Siberian Lemming, and Least Chipmunk. The Collared Pika and Dall Sheep occur in the extreme northwest corner around and west of Atlin. Characteristic birds include the Golden Eagle, Gyrfalcon, White-tailed Ptarmigan, Willow Ptarmigan, Rock Ptarmigan, Horned Lark, Snow Bunting, Water Pipit, and Rosy Finch.

RESOURCE VALUES

Most resource use of the Alpine Tundra zone is based on its high recreational and wildlife values. Recreational pursuits include hiking, camping, skiing, snowmobiling, horseback-riding, and hunting. Such uses are only locally intensive, but certainly the AT is one of the major playgrounds of the province, especially where there is ready access from urban centres.

The AT also provides some locally significant summer range for domestic cattle and sheep, primarily in the drier alpine regions of south-central British Columbia.

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Chapter 19: Non-tidal Wetlands

by

J. Pojar

INTRODUCTION

Most people are familiar with the terms "marsh," "swamp," and "bog," but only relatively recently have these well-known landscape units been grouped together under the single term "wetlands." We have no single, correct, ecologically sound definition for wetlands, primarily because they are so diverse and because the transition to uplands is often gradual.

A functional definition of wetlands stresses that saturation with water is the dominant factor determining the nature of soil development and the type of plant and animal communities living in the soil and on its surface (Cowardin *et al.* 1979). The common denominator of most wetlands is soil or substrate that is at least periodically saturated with or covered by water. Thus, the National Wetland Working Group of Canada defined wetlands as "lands having the water table at, near, or above the land surface or which are saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophilic vegetation and various kinds of biological activity which are adapted to the wet environment" (Tarnocai 1980). We have adopted a simpler definition suitable for most of British Columbia after Runka and Lewis (1981):

> *Wetlands are lands that are wet enough or inundated frequently enough to develop and support a distinctive natural vegetative cover that is in strong contrast to the adjacent matrix of better drained lands.*

Wetland classes recognized in Canada include shallow open waters, marsh, fen, swamp, and bog (Zoltai *et al.* 1975; Tarnocai 1980; National Wetlands Working Group 1988).

SHALLOW OPEN WATERS

This wetland class is composed of permanent, shallow (less than 2 m at the midsummer levels), standing water that lacks extensive emergent plant cover. Vegetation can be absent, or emergent plants (plants rooted in bottom materials and extending upwards above the water surface) can cover up to 10% of the surface. Shallow open waters often include various submerged and floating aquatic macrophytes. Submerged aquatic plants include species of *Myriophyllum* (water milfoil), *Utricularia* (bladderwort), *Isoetes* (quillwort), *Elodea canadensis* (Canadian waterweed), *Ceratophyllum demersum* (coontail), *Ranunculus aquatilis* (white water-buttercup), *Ruppia maritima* (ditch-grass), and *Subularia aquatica* (awlwort). Floating aquatics include both free-floating species (*Lemna* [duckweed] spp., *Spirodela polyrhiza* [great duckweed], *Azolla mexicana* [Mexican mosquito fern]) and floating species rooted in bottom materials (e.g., *Nuphar variegatum* [yellow waterlily], *Nymphaea tetragona* [pygmy waterlily], *Calla palustris* [water-arum], several species of *Sparganium* [bur-reed], *Callitriche* [water-starwort], and *Polygonum* [smartweed], and numerous species of *Potamogeton* [pondweed]).

Water chemistry is the key factor determining the different types of shallow open water; conditions range from soft fresh through hard fresh to saline water. Bottom substrate is another important determinant, especially of the type and abundance of rooted vegetation. This class of wetland (which includes what are often termed ponds and sloughs) is especially common throughout the Interior Plateau and the Great Plains regions.

MARSH

Marshes are wetlands that are permanently or seasonally inundated with nutrient-rich water, and that support extensive cover of emergent herbaceous vegetation rooting in mineral-rich substrate. The water level of marshes varies seasonally and from marsh to marsh. Marshes that dry by late summer expose matted vegetation and unvegetated mudflats or saltflats, but saturation persists near the surface. The substrate ranges from dominantly mineral materials to shallow, well-decomposed peat derived primarily from marsh vegetation. The substrate is strongly influenced by water chemistry, which in turn reflects basin geology and regional climate.

Emergent vegetation covers more than 10% of the surface in marshes. Some typical emergent species in British Columbia are *Typha latifolia* (cattail), *Scirpus lacustris* (great bulrush), *S. paludosus* (alkali bulrush), *Carex aquatilis* (water sedge), *C. rostrata* (beaked sedge), *C. lasiocarpa* (slender sedge), *Juncus balticus* (wire rush), *Equisetum fluviatile* (swamp horsetail), *Menyanthes trifoliata* (buckbean), and *Potentilla palustris* (marsh cinquefoil).

Marshes are especially common on the Interior Plateau, where geology and climate have combined to produce numerous poorly drained basins with nutrient-rich water. Some of the Interior marshes are even highly alkaline or saline. In contrast, ecological conditions in northeastern and north coastal British Columbia (where poorly drained basins are even more abundant) have generally resulted in the formation of organic substrates, and dominantly bog and fen rather than marsh formation.

FEN

Fens are wetlands composed of accumulations of well to poorly decomposed, non-sphagnic peats. Most fens have more than 40 cm of peat accumulation. Fen waters come mostly from groundwater and runoff from adjacent mineral uplands. As a result, fens are less acid and more mineral-rich than are bogs. Fen peat is well to moderately decomposed. Associated soils are Mesisols and Humisols.

Fen vegetation can be dominated by graminoids (grasses, sedges, rushes), low shrubs, or trees, often underlain by mosses. Typical fen shrubs include *Betula glandulosa* (scrub birch), *B. pumila* (swamp birch), willows (*Salix barclayi, S. glauca, S. maccalliana, S. pedicellaris,* among others), *Spiraea douglasii* (hardhack), *Myrica gale* (sweet gale), *Alnus tenuifolia* (mountain alder), *Cornus stolonifera* (red-osier dogwood), and *Potentilla fruticosa* (shrubby cinquefoil). Common herbs include *Carex* *rostrata*, *C. aquatilis*, *C. disperma* (soft-leaved sedge), *C. sitchensis* (Sitka sedge), *C. lasiocarpa*, *Trichophorum cespitosum* (tufted clubrush), *Deschampsia cespitosa* (tufted hairgrass), *Calamagrostis canadensis* (bluejoint), *Equisetum arvense* (common horsetail), *E. fluviatile*, *Platanthera dilatata* (white bog-orchid), and *Amerorchis rotundifolia* (round-leaved orchis). Characteristic trees are white and/or black spruce and tamarack, which is common only in the Boreal White and Black Spruce zone (BWBS) of northeastern British Columbia.

Fens typically have an abundance of "brown" mosses such as *Tomenthypnum nitens* (golden fuzzy fen moss) and species of *Calliergon* and *Drepanocladus*, as well as *Mnium*, *Plagiomnium* and *Rhizomnium* (leafy mosses), and *Aulacomnium palustre* (glow moss). Hummock-forming *Sphagnum* mosses are uncommon, except in fens that are transitional to bogs.

SWAMP

Swamps are wooded wetlands dominated by 25% or greater cover of trees or tall shrubs, and characterized by periodic flooding and nearly permanent subsurface water flow through various mixtures of mineral sediments and peat. Swamps are, like fens, rich in minerals and nutrients, but the characteristic water movement through swamps tends to make them better aerated than fens. Swamp waters thus have sufficient levels of dissolved oxygen to support either tall shrubs or trees.

Some typical swamp types are: western redcedar, Sitka spruce, or red alder swamps on the coast, usually with *Lysichiton americanum* (skunk cabbage); Engelmann, white, and/or black spruce types in the Interior; and tall deciduous shrub types, usually dominated by *Salix* spp., but often also with *Betula glandulosa* or *Alnus tenuifolia* or *Malus fusca* (Pacific crab apple).

The substrate of swamps ranges from mineral material with surface enrichment with organic matter, through mixtures (often interlayered) of mineral and organic matter, to organic accumulations (usually woody and highly humified) of 50 cm or more. Associated soils are Gleysols, Humisols, and Mesisols.

BOG

Bogs are wetlands covered or filled with poorly to moderately decomposed *Sphagnum*-derived peats. Bog surfaces are often raised or level with their immediate surroundings, and thus are little affected by nutrient-rich groundwater from the surrounding mineral soils. Precipitation, a relatively poor source of dissolved ions, is the major source of water to the upper peat. Hence, the upper peat layer of bogs is strongly acid and low in nutrients. Peat materials in bogs derive primarily from *Sphagnum* moss and forest materials (decaying wood and litter); typical bog peat is sometimes underlain by more decomposed fen peat. Bog soils are usually Fibrisols, Mesisols, or Humisols; Organic Cryosols occur in some of the bogs of the BWBS in the Fort Nelson Lowland.

Bog vegetation in the Interior typically has a dominant surface cover of *Sphagnum* mosses with variable amounts of poorly growing or stunted black spruce, low or dwarf ericaceous shrubs (especially *Ledum groenlandicum* [Labrador tea] and *Oxycoccus oxycoccos* [bog cranberry]), *Carex* spp. and *Eriophorum* spp. (cotton-grasses), and lichens. Coastal bogs may or may not have a continuous matrix of *Sphagnum* moss. Typical tree species are shore pine and yellow-cedar, and *Trichophorum caespitosum* characterizes the herb layer along with various species of *Carex* and *Eriophorum*.

Bogs are especially abundant in the BWBS on the flat, poorly drained terrain of the Great Plains and on the outer coastal lowlands, in the hypermaritime subzones of the Coastal Western Hemlock zone.

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APPENDIX 1: Preliminary list of site associations in British Columbia[1]

CONIFEROUS FORESTS

Amabilis Fir Forests

(CWH; occasionally in the ICH along the Coast transition)

BaCw[2] — Devil's club
BaCw — Foamflower
BaCw — Oak fern
BaCw — Salmonberry
BaSs — Devil's club

Subalpine Fir Forests

(ESSF; infrequent in SBS, ICH, BWBS, and SWB)

Bl — Alder — Horsetail
Bl — Azalea — Cow parsnip
Bl — Azalea — Feathermoss
Bl — Azalea — Gooseberry
Bl — Azalea — Oak fern
Bl — Azalea — Pipecleaner moss
Bl — Azalea — Rattlesnake plantain
Bl — Azalea — Rhododendron
Bl — Azalea — Soopolallie
Bl — Azalea — Step moss
Bl — Devil's club — Lady fern
Bl — Devil's club — Rhododendron
Bl — Globeflower — Horsetail
Bl — Gooseberry — Foamflower
Bl — Gooseberry — Horsetail
Bl — Gooseberry — Oak fern
Bl — Gooseberry — Valerian
Bl — Grass-of-Parnassus — Horsetail
Bl — Grouseberry — Cladonia
Bl — Grouseberry — Valerian
Bl — Horsetail — Feathermoss
Bl — Horsetail — Glow moss
Bl — Horsetail — Leafy moss
Bl — Horsetail — Sphagnum
Bl — Huckleberry — Arnica
Bl — Huckleberry — Brachythecium
Bl — Huckleberry — Crowberry
Bl — Huckleberry — Falsebox
Bl — Huckleberry — Feathermoss
Bl — Huckleberry — Heron's-bill
Bl — Huckleberry — Leafy liverwort
Bl — Huckleberry — Mountain liverwort
Bl — Huckleberry — Thimbleberry
Bl — Huckleberry — Utah honeysuckle
Bl — Lady fern — Horsetail
Bl — Lingonberry
Bl — Oak fern — Bluebells
Bl — Oak fern — Brachythecium
Bl — Oak fern — Heron's-bill
Bl — Oak fern — Knight's plume
Bl — Oak fern — Sarsaparilla
Bl — Rhododendron — Azalea
Bl — Rhododendron — Falsebox
Bl — Rhododendron — Feathermoss
Bl — Rhododendron — Foamflower
Bl — Rhododendron — Grouseberry
Bl — Rhododendron — Heron's-bill
Bl — Rhododendron — Horsetail
Bl — Rhododendron — Lady fern
Bl — Rhododendron — Mountain-heather
Bl — Rhododendron — Oak fern
Bl — Rhododendron — Queen's cup
Bl — Rhododendron — Valerian
Bl — Trapper's tea
Bl — Trapper's tea — Valerian
Bl — Twinberry — Lady fern
Bl — Valerian — Arnica
Bl — Valerian — Groundsel
Bl — Valerian — Oak fern
Bl — Valerian — Sickle moss
BlBa — Azalea — Pipecleaner moss
BlBa — Oak fern — Lady fern
BlBa — Rhododendron
BlHm — Azalea
BlHm — Cladonia
BlHm — Devil's club — Lady fern
BlHm — Feathermoss
BlHm — Heron's-bill
BlHm — Horsetail
BlHm — Huckleberry
BlHm — Oak fern
BlHm — Oak fern — Leafy moss
BlHm — Rhododendron — Leafy liverwort
BlHm — Rhododendron — Oak fern
BlHm — Rhododendron — Pipecleaner moss
BlHm — Twistedstalk
BlPa — Azalea
BlPa — Cladonia
BlPa — Juniper
BlPl — Cladina

Subalpine Fir Forests - continued

BlPl — Crowberry — Cladina
BlPl — Juniper — Cladonia
BlPl — Juniper — Rhacomitrium
BlSb — Labrador tea

Interior Western Redcedar — Western Hemlock Forests
(ICH and IDF)

Cw — Devil's club — Foamflower
Cw — Devil's club — Ostrich fern
Cw — Mountain alder — Skunk cabbage
CwFd — Dogwood
CwFd — Falsebox
CwFd — Falsebox — Feathermoss
CwFd — Feathermoss
CwFd — Hazelnut
CwFd — Juniper — Falsebox
CwFd — Soopolallie — Twinflower
CwHw — Devil's club — Lady fern
CwHw — Devil's club — Sarsaparilla
CwHw — Horsetail
CwHw — Oak fern
CwHw — Oak fern — Foamflower
CwHw — Oak fern — Spiny wood fern
CwHw — Utah honeysuckle — Oak fern
CwHw — White pine — Devil's club
HwCw — Cladonia
HwCw — Falsebox — Feathermoss
HwCw — Falsebox — Step moss
HwCw — Feathermoss
HwCw — Juniper — Falsebox
HwCw — Spruce — Step moss
HwCw — Step moss

Coastal Western Redcedar Forests
(CWH and CDF)

Cw — Black twinberry
Cw — Devil's club
Cw — Foamflower
Cw — Indian plum
Cw — Lady fern
Cw — Salmonberry
Cw — Skunk cabbage
Cw — Slough sedge
Cw — Snowberry
Cw — Solomon's seal
Cw — Sword fern
CwBg — Foamflower
CwFd — Kindbergia
CwHw — Blueberry
CwHw — Sword fern
CwSs — Conocephalum
CwSs — Devil's club
CwSs — Foamflower
CwSs — Salal
CwSs — Skunk cabbage
CwSs — Swordfern
CwYc — Goldthread
CwYc — Salal

Interior Western Redcedar — Spruce Forests
(mainly ICH; often in IDF)

CwSx — Devil's club — Horsetail
CwSxw — Aspen
CwSxw — Devil's club — Horsetail
CwSxw — Douglas maple — Fairybells
CwSxw — Falsebox
CwSxw — Falsebox — Feathermoss
CwSxw — Falsebox — Knight's plume
CwSxw — Falsebox — Soopolallie
CwSxw — Falsebox — Wintergreen
CwSxw — Oak fern
CwSxw — Oak fern — Bunchberry
CwSxw — Oak fern — Electrified cat's-tail
CwSxw — Raspberry — Oak fern
CwSxw — Skunk cabbage
CwSxw — Soopolallie
CwSxw — Thimbleberry
CwSxw — Twinberry — Soft-leaved sedge
CwSxw — Velvet-leaved blueberry

Coastal Western Hemlock Forests
(CWH)

Hw — Flat moss
Hw — Queen's cup
Hw — Sphagnum
HwBa — Blueberry
HwBa — Bramble
HwBa — Pipecleaner moss
HwBa — Queen's cup
HwBa — Step moss

Coastal Western Hemlock Forests - continued

HwCw — Deer fern
HwCw — Salal
HwFd — Cat's-tail moss
HwFd — Kindbergia
HwPl — Cladina
HwPl — Feathermoss
HwSs — Blueberry
HwSs — Lanky moss
HwSs — Step moss

Interior Western Hemlock Forests
(ICH)

Hw — Azalea — Cladonia
Hw — Azalea — Skunk cabbage
Hw — Devil's club
Hw — Devil's club — Gooseberry
Hw — Kinnikinnick — Cladonia
Hw — Redcedar — Cladonia
Hw — Step moss
Hw — Wood horsetail — Sphagnum
HwBl — Oak fern

Coastal Douglas-fir Forests
(CDF and CWH)

Fd — Fairybells
Fd — Oniongrass
Fd — Salal
Fd — Sword fern
FdBg — Oregon grape
FdHw — Falsebox
FdHw — Salal
FdPl — Arbutus
FdPl — Cladina
FdPl — Kinnikinnick

Interior Douglas-fir Forests
(mainly IDF, but also common in PP, ICH, MS, and SBS, and occassionally in SBPS and ESSF)

Fd — Big sage — Pinegrass
Fd — Bluebunch wheatgrass — Needlegrass
Fd — Bluebunch wheatgrass — Pinegrass
Fd — Douglas maple — Step moss
Fd — Falsebox — Pinegrass
Fd — Feathermoss
Fd — Feathermoss — Step moss
Fd — Juniper — Big sage
Fd — Juniper — Bluebunch wheatgrass
Fd — Juniper — Cladina
Fd — Juniper — Grouseberry
Fd — Juniper — Haircap moss
Fd — Juniper — Kinnikinnick
Fd — Juniper — Pasture sage
Fd — Juniper — Peltigera
Fd — Juniper — Pinegrass
Fd — Juniper — Saskatoon
Fd — Penstemon — Pinegrass
Fd — Pinegrass — Aster
Fd — Pinegrass — Feathermoss
Fd — Pinegrass — Kinnikinnick
Fd — Saskatoon — Pinegrass
Fd — Snowberry — Balsamroot
Fd — Snowberry — Bluebunch wheatgrass
Fd — Soopolallie — Feathermoss
Fd — Water birch — Douglas maple
FdBl — Falsebox — Pinegrass
FdBl — Huckleberry
FdCw — Falsebox — Prince's pine
FdCw — Wavy-leaved moss
FdLw — Spruce — Pinegrass
FdPl — Cladonia
FdPl — Juniper
FdPl — Juniper — Pinegrass
FdPl — Pinegrass — Arnica
FdPl — Pinegrass — Feathermoss
FdPl — Pinegrass — Twinflower
FdPl — Sitka alder — Pinegrass
FdPl — Velvet-leaved blueberry — Cladonia
FdPy — Bluebunch wheatgrass — Balsamroot
FdPy — Bluebunch wheatgrass — Pinegrass
FdPy — Bluebunch wheatgrass — Rough fescue
FdPy — Bluebunch wheatgrass — Selaginella
FdPy — Ninebark
FdPy — Pinegrass
FdPy — Pinegrass — Feathermoss
FdPy — Pinegrass — Idaho fescue
FdPy — Snowberry — Bluebunch wheatgrass
FdPy — Snowberry — Pinegrass
FdPy — Snowberry — Saskatoon
FdPy — Snowberry — Spirea
FdPy — Snowbrush — Pinegrass
FdPy — Spirea — Feathermoss
FdPy — Western snowberry — Bluebunch wheatgrass

Mountain Hemlock — Amabilis Fir Forests
(MH)

BaHm — Oak fern
BaHm — Twistedstalk
HmBa — Blueberry
HmBa — Bramble
HmBa — Mountain-heather
HmSs — Blueberry

Mountain Hemlock — Yellow-cedar Forests
(MH)

HmYc — Deer cabbage
HmYc — Goldthread
HmYc — Mountain-heather
HmYc — Sphagnum
YcHm — Hellbore
YcHm — Skunk cabbage
YcHm — Twistedstalk

Tamarack Forests
(BWBS, and sometimes SBS)

Lt — Buckbean
Lt — Glow moss
Lt — Horsetail

Whitebark Pine Forests
(ESSF; see also BlPa site associations)

Pa — Junegrass

Lodgepole Pine Forests
(mostly in SBS, SBPS, BWBS and MS, but also in ESSF, IDF, ICH, ESSF, and SWB)

Pl — Cladina — Step moss
Pl — Cladonia — Haircap moss
Pl — Crowberry — Stereocaulon
Pl — Douglas-fir — Juniper
Pl — Dwarf blueberry — Sphagnum
Pl — Falsebox — Lupine
Pl — Feathermoss — Cladina
Pl — Fescue — Stereocaulon
Pl — Grouseberry — Cladonia
Pl — Grouseberry — Feathermoss
Pl — Grouseberry — Kinnikinnick
Pl — Grouseberry — Pinegrass
Pl — Huckleberry — Cladina
Pl — Huckleberry — Cladonia
Pl — Huckleberry — Pinegrass
Pl — Huckleberry — Velvet-leaved blueberry
Pl — Juniper — Dwarf blueberry
Pl — Juniper — Feathermoss
Pl — Juniper — Grouseberry
Pl — Juniper — Lupine
Pl — Juniper — Pinegrass
Pl — Juniper — Ricegrass
Pl — Kinnikinnick — Cladonia
Pl — Kinnikinnick — Feathermoss
Pl — Lingonberry — Cladonia
Pl — Lingonberry — Feathermoss
Pl — Lingonberry — Velvet-leaved blueberry
Pl — Oregon-grape — Pinegrass
Pl — Pinegrass — Arnica
Pl — Pinegrass — Feathermoss
Pl — Pinegrass — Kinnikinnick
Pl — Pinegrass — Arnica
Pl — Pinegrass — Feathermoss
Pl — Pinegrass — Kinnikinnick
Pl — Pinegrass — Lupine
Pl — Scrub birch — Lichen
Pl — Scrub birch — Lingonberry
Pl — Soopolallie — Pinegrass
Pl — Sphagnum
Pl — Spirea — Pinegrass
Pl — Trapper's tea — Crowberry
Pl — Velvet-leaved blueberry — Cladonia
PlHw — Feathermoss
PlHw — Velvet-leaved blueberry
PlSb — Feathermoss
PlSe — Falsebox — Pinegrass
PlSe — Pinegrass

Shore Pine Forests
(CWH, and sometimes CDF)

Pl — Kinnikinnick
Pl — Sphagnum
PlYc — Rhacomitrium
PlYc — Sphagnum

Ponderosa Pine Forests
(BG and PP; also see FdPy site associations)

Py — Antelope brush — Red three-awn
Py — Antelope-brush — Kinnikinnick
Py — Big sage — Bluebunch wheatgrass
Py — Bluebunch wheatgrass
Py — Bluebunch wheatgrass — Cheatgrass
Py — Bluebunch wheatgrass — Fescue
Py — Bluebunch wheatgrass — Idaho fescue
Py — Bluebunch wheatgrass — Rough fescue
Py — Juniper — Kinnikinnick
Py — Red three-awn
Py — Rose — Bluebunch wheatgrass
Py — Rough fescue — Bluebunch wheatgrass
Py — Saskatoon — Bluebunch wheatgrass
Py — Sumac
PyAct — Nootka rose — Poison ivy
PyAt — Rose — Solomon's-seal

Black Spruce Forests
(mainly BWBS and SBS, although also in SBPS, SWB and ICH)

Sb — Cloudberry — Sphagnum
Sb — Creeping-snowberry — Sphagnum
Sb — Feathermoss — Bluebells
Sb — Horsetail — Sphagnum
Sb — Huckleberry — Spirea
Sb — Labrador tea
Sb — Labrador tea — Dwarf blueberry
Sb — Labrador tea — Sphagnum
Sb — Lingonberry — Coltsfoot
Sb — Lingonberry — Knight's plume
Sb — Moss
Sb — Scrub birch — Sedge
Sb — Soft-leaved sedge — Sphagnum
Sb — Sphagnum
Sb — Willow
Sb — Willow — Glow moss
SbLt — Step moss
SbPl — Feathermoss
SbSw — Feathermoss
SbSxw — Scrub birch — Sedge

White Spruce Forests
(mostly BWBS; also SWB, but poorly sampled and characterized)

Sw — Currant — Bluebells
Sw — Currant — Horsetail
Sw — Currant — Oak fern
Sw — Huckleberry — Step moss
Sw — Knight's plume — Step moss
Sw — Scouring-rush — Step moss
Sw — Soopolallie — Twinflower
Sw — Toad-flax — Horsetail
Sw — Wildrye — Peavine
Sw — Wildrye — Toad-flax
SwAt — Step moss
SwBl — Grey-leaved willow — Scrub birch
SwBl — Scrub birch — Tall bluebells

Hybrid Spruce Forests
(mostly from the SBS and MS, although also common in the IDF, ICH, and SBPS)

Sxl — Twinberry — Hazelnut
SxlEp — Devil's club
Sxw — Crowberry — Glow moss
Sxw — Crowberry — Knight's plume
Sxw — Devil's club
Sxw — Devil's club — Dogwood
Sxw — Devil's club — Knight's plume
Sxw — Devil's club — Lady fern
Sxw — Devil's club — Ostrich fern
Sxw — Devil's club — Spiny wood fern
Sxw — Devil's club — Step moss
Sxw — Dogwood — Horsetail
Sxw — Falsebox — Feathermoss
Sxw — Falsebox — Knight's plume
Sxw — Feathermoss — Brachythecium
Sxw — Gooseberry
Sxw — Gooseberry — Devil's club
Sxw — Gooseberry — Grouseberry
Sxw — Gooseberry — Sarsaparilla
Sxw — Horsetail
Sxw — Horsetail — Crowberry
Sxw — Horsetail — Glow moss
Sxw — Horsetail — Leafy moss
Sxw — Horsetail — Meadowrue

Sxw — Huckleberry
Sxw — Huckleberry — Dwarf blueberry
Sxw — Huckleberry — Falsebox
Sxw — Huckleberry — Highbush-cranberry
Sxw — Huckleberry — Labrador tea
Sxw — Huckleberry — Soopolallie
Sxw — Oak fern
Sxw — Ostrich fern
Sxw — Pink spirea
Sxw — Prickly rose — Coltsfoot
Sxw — Prickly rose — Sarsaparilla
Sxw — Prickly rose — Sedge
Sxw — Scrub birch — Feathermoss
Sxw — Scrub birch — Fen moss
Sxw — Soopolallie — Falsebox
Sxw — Soopolallie — Grouseberry
Sxw — Soopolallie — Snowberry
Sxw — Spirea — Feathermoss
Sxw — Spirea — Purple peavine
Sxw — Trapper's tea — Grouseberry
Sxw — Trapper's tea — Horsetail
Sxw — Twinberry
Sxw — Twinberry — Coltsfoot
Sxw — Twinberry — Oak fern
Sxw — Water birch
Sxw — Wintergreen — Feathermoss
SxwCw — Oak fern
SxwEp — Devil's club
SxwFd — Coltsfoot
SxwFd — Dogwood — Gooseberry
SxwFd — Douglas maple — Dogwood
SxwFd — Electrified cat's-tail
SxwFd — Falsebox
SxwFd — Feathermoss
SxwFd — Gooseberry — Feathermoss
SxwFd — Hazelnut
SxwFd — Knight's plume
SxwFd — Pinegrass
SxwFd — Purple peavine
SxwFd — Ricegrass
SxwFd — Thimbleberry
SxwFd — Toad-flax
SxwLw — Oregon-grape

Sitka Spruce Forests
(CWH; infrequent in the MH)

Ss — Deer fern
Ss — Kindbergia
Ss — Lily-of-the-valley
Ss — Reed grass
Ss — Salal
Ss — Salmonberry
Ss — Skunk cabbage
Ss — Slough sedge
Ss — Trisetum
SsHm — Reed grass
SsHw — Devil's club
SsHw — Oak fern
SsHw — Sword fern

DECIDUOUS FORESTS

Cottonwood/Balsam Poplar Forests

(understorey poorly characterized, but occurring in the CDF, CWH, BG, PP, IDF, ICH MS, SBS, ESSF, and BWBS)

Acb — Green alder
Acb — Dogwood
Act — Dogwood — Prickly rose
Act — Red-osier Dogwood
Act — Snowberry — Dogwood
Act — Water birch
Act — Willow

Aspen Forests
(mainly characterized in the BWBS, but also occurring in all zones except the MH, ESSF, and AT)

At — Black twinberry
At — Cow parsnip
At — Creamy peavine
At — Kinnikinnick
At — Labrador tea
At — Oak fern
At — Snowberry — Kentucky bluegrass
At — Soopolallie
AtEp — Dogwood

Red Alder Forests
(CWH and CDF; understory vegetation poorly characterized)

Dr — Lily-of-the-valley

Paper Birch Forests
(All zones except MH and AT; understory poorly characterized)

Ep — Star-flowered false Solomon's seal
EpAt — Thimbleberry — Falsebox

Garry Oak Forests
(CDF)

Qg — Brome
Qg — Ocean spray

SCRUB

Alder Shrublands
(CWH, MH, ESSF, SBS, and ICH)

Alder — Lady fern

Shrub-steppe
(mainly BG, PP and IDF; although infrequent in the SBS, MS, ESSF, and BWBS)

Antelope brush — Needle-and-thread grass
Big sage — Bluebunch wheatgrass
Big sage — Bluebunch wheatgrass — Balsamroot
Big sage — Bluebunch wheatgrass — Fescue
Big sage — Bluebunch wheatgrass — Idaho fescue
Big sage — Kentucky bluegrass
Big sage — Needle-and-thread grass
Big sage — Pinegrass
Juniper — Bluebunch wheatgrass
Juniper — Pinegrass
Prairie rose — Idaho fescue
Saskatoon — Bluebunch wheatgrass
Saskatoon — Slender wheatgrass

GRASSLANDS

Grasslands
(mostly BG, PP, and IDF, although also in BWBS, ESSF, SBS, MS and ICH)

Altai fescue
Balsamroot — Kentucky bluegrass
Bluebunch wheatgrass — Balsamroot
Bluebunch wheatgrass — Junegrass
Bluebunch wheatgrass — Needle-and-thread grass
Bluebunch wheatgrass — Pasqueflower
Bluebunch wheatgrass — Selaginella
Bluegrass — Slender wheatgrass
Bluejoint — Glow moss
Bluejoint — Sedge
Fescue — Bluebunch wheatgrass
Giant wildrye
Idaho fescue — Bluebunch wheatgrass
Kentucky bluegrass — Stiff needlegrass
Needle-and-thread grass — Junegrass
Pasture sage — Slender wheatgrass
Pasture sage — Western wheatgrass
Pinegrass — Meadowrue
Red three-awn — Needle-and-thread grass
Rough fescue — Bluebunch wheatgrass
Selaginella — Bluegrass
Spreading needlegrass
Spreading needlegrass — Slender wheatgrass

[1] Non-forested (alpine, wetland, and grassland) and deciduous ecosystems are poorly sampled and therefore inadequately represented in this summary. Zone codes are presented in Table 4 (pp. 56-57).

[2] Tree species codes are as follows:

Acb = balsam poplar
Act = cottonwood
At = aspen
Ba = amabilis fir
Bg = grand fir
Bl = subalpine fir
Cw = western redcedar
Dr = red alder
Ep = paper birch
Fd = Douglas-fir
Hm = mountain hemlock
Hw = western hemlock
Lw = western larch
Lt = tamarack
Pa = whitebark pine
Pl = lodgepole or shore pine
Py = ponderosa pine
Qg = Garry oak
Sb = black spruce
Se = Engelmann spruce
Ss = Sitka spruce
Sw = white spruce
Sx = hybrid spruce
Sxl = Roche spruce
Sxw = hybrid white spruce
Yc = yellow-cedar

APPENDIX 2. List of plant species

Abies amabilis	amabilis fir
Abies grandis	grand fir
Abies lasiocarpa	subalpine fir
Acer circinatum	vine maple
Acer glabrum	Douglas maple
Acer macrophyllum	bigleaf maple
Achillea millefolium	yarrow
Achlys triphylla	vanilla-leaf
Aconitum delphiniifolium	mountain monkshood
Agropyron repens	quack grass
Agropyron smithii	western wheatgrass
Agropyron spicatum	bluebunch wheatgrass
Agropyron trachycaulum	slender wheatgrass
Agropyron violaceum	broad-glumed wheatgrass
Aira spp.	hairgrasses
Alectoria ochroleuca	
Allium cernuum	nodding onion
Alnus crispa ssp. *crispa*	green alder
Alnus crispa ssp. *sinuata*	Sitka alder
Alnus rubra	red alder
Alnus tenuifolia	mountain alder
Amelanchier alnifolia	saskatoon
Amerorchis rotundifolia	round-leaved orchis
Andromeda polifolia	bog-rosemary
Anemone occidentalis	western pasqueflower
Antennaria dimorpha	low pussytoes
Antennaria lanata	woolly pussytoes
Antennaria microphylla	rosy pussytoes
Antennaria monocephala	one-headed pussytoes
Antennaria neglecta	field pussytoes
Aralia nudicaulis	wild sarsaparilla
Arbutus menziesii	arbutus
Arctagrostis latifolia	polargrass
Arctostaphylos rubra	red bearberry
Arctostaphylos uva-ursi	kinnikinnick
Aristida longiseta	red three-awn
Arnica cordifolia	heart-leaved arnica
Arnica fulgens	orange arnica
Arnica latifolia	mountain arnica
Artemisia campestris	northern wormwood
Artemisia campestris ssp. *borealis*	northern wormwood
Artemisia frigida	pasture sage
Artemisia norvegica ssp. *saxatilis*	mountain sagewort
Artemisia tridentata	big sagebrush
Asarum caudatum	wild ginger
Aster ciliolatus	fringed aster
Aster conspicuus	showy aster
Aster curtus	white-topped aster
Astragalus miser	timber milk-vetch
Athyrium filix-femina	lady fern
Aulacomnium palustre	glow moss
Azolla mexicana	Mexican mosquito fern
Balsamorhiza deltoidea	deltoid balsamroot
Balsamorhiza sagittata	arrow-leaved balsamroot
Barbilophozia floerkei	mountain leafy liverwort
Barbilophozia lycopodioides	common leafy liverwort
Betula glandulosa	scrub birch
Betula neoalaskana	Alaska paper birch
Betula occidentalis	water birch
Betula papyrifera	paper birch
Betula pumila	swamp birch
Blechnum spicant	deer fern
Brachythecium hylotapetum	
Bromus spp.	bromegrasses
Bromus tectorum	cheatgrass
Bromus vulgaris	Columbia brome
Bryum caespiticium	
Calamagrostis canadensis	bluejoint
Calamagrostis lapponica	Lapland reedgrass
Calamagrostis purpurascens	purple reedgrass
Calamagrostis rubescens	pinegrass
Calla palustris	water-arum
Calliergon	
Calliergon cordifolium	
Callitriche spp.	water-starworts
Caltha leptosepala	white marsh-marigold
Camassia leichtlinii	great camas
Camassia quamash	common camas
Campanula lasiocarpa	mountain harebell
Carex aquatilis	water sedge
Carex albonigra	two-toned sedge
Carex atrata	blackened sedge
Carex capitata	capitate sedge
Carex concinnoides	northwestern sedge
Carex disperma	soft-leaved sedge
Carex enanderi	Enander's sedge
Carex lasiocarpa	slender sedge
Carex lyngbyei	Lyngbye's sedge
Carex macloviana	thick-headed sedge
Carex microchaeta	small-awned sedge
Carex nardina	spikenard sedge
Carex nigricans	black alpine sedge
Carex obtusata	blunt sedge
Carex petasata	pasture sedge
Carex phaeocephala	dunhead sedge
Carex podocarpa	short-stalked sedge

Carex praegracilis	field sedge
Carex richardsonii	Richardson's sedge
Carex rostrata	beaked sedge
Carex scirpoidea ssp. *pseudoscirpoidea*	single-spiked sedge
Carex sitchensis	Sitka sedge
Carex spectabilis	showy sedge
Carex supina	spreading arctic sedge
Carex vaginata	sheathed sedge
Carex vesicaria	inflated sedge
Cassiope lycopodioides	club-moss mountain-heather
Cassiope mertensiana	white mountain-heather
Cassiope stelleriana	Alaskan mountain-heather
Cassiope tetragona	four-angled mountain-heather
Castilleja levisecta	golden Indian paintbrush
Castilleja miniata	common red paintbrush
Castilleja parviflora	small-flowered paintbrush
Ceanothus velutinus	snowbrush
Centaurea spp.	knapweeds
Ceratadon purpureus	
Ceratophyllum demersum	coontail
Cetraria cucullata	
Cetraria delisei	
Cetraria islandica	
Cetraria nigricans	
Cetraria nivalis	
Cetraria tilesii	
Chamaecyparis nootkatensis	yellow-cedar
Chamaedaphne calyculata	leatherleaf
Chimaphila umbellata	prince's pine
Chrysothamnus nauseosus	rabbit-brush
Circaea alpina	enchanter's nightshade
Cladina alpestris	
Cladina mitis	
Cladina rangiferina	reindeer lichen
Cladonia ecmocyna	
Cladonia gonecha	
Cladonia gracilis	
Cladothamnus pyrolaeflorus	copperbush
Clintonia uniflora	queen's cup
Conocephalum conicum	
Coptis aspleniifolia	fern-leaved goldthread
Cornicularia aculeata	
Cornicularia divergens	
Cornus canadensis	bunchberry
Cornus nuttallii	western flowering dogwood
Cornus stolonifera	red-osier dogwood
Corylus cornuta	beaked hazelnut
Crepis atrabarba	slender hawksbeard
Cytisus scoparius	Scotch broom
Dactylina arctica	
Dactylis glomerata	orchardgrass
Danthonia intermedia	timber oatgrass
Deschampsia cespitosa	tufted hairgrass
Dicranum acutifolium	
Dicranum fuscescens	curly heron's-bill moss
Dicranum polysetum	wavy-leaved moss
Dicranum scoparium	broom moss
Diploschistes scruposus	
Disporum hookeri	Hooker's fairybells
Distichium capillaceum	
Distichlis stricta	alkali saltgrass
Ditrichum flexicaule	
Dodecatheon hendersonii	broad-leaved shootingstar
Draba nivalis	snow draba
Drepanocladus exannulatus	
Drepanocladus revolvens	
Drepanocladus uncinatus	sickle moss
Drosera rotundifolia	round-leaved sundew
Dryas integrifolia	entire-leaved mountain-avens
Dryas octopetala	white mountain-avens
Dryopteris expansa	spiny wood fern
Elodea canadensis	Canadian waterweed
Elymus cinereus	giant wildrye
Elymus innovatus	fuzzy-spiked wildrye
Empetrum nigrum	crowberry
Epilobium angustifolium	fireweed
Epilobium latifolium	broad-leaved willowherb
Equisetum arvense	common horsetail
Equisetum fluviatile	swamp horsetail
Equisetum scirpoides	dwarf scouring-rush
Equisetum sylvaticum	wood horsetail
Equisetum telmateia	giant horsetail
Erigeron compositus	cut-leaved daisy
Erigeron linearis	line-leaved fleabane
Erigeron peregrinus	subalpine daisy
Erigeron speciosus	showy fleabane
Eriogonum heracleoides	parsnip-flowered buckwheat
Eriophorum spp.	cotton-grasses
Erythronium grandiflorum	glacier lily
Erythronium oreganum	white fawn lily
Festuca altaica	Altai fescue
Festuca brachyphylla	alpine fescue
Festuca idahoensis	Idaho fescue
Festuca occidentalis	western fescue
Festuca saximontana	Rocky Mountain fescue
Festuca scabrella	rough fescue
Festuca subulata	bearded fescue

Festuca viridula	green fescue
Fragaria virginiana	wild strawberry
Galium aparine	cleavers
Galium boreale	northern bedstraw
Galium triflorum	sweet-scented bedstraw
Gaultheria humifusa	alpine-wintergreen
Gaultheria shallon	salal
Gentiana glauca	glaucous gentian
Geocaulon lividum	bastard toad-flax
Goodyera oblongifolia	rattlesnake-plantain
Goodyera repens	dwarf rattlesnake orchid
Gymnocarpium dryopteris	oak fern
Heracleum lanatum	cow-parsnip
Hieracium albiflorum	white-flowered hawkweed
Hieracium gracile	slender hawkweed
Hierochloe alpina	alpine sweetgrass
Holodiscus discolor	ocean-spray
Hordeum jubatum	foxtail barley
Hylocomium splendens	step moss
Isoetes spp.	quillworts‘
Juncus arcticus	arctic rush
Juncus balticus	wire rush
Juncus drummondii	Drummond's rush
Juncus parryi	Parry's rush
Juniperus communis	common juniper
Juniperus scopulorum	Rocky Mountain juniper
Kalmia microphylla ssp. *occidentalis*	bog-laurel
Kindbergia oregana	Oregon beaked moss
Kindbergia praelonga	
Kobresia myosuroides	Bellard's kobresia
Koeleria macrantha	junegrass
Larix laricina	tamarack
Larix lyallii	alpine larch
Larix occidentalis	western larch
Lathyrus nevadensis	purple peavine
Lathyrus ochroleucus	creamy peavine
Lecanora spp.	
Lecidea spp.	
Ledum groenlandicum	Labrador tea
Lemna spp.	duckweeds
Leptarrhena pyrolifolia	leatherleaf saxifrage
Leucolepis menziesii	palm tree moss
Lilium columbianum	tiger lily
Limnanthes macounii	Macoun's meadowfoam
Linnaea borealis	twinflower
Linum lewisii	wild blue flax
Listera cordata	heart-leaved twayblade

Loiseleuria procumbens	alpine azalea
Lomatium macrocarpum	large-fruited desert-parsley
Lonicera ciliosa	western trumpet honeysuckle
Lonicera involucrata	black twinberry
Lonicera utahensis	Utah honeysuckle
Luetkea pectinata	partridgefoot
Lupinus arcticus	arctic lupine
Lupinus sericeus	silky lupine
Luzula arctica	arctic woodrush
Luzula arcuata	curved alpine woodrush
Luzula parviflora	small-flowered woodrush
Luzula spicata	spiked woodrush
Luzula wahlenbergii	Wahlenberg's woodrush
Lycopodium alpinum	alpine clubmoss
Lycopodium annotinum	stiff clubmoss
Lycopodium sitchense	Alaska clubmoss
Lysichiton americanum	skunk cabbage
Mahonia aquifolium	tall Oregon-grape
Mahonia nervosa	dull Oregon-grape
Maianthemum canadense	wild lily-of-the-valley
Maianthemum dilatatum	false lily-of-the-valley
Malus fusca	Pacific crab apple
Melica subulata	Alaska oniongrass
Menyanthes trifoliata	buckbean
Menziesia ferruginea	false azalea
Mertensia paniculata	tall bluebells
Mimulus lewisii	pink monkey-flower
Mitella breweri	Brewer's mitrewort
Mitella nuda	common mitrewort
Mitella pentandra	five-stamened mitrewort
Mnium blyttii	
Muehlenbergia asperifolia	alkali muhly
Myrica gale	sweet gale
Myriophyllum spp.	water milfoils
Nephroma arcticum	
Nuphar lutea	yellow waterlily
Nymphaea tetragona	pygmy waterlily
Oemleria cerasiformis	Indian-plum
Oplopanax horridus	devil's club
Opuntia fragilis	brittle prickly-pear cactus
Orthilia secunda	one-sided wintergreen
Oryzopsis asperifolia	rough-leaved ricegrass
Oryzopsis pungens	short-awned ricegrass
Osmorhiza chilensis	mountain sweet-cicely
Oxycoccus oxycoccos	bog cranberry
Oxyria digyna	mountain sorrel
Oxytropis nigrescens	blackish locoweed
Oxytropis variens	Alaskan locoweed

APPENDIX 2. Continued

Paludella squarrosa	
Parmelia separata	
Parnassia fimbriata	fringed grass-of-Parnassus
Paxistima myrsinites	falsebox
Pedicularis bracteosa	bracted lousewort
Pedicularis ornithorhyncha	bird's-beak lousewort
Pellia epiphylla	
Peltigera aphthosa	
Peltigera canina	dog lichen
Peltigera malacea	
Peltigera scabrosa	
Penstemon fruticosus	shrubby penstemon
Petasites frigidus var. *frigidus*	sweet coltsfoot
Petasites frigidus var. *palmatus*	palmate coltsfoot
Phalaris arundinacea	reed canarygrass
Philadelphus lewisii	mock-orange
Phleum alpinum	alpine timothy
Phleum pratense	timothy
Phragmites australis	common reed
Phyllodoce empetriformis	pink mountain-heather
Phyllodoce glanduliflora	yellow mountain-heather
Physconia muscigena	
Physocarpus malvaceus	mallow ninebark
Picea engelmannii	Engelmann spruce
Picea engelmannii x *glauca*	hybrid white spruce
Picea glauca	white spruce
Picea glauca x *sitchensis*	Roche spruce
Picea mariana	black spruce
Picea sitchensis	Sitka spruce
Picea x *lutzii*	Roche spruce
Pinus albicaulis	whitebark pine
Pinus banksiana	jack pine
Pinus contorta	lodgepole pine
Pinus contorta var. *contorta*	shore pine
Pinus contorta var. *latifolia*	lodgepole pine
Pinus flexilis	limber pine
Pinus monticola	western white pine
Pinus ponderosa	ponderosa pine
Plagiomnium ellipticum	
Plagiomnium insigne	
Plagiomnium venustum	
Plagiothecium undulatum	flat moss
Platanthera dilatata	white bog-orchid
Pleurozium schreberi	red-stemmed feathermoss
Poa arctica	arctic bluegrass
Poa glauca	glaucous bluegrass
Poa leptocoma	bog bluegrass
Poa pratensis	Kentucky bluegrass
Poa rupicola	timberline bluegrass
Poa sandbergii	Sandberg's bluegrass
Polemonium caeruleum	tall Jacob's-ladder
Polygonum spp.	smartweeds

Polygonum viviparum	alpine bistort
Polystichum munitum	sword fern
Polytrichum juniperinum	juniper haircap moss
Polytrichum piliferum	awned haircap moss
Polytrichum strictum	
Populus balsamifera ssp. *balsamifera*	balsam poplar
Populus balsamifera ssp. *trichocarpa*	black cottonwood
Populus tremuloides	trembling aspen
Potamogeton spp.	pondweeds
Potentilla diversifolia	diverse-leaved cinquefoil
Potentilla fruticosa	shrubby cinquefoil
Potentilla hyparctica	arctic cinquefoil
Potentilla palustris	marsh cinquefoil
Potentilla pensylvanica	prairie cinquefoil
Potentilla uniflora	one-flowered cinquefoil
Prunus emarginata	bitter cherry
Prunus virginiana	choke cherry
Pseudotsuga menziesii	Douglas-fir
Pseudotsuga menziesii var. *menziesii*	coastal Douglas-fir
Pteridium aquilinum	bracken
Ptilium crista-castrensis	knight's plume
Puccinellia nuttalliana	Nuttall's alkaligrass
Purshia tridentata	antelope-brush
Pyrola asarifolia	pink wintergreen
Quercus garryana	Garry oak
Ranunculus aquatilis	white water-buttercup
Ranunculus eschscholtzii	subalpine buttercup
Ranunculus nivalis	snow buttercup
Rhacomitrium heterostichum	
Rhacomitrium lanuginosum	
Rhizocarpon spp.	
Rhizomnium magnifolium	
Rhizomnium nudum	
Rhododendron albiflorum	white-flowered rhododendron
Rhytidiadelphus loreus	lanky moss
Rhytidiadelphus triquetrus	electrified cat's-tail
Rhytidiopsis robusta	pipecleaner moss
Rhytidium rugosum	
Ribes lacustre	black gooseberry
Ribes triste	red swamp currant
Rosa acicularis	prickly rose
Rosa gymnocarpa	baldhip rose
Rosa woodsii	Wood's rose
Rubus arcticus	dwarf nagoonberry
Rubus chamaemorus	cloudberry
Rubus parviflorus	thimbleberry

Rubus pedatus	five-leaved bramble
Rubus pubescens	trailing raspberry
Rubus spectabilis	salmonberry
Rubus ursinus	trailing blackberry
Ruppia maritima	ditch-grass
Salix alaxensis	Alaska willow
Salix arctica	arctic willow
Salix barclayi	Barclay's willow
Salix barrattiana	Barratt's willow
Salix bebbiana	Bebb's willow
Salix cascadensis	Cascade willow
Salix commutata	variable willow
Salix glauca	grey-leaved willow
Salix lanata	woolly willow
Salix maccalliana	Maccall's willow
Salix myrtillifolia	bilberry willow
Salix pedicellaris	bog willow
Salix planifolia	tea-leaved willow
Salix polaris	polar willow
Salix pseudomonticola	mountain willow
Salix reticulata	netted willow
Salix reticulata ssp. *nivalis*	snow willow
Salix scouleriana	Scouler's willow
Sambucus racemosa	red elderberry
Salicornia europaea	European glasswort
Sanicula crassicaulis	Pacific sanicle
Saxifraga tricuspidata	three-toothed saxifrage
Scapania bolanderi	
Scirpus spp.	bulrushes
Scirpus lacustris	great bulrush
Scirpus paludosus	alkali bulrush
Sedum spp.	stonecrops
Selaginella densa	compact selaginella
Senecio lugens	black-tipped groundsel
Senecio pauciflorus	rayless alpine butterweed
Senecio triangularis	arrow-leaved groundsel
Shepherdia canadensis	soopolallie
Silene acaulis	moss campion
Sisyrinchium douglasii	satin-flower
Smilacina racemosa	false Solomon's-seal
Smilacina stellata	star-flowered false Solomon's-seal
Solidago spathulata	spike-like goldenrod
Sorbus sitchensis	Sitka mountain-ash
Sparganium spp.	bur-reeds
Sphagnum capillaceum	common red sphagnum
Sphagnum recurvum	
Sphagnum squarrosum	
Spiraea betulifolia	birch-leaved spirea
Spiraea douglasii	hardhack
Spirodela polyrhiza	great duckweed
Sporobolus cryptandrus	sand dropseed
Stachys cooleyi	Cooley's hedge-nettle
Stellaria longipes	long-stalked starwort
Stereocaulon paschale	
Stipa comata	needle-and-thread grass
Stipa hymenoides	Indian-ricegrass
Stipa occidentalis	stiff needlegrass
Stipa richardsonii	spreading needlegrass
Stipa spartea	porcupinegrass
Streptopus amplexifolius	clasping twistedstalk
Streptopus roseus	rosy twistedstalk
Streptopus streptopoides	small twistedstalk
Suaeda depressa	seablite
Subularia aquatica	awlwort
Symphoricarpos albus	common snowberry
Symphoricarpos mollis	trailing snowberry
Symphoricarpos occidentalis	western snowberry
Taxus brevifolia	western yew
Thalictrum occidentale	western meadowrue
Thamnolia subuliformis	
Thuja plicata	western redcedar
Tiarella trifoliata	three-leaved foamflower
Tiarella unifoliata	one-leaved foamflower
Tomenthypnum nitens	golden fuzzy fen moss
Tortula ruralis	
Tragopogon dubius	yellow salsify
Trichophorum caespitosum	tufted clubrush
Trientalis latifolia	broad-leaved starflower
Trifolium spp.	clovers
Trillium ovatum	western trillium
Trisetum spicatum	spike trisetum
Tsuga heterophylla	western hemlock
Tsuga mertensiana	mountain hemlock
Typha latifolia	cattail
Umbilicaria spp.	
Urtica dioica	stinging nettle
Utricularia spp.	bladderworts
Vaccinium alaskaense	Alaskan blueberry
Vaccinium caespitosum	dwarf blueberry
Vaccinium deliciosum	blue-leaved huckleberry
Vaccinium membranaceum	black huckleberry
Vaccinium myrtilloides	velvet-leaved blueberry
Vaccinium ovalifolium	oval-leaved blueberry
Vaccinium parvifolium	red huckleberry
Vaccinium scoparium	grouseberry
Vaccinium uliginosum	bog blueberry
Vaccinium vitis-idaea	lingonberry
Valeriana scouleri	Scouler's valerian
Valeriana sitchensis	Sitka valerian

APPENDIX 2. Continued

Vahlodea atropurpurea	mountain hairgrass
Vicia spp.	vetches
Veratrum viride	Indian hellebore
Viburnum edule	highbush-cranberry
Vicia americana	American vetch
Viola canadensis	Canada violet
Viola glabella	stream violet
Viola orbiculata	round-leaved violet
Vulpia spp.	fescues

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