Chapter 3: British Columbia: The Environmental Setting

2 authors, including:

Del Meidinger
Meidinger Ecological Consultants Ltd.
47 PUBLICATIONS **2,543** CITATIONS

SEE PROFILE

Chapter 3:
British Columbia: The Environmental Setting

by

J. Pojar and D. Meidinger

INTRODUCTION 40

PHYSIOGRAPHY 40
- Coast Mountains and Islands 40
- Interior Plateau 40
- Columbia Mountains and Southern Rockies 42
- Northern and Central Plateaus and Mountains 42
- Great Plains 42

CLIMATE 43

SOIL 43

TERRESTRIAL VEGETATON 45
- Coniferous Forest 45
- Deciduous Forest 46
- Scrub 46
- Grass 47
- Broad-leaved Herb 48
- Bryoid 48

WILDLIFE 49

BIOGEOCLIMATIC ZONES 51

ZONE DESCRIPTIONS 58

LITERATURE CITED 66

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.

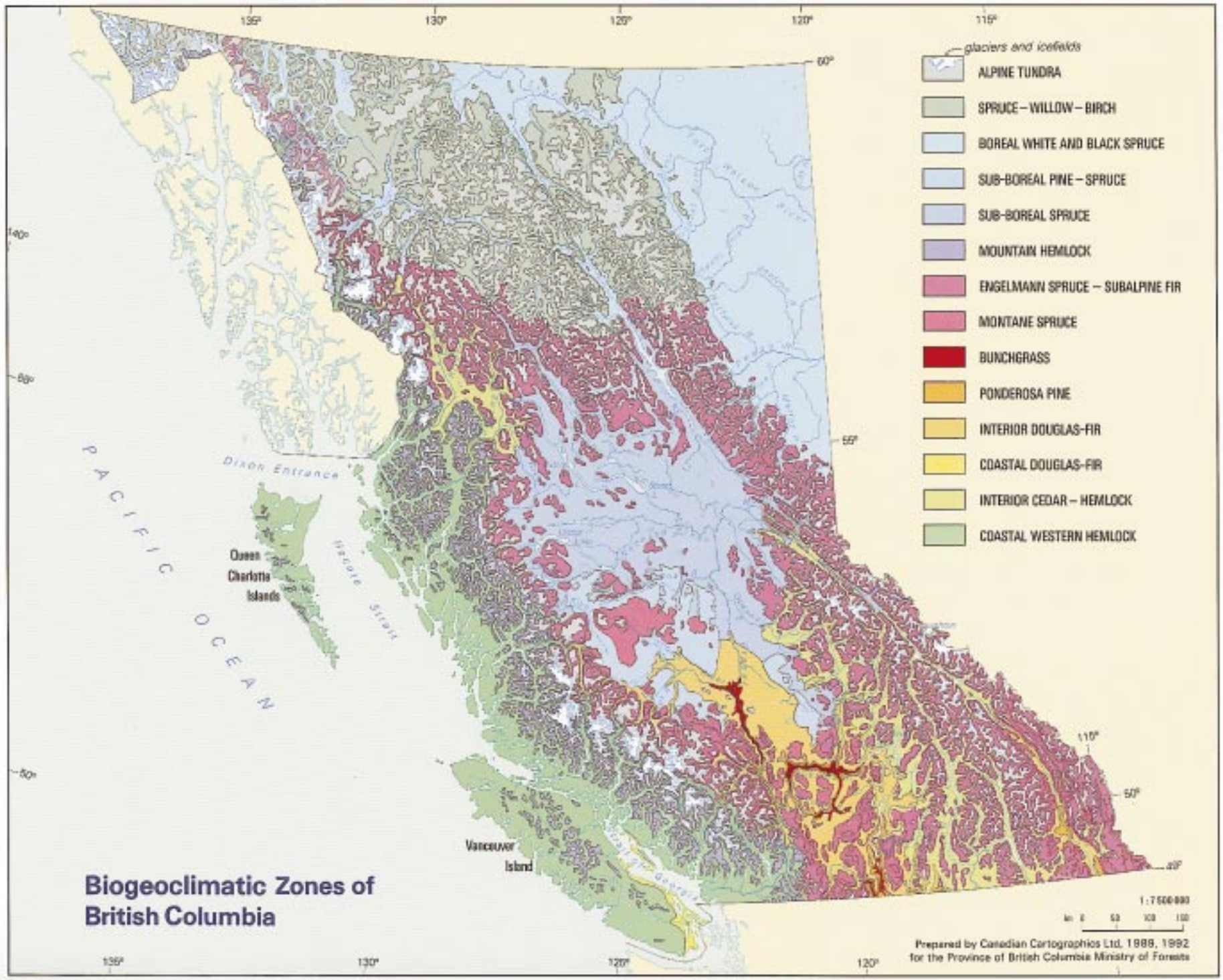
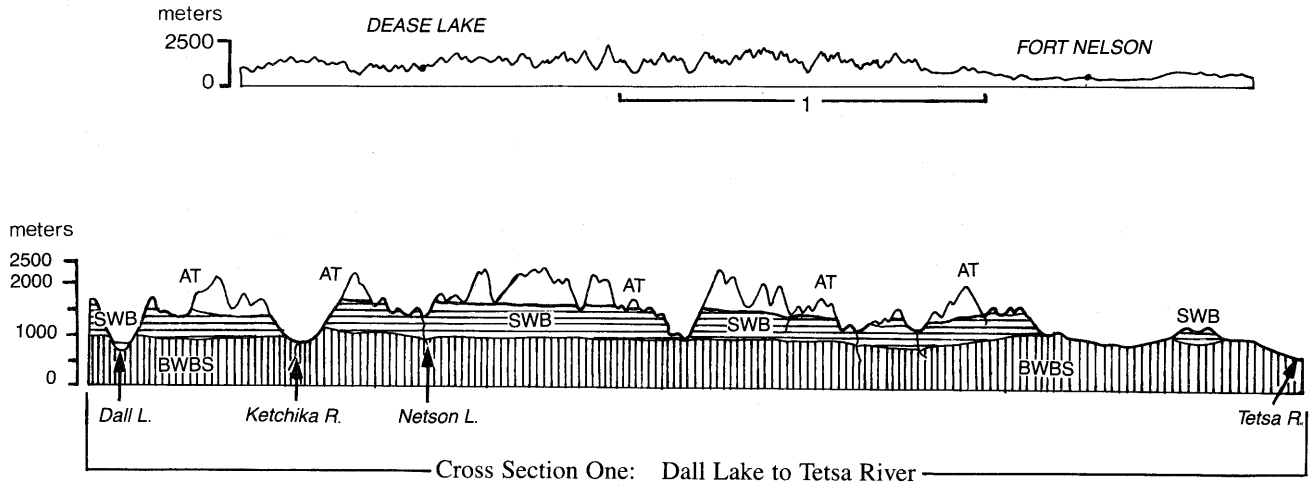
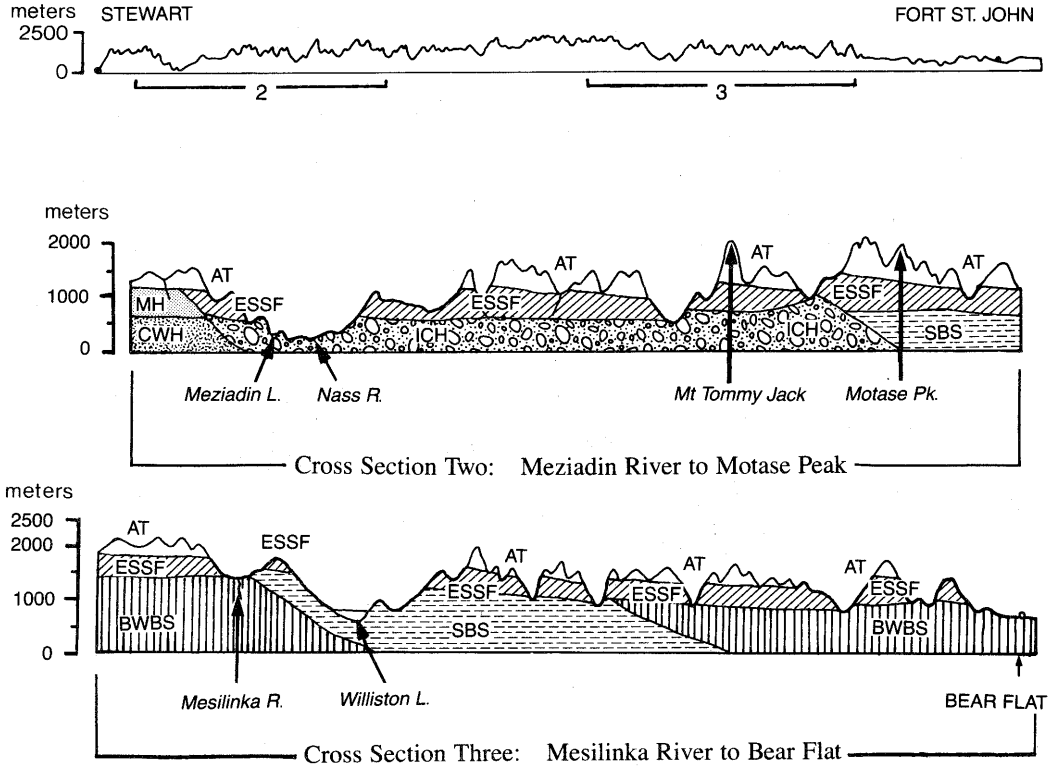


FIGURE 10. Biogeoclimatic zones of British Columbia.

DEASE LAKE to FORT NELSON



STEWART to FORT ST. JOHN

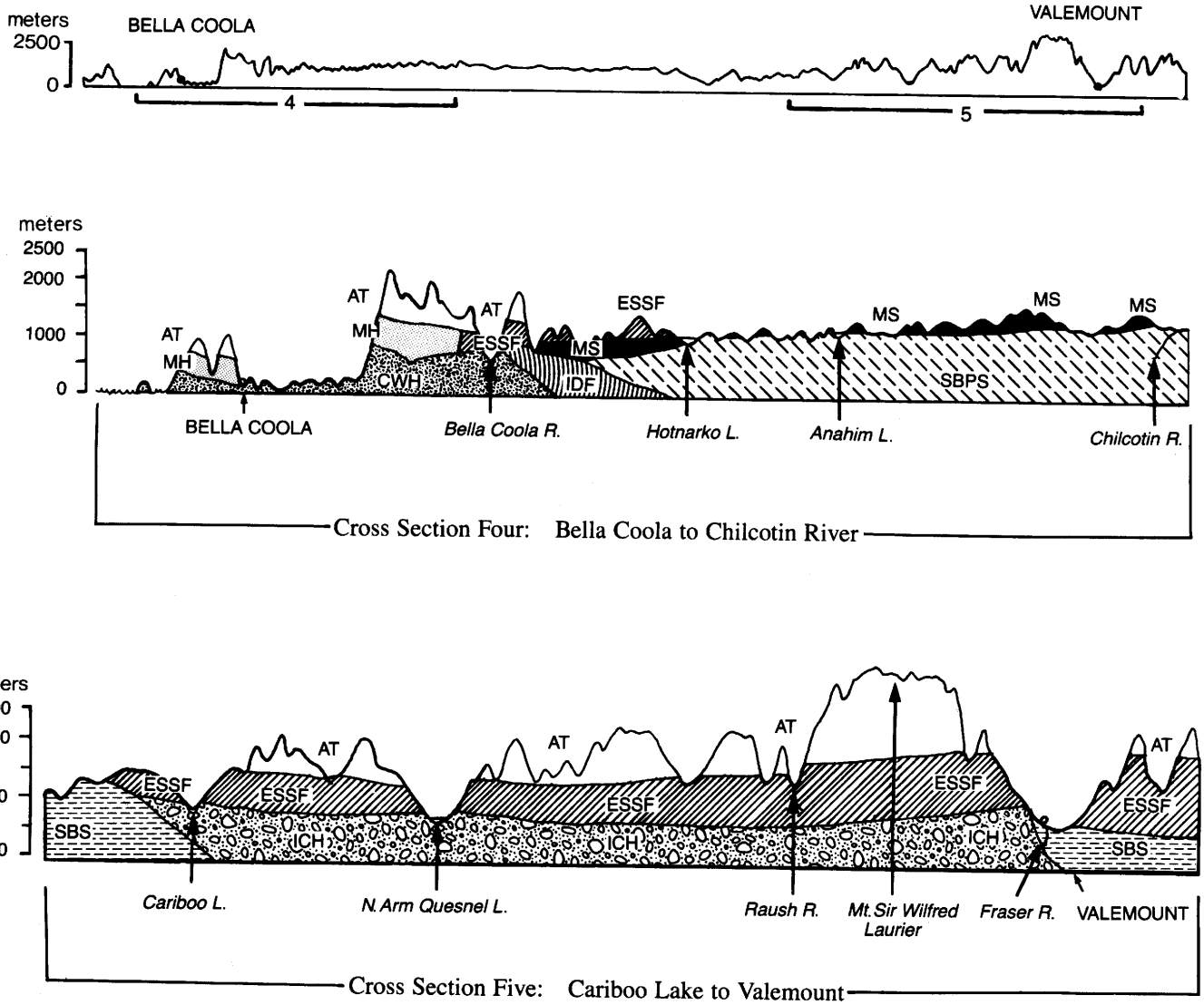


Biogeoclimatic Zones

AT	Alpine Tundra
BWBS	Boreal White and Black Spruce
ESSF	Engelmann Spruce — Subalpine Fir
ICH	Interior Cedar — Hemlock
MH	Mountain Hemlock
SBS	Sub-Boreal Spruce
SWB	Spruce — Willow — Birch

FIGURE 11. Eight representative cross sections of biogeoclimatic zones.

BELLA COOLA to VALEMOUNT

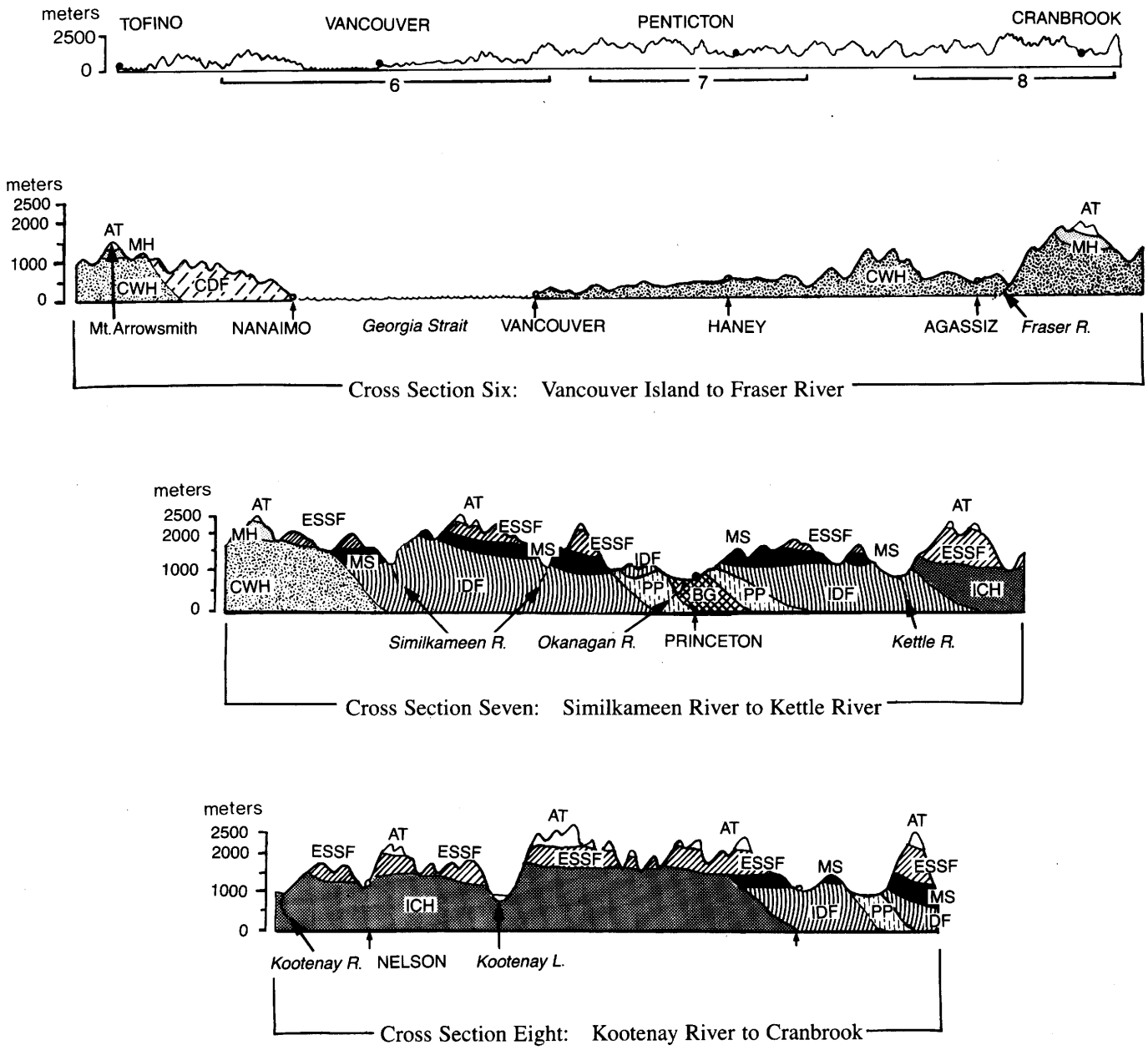


Biogeoclimatic Zones

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



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) >10	No. of months with mean temp (°C) <0	No. of frost free days	Frost free period (days)	Accumulated degree (°C) days above 5	Accumulated degree (°C) days 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.

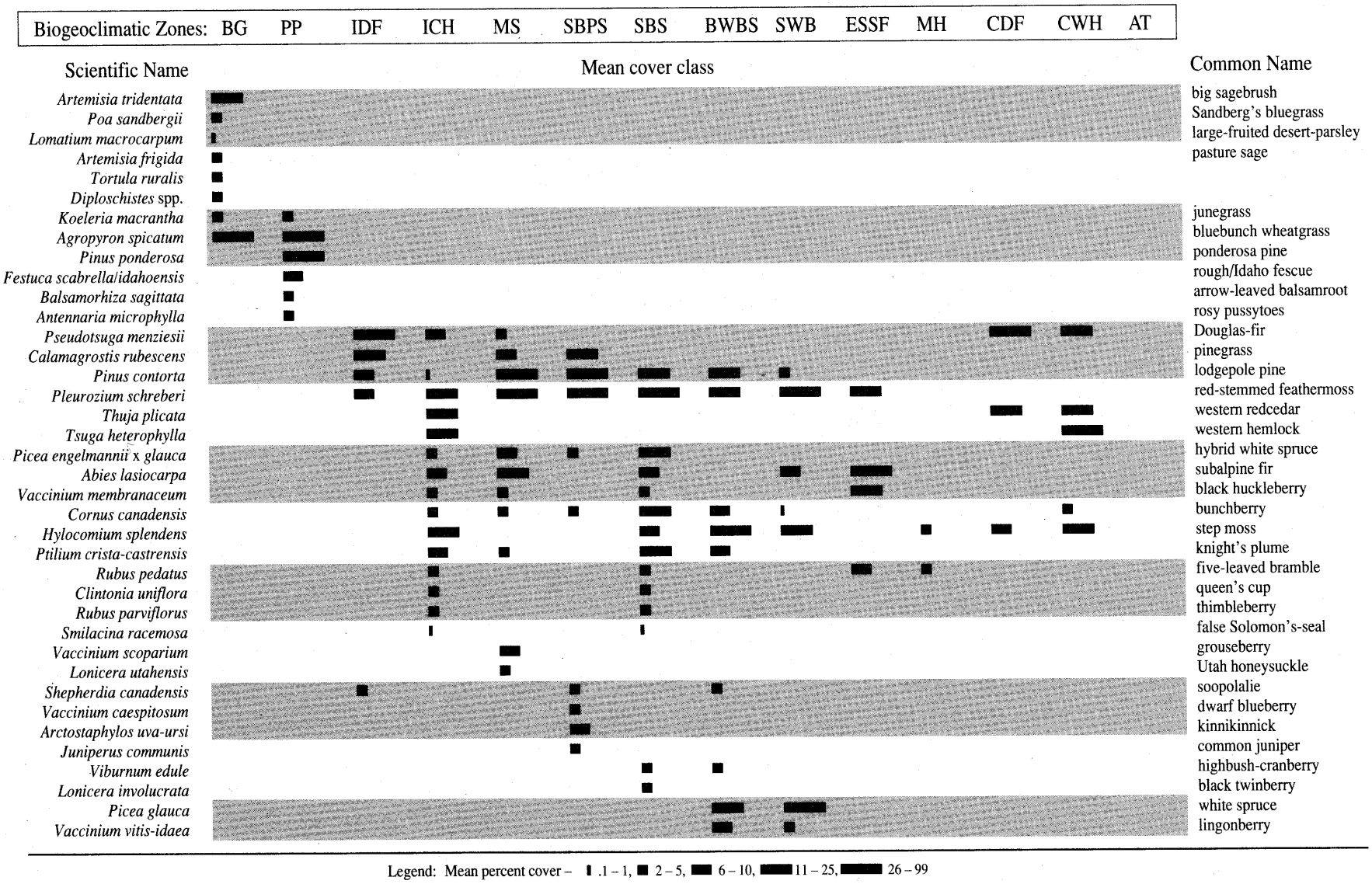


FIGURE 12. Zonal vegetation of the biogeoclimatic zones of British Columbia.

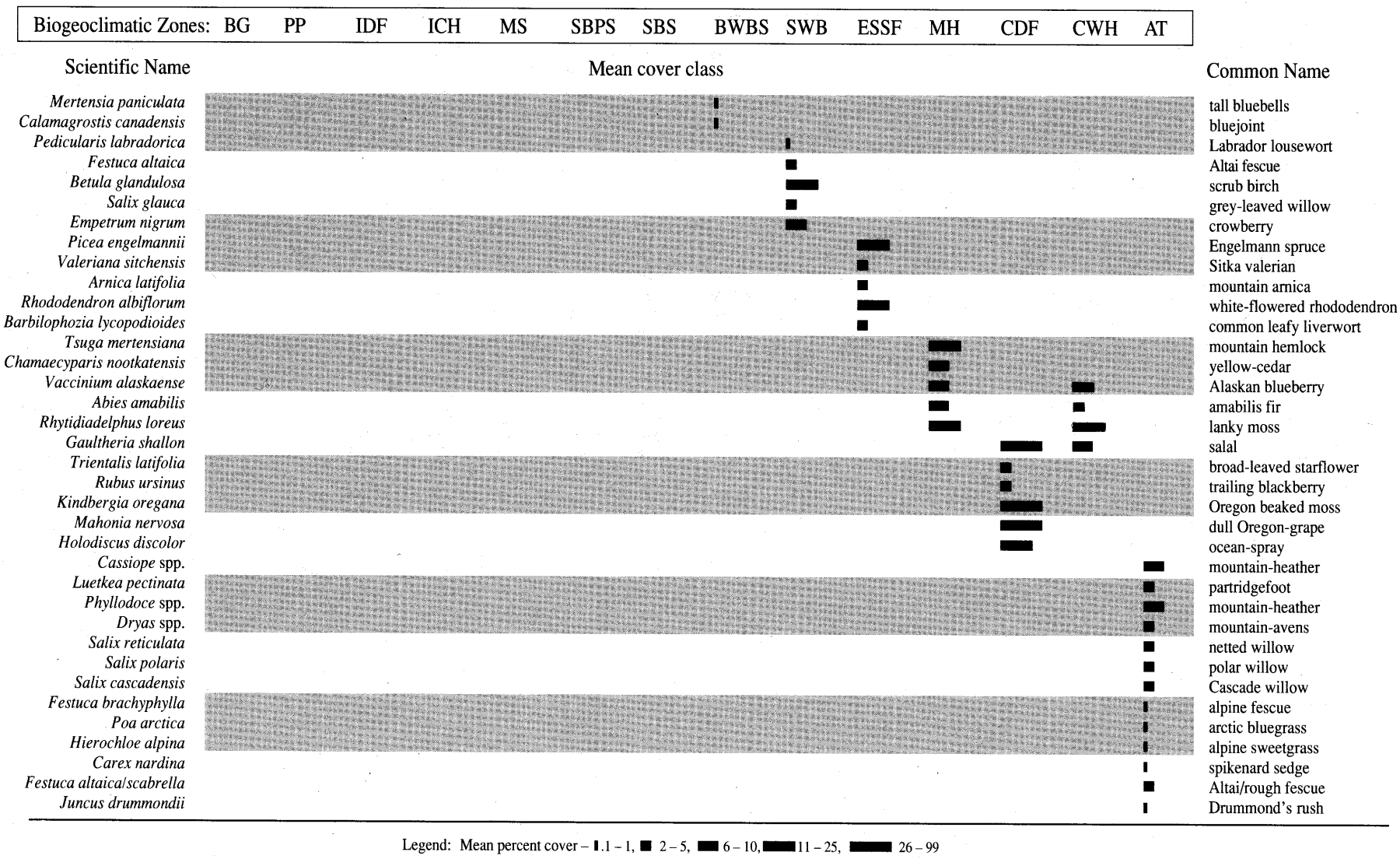
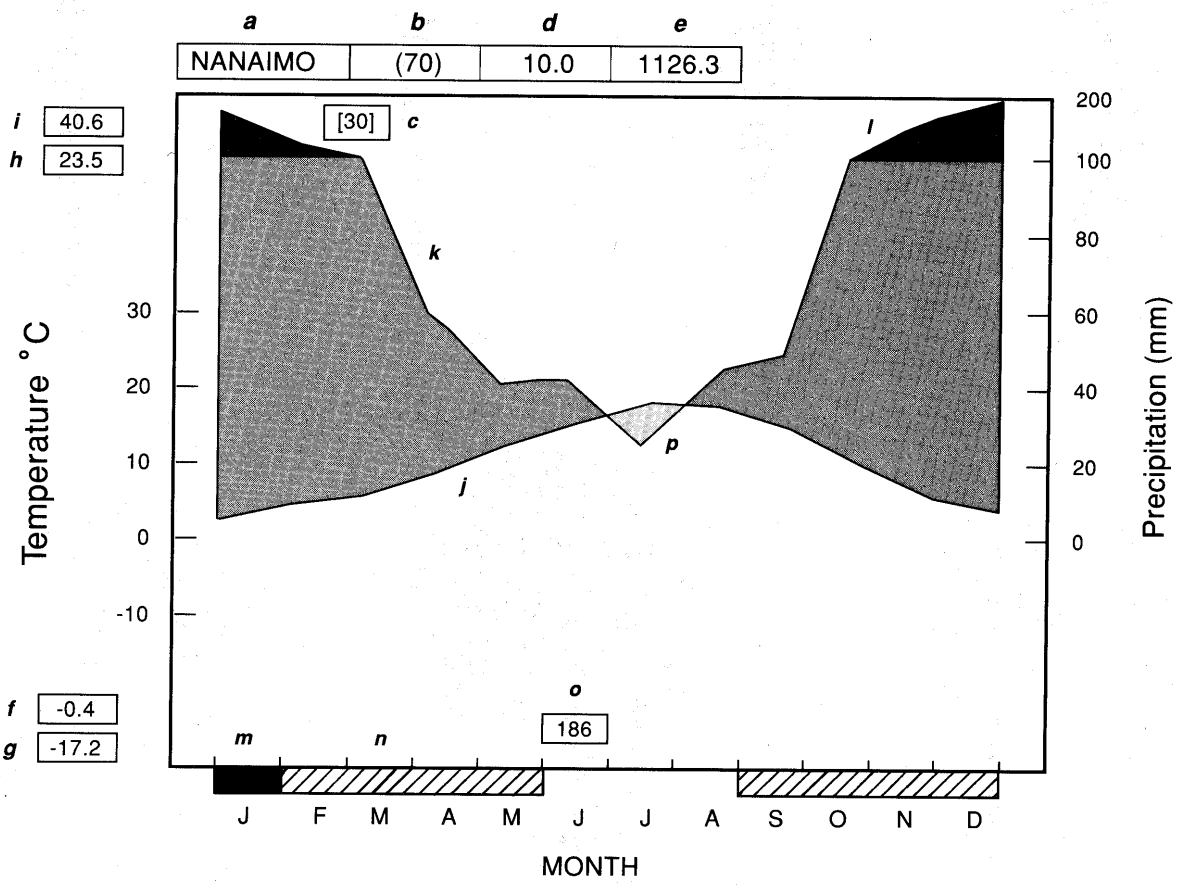


FIGURE 12. Continued.



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.

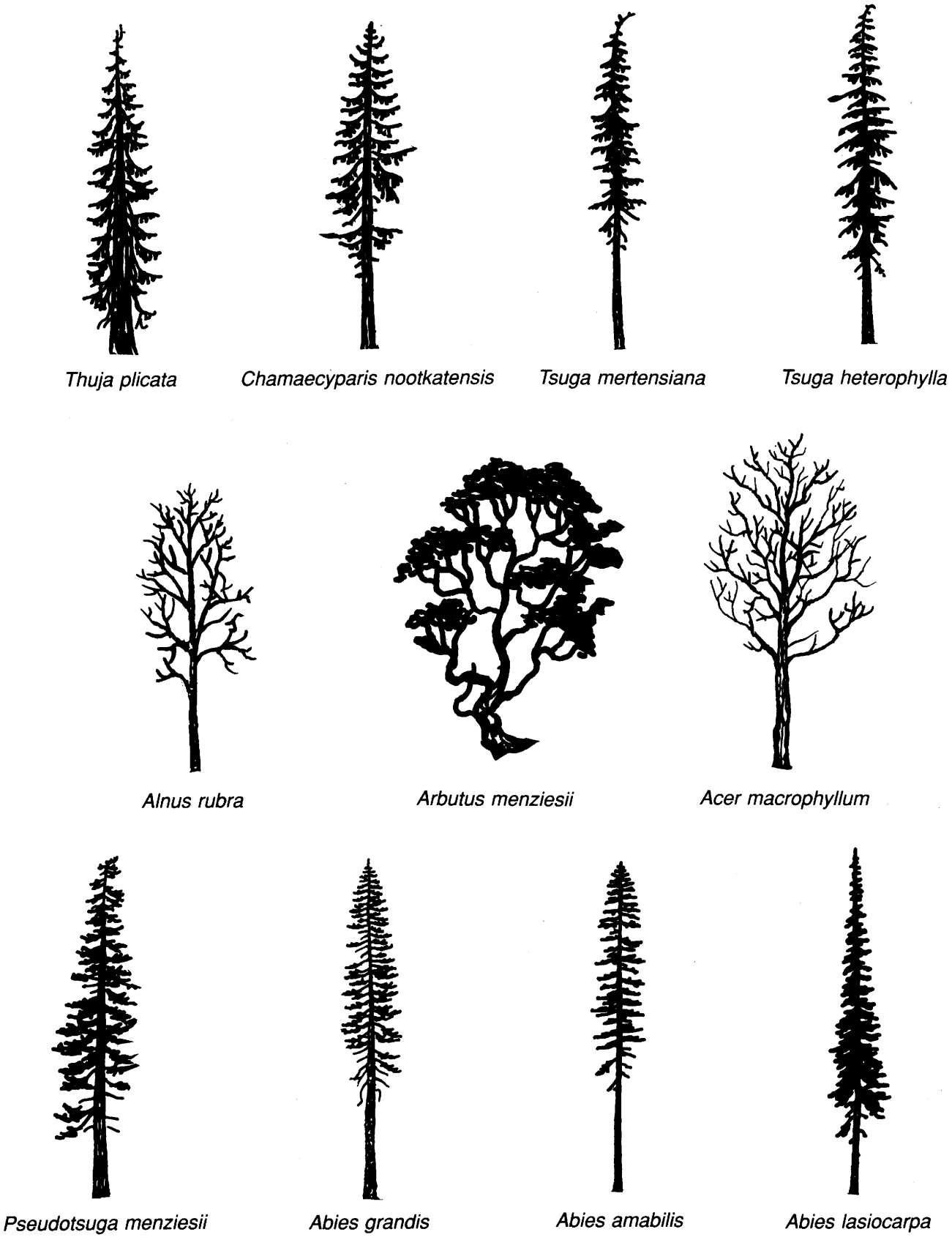


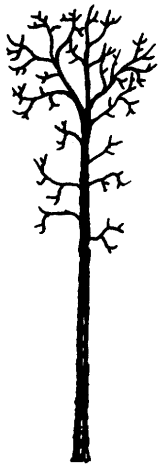
FIGURE 14. Tree species silhouettes used in schematic slope diagrams.

Larix occidentalis

Pinus monticola

Pinus contorta

Pinus ponderosa



Populus balsamifera ssp. *trichocarpa*

Quercus garryana

Populus tremuloides

Picea sitchensis

Picea engelmannii

Picea mariana

Picea glauca

FIGURE 14. Continued.

LITERATURE CITED

Agriculture Canada. 1987. The Canadian system of soil classification. 2nd ed. Agric. Can. Publ. 1646. Ottawa, Ont.

Cannings, R.A. and A.P. Harcombe (editors). 1990. The vertebrates of British Columbia: scientific and English names. Royal B.C. Museum Heritage Record No. 20; Wildl. Rep. No. R24. B.C. Min. Mun. Affairs, Rec. and Culture and B.C. Min. Environ., Victoria, B.C.

Carey, A.B. 1989. Wildlife associated with old-growth forests in the Pacific Northwest. Nat. Areas J. 9(3):151-162.

Demarchi, D.A. 1988. Ecoregions of British Columbia. Map at 1:2000000. B.C. Min. Environ., Wildl. Br., Victoria, B.C.

Demarchi, D.A. and E.C. Lea. 1989. Biophysical habitat classification in British Columbia: an interdisciplinary approach to ecosystem evaluation. *In* Proc. Conf. on Land Classifications Based on Vegetation: Applications for Resource Management. November 17-19, 1987, Moscow, Idaho. D.E. Ferguson, P. Morgan, and F.D. Johnson (compilers). U.S. Dep. Agric. For. Ser., Gen. Tech. Rep. INT-257. Ogden, Utah, pp. 275-276.

Demarchi, D.A. and R.A. Demarchi. 1987. Wildlife habitat - the impacts of settlement. Chap. 10. *In* Our wildlife heritage - 100 years of wildlife management. The Centennial Wildl. Soc. of B.C. Morriss Printing Company Ltd., Victoria, B.C., pp. 159-177.

Demarchi, D.A., R.D. Marsh, A.P. Harcombe, and E.C. Lea. 1990. The environment (of British Columbia). *In* The birds of British Columbia. Vol. 1. R.W. Campbell, N.K. Dawe, I. McTaggart Cowan, J.M. Cooper, G.W. Kaiserr and M.C.E. McNall. Royal B.C. Museum, Victoria, B.C., pp. 55-144.

Douglas, G., G.B. Straley, and D. Meidinger. 1989. The vascular plants of British Columbia. Part 1 - Gymnosperms and Dicotyledons (Aceraceae through Cucurbitaceae). B.C. Min. For., Special Rep. Series 1. Victoria, B.C.

Douglas, G., G.B. Straley, and D. Meidinger (editors). 1990a. The vascular plants of British Columbia. Part 2 - Dicotyledons (Diapensiaceae through Portulacaceae). B.C. Min. For., Special Rep. Series 2. Victoria, B.C.

_____ . [1990b]. The vascular plants of British Columbia. Part 3 - Dicotyledons (Primulaceae through Zygophyllaceae) and Pteridophytes. B.C. Min. For., Special Rep. Series 3. Victoria, B.C. In press.

Fosberg, F.R. 1967. A classification of vegetation for general purposes. *In* Guide to the check sheet for IBP areas. G.F. Peterken (editor). IBP Handb. No. 4. Blackwell Scientific Publications, Oxford and Edinburgh, pp. 73-133.

Harcombe, A.P. (technical editor). 1988. Wildlife habitat handbooks for the Southern Interior ecoprovince. Vol. 1-8. B.C. Min. Environ. and B.C. Min. For., Queen's Printer, Victoria, B.C.

Holland, S.S. 1976. Landforms of British Columbia: a physiographic outline. 2nd ed. B.C. Dep. Mines Pet. Resources, Bull. No. 48. Victoria, B.C.

Ireland, R.R., G.R. Brasard, W.B. Schofield, and D. Vitt. 1987. Checklist of the mosses of Canada II. Lindbergia 13:1-62.

MacArthur, R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton Univ. Press, Princeton, N.J.

Meidinger, D. (compiler). 1987. Recommended vernacular names for common plants of British Columbia. B.C. Min. For., Res. Rep. No. RR87002-HQ. Victoria, B.C.

Meslow, E.C., C. Maser, and J. Verner. 1981. Old-growth forests as wildlife habitat. Trans. N. Amer. Wildl. and Nat. Resources Conf. 46:329-335.

Noble, W.J., T. Ahti, G. Otto, and I. Brodo. 1987. A second checklist and bibliography of the lichens and allied fungi of British Columbia. Nat. Museum of Canada, Syllogeus No. 61. Ottawa, Ont.

Ricklefs, R.E. 1988. Ecology. 3rd ed. Chiron Press, New York, N.Y.

Stotler, R. and B. Crandall-Stotler. 1977. A checklist of the liverworts and hornworts of North America. Bryologist 80:405-428.

Taylor, R.D. and B. MacBryde. 1977. Vascular plants of British Columbia: A descriptive resource inventory. The Botanical Garden, Univ. B.C., Tech. Bull. No. 4. Vancouver, B.C.

Valentine, K.W.G., P.N. Sprout, T.E. Baker, and L.M. Lavkulich. 1978. The soil landscapes of British Columbia. B.C. Min. Environ., Resource Anal. Br., Victoria, B.C.