

The Ecozones of British Columbia, with special reference to Lepidoptera

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Introduction

This treatment of the ecozones of British Columbia is slightly modified from the one I wrote in *The Checklist of the Lepidoptera of British Columbia, Canada* (Pohl *et al.* 2015). Ecozone and Biogeoclimatic Zone information is integrated. Authors of annotated checklists of various taxa in the province might find it a useful framework in which to discuss the biodiversity and distribution of species in the groups in question.

The most useful summaries of British Columbia's environment are found in Meidinger and Pojar (1991), BC Ministry of Forests and Range (2013), Demarchi (1996), and Cannings and Cannings (1996). The following details are mostly taken from these publications.

Large and diverse, British Columbia (BC) is exceptionally variable physically and biologically. Covering almost 950,000 sq km, the province spans 11 degrees of latitude and 25 degrees of longitude. It is about 1300 km from the southern coast of Vancouver Island to the northern boundary at 60° N and, along this latitude, the boundary with the Yukon and the Northwest Territories stretches almost 1100 km. Mountains and the sea-bound coast, studded with islands, epitomize BC, and the region is mostly cool, moist, forested and mountainous. But such generalities do not do justice to the striking diversity of wet and dry forests, grasslands, wetlands, scrub and alpine tundra forming complex mosaics of habitat across vast plateaus, valleys and plains lying among several northwest-southeast trending mountain ranges. Climates range from semi-arid and Mediterranean to subarctic and alpine. The complex interaction of geology, physiography, climate, glaciations and subsequent colonization by organisms, and competition among species has produced ecosystems supporting a tremendous variety of life.

The Pacific Ocean and the mountains to its east mould BC's climates. The ocean is a reservoir of heat and moisture and, in winter, frontal systems from the North Pacific move eastward, encountering successive mountain barriers that face the westerly winds. These mountains determine the general distribution of precipitation and the balance between oceanic and continental air masses in different parts of the province. BC's wettest climates prevail along the coast, especially on the windward slopes of the mountains of Vancouver Island, Haida Gwaii and the mainland coast. As it climbs the mountains, water-laden air drops large quantities of rain and snow but, as the drier air descends over the eastern slopes, it warms by compression. These high Coast Mountains produce a strong rain shadow that generates the driest climates in the province in the bottoms of southern Interior valleys, especially the Fraser, Thompson and Okanagan valleys. More moisture is released as the air continues its journey eastward, ascending ranges such as the Skeena, Cassiar, Columbia, and others, before the most massive barrier of them all, the Rockies. The mountains also restrict the westward flow of cold continental arctic air masses from east of the Rocky Mountains and, except for the Great Plains region of northeastern BC, the province has a more moderate winter climate than most of western and central Canada. In

summer, the prevailing westerlies weaken and the climate is controlled by a strong high-pressure centre in the northeast Pacific that greatly reduces the frequency and intensity of Pacific storms.

There have been several major attempts to capture the essence of BC's physical and biological diversity through the identification and mapping of ecosystems. Munro and Cowan (1947) developed one of the first for their work on BC's bird fauna; their biotic areas concept subsequently was used in several Provincial Museum publications from the 1940s to the 1970s, including handbooks on mammals (Cowan and Guiguet 1965) and dragonflies (Cannings and Stuart 1977). The biogeoclimatic zone concept produced one of the most detailed and useful systems (Meidinger and Pojar 1991). Developed by plant ecologists, it is based on climatic and topographical factors and, according to the tree species that dominate in climax forests (or grasses in treeless grasslands), 16 major zones are defined. The Alpine Tundra Zone has recently been divided into three zones (MacKenzie 2006) but, for simplicity, we are retaining the original, general one here. The biogeoclimatic zones are further subdivided based on climate and vegetation; the province is mapped at the subzone variant level. Dennis Demarchi (1996), a wildlife biologist, developed a different system, one less controlled by elevation and edaphic factors. At the general level his ecoregion scheme divides BC into broad climatic areas but then separates these areas according to major physiographic regions such as plateaus, mountain ranges and valleys. There are ten ecoprovinces in British Columbia; their size and broad internal uniformity make them useful units for the general discussion of geographic distribution of organisms in the province. In their popular treatment of the natural history of the province, Cannings and Cannings (1996) simplified the complex terrestrial ecosystems into five, roughly based on groups of biogeoclimatic zones – temperate rain forests, mountaintops, spruce forests, montane forests and grasslands. A useful summary of BC's geological and glacial history is given in Cannings *et al.* (2011). BC wetlands are classified by MacKenzie and Moran (2004). No distribution patterns of Lepidoptera have yet been correlated with the wetland associations defined in this classification, although this has been done for dragonflies (Cannings *et al.* 2008)

Ecozones of British Columbia

The ecozone treatment for Canada is published by the Ecological Stratification Working Group (1995). It is allied to the Demarchi scheme. Canada is divided into 15 separate terrestrial ecozones, which can be considered “discrete systems resulting from interplay of geologic, landform, soil, vegetation, climatic, water and human factors” (Parks Canada 2013). There are five ecozones in BC (Fig. 1): the Pacific Maritime Ecozone encompasses the Pacific Coast east to the height of land in the Coast Mountains; The huge Montane Cordillera Ecozone contains all the rest of southern and central BC west of (and including) the Rocky Mountains north to about 57°N; the Boreal Cordillera Ecozone covers the rest of the province to the north between the Coast and Rocky Mountains; and the Boreal Plains and Taiga Plains ecozones occupy the southern and northern halves, respectively, of the province east of the Rocky Mountains. References to biogeoclimatic zones within these ecozones are made when ecosystem characteristics are summarized.

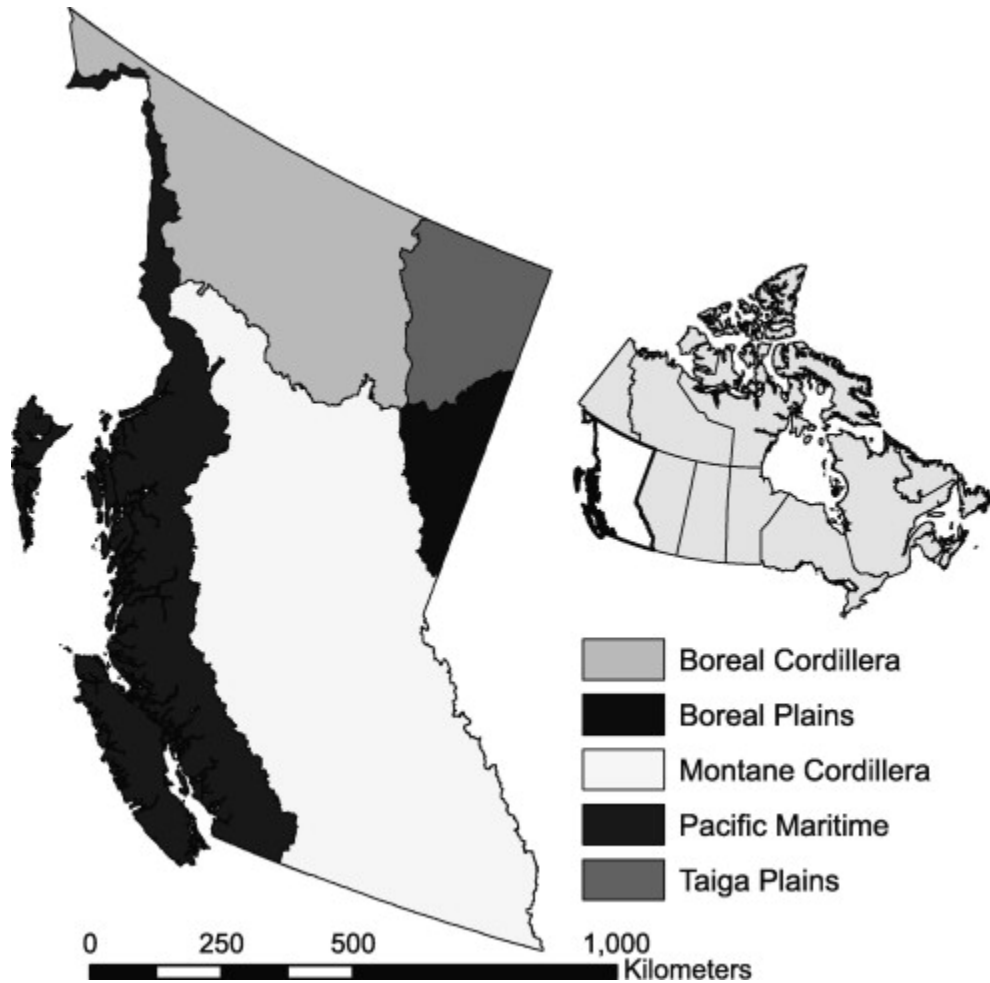


Figure 1. Ecozones of British Columbia (from Metsaranta *et al.* 2011).

Pacific Maritime Ecozone

The Pacific Maritime Ecozone borders the Pacific Ocean, which strongly dictates the characteristics of the region. Two parallel mountain belts (the discontinuous St. Elias-Insular Mountains and the Coast-Cascade Mountains) and a central, mostly submerged coastal trough, form this ecozone. In the west, it includes the coastal islands; the eastern boundary lies along the height of land in the massive Coastal Mountains; in the east, it abuts the Montane Cordillera Ecozone in the south and the Boreal Cordillera Ecozone in the north. Covering more than

195,000 sq km, it also includes a small corner of southwestern Yukon. Thus, the Pacific Maritime Ecozone runs the entire north-south length of BC, from southern Vancouver Island to the 60th parallel. The Coast Mountains, capped by glaciers at the highest elevations, dominate much of the landscape, rising steeply from the fiords and channels that dissect the coastline. Mount Waddington (4019 m) is the highest point in the ecozone and is the highest mountain completely within BC.

The main biogeoclimatic zone is the Coastal Western Hemlock Zone (CWH), which occupies low to middle elevations (900 m on windward slopes in the south and mid-coast, 1050 m on leeward slopes and to 300 m in the north) mostly west of the Coast Mountains. On average, this is the wettest biogeoclimatic zone in BC, with cool summers and mild winters. Mean annual precipitation for the zone as a whole averages about 2230 mm, with less than 15% of the total falling as snow in the south but up to 50% in the north. The mean annual temperature is about 8°C; the mean monthly temperature is above 10°C for half the year and the mean temperature of the coldest month is 0.2°C. Characteristic features are the prominence of Western Hemlock (*Tsuga heterophylla* (Raf.) Sarg.), the sparse herb layer and the abundance of several moss species (especially *Hylocomium splendens* (Hedwig) Schimper and *Rhytidiadelphus loreus* (Hedw.) Warnst. The most common wetter maritime forests are dominated by mixtures of Western Hemlock, Western Redcedar (*Thuja plicata* Donn ex D. Don), Sitka Spruce (*Picea sitchensis* (Bong.) Carr.), and variable amounts of Yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach.) and Amabilis Fir (*Abies amabilis* (Douglas ex Loudon), the latter two species being most abundant in wetter areas. This vegetation type features a well developed shrub layer of ericaceous species such as Red Huckleberry (*Vaccinium parvifolium* Sm.) and Salal (*Gaultheria shallon* Pursh). Bogs are strikingly abundant over much of the hypermaritime landscape, especially on the coastal lowlands. Drier maritime forests support significant stands of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco, north to about 53°N.

The other lowland biogeoclimatic zone is the Coastal Douglas-fir zone (CDF), limited to small regions of southeastern Vancouver Island, some islands in the Gulf of Georgia, and a narrow strip of the nearby mainland, where it lies mostly below 150 m elevation. The CDF lies in the rain shadow of the Vancouver Island and Olympic mountains. It has warm, dry summers and mild, wet winters -- the mean annual temperature ranges from 9.2 to 10.5°C. Mean annual precipitation varies from about 650 to 1250 mm and only about 5% falls as snow. Most modern forests in the CDF have regenerated after logging and old growth is rare. Douglas-fir is the most common tree species in upland forests. Western Redcedar, Grand Fir (*Abies grandis* (Douglas ex D. Don) Lindley), Arbutus (*Arbutus menziesii* Pursh), Garry Oak (*Quercus garryana* Douglas ex Hook.), and Red Alder (*Alnus rubra* Bong.) are common species. The tree species composition of forest stands varies considerably as a result of widespread human disturbance. The Garry Oak meadows and associated ecosystems contain many rare plant species, eg, Deltoid Balsamroot (*Balsamorhiza deltoidea* Nutt.) and Golden Paintbrush (*Castilleja levisecta* Greenm.).

The subalpine elevations of the coastal mountains fall in the Mountain Hemlock Zone (MH). This zone occurs all along the entire coast in BC, occupying elevations of 900-1800 m in the south and 400 to 1000 m in the north. The coastal subalpine climate is characterized by short, cool summers, and long, cool, wet winters, with heavy snow cover for several months. Mean annual temperature varies from 0 to 5°C. Mean annual precipitation probably ranges from 1700

to 5000 mm, of which up to 70% is snow, resulting in a long lasting snowpack and a short growing season. Spring and summer are often relatively dry, but autumn and winter are very wet. Mountain Hemlock (*Tsuga mertensiana* (Bong.) Carr.), Amabilis Fir, and Yellow-cedar are the most common tree species. Lodgepole Pine (*Pinus contorta* Douglas ex Loudon) thrives on very dry sites and Subalpine Fir (*Abies lasiocarpa* (Hook.) Nutt.) and Whitebark Pine (*Pinus albicaulis* Engelm.) grow near timberline. Forests are largely confined to lower elevations of the zone and, with increasing elevation, trees grow in patches, and along ridges where the snow melts earlier. These patches form a mosaic with subalpine heath, meadow, and fen vegetation. The predominance of ericaceous shrubs is characteristic of the zone; *Vaccinium* species, False Azalea (*Menziesia ferruginea* Sm.), and White-flowered Rhododendron (*Rhododendron albiflorum* Hook.) often dominate in continuous forest.

The Alpine Tundra Zone (AT) occurs on high mountains in the Pacific Maritime Ecozone, above about 2250 m in the south and 1000 m in the north. The newly designated zone in the mountains of the Pacific Maritime Ecozone is the Coastal Mountain-heather Alpine (CMA). The harsh alpine climate is cold, windy, and snowy, and characterized by low growing season temperatures and a very short frost-free period. The mean annual temperature usually ranges from -4 to 0°C and the average temperature remains below 0°C for 7-11 months. Mean annual precipitation is 700-3000 mm and 70-80% of this falls as snow. Alpine vegetation is dominated by shrubs, herbs, bryophytes, and lichens. Huge areas at the higher elevations are simply rock, snow and ice. Although the zone is, by definition, treeless, it supports stunted, shrub-like tree species such as Mountain Hemlock and Whitebark Pine at lower elevations. Important dwarf shrubs include mountain heathers (*Cassiope* spp. and *Phyllodoce* spp.). Herb meadows dominated by broad-leaved forbs are also common in the alpine, especially at middle and lower elevations, developing on sites with deep soils, in seepage areas, or along alpine streams. 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, but some mosses, liverworts and numerous lichens persist at the upper limits of vegetation

Characteristic Lepidoptera species more or less restricted in Canada to the Ecozone include Sara's Orangetip (*Anthocharis sara* Lucas), and the underwing moth *Catocala aholibah* Strecker, whose caterpillar eats the foliage of Garry Oak. Several species and subspecies are considered at-risk in the region, including Taylor's Checkerspot (*Euphydryas editha taylori* (W.H. Edwards)), Johnson's Hairstreak *Callophrys johnsoni* (Skinner), which feeds on mistletoe (*Arceuthobium* spp.) growing on Western Hemlock; and the Sand-verbena Moth, *Copablepharon fuscum* Troubridge & Crabo, which inhabits a few coastal dune localities. The mild winters of the Zone allow many species to fly in the coldest parts of the year. The holarctic geometrid *Triphosa haesitata* appears on many mid-winter days in the region and the introduced *Operophtera brumata* Linnaeus (Winter Moth), a pest of many trees and shrubs, including Garry Oak and various tree fruits, is active in low temperatures.

The Pacific Maritime Ecozone has an unusually high number of alien species of Lepidoptera, many of which were first introduced into North America in the region, for example, the sphingid *Deilephila elpenor* (Linnaeus). Others first introduced to eastern North America have colonized the West independently from Eastern Asia, or secondarily from eastern North America through the Vancouver area (e.g. *Noctua pronuba* Linnaeus). Some have been purposefully introduced as

biological control agents; *Tyria jacobaeae* (Linnaeus), a day-flying tiger moth that attacks the noxious weed, Tansy Ragwort (*Senecio jacobaeae* Linnaeus), is a good example.

The Lepidoptera of the Pacific Maritime Ecozone have been studied since the early days of entomological activity on Vancouver Island and the adjacent mainland. Early publications include Taylor (1884), Danby (1894) and Harvey (1904). Most other published information is found in subsequent provincial lists and systematic or behavioural studies on specific genera or species (e.g. Blackmore 1927, Hardy 1959, R. Guppy 1956, C. Guppy 1998, Shepard 1977), Miskelly 2009), and much useful information on economically important species has been documented by the Canadian Forest Service (eg, Duncan 2006), Agriculture Canada and other agencies. From the 1990s onward, considerable research for conservation purposes has occurred, at least in the southern coastal region (Shepard 1995; COSEWIC 2000, 2003; Miskelly 2004).

Montane Cordillera

The Montane Cordillera Ecozone in BC stretches from the eastern slopes of the Coast and Cascade mountains in the west to the Rocky Mountains in the east, from the US border at 49°N in the south to about 57°N in the north. In addition, it includes the eastern slopes of the Rockies in Alberta and, all-told, covers an area of 473 000 square kilometres. BC contains 90% of the ecozone. It is the province's largest and most diverse ecozone, with ecosystems ranging from alpine tundra and cold conifer forests to riparian woodland, dry sagebrush steppes and arid grasslands. The ecozone is mountainous around the edges, especially in the southeast quadrant but, centrally, contains an extensive system of plateaus about 300 km wide and 650 km long, lying at altitudes of 600-1200 m. The southern part of the region is dissected by the Fraser River and its major tributaries while relatively smaller areas to the north are drained by other large rivers, such as the Skeena, flowing west and the tributaries of the Peace, flowing east. The mountain systems along the eastern parts of the ecozone consist of ranges trending north-south and separated by large valleys. There are two main units -- the Cassiar-Columbia mountains and the Rocky Mountain Trench immediately to the east; and the Rocky Mountains on the eastern boundary of the ecozone. The highest elevations in these mountains generally occur in the south, where summits regularly reach 3000 m; the highest point is Mt. Robson at 3954 m. Between latitudes 54° N and 56° N, the mountains are less rugged and the peaks usually are below 2000 m.

This complex topography produces large differences in temperature and precipitation throughout the ecozone. Much of the region has an interior continental climate dominated by easterly moving air masses that produce cool wet winters and warm dry summers. The Interior plateau, being in the rain shadow of the Coast Mountains, in some areas has less than 300 mm mean annual precipitation. However, in the Selkirk Mountains precipitation reaches 2500-3500 mm and 1500-2500 mm falls in the Rocky Mountains. Most of interior BC is strongly influenced by both continental and maritime air masses, the latter being more prevalent in the south. The southern interior valleys thus experience warmer winter temperatures than those in the north. The valley bottoms are characterized by hot, dry summers and moderately cold winters with little snowfall. High summer temperatures above 30°C are common. In the South Okanagan, the mean July daily temperature is above 22° C.

The Montane Cordillera Ecozone is vast and variable, containing 12 biogeoclimatic zones. The Bunchgrass Zone is confined to the lower elevations of the driest and hottest valleys of the southern parts of the ecozone. Bluebunch Wheatgrass (*Pseudoroegneria spicata* (Pursh) A. Löve) is the dominant bunchgrass on undisturbed sites. At lower elevations Big Sagebrush (*Artemisia tridentata* Nutt.) is common, particularly in overgrazed areas. Ponderosa Pine (*Pinus ponderosa* Lawson and C. Lawson) and Douglas-fir occasionally occur in draws and on well-drained soils, although the dry climate restricts their growth. The Ponderosa Pine zone is the warmest and driest forest zone, confined to a narrow band in the driest and warmest valleys of the southern interior of British Columbia. It usually borders the Bunchgrass Zone. Ponderosa Pine is the dominant tree; Douglas-fir is common on cooler and moister sites. Where not overgrazed, the understory includes abundant grasses such as Bluebunch Wheatgrass and Rough Fescue (*Festuca scabrella* Rydb.). The Interior Douglas-fir Zone is the second warmest forest zone of the ecozone, occurring in the rain shadow of the Coast and Purcell Mountains. Douglas-fir is the dominant tree. Fires have resulted in even-aged Lodgepole Pine stands at higher elevations in many areas. Ponderosa Pine is the common seral tree at the lower elevations. Pinegrass (*Calamagrostis* spp.) dominates the understory.

The Engelmann Spruce-Subalpine Fir (ESSF) Zone is the subalpine zone over most of the mountainous parts of the Montane Cordillera Ecozone. The climate is severe, with a short cool growing season and long cold winters. At upper elevations the forest is open parkland, with trees clumped and interspersed with meadow, heath and grassland. Engelmann Spruce (*Picea engelmannii* Parry ex Engelm.), Subalpine Fir and Lodgepole Pine are the dominant trees. The long, cold winters and short, cool growing season of the Alpine Tundra Zone create conditions too severe for the growth of most woody plants, except in dwarf form. The Boreal Altai Fescue Alpine occurs in the northern Rocky Mountains, and the lee side of the Coast Mountains as far south as the Chilcotin. Winters are very cold and long, and the summers are brief and cool. The vegetation is primarily dwarf willows, grasses, sedges and lichens. Interior Mountain-heather Alpine occupies the entire Columbia Mountains, the southern Rocky Mountains, and the lee side of the Coast and Cascade Mountains. It occurs above 2500 m in the south, and above 1800 m in the north, with relatively warm summers, but very variable precipitation. The vegetation is variable, depending on snow depth, with mountain-heather (*Phyllodoce* spp.) typical in the snowier climates, and mountain-avens (*Dryas* spp) typical in the driest climates.

The Sub-boreal Pine-Spruce Zone (SBPS) occurs mostly in the Chilcotin, the high plateau of the west central region of the ecozone, in the rain shadow of the Coast Mountains. The zone is characterized by many even-aged Lodgepole Pine stands, the result of an extensive fire history. Lichens and/or feathermosses usually dominate the understory. Pinegrass and Kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.) are also common. These forests and those of the Sub-boreal Spruce Zone (SBS) have been badly damaged by Mountain Pine Beetle outbreaks. The latter zone occurs in the central plateau, centred on Prince George. Although the climate is severe, the winters are shorter and the growing season longer than in the boreal zones. Hybrid Engelmann-White Spruce and Subalpine Fir are the dominant trees, although there are extensive stands of Lodgepole Pine in the drier parts of the zone. The Boreal White and Black Spruce Zone (BWBS) occupies the valleys in the extreme northern part of the ecozone, for example in the Omineca Mountains. Winters are long and cold and the growing season short, with the ground remaining frozen for much of the year. Where flat, the landscape is typically a mosaic of Black

Spruce (*Picea mariana* (Mill.) Britton, Sterns & Poggenb.), White Spruce (*Picea glauca* (Moench) Voss) and Trembling Aspen (*Populus tremuloides* Michx.) stands. The Montane Spruce Zone (MS) occurs in the south central interior of BC at middle elevations, and is most extensive on plateau areas. Winters are cold and summers moderately short and warm. Engelmann and hybrid spruce, and varying amounts of Subalpine Fir, are the characteristic tree species. Owing to past wildfires, successional forests of Lodgepole Pine, Douglas-fir and Trembling Aspen are common.

In southeastern BC. the Interior Cedar-Hemlock Zone (ICH) predominates at lower to middle elevations; this is the so-called Interior Wet Belt region of BC. Winters are cool and wet, and summers are generally warm and dry. Western Hemlock and Western Redcedar are characteristic climax trees, but spruce (White-Engelmann hybrids) and Subalpine Fir are common. Western Larch (*Larix occidentalis* Nutt.), 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. Wet sites often support a dense undergrowth of Devil's Club (*Oplomanax horridus* (Sm.) Miq.). The ICH also occurs in the farthest reaches of the northwestern part of the ecozone in the coastal influenced lower and middle elevations in the central to upper Skeena and Nass River drainages. The ESSF is the subalpine zone above the ICH.

The Lepidoptera of the Montane Cordillera in Canada are discussed in some detail by Lafontaine and Troubridge (2011). Characteristic species usually not found in other ecozones in BC include *Danaus plexippus* (Linnaeus), the Monarch; *Papilio multicaudata* Kirby, a large swallowtail typical of the southern valleys; *Papilio machaon oregonius* Edwards, a species of southern grasslands; and *Papilio indra* Reakirt, primarily a Great Basin montane swallowtail that barely reaches the northern limits of its range in Manning Provincial Park. Moths include *Hypercompe permaculata* (Packard), an aridland tiger moth of the Great Plains that is known in BC only in the Columbia Valley and *Acronicta cyanescens* (Hampson), a noctuid that feeds on *Ceanothus* from BC south to New Mexico. Most of the threatened and endangered species in the ecozone are Great Basin species associated with grasslands in the southern valleys, especially the Okanagan. Much of this habitat has been converted to agriculture or urban environments. Butterflies are better known than moths in this context -- Guppy *et al.* (1994) listed 52 species and subspecies of conservation concern in BC; 17 of these occur in the Montane Cordillera Ecozone (Lafontaine and Troubridge 2011). Species most at risk are probably the Mormon Metalmark (*Apodemia mormo* (C. & R. Felder)), Behr's Hairstreak (*Satyrium behrii* (Edwards)), Sagebrush Sooty Hairstreak (*Satyrium semiluna* Klots), Grey Copper (*Lycaena dione* (Scudder)), Sonoran Skipper (*Polites sonora* (Scudder)), and the California Hairstreak (*Satyrium californica* (Edwards)).

The Montane Cordillera Ecozone has many alien Lepidoptera; a significant number are agricultural pests (especially those associated with fruit trees and grapes) that have been introduced into the Ecozone, probably with host plants or their fruit. Examples of pests of apples include Codling Moth (*Cydia pomonella* (Linnaeus)) and Apple Clearwing Moth (*Synanthedon myopaeformis* (Borkhausen)).

A notable characteristic of the flora and fauna of the Montane Cordillera Ecozone is the presence of Boreal and Cordilleran species pairs. A Boreal species often ranges across the northern forests of the continent and south into the western mountains for varying distances, frequently meeting a

closely related Montane Cordilleran species in central regions of the ecozone. Hybrids often occur where the species overlap. Some Lepidoptera species show this pattern, a result of post-glacial recolonization of the West. Examples of Boreal/Cordilleran species pairs are the White Admiral (*Limenitis arthemis* (Drury) and Lorquin's Admiral (*Limenitis lorquini* (Boisduval)); and the Canadian Tiger Swallowtail (*Papilio canadensis* Rothschild & Jordan) and Western Tiger Swallowtail (*Papilio rutulus* Lucas).

The highly diverse fauna of the ecozone has been documented by many workers over the years. Some of the earliest collectors and compilers were W.H. Danby and C. de B. Green (1893), who worked in the Kootenay and Okanagan regions, among other places, and published an early BC list. H.G. Dyar and J.W. Cockle documented early material from the Kootenay region (Dyar 1904). A.W. Phair (1919) and J. McDunnough (1927) collected extensively around Lillooet. T.A. Molliet (1947) collected in the North Thompson area and W.R. Buckell in the Shuswap region (Buckell 1947). As in other parts of BC, much useful information on economically important species in the ecozone has been documented by Canadian Forest Service entomologists (eg, Ross & Evans 1957, Sugden 1968). Other reports of studies in the Montane Cordillera include Threatful (1989) in Mount Revelstoke and Glacier National Parks, Kondla in the Pend d'Oreille Valley, and Fischer *et al* (2000) in the Chilcotin.

Boreal Cordillera

The Boreal Cordillera Ecozone occupies northern BC from about 56°N north to the Yukon border and from the crest of the Coast Mountains east to the eastern slopes of the Rocky Mountains. On the west it borders the Pacific Maritime Ecozone, on the east the Taiga Plains, and on the south the Montane Cordillera. It also extends into southern Yukon. In BC the Skeena, Cassiar, Ominica, and northern Rocky mountains are included; these ranges are lower and less rugged than the Coast Mountains and the systems of southeastern BC. Most associated plateaus, such as the Stikine, show well-eroded, moderate relief; basins, such as the Liard, have low-lying, gentle topography. Major rivers include the Stikine, Dease, and Ketchika; the last flows north in the Rocky Mountain Trench. In the mid-elevation Spruce-Willow-Birch Zone, the winters are long and cold, summers brief and cool. The mean annual temperature ranges from -0.7 to -0.3°C; average temperatures usually are above 10°C for only one month a year. Mean annual precipitation is 460 to 700 mm with 35 to 60% falling as snow. Moist Pacific air frequently produces summer storms but more stable air prevails in winter.

Three main biogeoclimatic zones occur in the ecozone. At the lowest elevations, the Boreal White and Black Spruce Zone (BWBS) occupies the major river and lake valleys north of about 56°N. The Spruce-Willow-Birch zone (SWB) occurs in the subalpine above the BWBS over most of its range in the province and the Alpine Tundra Zone (Boreal Altai Fescue Zone) lies above tree-line. In the far western border of the Boreal Cordillera Ecozone, on the eastern slopes of the Coast Mountains, the SWB is replaced some valleys by the Sub-boreal Spruce Zone (SBS) and subalpine slopes are in the Engelmann Spruce-Subalpine Fir Zone (ESSF). Boreal Altai Fescue Alpine Zone (BAFA)

The BWBS occurs at the lowest elevations to about 1000-1100 m. The majority of the zone lies above 600 m. Forests predominate in the better-drained sections of the zone, where mixed Trembling Aspen and White Spruce forests dominate the landscape. Relatively open pine and 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 moraines or lacustrine soils. Dense Black Spruce and moss communities develop on poorly drained sites. Grassland and scrub communities occur on steep, south-facing slopes above many of the major rivers such as the Stikine. Forest fires are frequent throughout the zone, maintaining most of the forests in various successional stages.

The SWB is the most northerly subalpine zone in BC and here it 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 and Liard plateaus. Elevations of the SWB in northern British Columbia range between 1000 and 1700 m in the southern parts of the zone, and between 900 and 1500 m in the north. The SWB is usually the subalpine zone above the BWBS in northern BC, occupying a position comparable to that of the ESSF above the lower elevation zones farther south. The SWB is generally forested with White Spruce and variable amounts of pine and aspen in the valley bottoms and on lower slopes with Subalpine Fir higher on the slopes. Upper elevations of the SWB (essentially a scrub/parkland subzone) are dominated by fairly tall deciduous shrubs, mainly Scrub Birch (*Betula glandulosa* Michx.) and several willows, including *Salix glauca* L. Subalpine grasslands are frequent but not too extensive in this zone, especially on steep south slopes; *Festuca altaica* Trin. is typical.

The Alpine Tundra Biogeoclimatic Zone of the Boreal Cordillera Ecozone, which is extensive on the landscape above 1000m elevation, is characterized by dwarf willows (especially *Salix reticulata* L. and *S. polaris* Wahlenb.), grasses (especially *Festuca altaica*), sedges, and lichens. Since 2006 it has been designated the Boreal Altai Fescue Zone.

Characteristic Lepidoptera species more or less restricted in BC to the ecozone are mostly species of the alpine tundra and include *Parnassius phoebus* (Fabricius), *Pieris angelika* Eitschberger, *Colias hecla* Lefèbvre, *Boloria polaris* (Boisduval), *Erebia rossii* (Curtis), and *E. pawlowskii* Ménériés. *Euchloe naina* Kozhantshikov, *Boloria natazhati* (Gibson), *Erebia mackinleyensis* Gunder, and *Oeneis philipi* Troubridge are Beringian species, that is, they occur mainly in unglaciated regions of the far Northwest. *Parnassius evermanni* Ménériés and *Papilio machaon aliaska* Scudder are typically northern species with more widespread ranges; the former also lives in some areas of the northern Montane Cordillera Ecozone and the latter also occurs east of the Rockies in BC.

A few early naturalists made collections in the ecozone; for example, E.M. Anderson brought back specimens to the Provincial Museum from a trip to Atlin in 1914 (Provincial Museum 1916). However, the majority of records in the ecozone were documented after World War II when significant roads such as the Alaska Highway opened up much of the North. At this time, the Northern Insect Survey (Canadian National Collection) made surveys across northern BC from Atlin to Summit Lake and Fort Nelson (the last locality is in the Taiga Plains Ecozone). Various lepidopterists such as C. Guppy, J. Shepard, N. Kondla, J. Troubridge and others have

collected in the ecozone, looking especially for seldom-observed northern endemics and Beringian species at places such as Pink Mountain, Stone Mountain, Atlin and the Haines Road.

Taiga Plains

The Taiga Plains Ecozone is a low-lying region centred on the Mackenzie River and its many tributaries. The Northwest Territories contains about 90% of the Taiga Plains and relatively small southern sections lie in northeastern BC and northern Alberta. In BC it is bounded by the Rocky Mountains to the west and the Boreal Plains Ecozone to the south. About 10% of BC lies east of the Rockies and the Taiga Plains roughly comprises the northern half of this region. The ecozone is a northern extension of the interior plains that are characteristic of the Prairie provinces and typically consists of subdued relief consisting of broad lowlands and plateaus, which are crossed by numerous rivers, especially the Liard and its large tributary, the Fort Nelson River. Extensive wetlands, especially peatlands, are common in the lowland areas. Differences in drainage, precipitation and fire history can result in complex mosaics of wetlands and forest types. The subarctic climate is characterized by short, cool summers and long, cold winters. Mean annual temperature is -2.9 to 2°C and, although daily maximum temperatures can be quite high in mid-summer, monthly averages remain below 0°C for about half the year. Annual precipitation averages between 330 and 570 mm, with 35-55% 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.

The Boreal White and Black Spruce zone (BWBS) is the sole biogeoclimatic zone in the Taiga Plains within BC. In northeastern BC this lowland to montane zone ranges from about 230 to 1300 m. White spruce, Trembling Aspen, Lodgepole Pine, Black Spruce, Balsam Poplar (*Populus balsamifera* L.), Tamarack (*Larix laricina* (Du Roi) K. Koch), Subalpine Fr, and Common Paper Birch (*Betula papyrifera* Marshall) 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. The poorly drained lowlands are characterized by accumulations of peat that insulate frozen ground, resulting in lenses of permafrost. Black Spruce and occasionally Tamarack are the main trees on organic terrain. On better drained sites at higher elevations, mixed Trembling Aspen-White Spruce forests dominate. The most productive forests (White Spruce and Balsam Poplar) occur on rich alluvial sites and Tamarack forms pure stands only in minerotrophic fens. Some common species of these fens are Scub Birch, Swamp Birch (*Betula pumila* L.), Leatherleaf (*Chamaedaphne calyculata* (L.) Moench), Sweet Gale (*Myrica gale* L.), and Labrador Tea (*Ledum groenlandicum* Oeder).

Characteristic Lepidoptera are boreal or more widespread species that mainly occur east of the Rocky Mountains. Examples are *Callophrys niphon* (Hübner), whose larvae feed on pines and *Phyciodes batesii* (Reakirt), a denizen of aspen woodland. *Plebejus optilete* (Knoch) feeds on *Vaccinium* and lives in peatlands at lower elevations; in the Boreal Cordillera it is also found in higher elevation meadows. *Papilio machaon*, the Old World Swallowtail, is widespread in northern BC; it is a typical inhabitant of openings in the boreal forest of the Taiga Plains Ecozone.

Boreal Plains

The Boreal Plains Ecozone consists of low-lying valleys and plains stretching across the northern Great Plains from Manitoba to northeastern BC and contains much of the huge boreal forests in western Canada. The main watersheds drain this region from west to east -- the Saskatchewan, Beaver, Athabasca, Slave and Peace. In BC the ecozone occupies the southern half of the region east of the Rocky Mountains, that area largely drained by the Peace River and its tributaries. The continental climate is determined by Rocky Mountains to the west, blocking moisture from the Pacific and leaving the region at the mercy of arctic air masses in the winter. General climatic and vegetational descriptions are similar to those of the adjacent Taiga Plains Ecozone (see above), although the ecozone in BC generally has milder temperatures. The mean annual temperature of about 0.5°C; the mean summer temperature is 13°C and the mean winter temperature is -14°C. The mean annual precipitation ranges from 350 to 600 mm.

As in the Taiga Plains Ecozone, the Boreal White and Black Spruce zone (BWBS) is the sole biogeoclimatic zone in the Boreal Plains Ecozone within BC. In addition to the diverse boreal forest mosaic of the BWBS, with White Spruce and Trembling Aspen typically predominating in this ecozone, distinctive grassland and scrub communities occur in patchworks on steep, south facing slopes above rivers, most notably the Peace. Common shrubs include Prickly Rose (*Rosa acicularis* Lindl.), Wood's Rose (*Rosa woodsii* Lindl.), Saskatoon (*Amelanchier alnifolia* Nutt.), and Western Snowberry (*Symphoricarpos occidentalis* Hook.). Herbs and grasses include Pasture Sage (*Artemisia frigida* Willd.), Northern Wormwood (*Artemisia campestris* L.), Western Wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve), Junegrass (*Koeleria macrantha* (Ledeb.) Schult.), and Needle-and-thread Grass (*Hesperostipa comata* (Trin. & Rupr.) Barkworth).

In BC, several butterfly taxa are more or less restricted to the dry habitats of the Peace River Valley. *Papilio machaon pikei* Sperling flies on the dry grassland slopes along the Peace River near the Alberta boundary. *Satyrium liparops* (Boisduval) feeds on *Amelanchier* and *Hesperia assiniboia* (Lyman) on grasses along the south-facing banks of the Peace. *Phyciodes batesii* (Reakirt) is typical of Trembling Aspen woods and associated meadows and *Oeneis alberta* Elwes flies in bunchgrass grasslands. The main documentation of the Lepidoptera of the Boreal Plains Ecozone is by Kondla *et al.* (1994) and Shepard (2000), who mainly studied the fauna of the Peace River region.

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