The Biodiversity Atlas of British Columbia

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Written by M. A. Austin and A. Eriksson
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**FOREWORD**

Imagine flying over British Columbia in a small airplane. You look down on a shifting array of landscapes that begin in the west where the long coastline undulates with rocky intertidal areas, sandy beaches, fjords and islands. Below, a herd of sea lions hauls out on a group of rocky islets and schools of salmon congregate at the mouths of rivers. Travelling inland, you pass over alpine meadows and mountaintops of rock, ice and snow that give way to vast green forests, broad valleys and grasslands. A grizzly bear ambles up a mountain ridge looking for berries. A cougar hunts for prey at the edge of a pond. Everywhere you look you see water – streams, lakes and wetlands – and great river systems that wind their way to the sea where they expand into wide floodplains. A flock of snow geese rises off a marsh. A steelhead breaks through the surface of a lake. Moving east, interior dry forests meet the flanks of the Rocky Mountains, and in the northeast, you see the rolling Interior Plains where broad-winged hawks soar above the grasslands. But most of the wild inhabitants of the province are hidden or too small to distinguish from your vantage point. To fully appreciate the complexity and abundance of the biological diversity of B.C. – life in all its forms and the physical substrates that support it – you would have to walk the landscape armed with field glasses, a microscope, scuba gear and a camera. And even then you would only be scratching the surface.

With sixty descriptive maps and accompanying text, *The Biodiversity Atlas of British Columbia* provides a broad overview of the province’s range of terrestrial and freshwater biological diversity. Bringing together data from numerous sources summarized in map form, the *Atlas* provides a window to B.C.’s diverse ecosystems, the species that live in them, and the elements of British Columbia’s biodiversity that make it globally significant. The *Atlas* also presents a visual perspective of a number of human-induced threats, including climate change, affecting biodiversity in B.C. today.
The *Atlas* is designed to serve as a companion document to *Taking Nature’s Pulse: The Status of Biodiversity in British Columbia* – a comprehensive scientific assessment of biodiversity in the province. Both the *Atlas* and *Taking Nature’s Pulse* are projects of Biodiversity BC, a partnership of conservation groups and government agencies.

Although there are currently a wide variety of conservation tools and measures in place to conserve biodiversity in B.C., *The Biodiversity Atlas of British Columbia* does not attempt to provide an assessment of these. Its purpose is to present maps illustrating aspects of biodiversity in the province and related threats from human activity. An assessment of the extent to which management tools have proven to be effective in maintaining biodiversity is something that can better be done in the context of determining future priorities and actions for biodiversity conservation.
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- Matt Austin, B.C. Ministry of Environment;
- Dan Buffett, Ducks Unlimited Canada;
- Dave Nicolson, formerly with Nature Conservancy of Canada;
- Geoff Scudder, The Nature Trust of British Columbia; and
- Victoria (Tory) Stevens, B.C. Ministry of Environment.

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*Previously represented by Canadian Parks and Wilderness Society.*
INTRODUCTION

British Columbia, Canada’s westernmost province, is famous for its abundance and diversity of life. Under the influence of the Pacific Ocean and with mountainous terrain that covers most of the land base, the province has a rich variety of life that is unparalleled in the rest of Canada. Large tracts of relatively undisturbed land support populations of large carnivores and ungulates, the country’s only temperate rainforests produce giant trees the height of skyscrapers, and unique populations of fish have evolved in isolation since the last ice age. Millions of migrating birds and populations of marine mammals travel along the coast every year, stopping over to feed or rest. Thousands of smaller species that inhabit the wide variety of ecosystems from the sea to the mountain tops go largely unnoticed: insects and amphibians, lichens and reptiles, fungi and flowering plants and more; yet all are important components of British Columbia’s natural legacy.

This variety of life in all its forms is termed **biodiversity**: the variety of species and ecosystems on Earth and the ecological processes of which they are a part—including ecosystem, species and genetic diversity components.¹ The Biodiversity Atlas of British Columbia provides a map-based, province-wide overview for a selection of ecosystems and species in both the terrestrial and freshwater realms. Not included in this atlas are species and ecosystems that are exclusively in the marine realm. The marine realm is currently part of comprehensive planning initiatives under the auspices of the Canada Oceans Act and led by Fisheries and Oceans Canada.² Also included are maps of a number of threats currently affecting biodiversity in the province. The Atlas is a companion document to Taking Nature’s Pulse: The Status of Biodiversity in British Columbia and Ecological Concepts, Principles and Applications to Conservation. Collectively these publications are intended to guide government and non-government organizations and citizens in taking action to conserve biodiversity.

¹ See Pacific Ocean status reports at: [www.pac.dfo-mpo.gc.ca/SCI/psarc/OSRs/Ocean_SSR_e.htm](http://www.pac.dfo-mpo.gc.ca/SCI/psarc/OSRs/Ocean_SSR_e.htm).
While the best available data was used in the development of the Atlas, the process has illuminated some gaps in our knowledge. More data has been collected near urban areas and roads, some areas of the province have never been surveyed, distribution and population studies have been limited in the past due to a focus on species of commercial importance, and genetic diversity has not been well studied. It is important to keep these limitations in mind while viewing the maps.

**How to Read the Biodiversity Atlas**

*The Biodiversity Atlas of British Columbia* is divided into four sections. The first section, *Ecosystems*, presents maps that characterize the province in a variety of ways from topography to land cover, including commonly used classification systems. Section two, *Species*, summarizes known biological data for native species in the province using richness analyses. The third section, *Special Elements of Biodiversity*, describes and maps some elements of biodiversity that are nationally or globally significant. Section four, *Threats to Biodiversity*, examines the major stresses to biodiversity and human-induced sources of those stresses, including climate change.

References are cited by number (e.g.,³) and provided in order at the end of the document in the section titled *Notes* beginning on page 127. Cross-references within the Atlas are indicated by a page number (e.g., p.5). Footnotes are indicated by letter (e.g.,⁴) and provided at the bottom of the relevant page. All glossary items are highlighted in green when first used from this point forward in the body of the text and defined in the glossary which begins on page 124. Scientific names are given only with the first mention of a species within the body of the text. Species common names are not capitalized except for proper nouns (e.g., great blue heron; Oregon spotted frog). Units of measurement are abbreviated (e.g., 2 metres = 2 m, 10 kilometres = 10 km).

**How The Maps Were Created**

The maps presented in the Atlas were created using a variety of methods. The ecosystem maps (pp.8-33) and the special elements maps (pp.71-75) are simply displays of existing datasets applied to the Atlas format. Sources for these data sets are listed on each map. The maps for species richness (pp.35-69) and the maps for threats to biodiversity (pp.76-123) were developed specifically for the Atlas using detailed analyses as outlined below.

*Maps for Species Richness*

Species richness is a common measure of biodiversity calculated as the number of species within a specific area of interest. An area of high species richness supports a larger number of different species than an area of low richness. To produce the species richness display on a map, the province was divided into 1,208 grid cells, based on the 1:50,000
National Topographic System map sheet grid, and the number of species in each grid cell counted. Each
grid cell corresponds to a particular area in B.C. ranging in size from 780 km² to 1,030 km². The grid cells
range in size because they follow lines of latitude and longitude along the curvature of the earth.

The number of species in each of the 1,208 grid cells was counted electronically using computerized
location data from surveys and incidental sightings. Inventory has been particularly limited for some groups
of species [i.e., amphibians (p.46), perching birds (p.48), reptiles and turtles (p.54), insects (p.56), butterflies
(p.58), damselflies and dragonflies (p.60), and crustaceans (p.62)]. This limitation is reflected in the maps,
and evident as areas categorized as 'no observations'. Data was available for 2,640 species of vertebrates,
invertebrates, and vascular and non-vascular plants native to B.C. Only species locations recorded between
1961 and 2006 were included in the analysis because historic occurrences may no longer be representative of
current species locations due to pressures from land use and climate change. Once the species were counted,
each grid cell was coloured according to the categories specific to each map as outlined in the map legend.
See Understanding the Maps on the following two pages for further explanation of the map categories.

Maps for Threats to Biodiversity
This series of maps required the creation of analysis units for calculating measures such as road density. To
begin, overlays of ecosections\(^5\) (p.18), biogeoclimatic subzones and variants\(^4\) (p.20), and third-order watersheds\(^5,6\) were performed. The areas occupied by unique combinations of the polygons from the three layers
(biogeoclimatic subzones/variant x ecosections x watersheds) were used as the basic biodiversity spatial
analysis units (analysis units) (Map 1). The resulting distribution across the province was 72,335 polygons
ranging in size from 1 km² to 1,530 km² with 96% less than 50 km² (Table 1). Small areas of overlap (less than
1 km²) were merged into larger neighbouring polygons.

The calculations within analysis units were carried out using a computerized grid approach to data pro-
cessing and summarization called Hectares BC\(^7\). The province was divided into approximately 95 million one-
hectare squares (100 m on a side), also called a raster grid. Specific maps were generated by superimposing
one or more data layers of interest (e.g., area recently logged) over the raster grid system. Data for each grid
square was determined (e.g., recently logged or not recently logged) and summary measurements were then
calculated for each analysis unit using a specific formula designed for that feature based on the data attribute.
For example, the map for percentage land logged since the 1970s (p.105) was calculated using the formula:
[(total area of all grid cells in an analysis unit that were recently logged minus water area) divided by (total
area of the analysis unit minus water area) x 100]. The analysis unit is then coloured on the map according to
the legend scale for each map described in detail in Understanding the Maps (p.5).

### Table 1. Size Distribution for Biodiversity Spatial Analysis Units

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<th>AREA</th>
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<td>147</td>
</tr>
<tr>
<td>111 – 120</td>
<td>121</td>
</tr>
<tr>
<td>121 – 130</td>
<td>89</td>
</tr>
<tr>
<td>131 – 140</td>
<td>98</td>
</tr>
<tr>
<td>141 – 150</td>
<td>75</td>
</tr>
<tr>
<td>151 – 160</td>
<td>55</td>
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<tr>
<td>161 – 170</td>
<td>48</td>
</tr>
<tr>
<td>171 – 180</td>
<td>44</td>
</tr>
<tr>
<td>181 – 190</td>
<td>47</td>
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<tr>
<td>191 – 200</td>
<td>37</td>
</tr>
<tr>
<td>201 – 210</td>
<td>28</td>
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<tr>
<td>211 – 220</td>
<td>27</td>
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<tr>
<td>221 – 230</td>
<td>19</td>
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<tr>
<td>231 – 240</td>
<td>15</td>
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<tr>
<td>241 – 250</td>
<td>12</td>
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<tr>
<td>251 – 260</td>
<td>10</td>
</tr>
<tr>
<td>261 – 270</td>
<td>12</td>
</tr>
<tr>
<td>271 – 280</td>
<td>19</td>
</tr>
<tr>
<td>281 – 290</td>
<td>12</td>
</tr>
<tr>
<td>291 – 300</td>
<td>10</td>
</tr>
<tr>
<td>301 – 1,530</td>
<td>212</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72,335</strong></td>
</tr>
</tbody>
</table>
Example of biodiversity spatial analysis units

Legend

- Road
- River/Stream
- Lake
- Ecosections
- Watersheds
- Biogeoclimatic Ecosystem Classification Variant

Enlargement Area

Enlargement 1: Ecoregion, watershed and Biogeoclimatic Ecosystem Classification variant boundaries

Enlargement 2: Biodiversity and spatial analysis units

*Each colour denotes a separate analysis unit.

Data sources:
- Biogeoclimatic Ecosystem Classification (v. 6.0), Freshwater Atlas (3rd order watersheds), Ecoregions (v. 2.01)

Map by:
- Caslys Consulting Ltd

Projection:
- BC Albers NAD83

Produced for:
- [BC Diversity](https://www.biodiversity.bc.ca)

January 29, 2009
The measurement units for the absolute values resulting from each calculation vary for each specific map and can be expressed as a proportion, a percentage, a density (i.e., km/km²) or an index value. Index values are expressed in units unique for the particular map, each explained in the accompanying text. For example, the water pollution index (p.122) is expressed as a number, where the potential for water pollution impacts based on provincial discharge permits increases as the index number increases.

UNDERSTANDING THE MAPS

The maps for species and for threats consist of a main map and a smaller inset map, which present the data in two different ways. These two cartographic approaches for presenting data were used to meet three sometimes conflicting goals: following consistent mapping methods; allowing for comparisons between maps; and accurately representing the distribution of data values, while showing spatial variation within B.C.

The main map uses ten percentile classes, each of which generally incorporates the same number of analysis units. In effect, one-tenth of the analysis units are in each percentile class no matter what range of values are represented. For example, if an analysis unit has a road density (p.107) that is greater than or equal to 60% of the other analysis units, it is in the 60th percentile.

Many maps have an inset in the lower left corner comparing mapping of the same data using an equal interval approach, in which the data are divided into 10 equally spaced classes based on the range of the measurements, where each class may contain a different number of analysis units. For example, the road density values (p.107) range from 0-22.1 km/km², so the first class contains all analysis units with a value between 0 and 2.21 km/km², the second class contains all analysis units with a value between 2.22 and 4.42 km/km² etc.

b In order to convert the absolute values of the analysis units to percentiles, all summary data values for the analysis units were sorted from lowest to highest and ranked starting with 1. The ranks were then converted to a percentile using the formula: rank-1/total number of analysis units.

c Most of the maps use ten categories. Exceptions occur for the climate change seasonal trends maps (pp.99-101), and maps for areas upstream of a dam (p.113), nitrogen oxides emissions density (p.119), and sulphur oxides emission density (p.121), all of which have less than 10 categories. Some of the native species richness maps (pp.36-69) have 11 classes because “no observations” was treated as a separate class.

d Exceptions to the rule of each percentile class having the same number of analysis units occurred in cases where more than one-tenth of the analysis units had the same value (this happened where large numbers of analysis units had 0 values such as for road density). In those instances the remaining classes have an equal number of analysis units that is less than one-tenth of the total number (e.g., if the first class included 55% of analysis units all tied with a value of 0 the remaining 9 classes would each have 5% of the analysis units).

e The analysis units vary in size and therefore, one-tenth of analysis units does not necessarily equal one-tenth of the area of the province.
Each category of corresponding percentiles (or equal interval classes) for a single analysis unit was translated into colours on the map. For example, on species richness maps (pp.36-69), analysis units with the highest category of richness values are coloured dark green, those with the lowest richness values are dark brown. No colour (grey background shade is visible) means either that the attribute data is not present or that the data is deficient for the analysis unit.

**DATA SOURCES**

The data analyzed and presented on the maps came from a variety of sources, summarized in the lower right hand corner of each map.

The base maps were developed from the Natural Resources Canada 1:7,500,000 scale National Atlas and base data distributed with Environmental Systems Research Institute’s (ESRI) ArcMap software (www.esri.com). The political boundaries, roads, rivers, lakes and city locations came from the National Atlas. The grey hillshade (used to depict the land) and the bathymetric data (used to depict the ocean) came from the ESRI dataset.

The map has been projected to the province’s standard map projection which is BC Albers using North American Datum 1983.

Two important sources of provincial land cover and land use data are the Baseline Thematic Mapping (BTM version 1&2) and Terrain Resources Information Management Mapping (TRIM). Figure 1 shows the dates of BTM and TRIM mapping which vary across the province. Note that neither has been updated in some time, therefore this time period is a limitation for some of the maps in the Ecosystem and Threats sections.
 FIGURE 2: How to read the maps

Note: It is important to read the exact specifications listed in the legend to each map, as they may differ even on similar maps.
An ecosystem can be a small as a single log.

PHOTO: TORY STEVENS.

**ECOSYSTEMS**

An ecosystem is a dynamic complex of plants, animals and microorganisms, and the abiotic environment in which they live, all interacting as a functional unit. Ecosystems can be examined at a wide range of scales from a single log in a forest to an entire forest type covering thousands of square kilometres.

The latitude, coastline and topography of B.C., and the resulting climatic variation have created a wide diversity of ecosystems from intertidal areas to forests to grasslands to alpine ice and snow. The province stretches from the 48° north latitude at its most southerly point on Vancouver Island to the 60° north latitude, and rises in altitude from sea level to more than 4,000 m at the peaks of the highest mountains – Mt. Waddington in the Coast Mountains, and Mt. Fairweather on the Alaska-B.C. border at the south end of the St. Elias Mountains.  

B.C. has some of the highest mountain ranges in Canada and these mountain systems give rise to over a dozen large rivers: the Fraser, Thompson, Kootenay, Columbia, Parsnip, Finlay, Peace, Kechika, Liard, Skeena, Nass, Stikine and Taku (Map 2). B.C. has the longest valley in North America – the 1,400 km long Rocky Mountain Trench – and Canada's longest coastline at approximately 29,000 km and shares the world's only interior temperate rainforest with Idaho, Montana and Washington.

Ecosystems are dynamic over space and time, and can be difficult to characterize as discrete units. The following section presents a number of ways of viewing the broad-scale terrestrial and freshwater ecosystems of British Columbia, including a variety of classification systems developed specifically for the province.
Topography and Climate

Much of the character of British Columbia’s biodiversity can be explained by the province’s mountainous topography and the resulting climatic conditions. The province lies within the Cordilleran mountain system of western North America, with the Coast Mountains to the west, the Rocky Mountains and the Columbia Mountains in the east, and the Cassiar-Omineca Mountains in the north (Map 2). The elevation map (Map 3) emphasizes that the majority of the land exceeds 1,000 m in altitude, including much of the Interior Plateau to the west of Prince George. Lower elevation land below 1,000 m occurs only along river valleys, in the northeast Interior Plains and along the coast.

While high mountains, rock, ice and snow add to the overall diversity of habitat in the province, they do not provide conditions conducive to the survival of most species. Below 1,000 m where climatic conditions are less severe, productivity is higher and habitats tend to be more diverse. As a result, species richness (p.36) tends to be greater in the low elevation areas, particularly the warm, moist, valley bottoms in the south of the province. These same areas are attractive places for humans to live, recreate and work. The mountainous topography in B.C. has limited many human activities to low elevation areas. Consequently, the greatest impacts on biodiversity (pp.76-123) occur on flatter land in the southern valley bottoms, the Interior Plateau and in the northeast. Pressures on freshwater biodiversity are also relatively high overall as the major rivers and lakes occur in the valley bottoms. As well, the mountainous terrain makes it relatively easy to build dams on river systems (p.112).
Topography and Climate continued...

Climatic conditions are influenced greatly by topography as well as a number of other factors such as ocean currents and latitude. Map 4 shows four standard climate variables across the province as measured between 1961 and 1990: mean annual temperature, mean annual precipitation, precipitation as snow and Growing Degrees Days (GDD). Growing Degree Days refers to the annual sum of degrees Celsius above the base of 5°C based on daily mean temperatures (the average of the daily maximum and minimum). For example, ten days at 6°C is 10 GDD while 10 days at 10°C is 50 GDD.

The moderating influence of the Pacific Ocean is evident from the maps with the warmest temperatures, relatively high precipitation and lower snowfall, and high GDD occurring along the coast. Warm, moist air from the Pacific Ocean releases its moisture as rain or snow as it rises over the Coast Mountains, producing the highest rainfall and some of the most productive forests in Canada. Inland, the continental air mass creates greater extremes of temperature and precipitation than on the coast. The province’s driest regions occur in the southern interior, in the rain shadow to the east of the Coast Mountains. The warm Pacific air rises once again as it travels east, creating an interior wet belt in the Columbia Mountains west of, and within parts of, the Rockies. The Peace region in the northeast, an extension of the Interior Plains of Alberta, is characterized by low elevation rolling hills and a cold northern climate in winter. Climate in the province is also influenced in the summer by warm or hot air from the Great Basin and the Columbia Basin to the south in the United States.

Organisms are sensitive to changes in climate and, although many individuals, species and ecosystems can tolerate some climatic variation, extremes of high and low temperature and precipitation determine the distribution of many species and the ecosystems in which they live (p. 88). Climate is a major factor in the net primary productivity of ecosystems (p.16) and is a key consideration in the classification of B.C.’s broad-scale ecosystems such as Ecoregions (p.18) and biogeoclimatic zones (p.20).
Land Cover

The land cover map provides a view of the province in terms of the kinds of basic ecosystem types referred to in common terms such as grasslands, wetlands and forests (Map 5). Within each of these categories, a wide range of ecosystems occurs. Forests, for example, range from riparian forest to swamp forest to steep, shallow areas with low productivity, parkland and krummholz.

B.C. is predominantly a land of trees, rock and ice. More than 70% of the total land area is forest and 13% is alpine (Figure 3). While not a specific category, rock covers almost 10% of the province, with the majority (close to 9%) occurring in the alpine.

The rarest land cover type is grassland (1%). Grasslands are not only naturally rare on the landscape, they are also of conservation concern (p. 22). The two major biogeoclimatic zones that represent grasslands in B.C. – Ponderosa Pine and Bunchgrass – are considered critically imperilled. More than one-third of B.C.’s vertebrates of conservation concern depend on grasslands for their survival.

Similarly, more than 30% of species of conservation concern depend on wetlands. Due to the scale of the display and the small size of many wetlands, most are not visible on the map.

Freshwater in lakes, rivers, and reservoirs occupies only 3% of the area of the province yet supports a large proportion of B.C.’s plants and animals, including people (Figure 3).

FIGURE 3: Land cover types in B.C. as percentage of total area of province.
SOURCE: Produced for this report.
*Areas mapped as urban, agriculture, recreation (e.g., golf courses) or mining.
**Forest and other=All areas not mapped into the other six categories; the vast majority is forest.

Sources: Grasslands – Grasslands Conservation Council; Glaciers – Terrain Resource Information Management mapping; Enhanced Base Map (TRIM: EBM); Wetlands – Terrain Resource Information Management mapping: Enhanced Base Map (TRIM: EBM); Freshwater – Lakes, rivers and reservoirs from Terrain Resource Information Management mapping: Enhanced Base Map (TRIM: EBM); Alpine – Baseline Thematic Mapping (BTM 1 & 2) 1991-1997; Human dominated – Baseline Thematic Mapping (BTM 1 & 2); Forest – Total provincial land area minus all other land classes.

* Wetlands include freshwater wetlands but not estuarine areas on the coast.
**All areas not mapped into the other six classes.**

**Produced for:**
- BTM - Baseline Thematic Mapping
- TRIM-EBM - Terrain Resource Information Management - Enhanced Base Map
- GCC - Grasslands Conservation Council

**Data sources:**
- Baseline Thematic Mapping
  (v. 1 and 2 merged)
- Terrain Resource Information Management
  Enhanced Base Map
- Grasslands Conservation Council

**Map by:**
Caslys Consulting Ltd

**Projection:**
BC Albers NAD83

**Produced for:**
February 25, 2009
Net Primary Productivity

The net primary productivity (NPP) of an ecosystem is the difference between total photosynthesis by plants and total plant respiration. NPP is a measure of the rate of production of the net useful chemical energy (in the form of carbon) available for the growth and reproduction of primary producers and for consumption by herbivores. In terrestrial ecosystems, primary production is carried out mostly by vascular plants (with a small fraction coming from algae and non-vascular plants such as mosses and liverworts). Algae carry out the majority of primary production in aquatic systems.

Map 6 shows patterns of average net primary productivity on land across the province under the climatic conditions occurring between 1960 and 2000 and based on the land cover present in 2000. The map, produced from national data, is at a fairly coarse resolution of 5x5 km. Finer resolution regional mapping specific for B.C. has not yet been carried out. In general, land with greater plant cover will have greater net primary productivity as can be seen when Map 5 (p.15) is compared with Map 6 (p.17). The highest net primary productivity occurs in the forested areas of the province, with the lowest productivity in the alpine regions. All forms of life on earth rely directly or indirectly on primary production and therefore higher levels of net primary productivity generally support more life in terms of both density and diversity, making it a good predictor for species richness (p.36).

Net primary productivity in terrestrial ecosystems is most often measured as mass of carbon fixed per unit area per year (g C/m²/yr) and is a major component of the carbon cycle. NPP is useful in climate science to calculate how much carbon is removed from the atmosphere by plants.

Water, temperature and light have the greatest influence on net primary productivity. Therefore, climate is an important driver of NPP. Plant growth can be limited by extreme temperatures and/or low levels of water and light. Climate change (p.88) has the potential to dramatically alter NPP in some ecosystems.
**Ecoregion Classification**

British Columbia is a province with great ecological complexity. In light of this complexity, the Ecoregion classification system was developed to provide a systematic view of the broad ecological relationships in the province. The system is organized according to five hierarchical levels: Ecodomain, Ecodivision, Ecopprovince, Ecoregion and Ecosystem. The highest two levels of this classification, Ecodomain and Ecodivision, are very broad and place British Columbia in a global context. Ecop provinces, Ecoregions, and Ecosystems, progressively more detailed and narrow in scope, relate different segments of the province to one another based on areas of similar climate, physiography, oceanography, hydrology, vegetation, and wildlife potential. Within the terrestrial environment each Ecoregion and Ecosystem can be further subdivided by biogeoclimatic criteria to provide a basis for detailed interpretation of climate, topography, soil, and vegetation reflected by the plant and animal communities present. Ecosystems combined with biogeoclimatic subzones and variants (p.20) and third-order watersheds (p.128) form the basis of the biodiversity spatial analysis units (pp.3 and 4) used to produce the maps presented in the Threats to Biodiversity section of the Atlas (p.76).

The map shows the ten Ecop provinces and the 139 Ecosystem divisions for the province (Map 7).
Biogeoclimatic Ecosystem Classification

Biogeoclimatic Ecosystem Classification (BEC) zones, commonly referred to as biogeoclimatic zones, are large geographical areas sharing similar climate and vegetation. The BEC system was developed specifically for B.C. in the 1960s and early 1970s and continues to be revised and updated. Sixteen biogeoclimatic zones are recognized for British Columbia (Map 8). Each of the zones is identified by the dominant vegetation type or a climatic modifier (e.g., Coastal Douglas-fir, Montane Spruce, etc.) and referred to by an abbreviation (e.g., Coastal Douglas-fir = CDF; Montane Spruce = MS). Twelve of the zones are forested, three are alpine and one is dominated by grasses.

The zones are divided into subzones, based on differences in regional climate. Variants are still finer subdivisions of subzones, which reflect local variation within the subzone-level climate (e.g., areas that are slightly wetter or warmer than other areas in the subzone). While not displayed on the map, biogeoclimatic subzones and variants, combined with third-order watersheds (p.128) and Ecosystems (p.18), form the basis of the biodiversity spatial analysis units (pp.4) used to produce the maps presented in the Threats to Biodiversity section of the Atlas (p.76).

Table 2 summarizes the area of each of B.C.’s biogeoclimatic zones, listing them in order of rarity (from most common to rarest). The least common zones, Coastal Douglas-fir, Bunchgrass and Ponderosa Pine, are all dry, low-elevation or valley-bottom zones, and together make up less than 1% of the province’s land area. The most common zones are Engelmann Spruce–Subalpine fir, Boreal White and Black Spruce, and Coastal Western Hemlock, all predominantly forested ecosystems.

### Table 2. Areal Extent of Biogeoclimatic Zones in B.C.

<table>
<thead>
<tr>
<th>Biogeoclimatic Zone</th>
<th>Area (km²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engelmann Spruce–Subalpine Fir (ESSF)</td>
<td>170,364</td>
<td>18%</td>
</tr>
<tr>
<td>Boreal White and Black Spruce (BWBS)</td>
<td>153,367</td>
<td>17%</td>
</tr>
<tr>
<td>Coastal Western Hemlock (CWH)</td>
<td>102,253</td>
<td>11%</td>
</tr>
<tr>
<td>Sub-Boreal Spruce (SBS)</td>
<td>92,346</td>
<td>10%</td>
</tr>
<tr>
<td>Spruce–Willow–Birch (SWB)</td>
<td>80,101</td>
<td>9%</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine (BAFA)</td>
<td>76,812</td>
<td>8%</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine (CMA)</td>
<td>52,007</td>
<td>6%</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock (ICH)</td>
<td>50,915</td>
<td>5%</td>
</tr>
<tr>
<td>Interior Douglas-fir (IDF)</td>
<td>40,418</td>
<td>4%</td>
</tr>
<tr>
<td>Mountain Hemlock (MH)</td>
<td>36,572</td>
<td>4%</td>
</tr>
<tr>
<td>Montane Spruce (MS)</td>
<td>27,795</td>
<td>3%</td>
</tr>
<tr>
<td>Sub-Boreal Pine Spruce (SBPS)</td>
<td>22,359</td>
<td>2%</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine (IMA)</td>
<td>17,681</td>
<td>2%</td>
</tr>
<tr>
<td>Ponderosa Pine (PP)</td>
<td>2,896</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Bunchgrass (BG)</td>
<td>2,048</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Coastal Douglas-fir (CDF)</td>
<td>1,310</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>929,244</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Source:** Prepared for this report.

**Notes:** Areas of ecosystem conversion (p.80), as well as lakes and rivers, were removed from each zone for this analysis.

The BEC system was developed independently of Ecoregion Classification (p.18). In order to provide a place of intersection for the two systems, ecozone boundaries were moved to the nearest biogeoclimatic variant boundary so that an ecozone always shares a boundary with a variant.
The conservation status of each of the biogeoclimatic zones was determined using a modification of NatureServe\textsuperscript{1} methods used for assessing species (p. 40). Conservation status rankings were based on criteria that included rarity, trends and the level of threat from human activity.\textsuperscript{30} The threat assessment carried out as part of this process included the effects of residential development, agriculture and aquaculture, energy production and mining, transportation and service corridors, biological resource use (e.g., hunting and collecting, logging, fishing), human intrusion and disturbance, natural systems modification (e.g., fire and fire suppression, dams and water management), invasive and problem species, pollution, geological events, and climate change and severe weather.

Specific information used in the assessments included the overlap of the present and projected biogeoclimatic zone climate envelopes (p.20),\textsuperscript{31} the proportion of the zone with roads and other linear development features present (p.107) and the proportion of the zone recently logged (p.105). Four biogeoclimatic zones are of conservation concern in the province: three in the interior (Bunchgrass, Ponderosa Pine and Interior Douglas-fir) and one on the coast (Coastal Douglas-fir) (Table 3). Collectively, these zones occupy less than 5% of B.C.’s area (Map 9).

### Table 3. Conservation Status of Biogeoclimatic Zones in B.C.

<table>
<thead>
<tr>
<th>Biogeoclimatic Zone</th>
<th>Conservation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunchgrass</td>
<td>Imperilled (S2)</td>
</tr>
<tr>
<td>Coastal Douglas-fir</td>
<td>Imperilled (S2)</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>Imperilled/Vulnerable (S2/S3)</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>Vulnerable (S3)</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Boreal White and Black Spruce</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Sub-Boreal Spruce</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>Apparently secure (S4)</td>
</tr>
<tr>
<td>Engelmann Spruce–Subalpine Fir</td>
<td>Secure (S5)</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>Secure (S5)</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>Secure (S5)</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>Secure (S5)</td>
</tr>
</tbody>
</table>


**Notes:** **Boldface** indicates biogeoclimatic zone is of conservation concern. The global conservation status (G rank) for the biogeoclimatic zones was considered relative to the provincial conservation status (S rank) and in all cases was assumed to be similar; therefore, the G and S rankings were the same. Only the S rank is reported.

\textsuperscript{1}NatureServe is an international network that includes the B.C. Conservation Data Centre. For more information see [www.natureserve.org/explorer](http://www.natureserve.org/explorer).
BIOGEOCLIMATIC ZONES WITH MAJORITY OF GLOBAL RANGE IN B.C.

For each biogeoclimatic zone, the proportion of its global range that occurs in B.C. was determined using maps covering a number of neighbouring jurisdictions, combined with expert knowledge where the zones were believed to extend beyond the limits of available information. Proportion of global range is described by seven classes ranging from 1 (Endemic: 100% of global range in British Columbia) to 7 (Low and Localized: less than 10% of range in British Columbia and occurs over less than 30% of the province) (Table 4).

Six of the 16 zones have more than 50% of their global range in B.C. (Classes 1-3) (Map 10). These six zones collectively cover about one-quarter of the province. B.C. has 70-80% of the global range of the Coastal Douglas-fir zone, one of the province’s four zones of conservation concern (p.22), which further emphasizes the importance of B.C. for its conservation. Two zones – the Sub-Boreal Pine–Spruce and the Sub-Boreal Spruce – are endemic to B.C., meaning they are found nowhere else in the world.

Both are forested ecosystems located in the north-central part of the province.

Except for the two endemic zones, all of the province’s biogeoclimatic zones are shared with neighbouring jurisdictions. For example, the Interior Cedar-Hemlock zone is distributed across British Columbia, Montana, Idaho, Washington and Oregon.

### Table 4. Classification System for Proportion of Global Range: Ecosystems.

<table>
<thead>
<tr>
<th>Global Range Class</th>
<th>Percent of Global Range that Occurs in B.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100% of global range</td>
</tr>
<tr>
<td>2</td>
<td>75–99% of global range</td>
</tr>
<tr>
<td>3</td>
<td>51–74% of global range</td>
</tr>
<tr>
<td>4</td>
<td>30–50% of global range</td>
</tr>
<tr>
<td>5</td>
<td>11–29% of global range</td>
</tr>
<tr>
<td>6</td>
<td>less than 10% of global range, and occurs over more than 30% of the province</td>
</tr>
<tr>
<td>7</td>
<td>less than 10% of global range, and occurs over more than 30% of the province</td>
</tr>
</tbody>
</table>


Notes: **Boldface** indicates that ecosystems in this global range class are included on Map 10.

### Notes

1. Ideally, information on the condition of the biogeoclimatic zones in areas outside the province would have been considered (particularly regarding ecosystem conversion); however, those data were not readily available.
MAP 10
Biogeoclimatic zones for which B.C. has the majority of the global range

Legend
City
Road
River/Stream
Lake
Zone
Sub-Boreal Pine – Spruce
Sub-Boreal Spruce
Mountain Hemlock
Montane Spruce
Coastal Douglas-fir
Interior Cedar – Hemlock

Status assessment from

Data sources:
Biogeoclimatic Ecosystem Classification (v. 6.0)

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
Biodiversity B.C.

February 25, 2009
Ecological Communities

Ecological communities are ecosystems classified at a much finer resolution than biogeoclimatic zones. The same community can occur in more than one zone. To date, 611 ecological communities have been described in B.C. (Table 5). Although not all ecological communities in the province have been described, the current list represents a majority of the province’s ecological communities. Ecological community classification is the most incomplete for alpine ecosystems, but this is a focus of current classification work.

Of the ecological communities described in B.C., 532 (87%) have had their provincial conservation status assessed and 340 (56% of the total number described) are of provincial conservation concern (Table 5). Ecological communities in B.C. have not yet been fully mapped, however three types of ecosystem mapping have been carried out in some areas: Terrestrial Ecosystem Mapping (TEM), Predictive Ecosystem Mapping (PEM) and Sensitive Ecosystem Inventory (SEI). Ecosystem mapping can be used to predict sites where conditions might support specific ecological communities.

TEM is a standard inventory method based on airphoto interpretation supported by intensive ground visitation that delineates areas of land and shallow water that are homogenous with respect to landform, soils, climax vegetation, and wildlife. TEM covers approximately 20% of the province.

PEM maps the same classification and most of the same attributes as TEM, but rather than being photo-interpreted, the map units and their attributes are modelled on the basis of existing information, typically including digital elevation models, Vegetation Resource Inventory, and focussed terrain mapping. As a result PEM is less accurate than TEM but also less costly. PEM covers approximately 50% of the province.

SEI identifies rare and fragile ecosystems in an area using air photography and field checking of the data. Ecosystems identified in SEI are often the remnants of the natural ecosystems that once occupied a much larger area.

### TABLE 5. PROVINCIAL CONSERVATION STATUS OF ECOCLOGICAL COMMUNITIES IN B.C. BY BIOGEOCLIMATIC ZONE.

<table>
<thead>
<tr>
<th>BIOGEOCLIMATIC ZONE</th>
<th>NUMBER OF COMMUNITIES DESCRIBED</th>
<th>PERCENTAGE OF COMMUNITIES DESCRIBED THAT ARE OF PROVINCIAL CONSERVATION CONCERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Douglas-fir</td>
<td>36</td>
<td>97%</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>30</td>
<td>93%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>29</td>
<td>93%</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>128</td>
<td>83%</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>87</td>
<td>82%</td>
</tr>
<tr>
<td>Sub-Boreal Spruce</td>
<td>92</td>
<td>61%</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock</td>
<td>89</td>
<td>52%</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>38</td>
<td>50%</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>66</td>
<td>47%</td>
</tr>
<tr>
<td>Boreal White and Black Spruce</td>
<td>52</td>
<td>25%</td>
</tr>
<tr>
<td>Engelmann Spruce–Subalpine Fir</td>
<td>149</td>
<td>21%</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>43</td>
<td>19%</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>21</td>
<td>5%</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>23</td>
<td>4%</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>39</td>
<td>3%</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>53</td>
<td>2%</td>
</tr>
<tr>
<td>Province</td>
<td>611</td>
<td>56%</td>
</tr>
</tbody>
</table>

Source: Prepared for this report with data from the B.C. Conservation Data Centre.
Notes: Boldface indicates biogeoclimatic zone is of conservation concern. Some ecological communities occur in more than one biogeoclimatic zone.
Major Drainage Areas

Freshwater is an essential ingredient for life on earth. Most fresh water is frozen or underground, locked either in polar ice caps and permafrost or in underground aquifers, many with recharge times of thousands of years. Rivers, lakes, wetlands, soil moisture and water vapour together hold 0.01% of the planet’s total water supply (including salt water) and just under 0.4% of the world’s fresh water (Figure 4). British Columbia holds 25% of Canada’s freshwater supply and 5% of the world’s supply.

Fresh water available in lakes, streams, reservoirs and wetlands provides vital habitat for a disproportionate number of B.C.’s species, including a wide variety of native plants, fungi, fish, mussels, crayfish, snails, reptiles, amphibians, insects, micro-organisms, birds and mammals that live in, on, and around water. Approximately 25% of native vertebrate, invertebrate and vascular plant species that have been assessed for ecosystem requirements in B.C. are associated with freshwater ecosystems. In addition to providing water, food, habitat, and physical, chemical and hydrologic processes, freshwater ecosystems are required for life cycle stages of many organisms, such as salmon (for spawning) and dragonflies (for larval development). Freshwater ecosystems also provide humans with essential services.

Freshwater ecosystems are highly variable and dynamic. They interact closely with adjacent riparian areas and nearshore communities, sharing physical habitats and ecological and environmental processes, and are highly sensitive to climate change (p.88).

One broad scale division of freshwater ecosystems in British Columbia is the Major Drainage Area (MDA). There are nine Major Drainage Areas in the province (Map 12). With the exception of the Coastal area, each defines the drainage basin of a major river system. The Coastal area comprises many small coastal rivers and streams that drain directly into the Pacific Ocean.

**FIGURE 4:** The world’s water supply.

CONSERVATION STATUS OF MAJOR DRAINAGE AREAS IN B.C.

According to an assessment of conservation status using the same methods applied to biogeoclimatic zones (p. 22), four of the nine Major Drainage Areas of B.C. are of conservation concern (Table 6, Map 13). These four areas occupy 83% of the province.

The Columbia River drainage, which is highly impacted by dams (p. 112) is ranked as imperilled. The Fraser system, one of the largest river systems in the world, which flows through the highly populated Fraser Valley, is ranked as imperilled/vulnerable.

While the Coastal and Mackenzie Major Drainage Areas are both ranked as vulnerable/apparently secure, it is important to keep in mind that impacts in a single watershed within the Coastal system, which is made up of many individual watersheds, will be restricted to that watershed. Impacts in the other Major Drainage Areas have the potential to spread downstream throughout the entire drainage basin.

<table>
<thead>
<tr>
<th>MAJOR DRAINAGE AREA</th>
<th>CONSERVATION STATUS</th>
<th>TOTAL AREA (km²)</th>
<th>PERCENT OF PROVINCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia</td>
<td>Imperilled (S2)</td>
<td>102,798</td>
<td>11%</td>
</tr>
<tr>
<td>Fraser</td>
<td>Imperilled/vulnerable (S2S3)</td>
<td>231,459</td>
<td>25%</td>
</tr>
<tr>
<td>Coastal</td>
<td>Vulnerable/apparently secure (S3S4)</td>
<td>164,115</td>
<td>17%</td>
</tr>
<tr>
<td>Mackenzie</td>
<td>Vulnerable/apparently secure (S3S4)</td>
<td>278,667</td>
<td>30%</td>
</tr>
<tr>
<td>Taku</td>
<td>Apparently secure/secure (S4S5)</td>
<td>16,585</td>
<td>2%</td>
</tr>
<tr>
<td>Stikine</td>
<td>Apparently secure/secure (S4S5)</td>
<td>49,631</td>
<td>5%</td>
</tr>
<tr>
<td>Yukon</td>
<td>Apparently secure/secure (S4S5)</td>
<td>24,950</td>
<td>3%</td>
</tr>
<tr>
<td>Skeena</td>
<td>Apparently secure/secure (S4S5)</td>
<td>54,401</td>
<td>6%</td>
</tr>
<tr>
<td>Nass</td>
<td>Secure (S5)</td>
<td>21,530</td>
<td>2%</td>
</tr>
</tbody>
</table>


Notes: Boldface indicates the Major Drainage Area is of conservation concern.
Protected Areas

The International Union for Conservation of Nature (IUCN) World Commission on Protected Areas defines a protected area as an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.48 Protected areas in B.C. that are included on the map are national parks, provincial parks and protected areas, regional parks, and conservation lands (Table 7, Map 14).

National parks, administered by Parks Canada, protect representative natural areas of Canadian significance for public understanding, appreciation and enjoyment, while being maintained in an unimpaired state for future generations.49,50 Seven national parks are located in B.C. and occupy over 660,000 hectares.

Provincial parks and protected areas are those designated under several provincial acts and include ecological reserves; Class A, B, and C parks; protected areas, recreation areas, and conservancies.51,52,53,54 B.C. has over 13,000,000 hectares of provincially designated parks and protected areas.

Regional parks are those owned and managed by regional districts throughout the province. Not all regional parks are managed for conservation. Many regional parks are too small to show up on the map.

Conservation lands include lands managed for conservation purposes that are owned or administered by either the Ministry of Environment (MOE), the Canadian Wildlife Service (CWS) or by a non-governmental organization. The majority of conservation lands are presently administered by MOE with the largest area encompassed by Wildlife Management Area (WMA) designations. WMAs are lands requiring special protection and management under section 4 of the B.C. Wildlife Act.55 Conservation lands administered by CWS include National Wildlife Areas56 and Migratory Bird Sanctuaries.57 Non-governmental organizations own many properties which they either manage themselves or lease to MOE to manage. These areas are usually relatively small although the recent 55,000 ha Darkwoods property acquisition in the Selkirk Mountains just northeast of Creston is the largest single private conservation land property in the province.

### TABLE 7. PROTECTED AREAS IN B.C.

<table>
<thead>
<tr>
<th>PROTECTED AREA CATEGORY</th>
<th>APPROXIMATE AREA (HA)</th>
<th>PERCENTAGE OF PROVINCIAL AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>National parks</td>
<td>662,414</td>
<td>0.7%</td>
</tr>
<tr>
<td>Provincial parks and protected areas</td>
<td>13,008,110</td>
<td>14.3%</td>
</tr>
<tr>
<td>Regional parks*</td>
<td>79,584</td>
<td>0.1%</td>
</tr>
<tr>
<td>Conservation lands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildlife Management Areas</td>
<td>232,941</td>
<td>0.3%</td>
</tr>
<tr>
<td>All other conservation lands</td>
<td>98,812</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total</td>
<td>14,081,447</td>
<td>15.5%</td>
</tr>
</tbody>
</table>


NOTE: Federally designated marine protected areas are not included.

*Only those regional parks for which data were available are included in the table and on the map.
MAP 14

Parks, protected areas and conservation lands

Legend

* Note: Federally designated marine protected areas are not included.
** Regional parks information is not complete.
*** Land held for the purpose of conservation by the Ministry of Environment, Canadian Wildlife Service or a non-governmental organization.

Data sources:
  B.C. Conservation Land Forum, B.C. Ministry of Environment

Map by:
  Caslys Consulting Ltd

Projection:
  BC Albers NAD83

Produced for:
  Parks, protected areas and conservation lands

February 25, 2009
the biodiversity atlas of british columbia
Species

Species interact within ecosystems, performing essential ecological functions necessary for life on earth. With a wide variety of ecosystems resulting from its complex topography and climate, British Columbia supports a rich diversity of species. The province is home to more species of native vascular plants, mosses, mammals, butterflies and breeding birds than any other Canadian province or territory. More than 50,000 native species are thought to live here, the majority of which are yet to be described by science. Known species include 600 vertebrates, over 2,000 vascular plant species, 1,000 mosses and liverworts and at least 1,600 lichens. Invertebrate species alone are estimated to number in the tens of thousands.

Most species in British Columbia are poorly documented. Surveys and incidental observations are often sporadic and inconsistent and/or concentrated along roads and in areas of higher human population. Parts of the province have never been surveyed and a number of taxonomic groups have never been assessed. The only groups of organisms for which lists of species within the province are complete or near-complete are vascular plants and vertebrates within terrestrial ecosystems. Invertebrates, non-vascular plants, lichens, fungi, and many freshwater species are not well surveyed. It is thought that less than 10% of the invertebrates occurring within the province are known, particularly among soil organisms and arboreal species.

This section provides information on those native species for which computerized location data, collected between 1961 and 2006, is available. This is a fraction of the total species potentially found in B.C. Subspecies, varieties and populations, many of which are of conservation concern, have not been assessed for this report.

American bison (Bos bison), photo: Frank Leung.
Species Richness

Species richness is one common measure of biodiversity calculated as the number of species in a given area (p.2).

Map 15 shows patterns of species richness for 2,640 native species in 11 of the most well‐studied groups in B.C. (Table 8). Species richness for the species assessed is highest in the south of the province and on Vancouver Island, areas of highest human population. The biogeoclimatic zones with highest species richness are Ponderosa Pine, Coastal Douglas‐fir, Bunchgrass and Interior Douglas‐fir, all zones of conservation concern (p.22).

Note that the data are biased because of uneven survey effort. There are far fewer records from the northern part of the province than in the south where more people live and where surveys are more likely to be conducted. Species richness in many parts of the north is likely far greater than the maps depict. For example, some large areas appearing to have low species richness are the most inaccessible in the province (e.g., north of Spatsizi Provincial Park) and have not been well surveyed. Such is also the case along B.C.’s long, rugged coastline.

When data for 2,295 terrestrial species and 594 freshwater species are mapped separately, somewhat different patterns of species richness are evident (Map 16, p.38 and Map 17, p.39). While both maps show high species richness in the south of the province, areas of relatively high freshwater species richness extend further north. Note that areas of high freshwater species richness generally have fewer species than areas of high terrestrial species richness.

### Table 8. Native Terrestrial and Freshwater Species in B.C. Assessed for Species Richness.

<table>
<thead>
<tr>
<th>SPECIES GROUP</th>
<th>NUMBER OF NATIVE SPECIES MAPPED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALL SPECIES</td>
</tr>
<tr>
<td>Vertebrates</td>
<td>391</td>
</tr>
<tr>
<td>Amphibians</td>
<td>20</td>
</tr>
<tr>
<td>Birds</td>
<td>187</td>
</tr>
<tr>
<td>Freshwater Fishes</td>
<td>70</td>
</tr>
<tr>
<td>Mammals</td>
<td>102</td>
</tr>
<tr>
<td>Reptiles and Turtles</td>
<td>12</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>257</td>
</tr>
<tr>
<td>Butterflies and Skippers</td>
<td>172</td>
</tr>
<tr>
<td>Dragonflies and Damselflies</td>
<td>85</td>
</tr>
<tr>
<td>Vascular Plants</td>
<td>1,992</td>
</tr>
<tr>
<td>Ferns and Fern Allies</td>
<td>103</td>
</tr>
<tr>
<td>Conifers</td>
<td>25</td>
</tr>
<tr>
<td>Flowering Plants (Monocots)</td>
<td>525</td>
</tr>
<tr>
<td>Flowering Plants (Dicots)</td>
<td>1,339</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,640</td>
</tr>
</tbody>
</table>


**Note:** A terrestrial species requires terrestrial habitat for at least one of its life requisites. A freshwater species requires freshwater habitat (lakes, rivers, streams and wetlands) for at least one of its life requisites. A species can require both freshwater and terrestrial habitats and therefore will appear in numbers for both.
MAP 15
Species richness*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- 4 - 27
- 28 - 45
- 46 - 72
- 73 - 97
- 98 - 132
- 133 - 166
- 167 - 210
- 211 - 266
- 267 - 369
- 370 - 940

Units = number of species per grid square based on observations from 1961-2006 (2,640 species total).

Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

February 4, 2009

Compiled by the University of British Columbia

Published by: Caslys Consulting Ltd

Projection: BC Albers NAD83

Produced for:

Equi Interval Classification

Number of species
- 5 - 98
- 99 - 191
- 192 - 285
- 286 - 380
- 379 - 472
- 473 - 566
- 567 - 659
- 660 - 753
- 754 - 846
- 847 - 940

Area of Detail

Kilometres

0 100 200

Data sources:
Compiled by the University of British Columbia

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 4, 2009
Terrestrial species richness

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 2 - 39
- 40 - 80
- 81 - 117
- 118 - 156
- 157 - 205
- 206 - 265
- 266 - 337
- 338 - 423
- 424 - 557
- 558 - 840

Units = number of species per grid square based on observations from 1961-2006 (2,294 species total).

*Based on documented observations [the lack of an observation does not necessarily mean a species is not present].
MAP 17
Freshwater species richness*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 14
- 15 - 19
- 20 - 24
- 25 - 30
- 31 - 38
- 39 - 45
- 46 - 56
- 57 - 69
- 70 - 87
- 88 - 223

Units = number of species per grid square based on observations from 1961-2006 (594 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Data sources:
Compiled by the University of British Columbia

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 4, 2009
Species of Conservation Concern

Conservation status is the level of risk of extirpation (provincial loss) or extinction (global loss) for a species. Species of conservation concern are those classified as critically imperilled (1), imperilled (2), or vulnerable (3) by NatureServe Canada according to a set of criteria including number of occurrences, population size, extent of range, area of occupancy, population and habitat trends, type and severity of threats, level of protection and intrinsic vulnerability. The analysis of conservation status was applied at two geographic levels, global or range-wide (G) and subnational or province-wide (S). The conservation status rank of a species is usually different at each geographic level.

For example, the sharp-tailed snake (Contia tenuis) has a global conservation status rank of G5 indicating its secure status across its entire range; whereas it has a provincial conservation status rank of S1 to convey its very high risk of extirpation in B.C.

B.C. has the highest number of native species of global conservation concern in Canada compared to other provinces and territories. Of the 3,808 B.C. native species assessed for conservation status, 6% are of global conservation concern (Table 9). Map 18 shows species richness for all 233 species of global conservation concern. High concentrations occur on Vancouver Island, the Queen Charlotte Islands/Haida Gwaii and the Lower Mainland. Certain species groups such as invertebrates, lichens and fungi have not been well assessed for conservation status in the province.

Table 9. Summary of B.C. Native Species by Global and Provincial Conservation Status.

<table>
<thead>
<tr>
<th>Conservation Status Rank</th>
<th>Global (G Rank)</th>
<th>Provincial (S Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinct or Extirpated (GX, SX)</td>
<td>1 &lt;1%</td>
<td>14 &lt;1%</td>
</tr>
<tr>
<td>Historical* (GH, SH)</td>
<td>1 &lt;1%</td>
<td>28 &lt;1%</td>
</tr>
<tr>
<td>Critically Imperilled (G1, S1)</td>
<td>19 &lt;1%</td>
<td>301 8%</td>
</tr>
<tr>
<td>Imperilled (G2, S2)</td>
<td>40 &lt;1%</td>
<td>629 17%</td>
</tr>
<tr>
<td>Vulnerable (G3, S3)</td>
<td>172 5%</td>
<td>668 18%</td>
</tr>
<tr>
<td><strong>Total species of conservation concern</strong></td>
<td><strong>233 6%</strong></td>
<td><strong>1,640 43%</strong></td>
</tr>
<tr>
<td>Apparently secure or secure (G4, S4, G5, S5)</td>
<td>3,475 91%</td>
<td>2,055 54%</td>
</tr>
<tr>
<td>Not ranked or unrankable (GNR,SNR or GU, SU)</td>
<td>100 3%</td>
<td>100 3%</td>
</tr>
<tr>
<td><strong>Total number of species assessed</strong></td>
<td><strong>3,808</strong></td>
<td></td>
</tr>
</tbody>
</table>


*Historical means a species is possibly extinct or extirpated; known only from historical records, but there is still hope of rediscovery.

---

*a NatureServe Canada, part of an international NatureServe Network, provides scientific information about Canada’s species and ecosystems.*
MAP 18
Species richness: species of global conservation concern*

Legend
○ City
— Road
— River/Stream
— Lake

Number of species
No observations

<table>
<thead>
<tr>
<th>No. of species</th>
<th>Shaded area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 - 3</td>
</tr>
<tr>
<td>2</td>
<td>4 - 6</td>
</tr>
<tr>
<td>3</td>
<td>7 - 8</td>
</tr>
<tr>
<td>4</td>
<td>9 - 10</td>
</tr>
<tr>
<td>5</td>
<td>11 - 13</td>
</tr>
<tr>
<td>6</td>
<td>14 - 15</td>
</tr>
<tr>
<td>7</td>
<td>16 - 17</td>
</tr>
<tr>
<td>8</td>
<td>18 - 19</td>
</tr>
<tr>
<td>9</td>
<td>20 - 22</td>
</tr>
<tr>
<td>10 - 13</td>
<td>23 - 24</td>
</tr>
</tbody>
</table>

Units = number of species per grid square based on observations from 1961-2006 (233 species total).

Data sources:
Compiled by the University of British Columbia

Map by:
Caldy Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 4, 2009

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Species of conservation concern continued...

Forty-three percent of B.C. native species assessed for conservation status are of provincial conservation concern (Table 9). Map 19 shows the distribution of species richness for all 1,640 species of provincial conservation concern in B.C. Concentrations of species of provincial conservation concern are evident in the southern part of the province and on the large offshore islands. The high proportion of species of provincial conservation concern reflects, in part, the high number whose habitat in B.C. was rare even before European contact as well as the concentration of ecosystem conversion (p.80) in some areas. For example, close to 20% of the land area in the Bunchgrass and Ponderosa Pine biogeoclimatic zones (p.20) in the southern interior has been converted to human uses, with significant impacts to many native grassland species living there, including the burrowing owl (Athene cuniculari) and the yellow-breasted chat (Icteria virens). Both of these bird species are critically imperilled in the province. Almost 50% of the Coastal Douglas-fir zone (p.80) on Vancouver Island and the Gulf Islands has been converted to human uses, with less than 5% of the original area of the Garry oak ecosystems found in this zone remaining in near-natural condition. Garry oak and related ecosystems are home to many species of conservation concern such as the sharp-tailed snake (Contia tenuis) and Macoun's meadowfoam (Limnanthes macounii), a provincially imperilled plant.
MAP 19
Species richness: species of provincial conservation concern*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- 1 - 4
- 5 - 7
- 8 - 10
- 11 - 13
- 14 - 17
- 18 - 22
- 23 - 29
- 30 - 38
- 39 - 59
- 60 - 200

Units = number of species per grid square based on observations from 1961-2006 (1,640 species total).

*Based on documented observations. [the lack of an observation does not necessarily mean a species is not present].

Data sources:
Compiled by the University of British Columbia
Map by: Caslys Consulting Ltd
Projection: BC Albers NAD83
Produced for: BioDiversity BC

February 4, 2009
Proportion of Global Range for Species

The proportion of global range for a species was assessed based on seven classes ranging from 1 (Endemic: 100% of global range or population is in B.C.) to 7 (Low and Localized: less than 10% of range or population is in B.C. and occurs over less than 30% of the province) (Table 10). Species in classes 1-3 (Endemic, Very High and High) have a majority (greater than 50%) of their range, area or population within the province.

Consideration of the proportion of a species’ global range should be balanced by consideration of how the species is distributed across other jurisdictions. This is particularly important for species that are ranked low and widespread (meaning a low proportion of their global range occurs in B.C. but they still occupy greater than 30% of the province and by extension must have a large global range). For example, fishers (Martes pennanti) are sufficiently widespread globally that no jurisdiction has more than 10% of the global range.

Of 3,841 native species in 13 groups assessed for proportion of global range, 99 (3%) were determined to have greater than 50% of their range in B.C. Computerized location data was available for 82 of these 99 species. Species richness for these 82 species is mapped on the facing page (Map 20). Areas of the province with the highest number of species with the majority of their range in B.C. are concentrated in the south of the province, on the Queen Charlotte Islands/Haida Gwaii, and on Vancouver Island.

Table 10. Classification System for Proportion of Global Range: Species.

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Endemic</td>
<td>100% of the range, area or population is within the province</td>
</tr>
<tr>
<td>2 Very High</td>
<td>75-99% of the range, area or population is within the province</td>
</tr>
<tr>
<td>3 High</td>
<td>51-74% of the range, area or population is within the province</td>
</tr>
<tr>
<td>4 Moderately High</td>
<td>30-50% of the range, area or population is within the province</td>
</tr>
<tr>
<td>5 Intermediate</td>
<td>11-29% of the range, area or population is within the province</td>
</tr>
<tr>
<td>6 Low and Widespread</td>
<td>less than 10% of the range, area or population is within the province but occurs over greater than 30% of the province.</td>
</tr>
<tr>
<td>7 Low and Localized</td>
<td>less than 10% of the range, area or population is within the province and is localized, occurring over less than 30% of the province.</td>
</tr>
</tbody>
</table>


Note: Boldface indicates that species in this global range class are included on Map 20.
MAP 20
Species richness: species with a majority of their global range in B.C.*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10
- 11 - 12
- 13 - 14
- 15 - 16
- 17 - 19
- 20 - 35

Units = number of species per grid square based on observations from 1961-2006 (82 species total).

Data sources:
Compiled by the University of British Columbia

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
[Logo]

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Amphibians

British Columbia has 20 species of amphibians which include the salamanders, newts, toads and frogs. Amphibians, as small predators, play important roles in food chains and eat large numbers of insects. Except for three terrestrial salamanders, all amphibians are reliant on freshwater ecosystems for one or more of their life requisites, usually a larval stage.

Species richness for B.C.’s amphibians is shown on Map 21. The large area classified as ‘no observations’ indicates a particular lack of available data for this group.

Many species of amphibians are declining over most of their Canadian range. A single species, Oregon spotted frog (*Rana pretiosa*), is imperilled globally, while at the provincial level, 9 amphibians are of conservation concern (Table 11).

Fifty-five percent of the province’s amphibians have less than 10% of their range or population within B.C. and occur here at the northern extent of their ranges (p.44). Columbia spotted frog (*Rana luteiventris*), a species which is apparently secure (p.40) in its global range, is the only amphibian which has greater than 50% of its range or population in B.C.

Within Canada, thirteen species of native amphibians are found only in B.C., however none are endemic to the province.

**Table 11. Native Amphibians of Conservation Concern in B.C.**

<table>
<thead>
<tr>
<th>Species Name, Common Name</th>
<th>Global</th>
<th>Conservation Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ambystoma tigrinum</em>, tiger salamander</td>
<td>Secure (G5)</td>
<td>Imperilled (S2)</td>
</tr>
<tr>
<td><em>Ascaphus montanus</em>, Rocky Mountain tailed frog</td>
<td>Apparently secure (G4)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Ascaphus truei</em>, coastal tailed frog</td>
<td>Apparently secure (G4)</td>
<td>Vulnerable/apparently secure (S3S4)</td>
</tr>
<tr>
<td><em>Dicamptodon tenebrosus</em>, Pacific giant salamander</td>
<td>Secure (G5)</td>
<td>Imperilled (S2)</td>
</tr>
<tr>
<td><em>Plethodon idahoensis</em>, Coeur d’Alene salamander</td>
<td>Apparently secure (G4)</td>
<td>Vulnerable (S3)</td>
</tr>
<tr>
<td><em>Rana aurora</em>, red-legged frog</td>
<td>Apparently secure (G4)</td>
<td>Vulnerable/apparently secure (S3S4)</td>
</tr>
<tr>
<td><em>Rana pipiens</em>, northern leopard frog</td>
<td>Secure (G5)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Rana pretiosa</em>, Oregon spotted frog</td>
<td>Imperilled (G2)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Spea intermontana</em>, Great Basin spadefoot</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3)</td>
</tr>
</tbody>
</table>

MAP 21
Species richness: amphibians*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

Units = number of species per grid square based on observations from 1961-2006 (20 species total).

Data sources:
Compiled by the University of British Columbia
Map by: Caslys Consulting Ltd
Projection: BC Albers NAD83
Produced for:

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Perching Birds

Birds comprise the largest vertebrate group in British Columbia with 353 species. This is the most well-studied group in the province, surveyed yearly through programs such as the Christmas Bird Count and the Breeding Bird Survey. Birds play a number of ecological roles. Some, like golden eagles (*Aquila chrysaetos*) are top predators, while woodpeckers create cavities in trees that are used by other species for nesting, shelter and feeding. A large number of migratory birds pass through B.C., stopping to feed and rest during their long journeys.

Map 22 shows species richness for the 142 perching birds (passerines) for which computerized location data was available. The large area classified as ‘no observations’ indicates a particular lack of available data for this group.

The perching birds include, among others, the flycatchers, swallows, warblers, sparrows, wrens and finches – familiar birds of forests, open meadows, wetlands, and grasslands.

None of the perching birds are of conservation concern in their global range, but there are 18 species of conservation concern within B.C. (p.42) (Table 12).

### Table 12. Native Perching Birds of Conservation Concern in B.C.

<table>
<thead>
<tr>
<th>Species Name, Common Name</th>
<th>Conservation Rank Global</th>
<th>Conservation Rank Provincial</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ammmodramus leconteii</em>, Le Conte’s sparrow</td>
<td>Apparently secure (G4)</td>
<td>Vulnerable/apparently secure (S3S4B)</td>
</tr>
<tr>
<td><em>Ammmodramus nelsoni</em>, Nelson’s sharp-tailed sparrow</td>
<td>Secure (G5)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Ammmodramus savannarum</em>, grasshopper sparrow</td>
<td>Secure (G5)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Calcarius pictus</em>, Smith’s longspur</td>
<td>Secure (G5)</td>
<td>Vulnerable/apparently secure (S3S4B)</td>
</tr>
<tr>
<td><em>Catherpes mexicanus</em>, canyon wren</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3)</td>
</tr>
<tr>
<td><em>Chondestes grammacus</em>, lark sparrow</td>
<td>Secure (G5)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Dendroica castanea</em>, bay-breasted warbler</td>
<td>Secure (G5)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Dendroica tigrina</em>, Cape May warbler</td>
<td>Secure (G5)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Dendroica virens</em>, black-throated green warbler</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3B)</td>
</tr>
<tr>
<td><em>Dolichonyx oryzivorus</em>, bobolink</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3B)</td>
</tr>
<tr>
<td><em>Empidonax wrightii</em>, gray flycatcher</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3B)</td>
</tr>
<tr>
<td><em>Euphagus carolinus</em>, rusty blackbird</td>
<td>Apparently secure (G4)</td>
<td>Vulnerable/apparently secure (S3S4B)</td>
</tr>
<tr>
<td><em>Hirundo rustica</em>, barn swallow</td>
<td>Secure (G5)</td>
<td>Vulnerable/apparently secure (S3S4B)</td>
</tr>
<tr>
<td><em>Icteria virens</em>, yellow-breasted chat</td>
<td>Secure (G5)</td>
<td>Critically imperilled/imperilled (S1S2B)</td>
</tr>
<tr>
<td><em>Oporornis agilis</em>, Connecticut warbler</td>
<td>Apparently secure (G4)</td>
<td>Imperilled (S2B)</td>
</tr>
<tr>
<td><em>Oreoscoptes montanus</em>, sage thrasher</td>
<td>Secure (G5)</td>
<td>Critically imperilled (S1B)</td>
</tr>
<tr>
<td><em>Progne subis</em>, purple martin</td>
<td>Secure (G5)</td>
<td>Imperilled/vulnerable (S2S3B)</td>
</tr>
<tr>
<td><em>Wilsonia canadensis</em>, Canada warbler</td>
<td>Secure (G5)</td>
<td>Vulnerable/apparently secure (S3S4B)</td>
</tr>
</tbody>
</table>


Note: B indicates rank for breeding only.

---

1 Non-passerines are not included on the map owing to a lack of available computerized location data.
MAP 22
Species richness: perching birds*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1
- 2 - 4
- 5 - 9
- 10 - 15
- 16 - 22
- 23 - 34
- 35 - 44
- 45 - 59
- 60 - 82
- 83 - 123

Units = number of species per grid square based on observations from 1961-2006 (142 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Freshwater Fishes

Freshwater fishes in B.C. are a genetically fascinating group. Many fishes occurring in B.C. are found nowhere else in Canada and some are found nowhere else in the world. The complex topography and relatively recent glaciations of the province have resulted in rapid genetic divergence of some species, such as salmon, where an explosion of genetic diversity has occurred at the population level.

Map 23 shows species richness for 70 of B.C.’s freshwater fishes, including those taxa listed in Table 13, which have not been (and due to their taxonomic complexity may never be) assigned formal scientific names. These ‘unnamed’ taxa, many which are endemic to B.C., are scientifically important and almost all are of conservation concern (p. 40). For example, the pairs of limnetic and benthic sticklebacks (Gasterosteus sp.) found in several geographically isolated lakes, are fascinating examples of parallel evolution and represent some of the most interesting elements of B.C.’s freshwater fish biodiversity. Overall, close to 5% of B.C.’s species of freshwater fishes are of global conservation concern, while 34% are of provincial conservation concern. Eight freshwater fish species (7.5%) have the majority of their global range in B.C. (p. 44), including bull trout (Salvelinus confluentus), and Cowichan Lake (or Vancouver Island) lamprey (Lampetra macrostoma), both of which are critically imperilled in their global ranges.

Table 13. Endemic Freshwater Fishes in B.C. Currently Without Formal Scientific Species Names

<table>
<thead>
<tr>
<th>Species Name, Common Name</th>
<th>Global Conservation Rank</th>
<th>Provincial Conservation Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottus sp. 2, Cultus, pygmy sculpin</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 1, giant stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 16, Vananda Creek limnetic stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 17, Vananda Creek benthic stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 18, Misty Lake “lake” stickleback</td>
<td>Not ranked (GNR)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 19, Misty Lake “stream” stickleback</td>
<td>Not ranked (GNR)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 2, Enos Lake limnetic sticklebackw</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 3, Enos Lake benthic stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 4, Paxton Lake limnetic stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Gasterosteus sp. 5, Paxton Lake benthic stickleback</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td>Prosopium sp. 2, McCleese Lake pygmy whitefish</td>
<td>Critically imperilled (G1)</td>
<td>Not ranked (SNR)</td>
</tr>
<tr>
<td>Prosopium sp. 2, McClure Lake pygmy whitefish</td>
<td>Critically imperilled (G1)</td>
<td>Not ranked (SNR)</td>
</tr>
<tr>
<td>Spirinchus sp. 1, pygmy longfin smelt</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
</tbody>
</table>

MAP 23
Species richness: freshwater fishes*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 2 - 11
- 12 - 13
- 14 - 16
- 17 - 18
- 19
- 20 - 21
- 22 - 24
- 25
- 26 - 27
- 28 - 30

Units = number of species per grid square based on observations from 1961-2006 (70 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Mammals

Mammals are one of the most recognizable and varied groups of vertebrates, ranging in size from moles, shrews and bats to the biggest animals on earth: the baleen whales. An estimated 5,488 described species of mammals are found in the world,85 with 109 species native to B.C.86

B.C. is globally significant for its richness of large carnivore (e.g., wolves and cougars) and ungulate species (e.g., deer, elk, caribou and moose).87 The ranges of 17 species of carnivores and ungulates in North America have contracted toward British Columbia, where wild populations of these mammals, lost in many other jurisdictions, are still found (Figure 5).

Species richness for the 102 mammals for which computerized location data was available is shown on Map 24.88 Areas of high mammal richness for these species are concentrated in the south of the province and on Vancouver Island.

Four of B.C.’s native mammal species are of global conservation concern and 29 species are of provincial conservation concern (p.40).88 Five species have the majority of their global range (p.44) in the province: Keen’s myotis (Myotis keenii), mountain goat (Oreamnos americanus), northwestern deer mouse (Peromyscus keeni), Pacific water shrew (Sorex bendirii) and Vancouver Island marmot (Marmota vancouverensis);89 all are of conservation concern.90 Vancouver Island marmot, B.C.’s only endemic mammal, is critically imperilled in its global range.

FIGURE 5: Historic (a) and current (b) species richness for 17 carnivore and ungulate species that have undergone significant range contractions in North America.

MAP 24
Species richness: mammals*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 6
- 7
- 8
- 9
- 10
- 11 - 12
- 13 - 14
- 15 - 17
- 18 - 21
- 22 - 52

Units = number of species per grid square based on observations from 1961-2006 (102 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Data sources:
Compiled by the University of British Columbia
Map by:
Caslys Consulting Ltd
Projection:
BC Albers NAD83
Produced for:

February 4, 2009
Reptiles and Turtles

Compared to other parts of the world, British Columbia is a relatively inhospitable place for reptiles and turtles. There are about 6,500 species of reptiles and turtles in the world, most of which live in tropical and subtropical regions. B.C. has 12 species: 9 snakes, 2 lizards and 1 turtle. However, compared to the rest of Canada, which as a whole has about 40 species, B.C.’s reptile fauna is relatively rich, exceeded in species numbers only by Ontario and Quebec. This diversity is owing to the wide variety of suitable habitats in B.C. ranging from the hot, dry interior to the coastal rainforests.

Species richness for the 11 native species of reptiles and turtles for which computerized location data was available is presented on Map 25. The large area classified as ‘no observations’ indicates a particular lack of available data for this group, however, based on current data, the highest species richness is in the dry southern Okanagan region south of Kamloops and Kelowna.

Nine species of native reptiles and turtles are of conservation concern (p.40) (Table 14). Two species have been extirpated from the province, the western pond turtle (*Actinemys marmorata*), which is vulnerable in its global range, and the pigmy short-horned lizard (*Phrynosoma douglasii*), known only from the Okanagan.

**TABLE 14. NATIVE REPTILES AND TURTLES OF CONSERVATION CONCERN IN B.C.**

<table>
<thead>
<tr>
<th>SPECIES NAME, COMMON NAME</th>
<th>GLOBAL CONSERVATION RANK</th>
<th>PROVINCIAL CONSERVATION RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Actinemys marmorata</em>, western pond turtle</td>
<td>Vulnerable (G3)</td>
<td>Extirpated (SX)</td>
</tr>
<tr>
<td><em>Chrysemys picta</em>, western painted turtle</td>
<td>Secure (G5)</td>
<td>Vulnerable/apparently secure  (S3S4)</td>
</tr>
<tr>
<td><em>Coluber constrictor</em>, racer</td>
<td>Secure (G5)</td>
<td>Vulnerable/apparently secure  (S3S4)</td>
</tr>
<tr>
<td><em>Contia tenuis</em>, sharp-tailed snake</td>
<td>Secure (G5)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Crotalus oreganus</em>, western rattlesnake</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3)</td>
</tr>
<tr>
<td><em>Eumeces skiltonianus</em>, western skink</td>
<td>Secure (G5)</td>
<td>Imperilled/vulnerable (S2S3)</td>
</tr>
<tr>
<td><em>Hypsiglena torquata</em>, night snake</td>
<td>Secure (G5)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Phrynosoma douglasii</em>, pygmy short-horned lizard</td>
<td>Secure (G5)</td>
<td>Extirpated (SX)</td>
</tr>
<tr>
<td><em>Pituophis catenifer</em>, gopher snake</td>
<td>Secure (G5)</td>
<td>Vulnerable (S3)</td>
</tr>
</tbody>
</table>

MAP 25

Species richness: reptiles and turtles*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
No observations

1
2
3
4
5
6
7-8
9
10

Units = number of species per grid square based on observations from 1961-2006 (11 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).
Insects

Map 26 includes available location data for 1,383 native B.C. species from six insect groups: butterflies and skippers (order Lepidoptera); dragonflies and damselsflies (order Odonata); the stoneflies (order Plecoptera); the true bugs (order Hemiptera: Heteroptera); antlions, snakeflies, lacewings and allies (order Neuroptera); and the ground beetles (order Coleoptera, family Carabidae) (Table 15). Insects have not been well studied in British Columbia and large areas of the province have not been surveyed for this group, indicated by the number of grid cells on the map classified as 'no observations'.

Information about the butterflies and skippers, and the dragonflies and damselsflies can be found on pages 58 and 60 respectively.

The stoneflies of the order Plecoptera are aquatic insects found in or near fast-flowing streams or on rocky lakeshores. There are approximately 1,550 species of this order known worldwide with 460 species described in North America. Stoneflies are important sources of food for fish and other vertebrates, and are considered indicators of water quality, surviving only in clean, highly oxygenated water. Some stoneflies are carnivorous, others feed on bacteria, algae and plants.

The true bugs are primarily terrestrial and feed on plants (phytophagous), specifically plant fluids. They are common on grass, trees and shrubs. Some families, such as the assassin bugs (Reduviidae), flower bugs (Anthocoridae) and damsel bugs (Nabidae) are completely predaceous, as are some genera of plant bugs (Miridae) and stink bugs (Pentatomidae). Bedbugs (Cimicidae) feed on warm-blooded vertebrates. All the aquatic and semi-aquatic species are predaceous, feeding on other invertebrates, and sometimes small vertebrates.

The insects of the order Neuroptera are the antlions, snakeflies, lacewings and their allies. Most are terrestrial, usually found near their larval habitat. The adults of some species are predaceous, others feed on nectar and pollen, while the larvae are predaceous or parasitic.

The family Carabidae, commonly called the ground beetles, is the second largest family of beetles in North America. Although varied in appearance, most have shiny black, elongate, somewhat flattened, medium to large-sized bodies with long legs. Most adults are opportunistic predators of other invertebrates, although a few are specialist snail predators and some feed on the seeds of plants. The adults hide under objects during the day, emerging to hunt at night. The larvae are also predaceous. Ground beetles can be very sensitive to human activity and insecticides. Canada has about 930 species of ground beetle.

Little is known about the global and provincial conservation concern of insect groups in B.C.

<table>
<thead>
<tr>
<th>INSECT GROUP</th>
<th>NUMBER OF SPECIES MAPPED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butterflies and skippers (order Lepidoptera)</td>
<td>172</td>
</tr>
<tr>
<td>Dragonflies and damselsflies (order Odonata)</td>
<td>85</td>
</tr>
<tr>
<td>Stoneflies (order Plecoptera)</td>
<td>85</td>
</tr>
<tr>
<td>True bugs (order Hemiptera: Heteroptera)</td>
<td>581</td>
</tr>
<tr>
<td>Antlions, snakeflies, lacewings and allies (order Neuroptera)</td>
<td>74</td>
</tr>
<tr>
<td>Ground beetles (order Coleoptera, family Carabidae)</td>
<td>386</td>
</tr>
<tr>
<td>Total</td>
<td>1,383</td>
</tr>
</tbody>
</table>

MAP 26
Species richness: insects*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 2
- 3 - 5
- 6 - 8
- 9 - 13
- 14 - 19
- 20 - 26
- 27 - 35
- 36 - 50
- 51 - 86
- 87 - 526

Units = number of species per grid square based on observations from 1961-2006 (1,383 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Published by: University of British Columbia

Map by: Caslys Consulting Ltd

Projection: BC Albers NAD83

Produced for: BC Ministry of Forests, Lands and Natural Resource Operations

February 4, 2009

Area of Detail

Equal Interval Classification

Number of species
- No observations
- 1 - 54
- 55 - 106
- 107 - 159
- 160 - 211
- 212 - 264
- 265 - 316
- 317 - 369
- 370 - 421
- 422 - 474
- 475 - 526

Vancouver Island

Queen Charlotte Islands

Calgary

Edmonton

Prince Rupert

Fort St. John

Vancouver

Port Alberni

Prince George

Kamloops

Kelowna

Victoria

Yukon

Northwest Territories

United States

Northern Territories
**Butterflies and Skippers**

Butterflies and skippers are a subset of the large insect order Lepidoptera. The adults of the Lepidoptera are characterized by two pairs of large, membranous wings which are covered, as are the body and legs, with overlapping scales. Butterflies, many of which are brightly coloured, hold their wings vertically over the body when at rest and have a long, coiled, sucking proboscis (mouth part) and slender antennae with a clubbed tip. Skippers have proportionally smaller wings and larger bodies than butterflies and hooked antennae tips. Adult butterflies and skippers feed on the nectar of flowering plants and are important pollinators. Butterfly and skipper larvae feed strictly on plants.

British Columbia has 180 known native species of butterflies and skippers. The map displays species richness for the 172 species for which computerized location data was available (Map 27). The large area classified as ‘no observations’ indicates a particular lack of available data for this group.

Eighty-seven percent of this group have less than 10% of their range in B.C. Many of these species are at the northern edge of their range. Six species of the butterfly and skipper group are of conservation concern (p.40) in their global range (3.3%) (Table 16). At the provincial level, 46 species are of conservation concern. One species, viceroy (Limenitis archippus) has been extirpated from B.C. but is secure in the rest of its range. A single species, the Vidler’s alpine (Erebia vidleri), has the majority of its global range in the province (p.44), but is not of conservation concern.

<table>
<thead>
<tr>
<th>SPECIES NAME, COMMON NAME</th>
<th>GLOBAL CONSERVATION RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euphydryas gillettii, Gillette’s checkerspot</td>
<td>Imperilled (G2)</td>
</tr>
<tr>
<td>Boloria alberta, Albert’s fritillary</td>
<td>Vulnerable (G3)</td>
</tr>
<tr>
<td>Boloria natazhati, Beringian fritillary</td>
<td>Vulnerable (G3)</td>
</tr>
<tr>
<td>Callophrys johnsoni, Johnson’s hairstreak</td>
<td>Vulnerable (G3)</td>
</tr>
<tr>
<td>Colias occidentalis, western sulphur</td>
<td>Vulnerable (G3)</td>
</tr>
<tr>
<td>Oeneis philipi, Philip’s arctic</td>
<td>Vulnerable (G3)</td>
</tr>
</tbody>
</table>

**Table 16. B.C. Native Butterfly and Skipper Species of Global Conservation Concern in B.C.**

MAP 27
Species richness: butterflies*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1
- 2
- 3-4
- 5-7
- 8-10
- 11-15
- 16-21
- 22-30
- 31-38
- 39-99

Units = number of species per grid square based on observations from 1961-2006 (172 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Source: Compiled by the University of British Columbia
Map by: Caslyn Consulting Ltd
Projection: BC Albers NAD83

February 4, 2009
Dragonflies and Damselflies

The dragonflies and damselflies are a group of well-known insects from the order Odonata. The adults have two pairs of large, elongate, membranous and many-veined wings, which work independently to allow both backwards and forwards flight.99 This group is predaceous, the adults generally taking flying insects while on the wing, including other odonates. The juvenile naiads or nymphs live in freshwater, mostly in still water (lentic) habitats although a few are moving-water (lotic) inhabitants. They can also occur in acidic waters, or alkaline saline lakes. The naiads feed on aquatic invertebrates, tadpoles and sometimes fish.

Of the 4,870 species known world-wide, 430 have been recorded in Canada.100 All 85 native species known from British Columbia are included on the richness map (Map 28). The large area classified as ‘no observations’ indicates a particular lack of available data for this group.

As with butterflies and skippers, a large proportion (88%) of dragonfly and damselfly species have less than 10% of their global range in British Columbia (p.44).101 No species of this group have the majority of their global range in B.C. One species is of global conservation concern (p.40), the Quebec emerald (Somatochlora brevicincta), which lives near slightly acidic pools in mossy fens from the Cariboo to the Rocky Mountains and north to the Omineca Mountains. Twenty-one species of dragonfly and skipper are of concern at the provincial level.102

Quebec emerald (Somatochlora brevicincta).
Photo: Sidney Dunkle.
MAP 28
Species richness: dragonflies and damselflies*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1
- 2 - 3
- 4 - 5
- 6 - 7
- 8 - 9
- 10 - 12
- 13 - 15
- 16 - 20
- 21 - 28
- 29 - 50

Units: number of species per grid square based on observations from 1961-2006 (85 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Data sources:
Compiled by the University of British Columbia

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 4, 2009
Selected Freshwater Crustaceans: Diaptomid Copepods

Copepods are aquatic crustaceans found wherever there is water. The word copepod means oar-footed and refers to the five or six pairs of swimming legs that move together like the oars of a sculling shell. There are over 24,000 described species in the world. The copepods are a versatile group, found in habitats ranging from fresh to salt water, from subterranean caves to water in leaf litter, and from streams, rivers, and lakes to the sediment layer in the open ocean. They can live at the tops of mountains, in deep ocean trenches, and from cold polar ice to hot hydrothermal vents. Important links in the food chain, copepods are an important source of protein for fish, birds and other crustaceans. They are intermediate hosts of many human and animal parasites.

Free-living freshwater copepods include three Suborders: the Calanoida, the Cyclopoida and the Harpacticoida. The diaptomid copepods are a family within the Suborder Calanoida. The richness map includes all 85 species of native copepods from the family Diaptomidae known from British Columbia (Map 29). The large area classified as ‘no observations’ indicates a particular lack of available data for this group.

The diaptomid copepods typically occur in lakes, ponds and ditches, are planktonic and rarely found near shore. The group includes both freshwater species and those that live and thrive in inland saline lakes (Table 17). Saline lakes are those which have more than 3 g/l salt content (see also p.74). The southern interior plateau of B.C. is dotted with small saline ponds usually less than 1 km² in area, particularly in the Okanagan and Kamloops area and throughout the Interior Plateau.

<table>
<thead>
<tr>
<th>SPECIES NAME</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aglaodiaptomus leptopus</td>
<td></td>
</tr>
<tr>
<td>Hesperodiaptomus kiseri</td>
<td></td>
</tr>
<tr>
<td>Hesperodiaptomus nevadensis</td>
<td></td>
</tr>
<tr>
<td>Hesperodiaptomus novemdecimus</td>
<td></td>
</tr>
<tr>
<td>Hesperodiaptomus sp.nr.hirsutus</td>
<td></td>
</tr>
<tr>
<td>Leptodiaptomus connexus</td>
<td></td>
</tr>
<tr>
<td>Leptodiaptomus sicilis</td>
<td></td>
</tr>
</tbody>
</table>


NOTE: These species do not have common names.

Saline lake.
PHOTO: SARMA LIEPINS.
Species richness: selected freshwater crustaceans (diaptomid copepods)*

**Legend**
- City
- Road
- River/Stream
- Lake

**Number of species**
- No observations
- 1
- 2
- 3
- 4
- 5
- 6
- 7

Units = number of species per grid square based on observations from 1961-2006 (85 species total).

*Based on documented observations [the lack of an observation does not necessarily mean a species is not present].

**Data sources:**
Compiled by the University of British Columbia

**Map by:**
Caslys Consulting Ltd

**Projection:**
BC Albers NAD83

**Produced for:**

February 4, 2009
Vascular Plants

Vascular plants include flowering herbs, shrubs, trees and ferns with their allies (horsetails, club mosses and quillworts). These plants provide essential structure to terrestrial ecosystems and are a primary energy source for animals.106

B.C. is known to have 2,093 species of native vascular plants.107 Species richness for the 1,992 native vascular plants for which computerized location data was available (Table 18) is shown on Map 30. Highest species richness for the species assessed is concentrated in the south of the province and on Vancouver Island.

British Columbia is home to 91% of Canada’s native ferns and fern allies, including one endemic species, corrupt spleenwort (Asplenium adulterinum).108

The giant trees of British Columbia’s temperate rainforests, famous around the world for their size and longevity, are members of the conifers, a group that includes 26 species in three families: the Pinaceae, Cupressaceae, and Taxaceae. Two conifer species are of concern provincially (p.40): jack pine (Pinus banksiana) and limber pine (Pinus flexilis).109

Monocotyledons (monocots) are a group of flowering plants that tend to prefer low elevation grasslands and wetlands, ecosystems which are relatively uncommon in British Columbia. About 84% of the native monocots are at the edge of their global range in B.C. (p.44).110 A significant proportion of the monocots present (74%) belong to the grass-like plants or graminoids: the sedges (Cyperaceae), grasses (Poaceae), and rushes (Juncaceae). Other important families of monocots are the lilies (Liliaceae), orchids (Orchidaceae) and pondweeds (Potomagetonaceae). Two species have the majority of their global range in B.C.: tiger lily (Lilium columbianum) and broad-leaved twayblade (Listera convallarioides).111

Dicotyledons (dicots), the largest of the plant groups assessed, include 88 families of flowering plants such as aster (Asteraceae), pea (Fabaceae), mustard (Brassicaceae), rose (Rosaceae), snapdragon (Scrophulariaceae), buttercup (Ranunculaceae), willow (Salicaceae) and carrot (Apiaceae). About 4% of B.C.’s dicotyledon plants are of global conservation concern and 46% are of provincial conservation concern.112 Four of these dicot species of conservation concern are endemic to B.C.: Queen Charlotte false rue-anemone (Enemion savilei), Queen Charlotte avens (Geum schofieldii), Macoun’s meadow-foam (Limnanthes macounii), and Taylor’s saxifrage (Saxifraga taylori).113

Table 18. Native vascular plants in B.C. included on map 30.

<table>
<thead>
<tr>
<th>SPECIES GROUP</th>
<th>NUMBER OF SPECIES MAPPED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferns and Fern Allies</td>
<td>103</td>
</tr>
<tr>
<td>Conifers</td>
<td>25</td>
</tr>
<tr>
<td>Monocots</td>
<td>525</td>
</tr>
<tr>
<td>Dicots</td>
<td>1,339</td>
</tr>
<tr>
<td>Total</td>
<td>1,992</td>
</tr>
</tbody>
</table>


Tiger lily (Lilium columbianum). Photo: Werner Eigelsreiter.
MAP 30
Species richness: vascular plants*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 14
- 15 - 31
- 32 - 53
- 54 - 75
- 76 - 100
- 101 - 123
- 124 - 156
- 157 - 198
- 199 - 259
- 260 - 330

Units = number of species per grid square based on observations from 1961-2006 (1,992 species total).

Equal Interval Classification

Number of species
- No observations
- 1 - 64
- 65 - 127
- 128 - 190
- 191 - 253
- 254 - 316
- 317 - 378
- 379 - 441
- 442 - 504
- 505 - 567
- 568 - 630

*Based on documented observations [the lack of an observation does not necessarily mean a species is not present].
**Mosses**

The bryophytes include the mosses, liverworts and hornworts. These non-vascular plants lack well-developed water- and food-conducting systems. The lack of vascular tissues requires that bryophytes remain small and usually grow in places where water is available, making British Columbia a good place for this group. Some moss species that live in arid places such as grasslands can dry up and when wet again begin to photosynthesize almost immediately. All bryophytes lack true roots and are attached to the substrate by slender, root-like filaments called rhizoids.

Over 700 species of mosses are currently listed as occurring in B.C. Mosses are the most common of the non-vascular plants and the only bryophytes included on the map. Map 31 shows richness for the 690 known native moss species with available computerized location data.

Many mosses are naturally rare in the province. Compared to 12 other species groups assessed for conservation status (p.40), mosses have the second highest percentage of species of global conservation concern (12%) and the highest percentage of species of provincial conservation concern (65%). The five moss species known to be endemic to B.C. are all of conservation concern both globally and provincially (Table 19).

Knowledge of mosses and moss distribution in B.C. is limited and the group has been poorly inventoried. Information required to map richness for many mosses is incomplete.

![Roell's brotherella moss (Brotherella roelii). Photo: Steve Joya.](image)

**TABLE 19. CONSERVATION STATUS OF SOME ENDEMIC MOSSES IN B.C.**

<table>
<thead>
<tr>
<th>SPECIES NAME, COMMON NAME</th>
<th>GLOBAL CONSERVATION RANK</th>
<th>PROVINCIAL CONSERVATION RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pohlia pacifica</em>, Pacific pohlia moss</td>
<td>Imperilled (G2)</td>
<td>Critically imperilled to vulnerable (S1S3)</td>
</tr>
<tr>
<td><em>Ctenidium schofieldii</em>, Schofield’s ctenidium moss</td>
<td>Imperilled/vulnerable (G2G3)</td>
<td>Imperilled/vulnerable (S2S3)</td>
</tr>
<tr>
<td><em>Seligeria careyana</em>, Carey small limestone moss</td>
<td>Critically imperilled (G1)</td>
<td>Critically imperilled (S1)</td>
</tr>
<tr>
<td><em>Brotherella roellii</em>, Roell’s brotherella moss</td>
<td>Vulnerable (G3)</td>
<td>Vulnerable (S3)</td>
</tr>
<tr>
<td><em>Wijkia carlottae</em>, Carlottes’s wijkia moss</td>
<td>Imperilled (G2)</td>
<td>Imperilled (S2)</td>
</tr>
</tbody>
</table>

MAP 31
Species richness: mosses*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 4
- 5 - 9
- 10 - 13
- 14 - 17
- 18 - 23
- 24 - 31
- 32 - 42
- 43 - 56
- 57 - 79
- 80 - 253

Units = number of species per grid square based on observations from 1961-2006 (690 species total).

*Based on documented observations [the lack of an observation does not necessarily mean a species is not present].

Data sources:
Compiled by the University of British Columbia

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
February 4, 2009
Lichens

Lichens are the result of a symbiosis between fungi and either green algae or a cyanobacterium. The photosynthetic algae grow within the fungus, gaining protection from the elements and providing the fungus with carbohydrates, vitamins and proteins. The richest habitats for lichens are rocky headlands, open forests and alpine.

Old forests are important to many species of lichens, and in turn, lichens make a significant contribution of nitrogen to forests. Arboreal lichens are an important food source for woodland caribou. A number of lichen species found in British Columbia are endemic to the Pacific Northwest region (Alaska to California) (Table 20). In most cases, these species live on standing trees.

Included on Map 32 are the 1,008 native lichen species known to occur in British Columbia and for which computerized georeferenced distribution data is available. Information required to map richness for many lichens is incomplete. For the species assessed, lichen richness is highest in the south of the province and on Vancouver Island and the Queen Charlotte Islands/Haida Gwaii.

The conservation status (p.40) of lichens has not been assessed for the province.

TABLE 20. SOME B.C. LICHEN SPECIES ENDENTIC TO THE PACIFIC NORTHWEST REGION.

<table>
<thead>
<tr>
<th>Species Name, Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alectoria imshaugii, Imshaug’s witch’s hair lichen</td>
</tr>
<tr>
<td>Bryoria carlottae, Carlott’s horsehair lichen</td>
</tr>
<tr>
<td>Bryoria cervinula, horsehair lichen</td>
</tr>
<tr>
<td>Cladonia schoefeldia, a lichen</td>
</tr>
<tr>
<td>Fuscopannaria pacifica, a lichen</td>
</tr>
<tr>
<td>Fuscopannaria alaskana, a lichen</td>
</tr>
<tr>
<td>Hypogymnia heterophylla, seaside bone</td>
</tr>
<tr>
<td>Leptogium polycarpum, a lichen</td>
</tr>
<tr>
<td>Leptogium tacomae, a lichen</td>
</tr>
<tr>
<td>Lobaria silvae-veteris, a lichen</td>
</tr>
<tr>
<td>Massalongia microphylliza, littlelobed lichen</td>
</tr>
<tr>
<td>Neofuscelia subhosseana, erupted camouflage lichen</td>
</tr>
<tr>
<td>Nephroma occultum, cryptic paw</td>
</tr>
<tr>
<td>Physcia tribacia, rosette lichen</td>
</tr>
<tr>
<td>Pseudocyphellaria mallota, a lichen</td>
</tr>
<tr>
<td>Pseudocyphellaria perpetua, a lichen</td>
</tr>
<tr>
<td>Pseudocyphellaria rainierensis, oldgrowth specklebelly</td>
</tr>
</tbody>
</table>

Species richness: lichens*

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- No observations
- 1 - 2
- 3 - 4
- 5 - 7
- 8 - 10
- 11 - 15
- 16 - 20
- 21 - 29
- 30 - 45
- 46 - 65
- 66 - 222

Units: number of species per grid square based on observations from 1961-2006 (1,008 species total).

*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

Compiled by the University of British Columbia
Map by: Caslys Consulting Ltd
Projection: BC Albers NAD83

Produced for: Bio_diversity_BC

February 5, 2009
Special Elements of Biodiversity

B C is home to some elements of biodiversity that are of global significance either because they are important habitat for concentrations of species or because they are uncommon or even unique. These elements are among the things that make B.C. special. Their presence here relates to geography, geology and the relatively undisturbed character of large areas of the province.

Some examples of special elements found in B.C. include areas where birds, salmon or sea lions concentrate during certain seasons of the year; special communities of old-growth temperate rainforests and intact large mammal predator-prey systems. Also included are noteworthy features such as hot springs, large wetlands and saline lakes, all of which are inhabited by rare and specialized species.

The list of special elements presented in the following pages is not intended to be all-inclusive, but rather to highlight some uncommon B.C. species, communities and ecosystems of ecological significance for which mapping information was available. A selection of special elements related to species is described in Table 21 and mapped on page 73 (Map 33). Some special elements related to ecosystems are described in Table 22 and their locations mapped on page 75 (Map 34).

Many special elements of biodiversity found in the province are subject to numerous threats (p.76).
## Special Elements: Species

Table 21 lists the five special elements related to species that are included on Map 33.

### Table 21. Selected Special Elements of Biodiversity Related to Species in B.C.

<table>
<thead>
<tr>
<th>REALM</th>
<th>SPECIAL ELEMENT</th>
<th>DESCRIPTION</th>
<th>STATUS</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal concentrations of species</td>
<td>Major salmon spawning sites</td>
<td>Major salmon spawning sites are located where spawning populations exceed a defined species-specific number of individuals in two or more years.</td>
<td>Nearly 20% of B.C. and Yukon populations were of conservation concern in the 1990s. Trend is increasing.</td>
<td>Most mortality occurs in the marine realm, but freshwater and terrestrial threats include changing hydrology, sedimentation, artificial stream barriers, loss of estuaries and warming water.</td>
</tr>
<tr>
<td>Important bird areas</td>
<td>B.C. has globally significant seasonal concentrations of birds.</td>
<td>Most sites are not protected.</td>
<td>Concentrations of species are vulnerable to catastrophic events. Other threats: loss of intertidal habitat from ecosystem conversion, sea level rise, pollution and direct disturbance.</td>
<td></td>
</tr>
<tr>
<td>Steller sea lion rookeries/haulouts</td>
<td>Rookeries are rocky islands used for breeding. Haul-outs are non-breeding areas.</td>
<td>Species is of conservation concern in B.C. Two of three rookeries are protected.</td>
<td>Steller sea lions are vulnerable to catastrophic events at the three rookeries and threatened by shooting and entanglement in fishing gear.</td>
<td></td>
</tr>
<tr>
<td>Specific Feature</td>
<td>Microbialites</td>
<td>Fossilized mats formed by microbes, primarily cyanobacteria. Freshwater examples are globally rare, with two examples known in B.C.</td>
<td>Only one site is protected. Both are in fairly good condition.</td>
<td>Microbialites are subject to damage by recreational users of the lakes.</td>
</tr>
<tr>
<td>Special Community</td>
<td>Intact large mammal predator-prey systems</td>
<td>Predator-prey systems in which all of the native large carnivores and ungulates are present. Such systems have collapsed in much of the rest of North America.</td>
<td>28% of B.C. has intact systems.</td>
<td>Loss of large mammals is due to direct mortality (e.g., hunting, accidental road kill) and ecosystem conversion and degradation.</td>
</tr>
</tbody>
</table>

**NOTE:** Elements listed in this table are just a small sample of the special elements of biodiversity in B.C. They are used for illustrative purposes.
### Special Elements: Ecosystems

Table 22 lists the five special elements related to ecosystems that are included on Map 34. Some other special elements related to ecosystems for which provincial mapping data was not available include karst, a unique landscape created from soluble bedrock; serpentine soils formed from bedrock with high toxicity from heavy metals; and naturally fishless lakes.¹²⁴

<table>
<thead>
<tr>
<th>REALM</th>
<th>SPECIAL ELEMENT</th>
<th>DESCRIPTION</th>
<th>STATUS</th>
<th>THREATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Ecosystem Features</td>
<td>Saline lakes</td>
<td>Lakes or ponds with no outlet and a very high salt content. Home to invertebrate species not found in other water bodies.</td>
<td>Some are protected.</td>
<td>Saline lakes are often found in dry climates with agricultural pressures. They are especially vulnerable to climate change because most lack trees and shrubs to buffer them against air temperature change and are at threat from permanent dry out.</td>
</tr>
<tr>
<td></td>
<td>Hot springs</td>
<td>Hot springs are unique, self-contained habitats created from very hot water from deep within the earth.</td>
<td>Many are heavily used for recreation.</td>
<td>Vulnerable to pollution, disturbance and ecosystem conversion.</td>
</tr>
<tr>
<td>Large Wetlands (Freshwater)</td>
<td>Large wetlands are centres of both freshwater and terrestrial biodiversity. One example, Burns Bog, hosts organisms absent or rare elsewhere and is the largest raised bog in coastal North America.</td>
<td>Partially protected.</td>
<td>Large wetlands are threatened by pollution from agricultural and urban activities; motorized recreation; ecosystem conversion; and artificially managed water levels.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glacially influenced watersheds</td>
<td>Watersheds that have more than 5% of their area covered in glaciers are defined as glacially influenced.</td>
<td>Increasing temperatures over the past century have resulted in loss of glacial volume.</td>
<td>Continuing increases in temperature and changes in the type of precipitation will affect glaciers in the future. Many smaller glaciers have already melted. Lower-elevation glaciers are most affected.</td>
</tr>
<tr>
<td>Special Community</td>
<td>Old-growth temperate rainforests</td>
<td>Temperate rainforests are typically associated with coastal mountain ranges. Also occur in interior B.C. Province has the world’s greatest continuous extent of these forests.</td>
<td>Much of the low-lying, highly productive areas have been logged and/or converted to high human density areas or agriculture, or flooded by hydroelectric dams.</td>
<td>Remaining low-elevation forests are often highly fragmented by roads and forest harvesting.</td>
</tr>
</tbody>
</table>

**Note:** Elements listed in this table are just a small sample of the special elements of biodiversity in B.C. They are used for illustrative purposes.
Threats to Biodiversity

Compared to many other places in the world, biodiversity in British Columbia is in relatively good condition as illustrated by the global human footprint map (Map 35, p. 77). This map was developed by combining data for population density, land conversion, accessibility, and electrical power infrastructure to show the relative impact of human activity on the land.

However, at a finer scale of examination, it becomes evident that all is not well in some areas and for some aspects of the province’s biodiversity. People are attracted to the mild climate and productive land in British Columbia’s southern valleys, the south coast and islands, and the central plateau region (Map 36, p. 79). These are the same areas that provide prime habitat for most of the province’s species (p. 36). As a consequence, many human activities have had detrimental effects on the plants and animals which share the land base. Over 6% of B.C.’s assessed native species are of global conservation concern, the highest in the country (p. 40). Almost half (43%) are of provincial conservation concern. Four of B.C.’s 16 biogeoclimatic zones (p. 22) and four of B.C.’s nine Major Drainage Areas (p. 30) are of conservation concern, as are a large percentage of ecological communities (p. 26).

Ecosystem conversion (p. 80), ecosystem degradation, and the introduction and spread of alien species (p. 82) have been identified as the most significant stresses on biodiversity in B.C. Other important stresses include direct mortality of species, species disturbance, and environmental contamination (p. 116). Many human activities contribute to these stresses, and losses to biodiversity more often than not originate from more than one source. Multiple stresses can impact biodiversity at a magnitude greater than the sum of the individual threats, can be cumulative over time, and can incur cascading impacts on other components of biodiversity.
The human footprint index is based on four types of data as proxies for human influence: population density, land transformation, accessibility, and electrical power infrastructure. Larger values indicate higher impacts.

**Data sources:**

**Map by:**
Caslys Consulting Ltd

**Projection:**
BC Albers NAD83

**Produced for:**
BioDiversity

February 5, 2009
This section presents maps, tables and text describing some of the stresses on biodiversity in B.C. and the human-induced threats that contribute to those stresses. Specific maps are presented for two major stresses: terrestrial ecosystem conversion (p.80) and alien species (p.82). Maps are also provided for a number of human activities that contribute to ecosystem conversion and alien species, as well as to ecosystem degradation and environmental contamination. These include climate change (p.88), forestry (p.104), the building and use of transportation and utility corridors (p.106), water development (including dams) (p.110), oil and gas development (p.114), and industrial development (contaminated sites and pollution) (p.116). As a result of some aspects of these activities, ecosystems in B.C. are less able to support healthy populations of plants and animals, and to provide important ecosystem functions essential for human well-being.

Human-induced climate change has recently emerged as an important threat to biodiversity. A consequence of industrial and domestic activities that produce greenhouse gases – such as methane and carbon dioxide – climate change has already had measurable effects on species and ecosystems in British Columbia and is identified as the foremost threat to biodiversity in B.C.  

**Human Population Growth**

Since 1971, the human population of B.C. has almost doubled to 4.3 million and is expected to reach close to 6 million by 2031 (Figure 6). In the 2006 Canadian census, British Columbia was the third-fastest growing province in Canada, its population increasing by 5.3% between 2001 and 2006, compared to 4.9% between 1996 and 2001. Most of this growth has occurred where species richness (p.36) is highest: the lower mainland, the east and south coasts of Vancouver Island and the Okanagan (Map 36). The lower mainland has the highest human population densities with the maximum exceeding 125,000 people per km².

Many impacts on biodiversity are associated with population growth; the most immediate is the conversion (p.80) of natural landscapes to buildings, parking lots and playing fields. Other impacts include habitat fragmentation, predation of native species by domestic animals, disruption of surface water flow over imperious surfaces, pollution (p.116), and facilitation of alien species introductions (p.82). The impacts to biodiversity are relatively permanent; even reductions in human population (experienced in some areas of the province) do not necessarily improve the status of biodiversity, since infrastructure such as roads (p.106) and buildings remains. Given continued growth in low elevation areas, the impact of population growth and urban development on biodiversity is expected to intensify.

**FIGURE 6: Population growth for B.C. (1861–2006) with a projection to 2031.**

Human population density

Legend
- City
- Road
- River/Stream
- Lake

Population density
- < 1
- 1 - 10
- >10 - 100
- >100 - 1,000
- > 1,000

Units = number of people per km².

Data sources:
Statistics Canada (2006 Census)

Map by:
Calyx Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 5, 2009
Terrestrial Ecosystem Conversion

Ecosystem conversion is the direct and complete conversion of natural landscapes such as forests, wetlands or grasslands to landscapes of human uses (e.g., buildings, houses, parking lots, mines, reservoirs, and agricultural fields). Ecosystem conversion compromises or eliminates the ability of native species to survive in the new conditions and they adapt, move if they are able, or die. The result is reduced richness of species and the loss of ecological functions such as purification of air and water, decomposition, pollination, soil formation, and climate regulation.

The magnitude of ecosystem conversion varies spatially within the province (Map 37). The mountainous topography has limited human activity in high elevation areas, while areas below 1,000 m in elevation such as valley bottoms and coastal areas where human population is concentrated have experienced the greatest levels of ecosystem conversion. Significant ecosystem conversion is evident in and around urban centres, on the south-east coast of Vancouver Island, in the interior plateau, and along highway corridors.

The greatest degree of ecosystem conversion for the 16 biogeoclimatic zones, (Table 23) all three of which are of conservation concern (p.22). As of the 1990s, about 2% of provincial land has been converted to human dominated uses (Table 23).

TABLE 23. AREA OF TERRESTRIAL ECOSYSTEM CONVERSION IN B.C. SINCE EUROPEAN CONTACT.

<table>
<thead>
<tr>
<th>BIOGEOCLIMATIC ZONE</th>
<th>TOTAL LAND AREA BEFORE ECOSYSTEM CONVERSION (KM²)</th>
<th>AREA OF ECOSYSTEM CONVERSION (KM²)</th>
<th>AREA OF ECOSYSTEM REMAINING (KM²)</th>
<th>PERCENT OF LAND AREA CONVERTED TO HUMAN USES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Douglas-fir</td>
<td>2,561</td>
<td>1,251</td>
<td>1,310</td>
<td>49%</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>2,579</td>
<td>531</td>
<td>2,048</td>
<td>21%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>3,513</td>
<td>617</td>
<td>2,896</td>
<td>18%</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>42,721</td>
<td>2,302</td>
<td>40,419</td>
<td>5%</td>
</tr>
<tr>
<td>Boreal White and Black Spruce</td>
<td>159,473</td>
<td>6,106</td>
<td>153,367</td>
<td>4%</td>
</tr>
<tr>
<td>Sub-Boreal Spruce</td>
<td>95,551</td>
<td>3,206</td>
<td>92,345</td>
<td>3%</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>104,998</td>
<td>2,745</td>
<td>102,253</td>
<td>3%</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock</td>
<td>51,751</td>
<td>837</td>
<td>50,914</td>
<td>2%</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>22,643</td>
<td>284</td>
<td>22,359</td>
<td>1%</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>27,996</td>
<td>201</td>
<td>27,795</td>
<td>1%</td>
</tr>
<tr>
<td>Englemann Spruce–Subalpine Fir</td>
<td>170,564</td>
<td>200</td>
<td>170,364</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>36,590</td>
<td>18</td>
<td>36,572</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>80,131</td>
<td>30</td>
<td>80,101</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>76,828</td>
<td>17</td>
<td>76,811</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>17,682</td>
<td>1</td>
<td>17,681</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>52,000</td>
<td>3</td>
<td>51,997</td>
<td>&lt;1%</td>
</tr>
<tr>
<td><strong>Provincial total</strong></td>
<td><strong>947,581</strong></td>
<td><strong>18,349</strong></td>
<td><strong>929,232</strong></td>
<td><strong>2%</strong></td>
</tr>
</tbody>
</table>

SOURCE: Prepared for this report.
NOTE: Based on imagery taken between 1991 and 2001; ecosystem conversion that occurred after the images were taken is not included.
Terrestrial ecosystem conversion is the proportion of land area that falls within the following land uses: reservoirs; urban; agriculture; recreation; residential/agriculture mix; and mining.

February 5, 2009

Units = percentage of land and reservoir area.
Alien Species

Alien species are those that occur outside their native range owing to introduction by humans.\textsuperscript{137} Alien species can be introduced intentionally (e.g., plants used for agriculture or forestry use, or the release of pets), accidentally (e.g., species attached to equipment that is transported), or by escape from captive or commercial cultivation (e.g., escapes from zoos, farms and research facilities).\textsuperscript{138} Species that are native to some parts of B.C. can be alien species when moved to other areas of the province. For example, raccoon and deer are alien species on the Queen Charlotte Islands/Haida Gwaii.

Not all alien species are harmful, but invasive alien species are those species whose introduction and/or spread threaten biodiversity. One estimate is that about 10% of alien species become invasive.\textsuperscript{139} However, some species also exhibit a time lag between introduction and impact to biodiversity. For example, gorse (\textit{Ulex europaeus}) was introduced to B.C. at least 90 years ago\textsuperscript{140} and was only recently recognized as an invasive alien species.

Invasive alien species alter forest fire cycles, nutrient cycling, hydrology and energy budgets in native ecosystems.\textsuperscript{141} They displace native populations of plants and animals by occupying habitat and competing for resources.\textsuperscript{142} Alien species can affect native species through competition and predation, displacement, habitat degradation (e.g., removal or replacement of vegetation), hybridization and the introduction of diseases, as well as facilitating the spread of other non-native species.\textsuperscript{143}

A total of 809 alien species are listed by the B.C. Conservation Data Centre (CDC).\textsuperscript{144} The majority of alien species listed by the CDC are vascular plants. However, the inventory of many alien insects such as beetles, true bugs and plant lice are incomplete in B.C., and in other jurisdictions, the abundance of alien insects far exceeds that of alien vascular plants.\textsuperscript{145,146,147,148} Map 38 includes the 776 terrestrial and freshwater alien species of vertebrates, invertebrates and vascular plants for which computerized location data was available (Table 24).\textsuperscript{n}

Map 39 shows species richness for the 718 terrestrial alien species for which computerized location data was available. The spread of alien species tends to follow eco-

### TABLE 24. ALIEN SPECIES IN B.C. INCLUDED ON MAPS 38 TO 40

<table>
<thead>
<tr>
<th>SPECIES GROUP</th>
<th>NUMBER OF ALIEN SPECIES MAPPED</th>
<th>FRESHWATER AND TERRESTRIAL</th>
<th>FRESHWATER</th>
<th>TERRESTRIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Birds</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Freshwater Fishes</td>
<td>15</td>
<td>0</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Mammals</td>
<td>17</td>
<td>17</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Reptiles and Turtles</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Invertebrates</td>
<td>55</td>
<td>55</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Vascular Plants</td>
<td>680</td>
<td>637</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>776</strong></td>
<td><strong>718</strong></td>
<td><strong>64</strong></td>
<td></td>
</tr>
</tbody>
</table>

\textbf{Source:} Produced for this report.

\textbf{Notes:} A species can require both freshwater and terrestrial habitats and therefore will appear in numbers for both. Terrestrial includes wetland margins; freshwater includes species found in freshwater, wetland and marine.

\textsuperscript{n} Unlike the species richness maps (pp.66-70) where the analysis used data from point locations, the alien species maps were created by compiling lists of alien species for each Ecosite (p.18) and biogeoclimatic zone (p.20) combination. This methodology has the effect of lowering spatial precision. Every polygon of a biogeoclimatic zone in an Ecosite gets the same value whereas one may have a high road density (p.106) and many alien species while another may be relatively pristine.
Number of terrestrial and freshwater alien species*

Legend
- City
- Road
- River/Stream
- Lake
- Number of species
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 - 8
- 9 - 11
- 12 - 92

Units = number of alien species (776 alien species total).

*Taxonomic groups include: mammals, birds, freshwater fishes, reptiles, amphibians, insects and vascular plants.

Produced for: B.C. Ministry of Environment
Map by: Caslys Consulting Ltd
Projection: BC Albers NAD83

February 25, 2009
Alien species continued . . .

system degradation, with the greatest number of alien species found in areas of greatest human influence: the lower mainland, the east coast of Vancouver Island, along road systems and near urban centres. A study of the vegetation on seventeen grazed public grassland sites in south-eastern B.C. found that the percentage cover of non-natives ranged from 0–84% with an average of 35%.\textsuperscript{149} Introduced grasses in Garry oak meadows, a rare ecosystem of conservation concern within the Douglas-fir biogeoclimatic zone (p. 20), likely make up over 90% of the herb layer biomass.\textsuperscript{150} Lakes and islands are also particularly vulnerable to alien species because of their isolation from competition. The highest numbers of mapped alien species in higher level terrestrial ecosystems (p.20) are found in the Coastal Western Hemlock (579), Coastal Douglas-fir (515) and Interior Douglas-fir (335) biogeoclimatic zones (Table 25).

The number of alien vascular plants recognized in B.C. increased by 29% between

\begin{table}
\centering
\begin{tabular}{l|l}
\hline
\textbf{BIOGEOCLIMATIC ZONE} & \textbf{NUMBER OF SPECIES} \\
\hline
Coastal Western Hemlock & 579 \\
Coastal Douglas-fir & 515 \\
Interior Douglas-fir & 335 \\
Interior Cedar–Hemlock & 265 \\
Engelmann Spruce–Subalpine Fir & 232 \\
Ponderosa Pine & 187 \\
Montane Spruce & 182 \\
Bunchgrass & 148 \\
Mountain Hemlock & 120 \\
Sub-Boreal Spruce & 116 \\
Boreal White and Black Spruce & 88 \\
Coastal Mountain-heather Alpine & 56 \\
Interior Mountain-heather Alpine & 44 \\
Sub-Boreal Pine–Spruce & 37 \\
Boreal Altai Fescue Alpine & 19 \\
Spruce–Willow–Birch & 15 \\
\hline
\end{tabular}
\caption{Terrestrial alien species richness for biogeoclimatic zones in B.C.}
\end{table}

\textsuperscript{21}
Number of terrestrial alien species

Legend
- City
- Road
- River/Stream
- Lake

Number of species
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7-8
- 9-13
- 14-87

Units = number of alien species (718 alien species total).

*Taxonomic groups include: mammals, birds, reptiles, amphibians, insects and vascular plants.
Alien species continued . . .

1994 and 2006 (Figure 7). Note that the increase in detections of alien species over time is a function of both new introductions and better information (i.e., detections of alien species that had previously been introduced).

Map 40 shows species richness for the 64 freshwater alien species for which computerized location data was available. While the extent of the spread of alien species in the province appears less significant than for terrestrial alien species, alien freshwater fish species reported in B.C. have more than doubled from 7 in 1950 to 18 in 2005 (Figure 8). The number of water bodies identified that contain alien fish species increased over the same time period from 28 to 625.

Major Drainage Areas (p. 28) with the highest freshwater alien species richness are the Coastal, Fraser and Columbia (Table 26). Because the Coastal system is not a single connected watershed, the impact of the introduction of exotic species will be less widespread than an introduction into a system such as the Fraser, which is one large interconnected basin (p. 30).

While the general pattern of alien species introductions following ecosystem degradation appears to hold for both terrestrial and aquatic species, in some cases, alien species are capable of invading apparently unaltered ecosystems such as islands and lakes, which often have significant genetic and species-level diversity.

![Graph showing trends in the number of alien freshwater fish species established in B.C.](image)

**Figure 8:** Trends in the number of alien freshwater fish species established in B.C.


<table>
<thead>
<tr>
<th>MAJOR DRAINAGE AREA</th>
<th>NUMBER OF FRESHWATER ALIEN SPECIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal</td>
<td>25</td>
</tr>
<tr>
<td>Fraser</td>
<td>24</td>
</tr>
<tr>
<td>Columbia</td>
<td>22</td>
</tr>
<tr>
<td>Mackenzie</td>
<td>5</td>
</tr>
<tr>
<td>Skeena</td>
<td>2</td>
</tr>
<tr>
<td>Nass</td>
<td>1</td>
</tr>
<tr>
<td>Yukon</td>
<td>1</td>
</tr>
<tr>
<td>Stikine</td>
<td>0</td>
</tr>
<tr>
<td>Taku</td>
<td>0</td>
</tr>
</tbody>
</table>

**Source:** Produced for this report.
Number of freshwater alien species

Legend:
- City
- Road
- River/Stream
- Lake

Number of species:
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9 - 15

Units = number of alien species (64 alien species total).

Equal Interval Classification:

<table>
<thead>
<tr>
<th>Number of species</th>
<th>Equal Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3</td>
<td>Green</td>
</tr>
<tr>
<td>4 - 6</td>
<td>Light Green</td>
</tr>
<tr>
<td>7 - 9</td>
<td>Yellow</td>
</tr>
<tr>
<td>10 - 12</td>
<td>Orange</td>
</tr>
<tr>
<td>13 - 15</td>
<td>Brown</td>
</tr>
</tbody>
</table>

*Taxonomic groups include: mammals, birds, freshwater fishes, amphibians, insects and vascular plants.

Data sources:
B.C. Ministry of Environment

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 25, 2009

City:

Road:

River/Stream:

Lake:
Climate Change

Climate is the primary factor enabling and shaping the distribution of organisms and the nature and character of ecosystems,\textsuperscript{155} and is therefore a key driver of biological diversity. Climate is defined as the ‘average weather’ over a period of time (including extremes), representing the weather conditions that are typically expected for a location, the standard interval of measurement being 30 years.\textsuperscript{156} Temperature and precipitation – measured monthly, seasonally and annually – are used to represent climate. Global and regional climates vary over millennia, usually changing gradually but at times, such as during glacial conditions, shifting rapidly. British Columbia’s regions have experienced at least 4,000 years of relatively stable climate leading to the current pattern of ecosystems.\textsuperscript{157,158}

Rapid climate change is underway in response to human greenhouse gas (primarily CO\textsubscript{2}) emissions\textsuperscript{159} and biodiversity impacts are evident.\textsuperscript{160} The United Nations Intergovernmental Panel on Climate Change (IPCC) reports that the average global surface temperature has increased by nearly 1°C over the past century and is likely to rise by another 1.1 to 6.4°C by 2100.\textsuperscript{161} The resulting rate of change will be unprecedented in the last 750,000 years.\textsuperscript{162} The precise amount of warming and associated changes are uncertain, nevertheless significant warming has already taken place in northwest North America where changes are expected to occur faster and be more pronounced than the global average.\textsuperscript{163}

Organisms are sensitive to change in climate, although many individuals, species and ecosystems can tolerate some climatic variation. Extremes of high and low temperature and precipitation determine the distribution of many species. As a step toward understanding the effects of climate change on biodiversity, map-based indices were developed.\textsuperscript{164} Based on measured changes in temperature and precipitation from weather stations between 1971 and 2000,\textsuperscript{a} the indices provide information on how rapidly climate has been changing in the assessment period across the province. Three variables were applied to the indices:

- average rate of change in minimum temperature (1971-2000),
- average rate of change in maximum temperature (1971-2000),
- average rate of change in precipitation (1971-2000).

Each of the variables has been mapped for both absolute rate of change (Map 41, Map 43, Map 45) and relative rate of change (Maps 42, Map 44, Map 46).\textsuperscript{b}

The absolute rate of change represents the average of the magnitudes\textsuperscript{a} for each month’s rate of change in °C per decade for temperature and mm/decade for precipitation. Decade was chosen as a convenient unit for reporting (e.g., other units such as ‘per year’ or ‘per thirty years’ could have also been used). Map 41 shows the absolute rate of change in minimum temperature for Victoria on southern Vancouver Island was between 0.42 and 0.45°C per decade. Therefore, over the thirty year assessment period of 1971-2000, the absolute rate of change in minimum temperature for Victoria has been between 1.26 and 1.35°C.

\textsuperscript{a} For the purposes of this analysis, it was assumed that most elements of biodiversity will be responding to the most recent changes in climate, hence the use of the 1971-2000 time frame.

\textsuperscript{b} A non-standard method was used for computing the data for the maps. For details see Murdock, T.Q., A.T. Werner and D. Bronaugh. 2007. Preliminary Analysis of BC Climate Trends for Biodiversity. Biodiversity BC, Victoria, BC. 24pp. Available at: www.biodiversitybc.org.
MAP 4.1

Absolute rate of change in minimum temperature (average of all months) from 1971 to 2000

Legend
- City
- Road
- River/Stream
- Lake

Temperature change
- 0.00 - 0.35
- 0.36 - 0.41
- 0.42 - 0.45
- 0.46 - 0.50
- 0.51 - 0.54
- 0.55 - 0.59
- 0.60 - 0.64
- 0.65 - 0.71
- 0.72 - 0.82
- 0.83 - 0.98

Units = °C per decade.

Data sources:
- Pacific Climate Impacts Consortium (University of Victoria)

Map by:
- Caslys Consulting Ltd

Projection:
- BC Albers NAD83

Produced for:
- BioDiversity BC

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The relative rate of change represents the average of the magnitudes for each month's rate of change divided by the standard deviations for those measures for each month. The unit used for the mapping of relative rate of change is standard deviations/decade. Relative change gives a different picture of the rate of climate change than does absolute change. The difference between absolute and relative rate of change is illustrated with an example. Figure 9 shows average minimum temperatures in February for both Quesnel and Victoria. The average minimum temperature in Quesnel in February between 1971 and 2000 varied between -19 and -2°C (a total range of 17°C), while average minimum temperature in Victoria for the same month varied between -4 and +3°C (a smaller total range of only 7°C). A comparison of Map 41 and Map 42 for these 2 areas illustrates how a consideration of this year to year variability influences the relative rate of change for a variable. The absolute rate of change in minimum temperature for Quesnel (0.51 to 0.54°C per decade) and Victoria (0.46 to 0.50°C per decade) are similar (Map 41). In contrast, when the

**FIGURE 9:** Comparison in year to year variation in average minimum temperature for February for Quesnel and Victoria.

**SOURCE:** Prepared for this report from data retrieved from Environment Canada. Climate Data On-line. Available at [http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html](http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html).
MAP 42
Relative rate of change in minimum temperature (average of all months) from 1971 to 2000

Legend
- City
- Road
- River/Stream
- Lake

Temperature change
- 0.00 - 0.05
- 0.06 - 0.09
- 0.10 - 0.14
- 0.15 - 0.19
- 0.20 - 0.24
- 0.25 - 0.28
- 0.29 - 0.33
- 0.34 - 0.38
- 0.39 - 0.43
- 0.44 - 0.47

Units = standard deviations per decade averaged for all months.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslyn Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 5, 2009
historical variation is taken into account, the relative rate of change for Quesnel at 0.284 to 0.293 standard deviations per decade is significantly less than Victoria at 0.355 to 0.475 standard deviations per decade, one of the highest rates of change in the province (Map 42). Small changes in temperature and precipitation in areas with little year to year variability can have greater relative rates of change. From the perspective of biodiversity and the sensitivity of individual species, small average temperature changes in regions of narrow climatic variation (such as on southern Vancouver Island) may be of greater consequence than larger average temperature changes where the climatic variation is greater. Species historically exposed to large natural variation may have more capacity to tolerate large changes.

**TEMPERATURE**

Increasing temperature is most often cited as the primary element of climate change and likely the most reliable to project into the future. Previous analyses for British Columbia have shown that temperature changes have been larger in the cold seasons, larger for night time lows than daytime highs and larger in the areas of B.C that have more inter-annual variability. Temperatures have been rising across the province with more rapid increases in winter and spring. Changes in average temperatures can affect the timing of reproduction in plants and animals, timing of species migration, length of the growing season, species distributions and population sizes, and the frequency of pest and disease outbreaks.

As previously mentioned, in the interval 1971 to 2000, most of the changes in temperature have been increases (warming). The absolute change in average minimum temperature varied between 0.00°C per decade and 0.59°C per decade in the south of the province and on the central coast and up to 0.98°C per decade in the north (Map 41). Map 42 shows average minimum temperature relative to the year to year variation with many areas in the south and on the central coast showing some of the highest relative rates of change in the province. In general, the ocean has a moderating influence on temperatures and coastal areas tend to have less variability from year to year.

Maps 43 and 44 show absolute and relative rates of change for maximum temperature across the province. Maximum temperature changes have been smaller than changes in minimum temperature (e.g., highest changes of 0.68°C and 0.98°C per decade respectively). The highest absolute rates of change in maximum temperature (shown in brown) have occurred on the north half of Vancouver Island, the Queen Charlotte Islands/Haida Gwaii and along the central coast and in some areas of the north (Map 43). When year to year variability is taken into account, large relative changes in maximum temperature on southern Vancouver Island and along the north coast now stand out despite small absolute trends because the historical year to year variation is small at these locations (Map 44).
Relative rate of change in maximum temperature (average of all months) from 1971 to 2000

Legend
- City
- Road
- River/Stream
- Lake

Temperature change
- 0.00 - 0.15
- 0.15 - 0.16
- 0.16 - 0.17
- 0.17 - 0.19
- 0.20 - 0.21
- 0.21 - 0.22
- 0.22 - 0.23
- 0.24 - 0.26
- 0.27 - 0.37
- 0.38 - 0.54

Units = standard deviations per decade averaged for all months.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
BioDiversity BC

February 5, 2009
Previous studies of the magnitude and direction of climate change suggest that precipitation has increased in southern B.C. by 2 to 4% per decade and that total annual precipitation has increased in many parts of the province, most noticeably in the Okanagan and North Coast regions, which masks a shift toward drier winters in parts of the province.\textsuperscript{168,169} The long term annual precipitation trend shows widespread moistening of 10 to 30% per century in most of the province except the southwest where little change has occurred.\textsuperscript{170}

The maps presented here show that the province has experienced rates of absolute change in precipitation between 1971 and 2000 of up to 27.3 mm per decade (Map 45). The regions of the province experiencing the most significant rate of absolute change are those that generally get more rainfall, along the coast and the islands and along the west side of the Rocky Mountains. The use of the magnitude for monthly values in calculating absolute and relative change means that trends towards both wetter conditions and drier conditions in different months are included and do not cancel each other out. The analysis does not indicate whether an area is getting wetter or drier, only that change is occurring and at what rate per month. The seasonal trend map for precipitation on page 101 (Map 49) provides information about which areas of the province are experiencing increases or decreases in precipitation.

When natural variation is included in the analysis, it becomes apparent that the rates of change in precipitation are more significant in the south and central interior of the province where year to year variability in precipitation is less (Map 46).
Absolute rate of change in precipitation (average of all months) from 1971 to 2000

Legend
- City
- Road
- River/Stream
- Lake

Precipitation change:
- 0.00 - 1.98
- 1.99 - 2.55
- 2.56 - 3.18
- 3.19 - 3.84
- 3.85 - 5.37
- 5.38 - 6.74
- 6.75 - 7.92
- 7.93 - 9.55
- 9.56 - 11.61
- 11.62 - 27.28

Units = millimetres per decade.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 5, 2009
MAP 46

Relative rate of change in precipitation (average of all months) from 1971 to 2000

Legend
- City
- Road
- River/Stream
- Lake

Precipitation change
- 0.00 - 0.13
- 0.13 - 0.14
- 0.14 - 0.15
- 0.15 - 0.16
- 0.16 - 0.17
- 0.17 - 0.18
- 0.19 - 0.20
- 0.20 - 0.21
- 0.22 - 0.23
- 0.24 - 0.45

Units = standard deviations per decade averaged for all months.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslyn Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 5, 2009
SEASONAL TRENDS IN CLIMATE

The following series of seasonal maps show trends around the province for the three climate variables over the 30 years from 1971-2000. The trends are based on rates of change for temperature in °C per decade and rates of change in precipitation in millimetres per decade.

Minimum temperatures have been increasing across most of the province, more rapidly in winter, spring and summer, with the greatest rates of change (up to 2.0°C/decade) in the north in winter (Map 47).

The changes in maximum temperature vary widely compared to minimum temperatures (Map 48). Winters in much of the province have warmed strongly by up to 1.5°C per decade. Spring temperatures have also warmed by up to 0.75°C per decade. Summer maximum temperatures have warmed in the south and north, but actually cooled in the southeast and extreme northeast corner. Maximum fall temperatures have warmed in the south, but cooled by as much as 0.5°C per decade in much of the north.

Map 49 shows seasonal trends in precipitation. In general, the south of the province has been getting wetter in spring, summer and fall. The north has been wetter in summer and drier in spring and fall, except for the north coast and the northeast corner of the province which have been wetter in fall. Winter trends show that most of the province has been getting drier by about –2.9 mm per decade with pockets of more significant drying on the central coast and the southeast corner where precipitation in the Rocky Mountain Trench has decreased by as much as –8.9 mm per decade (dark orange colouring). Exceptions occur on Vancouver Island and the northwest corner of the province where precipitation in winter has been increasing.
Seasonal trends in minimum temperature from 1971 to 2000

Legend
- River/Stream
- Lake

Temperature trend
-0.25 to 0.00
0.00 to +0.25
+0.26 to +0.50
+0.51 to +0.75
+0.76 to +1.00
+1.01 to +1.25
+1.26 to +1.50
+1.51 to +1.75
+1.76 to +2.00

Units = °C per decade. Negative numbers indicate a decrease and positive an increase in temperature.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Cady’s Consulting Ltd

Projection:
BC Albers NAD83

Produced for:

February 4, 2009
MAP 48
Seasonal trends in maximum temperature from 1971 to 2000

Legend
- River/Stream
- Lake

Temperature trend
-0.50 to -0.25
-0.26 to 0.00
0.00 to +0.25
+0.26 to +0.50
+0.51 to +0.75
+0.76 to +1.00
+1.01 to +1.25
+1.26 to +1.50

Units = °C per decade. Negative numbers indicate a decrease and positive an increase in temperature.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
Biodiversity BC

February 4, 2009
MAP 49
Seasonal trends in precipitation from 1971 to 2000

Legend
- River/Stream
- Lake

Precipitation trend
-1.9 to -9.0
-0.9 to -6.0
-0.9 to -3.0
-2.9 to 0.0
+0.1 to +3.0
+3.1 to +6.0

Limits = millimetres per decade. Negative numbers indicate a decrease and positive an increase in precipitation.

Data sources:
Pacific Climate Impacts Consortium (University of Victoria)

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:
BC DIVERSITY
CONSERVING THE BIODIVERSITY OF BC
February 4, 2009

Winter - December, January and February
Spring - March, April and May
Summer - June, July and August
Fall - September, October and November
The mountain pine beetle (MPB) (Dendroctonus ponderosae) is a natural part of B.C.’s interior pine forest ecosystems. The adult beetle lays its eggs under the bark of mature pine trees. When the eggs hatch, the pine beetle larvae feed on the inner bark, cutting off the tree’s nutrient supply. The beetle also introduces a blue stain fungus into the sapwood, which prevents the tree from repelling the attacking beetles with pitch flow. A mountain pine beetle infestation can kill a host tree within a few weeks.

B.C. is currently experiencing the largest mountain pine beetle infestation ever recorded in the province. The outbreak is due to two factors: the large amount of mature pine – the beetle’s preferred host – present in B.C.’s interior forests as a result of past fire suppression and silvicultural practices; and the lack of sufficiently long periods of winter temperatures cold enough to kill overwintering beetles and keep the population in check. In the southern part of the mountain pine beetle’s range, drought during the past several years has also made the trees less able to resist attack.

As of 2006, 19% of B.C.’s forest had been infected by mountain pine beetle with an additional 32% expected to be affected by 2018 (Figure 10). The infestation peaked in 2004 and will have largely subsided by 2019. Map 50 shows areas of the province more than 10% impacted by mountain pine beetle up to and including 2007. The resulting changes in forest structure have a number of ramifications. Pine obligate species, such as the western pine elfin (Callophrys eryphon) and the pine subspecies of the red crossbill (Loxia curvirostra stricklandi), may suffer from the dramatic loss of pine in the province. Loss of mature forest canopy reduces habitat quality and quantity for many bird and mammal species, and winter cover for ungulates, although the increase in standing and fallen dead trees will provide habitat for woodpeckers and cavity nesting birds. New understory vegetation may benefit some species such as grouse, deer and bears. Reduction in transpiration as a result of extensive tree death is expected to significantly raise peak discharge in forest hydrology. The resulting increased run-off will have short-term effects on stream systems, including erosion. The effects of increased logging levels from the salvage of beetle-killed timber may be significant. The risk of fire in beetle-killed forests is increasing.

The effects of climate change have already expanded the amount of habitat suitable for mountain pine beetle by 75% in the past three decades, and the beetle has moved into Alberta. This trend is expected to continue.
Forestry

Seventy percent of B.C.’s land is covered by forest (p.14). Timber has or is expected to be harvested from approximately 46% (28.4 million ha) of this forest land base.\(^{189}\) Excluded are protected forests, other reserves and forests considered uneconomical for timber production. Some aspects of specific forestry activities such as the building of forest access roads, silviculture, and fire suppression can result in ecosystem degradation, and disturbance, affecting species and ecosystems.\(^{190}\)

Most forestry operations take place in the productive, easily accessible, low elevation valleys where the majority of species also live. An assessment of 3,199 B.C. native invertebrates and vascular plant species classified 41% as forest-associated, a 8% of which are of conservation concern.\(^{191}\) Many species (e.g., marbled murrelets, some lichens and invertebrates) are known to rely on old large trees and the oldest age classes of forests.\(^{192,193,194,195}\)

Approximately 9% of the total land area of British Columbia has been logged since the 1970s (Table 27, Map 51). Logging prior to this time is not reflected by the map or the table, but was significant in some areas of the province. This logging was often followed by ecosystem conversion, particularly near urban areas (p.80). The Coastal Douglas-fir zone (p.20) on the east coast of Vancouver Island and the Gulf Islands was almost entirely logged earlier in the century and old forest greater than 100 years of age now occupies only 4% of the area occupied 150 years ago.\(^{196}\) Similarly, only 0.5% of the old forest which once dominated areas of the central Okanagan now remains in fragmented patches of less than 3ha each.\(^{197}\)

Biogeoclimatic zones (p.20) with the greatest proportion logged since the 1970s are Sub-Boreal Spruce, Interior Douglas-fir, Montane Spruce and Interior Cedar-Hemlock (Table 29). Parts of the province that have had little or no logging are portions of the Central Coast and Rocky Mountain ranges (p.9) and in the northwest and north central regions, all of which are relatively inaccessible.

\(^{a}\) A forest-associated species is one with a measurable dependence on a forest ecosystem for any aspect of its life history.

\(^{r}\) Area logged=Percent of land area.

### Table 27. Percentage of Land Logged in B.C. Since the 1970s by Biogeoclimatic Zone.

<table>
<thead>
<tr>
<th>Biogeoclimatic Zone</th>
<th>Percentage of Total Land Area Logged Since 1970s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Boreal Spruce</td>
<td>23%</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>22%</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>22%</td>
</tr>
<tr>
<td>Interior Cedar-Hemlock</td>
<td>22%</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>17%</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>14%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>8%</td>
</tr>
<tr>
<td>Engelmann Spruce–Subalpine Fir</td>
<td>6%</td>
</tr>
<tr>
<td>Coastal Douglas-fir</td>
<td>6%</td>
</tr>
<tr>
<td>Boreal White and Black Spruce</td>
<td>5%</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>2%</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>&lt;0.5%</td>
</tr>
<tr>
<td><strong>Provincial</strong></td>
<td><strong>9%</strong></td>
</tr>
</tbody>
</table>

**Source:** Produced for this report.

**Notes:** Based on imagery taken between 1991 and 2001 that classified areas recently logged as up to 20 years old (as well as other sources for logging since the images were taken). Logging that occurred more than 20 years before the images were taken is not included.
Transportation and Utility Corridors

Roads and other linear features include primary, secondary and forestry roads, trails, hydro transmission corridors, seismic lines, pipelines, and railways. Roads and other linear features impede the movement of native species, facilitate invasion by alien species and alter predator-prey relationships. Roads can fragment ranges, populations, habitats and ecosystems, and reduce gene flow, resulting in loss of genetic diversity. Roads can impede the natural flow of water and soil across the landscape. Roads can increase access to previously inaccessible areas, resulting in increased road kill of wildlife and increased access for legal and illegal fishing and hunting. Both on-road and off-road vehicles can create disturbance, which can alter species behaviour.

The ecological impacts of roads can affect approximately 20 times the land area that the roads actually cover, making roads a useful index for cumulative impacts on biodiversity. Between 1988 and 2000, road length in B.C. increased by 48% from an estimated 387,000 km to over 570,000 km. By 2005, total road length was 702,574 km, a 23% increase in five years, and an 82% increase since 1988.

Table 28 compares the density of roads and other linear features (including seismic lines) for B.C.’s biogeoclimatic zones (p.20). The density of roads and other linear features varies across the province, with the greatest densities in the northeast, central interior and southwest (including Vancouver Island) and in the major valleys in the southern interior (Map 52). Seventy-six percent of B.C.’s roads are forest access roads. The area of high density in the northeast corner of the province is largely due to seismic lines used for oil and gas exploration (p.114). Although seismic lines are allowed to revert back to forest after use, thousands of kilometres of new lines are cut each year. Large tracts, predominantly mountainous, in the northwest of the province and along the central coast are relatively free of disturbance from roads and other linear features.

### Table 28. Density and Presence of Roads or Other Linear Features for B.C.’s Biogeoclimatic Zones

<table>
<thead>
<tr>
<th>Biogeoclimatic Zone</th>
<th>Road Density (km/km²)</th>
<th>Percentage of 1 Hectare Units with Roads Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Douglas-fir</td>
<td>4.7</td>
<td>38%</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>3.0</td>
<td>28%</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>2.8</td>
<td>25%</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>2.1</td>
<td>22%</td>
</tr>
<tr>
<td>Boreal White and Black Spruce</td>
<td>1.4</td>
<td>15%</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock</td>
<td>1.3</td>
<td>14%</td>
</tr>
<tr>
<td>Sub-Boreal Spruce</td>
<td>1.3</td>
<td>13%</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>1.3</td>
<td>14%</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>1.1</td>
<td>12%</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>0.9</td>
<td>9%</td>
</tr>
<tr>
<td>Engelmann Spruce–Subalpine Fir</td>
<td>0.3</td>
<td>3%</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>0.1</td>
<td>1%</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>0.1</td>
<td>1%</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>&lt;0.1</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>&lt;0.1</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>0.0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Province</strong></td>
<td></td>
<td><strong>8%</strong></td>
</tr>
</tbody>
</table>

**Source:** Produced for this report.

**Notes:** Density and percentage figures include other linear features.

---

1 Seismic lines are straight or meandering pathways 1.5-7-m wide and at least 2-km long, which are used in oil and gas exploration.

2 Data includes all main and secondary roads, including paved, unpaved, and rough roads; Forest Service Roads; and other forest and non-forest roads. The road length data did not include seismic lines. The 2000 data included approximately 30,000 km of trails, which were also included in the 2005 data (but no new trails were added into the data for 2005).
*Other linear development features include: transmission lines; railways; seismic lines; and pipelines.

Units = km/km².
OBSTACLES TO FISH PASSAGE

An estimated 66,000 new road crossings of streams were constructed in B.C. between 2000 and 2005, which represents an average of 13,369 new structures every year. Through GIS analysis, it has been estimated that there are approximately 550,000 km of resource roads in B.C. with approximately 444,000 stream crossings. Modelling of fish habitat has shown that over 313,000 of these crossings occur on stream reaches that have been classified as potential fish habitat. After adjusting for bridges and other open bottom structures (not as likely to impede upstream fish passage), the estimate for closed bottom culverts on fish streams is approximately 250,000.

When these crossings are poorly designed, built or maintained, they can represent a blockage to the upstream migration of fish, thereby disrupting connectivity and effectively cutting off thousands of kilometres of fish habitat across the province. Figure 11 illustrates how potential fish habitat is lost upstream of a culvert that fails to allow fish passage. Map 53 shows the density per square kilometre of potential obstacles on known fish bearing streams around the province. It is important to note that not all fish bearing streams have been documented and that not all crossings will act as barriers to fish passage.

Where total obstruction to all life stages of salmon exists in the lower reaches of a watershed, critical migrations and access to large areas of essential rearing and spawning habitat upstream may be eliminated, resulting in significant impacts on a salmon stock or population. In addition, the elimination of access for fish to large portions of a watershed can disrupt nutrient cycling by preventing anadromous salmon, which have spent part of their life cycle at sea, from transporting valuable nutrients and food into the farthest inland reaches of the province. Similarly, the dispersal of aquatic invertebrates, such as freshwater mussels, whose larvae travel throughout stream systems on the fins or gills of fish, may be limited.

Unfortunately, poorly functioning closed bottom culverts are very common in B.C. A number of culvert assessment projects show that 90% of the closed bottom structures on fish habitat were either partial or complete barriers to fish passage. Even a more conservative failure rate of 70% to 80% represents between 175,000 and 200,000 crossings which impede fish passage in some way.
**MAP 53**

Density of road crossings on fish-bearing streams*

**Legend**
- City
- Road
- River/Stream
- Lake

**Road/stream crossing density**
- 0.00
- 0.01 - 0.16
- 0.17 - 0.29
- 0.30 - 0.44
- 0.45 - 0.61
- 0.62 - 0.80
- 0.81 - 1.02
- 1.03 - 1.35
- 1.36 - 1.95
- 1.96 - 11.98

**Units** = number of road crossings on fish-bearing streams/km².

**Data sources:**

**Map by:**
- Caslys Consulting Ltd

**Projection:**
- BC Albers NAD83

**Produced for:**

---

*Not all fish-bearing streams have been documented.*
**Water Development**

Water development refers to activities and associated infrastructure relating to the usage of water for domestic, commercial, agricultural and industrial purposes. Mapping information was available for two aspects of water development in British Columbia: water diversion and dams.

**WATER DIVERSION**

Water licenses and short-term use approvals called water allocations are issued for a variety of purposes which include small domestic and large-scale municipal water supply, irrigation and agriculture, industrial and commercial uses, mining, habitat conservation, power production, and water storage. The diversion of water from lakes can cause excessive drawdown of surface water sources with consequent disruption of aquatic and riparian habitat. In rivers, water diversions reduce flow and lower water levels, which can create barriers to movement of fish and other aquatic species. Withdrawal of water from streams can affect the biological carrying capacity of the stream, cause changes in temperatures and alter life history stages of aquatic organisms, depending on when and how much water is removed. Fish and other animals are sometimes trapped or die when drawn into diversion channels or other in-stream structures, such as turbines. Wastewater diverted from industrial uses is often returned to the source waterbody with contaminants and/or significant changes in temperature.

Table 29 shows water allocation (excluding water storage, diversion for dams and allocations for conservation purposes) in B.C.’s nine Major Drainage Areas (p.28) with the highest allocations occurring in the Fraser, Coastal and Columbia areas. These allocations include about 30,000 licenses for a total permitted volume of over 21 billion kilolitres/year. Map 54 illustrates comparative levels of water diversion across the province. A license does not mean that 100% of the permitted water is diverted by a user; therefore the index reflects only the maximum potential for diversion. Between half and two-thirds of available surface water in populated regions of B.C. has been allocated. Over the past three decades, surface water use restrictions have increased with close to 30% of licensed stream length in the province now under restrictions. The majority of the restrictions are located in the southern Interior.

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*The calculation for the index values on the map uses the magnitude and dilution approach as shown for the water pollution index on page 122 (Fig.14).*

---

**Table 29. Surface Water Allocation in B.C. by Major Drainage Area**

<table>
<thead>
<tr>
<th>MAJOR DRAINAGE AREA</th>
<th>VOLUME OF LICENSED WATER ALLOCATION (KILOLITRES/YEAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraser</td>
<td>10,617,165,159</td>
</tr>
<tr>
<td>Coastal</td>
<td>6,960,674,550</td>
</tr>
<tr>
<td>Columbia</td>
<td>3,191,406,652</td>
</tr>
<tr>
<td>Skeena</td>
<td>547,689,512</td>
</tr>
<tr>
<td>Mackenzie</td>
<td>393,667,691</td>
</tr>
<tr>
<td>Stikine</td>
<td>1,002,531</td>
</tr>
<tr>
<td>Nass</td>
<td>816,950</td>
</tr>
<tr>
<td>Yukon</td>
<td>816,924</td>
</tr>
<tr>
<td>Taku</td>
<td>27,990</td>
</tr>
<tr>
<td><strong>Provincial total</strong></td>
<td><strong>21,713,267,959</strong></td>
</tr>
</tbody>
</table>

*Source: Prepared for this report based on data from the B.C. Ministry of Environment.*

**Notes:** This excludes water storage, diversion for dams and allocations for conservation purposes.
Table 29.

Surface water allocation in b.c. by major drainage area.

Index = kilolitres of licensed water diversion (excluding water storage, diversion for dams and conservation allocations) within or upstream of the analysis unit / maximum stream magnitude in, or upstream of, the analysis unit.

**Water diversion index**

<table>
<thead>
<tr>
<th>Index Range</th>
<th>Water Diversion Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 505,656,361</td>
<td>0</td>
</tr>
<tr>
<td>505,656,362 - 1,011,312,722</td>
<td>1 - 220</td>
</tr>
<tr>
<td>1,011,312,723 - 1,516,969,083</td>
<td>221 - 1,157</td>
</tr>
<tr>
<td>1,516,969,084 - 2,022,625,444</td>
<td>1,158 - 4,151</td>
</tr>
<tr>
<td>2,022,625,445 - 2,528,281,805</td>
<td>4,152 - 11,246</td>
</tr>
<tr>
<td>2,528,281,806 - 3,033,938,166</td>
<td>11,247 - 26,057</td>
</tr>
<tr>
<td>3,033,938,167 - 3,539,594,527</td>
<td>26,058 - 55,653</td>
</tr>
<tr>
<td>3,539,594,528 - 4,045,250,888</td>
<td>55,654 - 121,707</td>
</tr>
<tr>
<td>4,045,250,889 - 4,550,907,249</td>
<td>121,708 - 337,042</td>
</tr>
<tr>
<td>4,550,907,250 - 5,056,563,610</td>
<td>337,043 - 5,056,563,610</td>
</tr>
</tbody>
</table>

**Data sources:**
B.C. Ministry of Environment

**Map by:**
Cadys Consulting Ltd

**Projection:**
BC Albers NAD83

**Produced for:**
B.C. Ministry of Environment

**February 25, 2009**
Dams

Dams are built primarily for hydroelectric power generation, flood control, and irrigation. In B.C., mountainous terrain, high volume rivers, and long narrow valleys makes dam construction relatively easy (p.10). Ninety percent of B.C.’s electricity is generated by hydroelectric dams, and more than 70% of this is produced by dams on the Peace and Columbia Rivers.223

Of the 2,200 registered dams in British Columbia, 44 are for generating hydroelectric power, including 13 on the Columbia River, two on the Peace River, 11 in the Lower Mainland, seven on Vancouver Island, and two on the mainland coast.224,225 The thousands of other dams are generally small and used for domestic water sources, run-of-river power production, and local industrial uses.

Impacts from dams result in both ecosystem conversion and degradation related to infrastructure, upstream reservoirs and degradation of downstream ecosystems. The inundation of a reservoir upstream of a dam results in ecosystem conversion (p.80) through the extirpation of riparian and valley-bottom habitats, which typically support high levels of biodiversity.226 Besides decreasing biodiversity in adjacent riparian plant communities,227 flooded riparian vegetation can be a source of methane and CO₂, both greenhouse gases that contribute to climate change (p.88).228 Reservoirs slow the velocity of the water, trapping sediments and nutrients that normally deposit in estuaries and deltas downstream, and which instead build up on the bottom of the reservoir.229 Many species have difficulty adjusting to the sometimes daily fluctuations in water levels in a reservoir, and aquatic biodiversity is lower in a reservoir than in a lake of similar size and location.230

Dams can also create significant ecosystem degradation by hampering the movement of migratory fish species (which reduces the transfer of marine-derived nutrients into interior ecosystems) and some terrestrial species. Dams can change turbidity and sediment levels to which species and ecosystems are adapted, disrupt normal processes of river channel scouring and silt deposition, prevent normal downstream movement of large woody debris, change water temperature and oxygen conditions, provide habitat for alien species (p.82), and create unstable, early seral communities along shorelines.

A dam typically decreases the annual flood area below the dam and may increase flow during the summer so that the river no longer deposits sediments downstream. Decreased delivery of water and nutrients to downstream ecosystems, such as marshes and riparian areas, can cause a shift to species that are adapted to drier conditions. Water that flows through turbines into a river is colder and less oxygenated, because it originates from deep in the reservoir and does not mix with surface air. Vegetation, wildlife and fish populations can be altered for hundreds of kilometres downstream.231

Like large dams, small dams can also impede fish passage, trap nutrients and alter flow regimes. Cumulative impacts can result from the number of small dams on a river. Concerns include water diversion (p.110) and increases in construction of roads and transmission lines (p.106).

The Major Drainage Areas in B.C. (p.28) that are most significantly affected by dams are those of the Columbia, Coastal, Mackenzie and Fraser rivers, and less significantly, the Skeena River. A dam can influence extensive areas of the upstream watershed as illustrated by Map 55. Some river systems in B.C. are affected by dams built outside the province.

Dams have a functional lifespan and many hundreds of dams have been abandoned.232 Dam decommissioning, modification, removal and water use planning have been used on some B.C. rivers to restore fish habitat and water flow regimes.233
Oil and Gas Development

Primary and secondary impacts of oil and gas exploration and extraction can include ecosystem conversion, ecosystem degradation, species disturbance and environmental contamination of soil, water and air. At present, the majority of activities associated with petroleum or natural gas extraction in British Columbia take place in the relatively flat Interior Plains in the northeast corner (Map 56). Densities of oil and gas sites in this region can reach 14.7 sites/km². The map includes more than 32,000 oil and gas wells (average well pads are 1.4ha in size) and production facilities with most of the sites concentrated in the Boreal White and Black Spruce biogeoclimatic zone (p.20) at a density of 196 sites/1,000km² (Table 30). Many of these are inactive and will be subject to required reclamation.

<table>
<thead>
<tr>
<th>BIOTOPIC</th>
<th>DENSITY (NUMBER OF SITES / 1,000 KM²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boreal White and Black Spruce</td>
<td>196</td>
</tr>
<tr>
<td>Engelmann Spruce–Subalpine Fir</td>
<td>3</td>
</tr>
<tr>
<td>Coastal Douglas-fir</td>
<td>2</td>
</tr>
<tr>
<td>Montane Spruce</td>
<td>2</td>
</tr>
<tr>
<td>Spruce–Willow–Birch</td>
<td>2</td>
</tr>
<tr>
<td>Sub-Boreal Spruce</td>
<td>1</td>
</tr>
<tr>
<td>Interior Douglas-fir</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Interior Cedar–Hemlock</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Sub-Boreal Pine–Spruce</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Coastal Western Hemlock</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Bunchgrass</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Interior Mountain-heather Alpine</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Coastal Mountain-heather Alpine</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Boreal Altai Fescue Alpine</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Source: Prepared for this report.
Industrial Operations

Industrial operations refer to infrastructure and activities associated with large production facilities such as factories, pulp and paper mills, municipal landfills, refineries and smelters. The most significant impact of industrial operations is environmental contamination. Four examples of environmental contamination in B.C. for which mapping data was available are presented here: contaminated sites (including landfills), emissions of nitrogen oxides and sulphur oxides, and water pollution.

**CONTAMINATED SITES AND LANDFILLS**

A contaminated site is one which has become unsuitable for specified land and water uses owing to spills or deposits of chemicals during commercial and industrial activity. Toxic substances from some contaminated sites can migrate into soil, surface water and groundwater, posing a threat to the immediate and neighbouring land and water. Toxic chemicals can persist for many years and even decades. Activities related to vehicles and fossil fuels, such as petroleum and natural gas storage and distribution, vehicle salvage and wrecking, are the largest sources of environmental contamination in B.C., with benzene and toluene from gasoline found at two-thirds of the sites. Other chemicals include heavy metals such as lead, arsenic, cadmium and mercury; chlorophenols, benzo[a]pyrene and naphthalene from wood treatment; and polychlorinated biphenyls (PCBs) released from heavy electrical equipment.

Municipal landfills can be sources of ground and surface water pollution, as well as greenhouse gas emissions, primarily methane ($\text{CH}_4$) and carbon dioxide ($\text{CO}_2$). For example, groundwater contamination and gas emissions are a concern at Burns Bog, a 5,000-year-old, 30 km$^2$ raised bog in Delta, British Columbia near Vancouver (p.74). Burns Bog is the site of Canada’s largest landfill west of Toronto, and nine smaller landfills are situated adjacent to the bog.

As of 2008, over 9,000 sites were listed on the provincial registry. Not all of the sites in the registry are necessarily contaminated. Some were found to be clean after they were registered, others have been remediated or are awaiting complete assessment for degree of contamination. Over 2,000 contaminated sites and 634 landfills are portrayed on Map 57 at densities up to 7.7 sites/km$^2$ in the Lower Mainland and on Vancouver Island. Not surprisingly, contaminated sites and landfills are found predominantly along the highway system and in areas of human habitation.

Black bear (*Ursus americanus*). PHOTO: CRAIG FARISH.
Contaminated sites and landfills density

Legend
- City
- Road
- River/Stream
- Lake

Site density:
- 0.000
- 0.001 - 0.011
- 0.012 - 0.019
- 0.020 - 0.029
- 0.030 - 0.049
- 0.050 - 0.074
- 0.075 - 0.104
- 0.105 - 0.181
- 0.182 - 0.338
- 0.339 - 7.692

Units = sites/km².

Data sources:
B.C. Ministry of Environment
Map by:
Caslys Consulting Ltd
Projection:
B.C. Albers NAD83
Produced for:
B.C. Ministry of Environment

February 25, 2009
EMISSIONS OF NITROGEN OXIDES

Nitrogen oxides (NO₃) refer to a family of reactive gases emitted largely when fossil fuels are burned at high temperatures. Nitrogen oxides are released into the air from motor vehicle exhaust, the burning of coal, oil or natural gas, and during industrial processes such as arc welding, electroplating, engraving and dynamite blasting. NO₃ can also be formed naturally by lightning.244

Oxides of nitrogen in the atmosphere increase the amount of other greenhouse gases such as methane, which eventually oxidize to carbon dioxide, which is linked to climate change (p.88).245 High levels of nitrogen oxides can cause irritation to eyes, ears, throat and lungs, fatigue and gastric problems in humans and other animals. Long-term exposure may cause fluid build-up in the lungs, heart disease, decreased birth rates in animals and damage to the nervous system.246

The province-wide density of emissions (kg/year/km²) from human-initiated sources are shown on Map 58.v Total NOₓ emissions in 2000 in British Columbia were 338,631 tonnes, with more than 60% occurring in the Lower Fraser Valley (Figure 12). The most significant human-initiated sources of NOₓ in B.C. were marine transportation, heavy-duty diesel vehicles and the oil and gas industry. In the most populated region of the province, the Lower Fraser Valley, mobile sources (cars, trucks, aircraft, boats, trains and off-road vehicles) accounted for 88% of emissions.

It is important to note that the map indicates only the emissions of NOₓ at the point and time of discharge.247 Emissions will dissipate from the source over time. Highest densities of emissions occur near Vancouver at up to 904 kg/year/km².


v The data is based on models. The model for the Lower Mainland near Vancouver, which appears as a block of colour, was developed separately from the model used for the rest of the province.
MAP 58
Nitrogen oxides emission density

Legend
- City
- Road
- River/Stream
- Lake

NOx emission density*
- 0.00
- 0.01 - 0.50
- 0.51 - 1.00
- 1.01 - 100.00
- 100.01 - 904.11

*Units = kg/year/km².

*Only total emission data was available for two large areas in the lower mainland and, as a result, the average emission density is shown for each.
**EMISSIONS OF SULPHUR OXIDES**

Sulphur oxides (SO\(_x\)) are corrosive colourless gases produced by the combustion of fossil fuels containing sulphur and by power plants and factories that burn coal or oil for fuel. Animals exposed to high concentrations of sulphur dioxide exhibited decreased respiration, inflammation of airways and destruction of lung tissue.\(^{248}\)

Total SO\(_x\) emissions in 2000 in British Columbia were 138,105 tonnes.\(^{249}\) The major point source of sulphur oxides in B.C. is the oil and gas industry (62%) (Figure 13). Other significant sources are the pulp and paper industry and marine transportation. The province-wide density of emissions from all human-initiated sources is shown on Map 59,\(^{w}\) with the highest densities in the northeast Peace region where most of the oil and gas activity takes place.

It is important to note that the map indicates only the emissions of SO\(_x\) at the point and time of discharge.\(^{250}\) Emissions will dissipate from the source over time.

**FIGURE 13: Human-initiated sources of sulphur oxides in B.C.**


\(^w\)The data is based on models. The model for the Lower Mainland near Vancouver, which appears as a block of colour, was developed separately from the model used for the rest of the province.
*Only total emission data was available for two large areas in the lower mainland and, as a result, the average emission density is shown for each.
WATER POLLUTION

Environmental contamination in the form of water pollution can affect biodiversity by degrading habitat quality for aquatic species and by creating conditions that impair the health of plants and animals.

Under British Columbia’s Environmental Management Act, certain industries, trades, businesses, operations or activities discharging waste into streams and rivers require a permit. Information from this permit system was used to calculate a relative measure for the amount of water pollution occurring in the province. Because large volumes of water have a diluting effect on pollutants, the water pollution index, shown on Map 60, was calculated by dividing the total discharge fees (a proxy for discharge pollution) within or upstream of an analysis unit by the magnitude of the maximum magnitude stream within or upstream of that analysis unit. Magnitude, which differs from stream order, is a proxy value for the volume of water in the stream or river and is calculated by adding the magnitudes of incoming upstream tributaries as illustrated in Figure 14. For example, if an industrial site discharges effluent upstream into a mainstem with a magnitude of 2, the value of the discharge will decrease proportionally as it moves downstream through a magnitude 4 section, until it encounters another source of discharge.

The water pollution index is highest in the Coastal, Columbia, Fraser and Mackenzie Major Drainage Areas (p. 28) (Table 31). The extremely high index value for the Coastal area is owing to a number of large industrial sites near the coast that discharge effluent into the ocean. The water pollution index map does not indicate the volume or nature of the discharge or the level of pollution but shows only waterbodies with discharge inputs under permit. Therefore the index indicates pollution potential rather than actual pollution levels or severity.

FIGURE 14: Comparison of stream magnitude and order.

TABLE 31. WATER POLLUTION INDEX VALUES FOR MAJOR DRAINAGE AREAS IN B.C.

<table>
<thead>
<tr>
<th>MAJOR DRAINAGE AREA</th>
<th>WATER POLLUTION INDEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal</td>
<td>372</td>
</tr>
<tr>
<td>Columbia</td>
<td>32</td>
</tr>
<tr>
<td>Fraser</td>
<td>24</td>
</tr>
<tr>
<td>Mackenzie</td>
<td>10</td>
</tr>
<tr>
<td>Skeena</td>
<td>1</td>
</tr>
<tr>
<td>Stikine</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Nass</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Yukon</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Taku</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

SOURCE: Produced for this report.

* The only case in which magnitude is higher upstream occurs on side channels that are low magnitude.
Water pollution index

Legend
- City
- Road
- River/Stream
- Lake

Water pollution index
- 0.00
- 0.01 - 0.03
- 0.04 - 0.15
- 0.16 - 0.55
- 0.56 - 1.44
- 1.45 - 2.78
- 2.79 - 6.77
- 6.78 - 18.36
- 18.37 - 49.83
- 49.84 - 25,284.38

Index = $ value of licensed water pollution within or upstream of the analysis unit / maximum stream magnitude in, or upstream of, the analysis unit.

Data sources:
- B.C. Ministry of Environment

Map by:
- Caslys Consulting Ltd

Projection:
- BC Albers NAD83

Produced for:
- B.C. Government

February 25, 2009
Glossary

**Abiotic**: non-living chemical and physical factors in the environment, including solar radiation, water, atmospheric gases, soil and physical geography.

**Alien species**: a species occurring in an area outside its historically known natural range as a result of intentional or accidental dispersal by humans (i.e., movement of individuals) or direct human activities that remove a natural barrier (e.g., creation of a fish ladder to allow fish to move past a waterfall). Also known as an *exotic* or *introduced* species. See also *Invasive alien species*.

**Anadromous**: fish species that spawn (breed and lay eggs) in freshwater environments, but spend at least part of their adult life in a marine environment.

**Benthic**: the bottom substrate of an aquatic environment.

**Biodiversity**: the variety of species and ecosystems on earth and the ecological processes of which they are a part, including ecosystem, species and genetic diversity components.

**Bryophyte**: primitive plant in the plant phylum Bryophyta, lacking a vascular system and typically growing in moist habitats.

**Carnivore**: members of the Carnivora, an order of mammals with most well-developed incisors and canine teeth for tearing flesh.

**Cascading impacts**: impacts which initiate additional impacts – e.g., loss of a major predator causes population increases in prey species which deplete forage plants.

**Climate change**: a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended time period (typically decades or longer).

**Climate envelope**: the area of suitable climate for a species or ecosystem in terms of temperature and precipitation. Climate envelope models determine the current distribution of the species or ecosystem, then map the location of this same envelope under a climate change scenario.

**Conifer**: a cone-bearing tree having needles or scale-like leaves; usually evergreen (with the exception in B.C. of *Larix* species).

**Connectivity**: the degree to which ecosystem structure facilitates or impedes dispersal and flow across a landscape.

**Conservation concern**: globally or provincially critically imperilled (G1 or S1), imperilled (G2 or S2), or vulnerable (G3 or S3). Species, biogeoclimatic zones/subzones/variants, major drainage units and ecological communities of global conservation concern are ranked G1 to G3. Species, biogeoclimatic zones/subzones/variants, major drainage units and ecological communities of provincial conservation concern are ranked S1 to S3.

**Conservation status**: a measure of the risk of regional (i.e., provincial) extirpation or global extinction for an element of biodiversity, population, subspecies, species or ecosystem.

**Contaminated site**: one which has become unsuitable for specified land and water uses owing to spills or deposits of chemicals during commercial and industrial activity.

**Cumulative impact**: changes to the environment that are caused by a human action in combination with other past, present and future human actions.

**Cyanobacterium** [pl. cyanobacteria]: a photosynthetic bacterium generally blue-green in colour.

**Decomposition**: the breakdown of dead plant and animal matter into their inorganic constituents such as carbon and nitrogen.
**Dicot (dicotyledon):** a flowering, vascular plant with two cotyledons (primary embryonic leaves) in its seed (e.g., rose, aster, etc.).

**Direct mortality:** the direct killing of individuals (e.g. harvest, by-catch, road kills, intentional poisoning).

**Dispersal:** active or passive movement of individual organisms to different localities.

**Divergence (as in divergent evolution):** accumulation of differences between groups which can lead to the formation of new species, usually a result of different groups of the same species adapting to different environments.

**Ecosystem:** a dynamic complex of plant, animal and microorganism communities and their abiotic environment, all interacting as a functional unit.

**Ecosystem conversion:** replacement of natural communities with human-dominated systems (e.g., intensive agriculture) or physical works (e.g., mines, urban areas, reservoirs).

**Ecosystem degradation:** direct change to the structure of natural systems (e.g., through forest harvesting or water diversion).

**Endemic:** found only in a specified geographic region native to, and restricted to, a particular geographical region.

**Extinction (Extinct):** the elimination of a species or subspecies from its entire global range.

**Extirpation (Extirpated):** the elimination of a species or subspecies from a specified area, but not from its entire global range.

**Fungi:** single-celled, multinucleate or multicellular organisms that lack chlorophyll and vascular tissues; includes yeasts, moulds, smuts and mushrooms. Much of the organism can occur underground.

**Groundwater:** water in the soil and underlying geological strata.

**Habitat:** the natural environment in which an organism normally lives.

**Index value:** a number derived from a formula, used to characterize a set of data.

**Invasive alien species:** alien species that threaten biodiversity due to their ability to spread and out-compete or otherwise impact native species or dominate ecosystems.

**Invertebrate:** an animal without a backbone.

**Krummholz:** a stunted forest characteristic of the timberline.

**Large woody debris (LWD):** large pieces of wood, generally greater than 10 cm in diameter, in an aquatic environment, including sound or rotting logs, stumps and large branches that have fallen or been cut; when found on or near the forest floor this material is called coarse woody debris (CWD).

**Lichen:** an organism consisting of an outer fungal body enclosing photosynthetic algae or cyanobacteria.

**Limnetic:** of, or pertaining to, the deeper, open waters of a lake.

**Liverwort:** any of a class (Hepaticae) of bryophytic plants characterized by a thalloid gametophyte or sometimes an upright leafy gametophyte.

**Magnitude (in hydrology):** the volume of water in a stream or river.

**Mainstem:** the main channel of a river or stream.

**Migration:** movement from one place of residence to another on a regular basis.

**Monocot (monocotyledon):** a flowering, vascular plant that has a single cotyledon (primary embryonic leaf) in its seed (e.g., grass, sedge, rush, etc.).

**Native species:** a species that naturally occurs in an area as a result of its own movements (unaided by direct human actions allowing it to move past a natural barrier).

**Non-vascular plant:** a plant without specialized tissues for conducting water and nutrients (e.g., algae, mosses, fungi, lichen).

**Nutrient cycling:** circulation or exchange of elements, such as nitrogen and carbon dioxide, between non-living and living parts of the environment.

**Parkland:** the ecotone between a forested environment and an open environment such as alpine or grassland.

**Peak discharge (in hydrology):** river base flow increase, due to rain input, to its highest level.

**Photosynthesis:** the conversion of light energy into chemical energy by living organisms.

**Photosynthesize:** to perform the process of photosynthesis (i.e., using sunlight, CO₂ and water to form carbohydrates).

**Pollination:** the process in which pollen is transferred from an anther of male plant to a receptive stigma of a female plant.
**Population:** a group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group.

**Predator-prey system:** a system involving interactions between predators and their prey.

**Recharge time (in hydrology):** the time taken to replenish groundwater.

**Riparian:** a zone of transition between an aquatic and a terrestrial system, dependent upon surface or sometimes subsurface water. Riparian areas may be located adjacent to lakes, estuaries, rivers, or ephemeral, intermittent or perennial streams.

**Seral:** the series of plant community conditions that develop during ecological succession from bare ground (primary succession) or major disturbances (secondary succession) to the climax stage. Three main stages are typically recognized in a forest context: early-seral, mid-seral and late-seral.

**Special elements:** elements of biodiversity that are of global or regional significance either because they are important habitat for seasonal concentrations of species or because they are uncommon or even unique on a global or regional scale owing to their unusual ecological characteristics.

**Species:** in most living organisms, a species generally represents a complete, self-generating, unique ensemble of genetic variation, capable of interbreeding and producing fertile offspring.

**Species richness:** the number of species within a specified area.

**Stream order:** first order streams are those with no tributaries; two first order streams join to make a second order stream; two second order streams join to make a third-order stream, etc. See also third-order watershed.

**Stresses:** impaired aspects of biodiversity that result directly or indirectly from human activities. See also Threats.

**Subspecies:** a geographically defined aggregate of local populations that differs from other such subdivisions of a species.

**Taxon [pl. taxa]:** any one of the categories used in naming and classifying organisms (e.g., phylum, class, order, family, genus, species, subspecies, variety). See Taxon.

**Taxonomic group:** a group of organisms at the same level of organization in biological classification.

**Third-order watershed:** a watershed is the area drained by a river or stream, or a river system. First order streams are those with no tributaries; two first order streams join to make a second order stream, two second order streams join to make a third-order stream. A third-order watershed as mapped by Watersheds BC is a composite of third order streams and above.

**Threats:** the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation and/or impairment of biodiversity and natural processes.

**Topography:** the shape of the surface of the earth.

**Transpiration:** the evaporation of water from the aerial parts of plants, especially the leaves, but also stems, flowers and roots.

**Ungulate:** a hoofed mammal such as an elk or deer.

**Variety [pl. varieties]:** one of the categories used in naming and classifying organisms (e.g., phylum, class, order, family, genus, species, subspecies, variety). See Taxon.

**Vascular plant:** a plant with specialized tissues for conducting water and nutrients (e.g., tree, shrub, grass, etc.).

**Vertebrate:** an animal with a backbone (e.g., mammal, bird, reptile, amphibian, fish).
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the biodiversity atlas of british columbia