



THE BIODIVERSITY ATLAS OF BRITISH COLUMBIA

MARCH 2009

WRITTEN BY M. A. AUSTIN AND A. ERIKSSON

Bio
Diversity BC
CONSERVING THE VARIETY OF LIFE

The logo for Biodiversity BC features a detailed illustration of a salamander, likely a Hellbender, positioned over the word "Diversity". The letters "Bio" are in green, "Diversity" is in gold, and "BC" is in black. Below the main text, the tagline "CONSERVING THE VARIETY OF LIFE" is written in a smaller, black, sans-serif font.

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TABLE OF CONTENTS

Foreword	ix
Acknowledgements	xi
Introduction	1
How to Read the Biodiversity Atlas	2
How the Maps were Created	2
Understanding the Maps	3
Data Sources	5
Ecosystems	8
Topography and Climate	10
Land Cover	14
Net Primary Productivity	16
Ecoregion Classification	18
Biogeoclimatic Ecosystem Classification	20
Biogeoclimatic Zones of Conservation Concern	22
Biogeoclimatic Zones with Majority of Global Range in B.C.	24
Ecological Communities	26
Major Drainage Areas	28
Conservation Status of Major Drainage Areas in B.C.	30
Protected Areas	32
Species	35
Species Richness	36
Species of Conservation Concern	40

Proportion of Global Range for Species	44
Amphibians	46
Perching Birds	48
Freshwater Fishes	50
Mammals	52
Reptiles and Turtles	54
Insects	56
Butterflies and Skippers	58
Dragonflies and Damselflies	60
Selected Freshwater Crustaceans: Diaptomid Copepods	62
Vascular Plants	64
Mosses	66
Lichens	68
Special Elements of Biodiversity	71
Special Elements: Species	72
Special Elements: Ecosystems	74
Threats to Biodiversity	76
Human Population Growth	78
Terrestrial Ecosystem Conversion	80
Alien Species	82
Climate Change	88
Temperature	92
Precipitation	95
Seasonal Trends in Climate	98
Mountain Pine Beetle	102
Forestry	104
Transportation and Utility Corridors	106
Obstacles to Fish Passage	108
Water Development	110
Water Diversion	110
Dams	112
Oil and Gas Development	114

Industrial Operations	116
Contaminated Sites and Landfills	116
Emissions of Nitrogen Oxides	118
Emissions of Sulphur Oxides	120
Water Pollution	122
Glossary	124
Endnotes	127

List of Figures

FIGURE 1.	Vintage of Baseline Thematic Mapping (version 1 & 2 merged) and Terrain Resources Information Management Mapping.	6
FIGURE 2.	How to read the maps.	7
FIGURE 3.	Land cover types in B.C. as percentage of total area of province.	14
FIGURE 4.	The world's water supply.	28
FIGURE 5.	Historic (a) and current (b) species richness for 17 carnivore and ungulate species that have undergone significant range contractions in North America.	52
FIGURE 6.	Population growth for B.C. (1861-2006) with a projection to 2031.	78
FIGURE 7.	Trends in the number of alien vascular plant species established in B.C.	84
FIGURE 8.	Trends in the number of alien freshwater fish species established in B.C.	86
FIGURE 9.	Comparison in year to year variation in average minimum temperature for February for Quesnel and Victoria.	90
FIGURE 10.	Forests in B.C. affected by mountain pine beetle with projections to 2018.	102
FIGURE 11.	Potential loss of fish habitat owing to stream crossings that block fish passage.	108
FIGURE 12.	Human-initiated sources of nitrogen oxides in B.C.	118
FIGURE 13.	Human-initiated sources of sulphur oxides in B.C.	120
FIGURE 14.	Comparison of stream magnitude and order.	122

List of Maps

MAP 1.	Example of biodiversity spatial analysis units	4
MAP 2.	Major topographic features	9
MAP 3.	Elevation	11

MAP 4.	Standard climate variables	13
MAP 5.	Land cover	15
MAP 6.	Net primary productivity	17
MAP 7.	Ecoprovinces and ecosections	19
MAP 8.	Biogeoclimatic ecosystem classification - zones	21
MAP 9.	Biogeoclimatic zones of conservation concern	23
MAP 10.	Biogeoclimatic zones for which B.C. has the majority of the global range	25
MAP 11.	Ecosystem mapping as of 2006	27
MAP 12.	Major Drainage Areas	29
MAP 13.	Major Drainage Areas of conservation concern	31
MAP 14.	Parks, protected areas and conservation lands	33
MAP 15.	Species richness	37
MAP 16.	Terrestrial species richness	38
MAP 17.	Freshwater species richness	39
MAP 18.	Species richness: species of global conservation concern	41
MAP 19.	Species richness: species of provincial conservation concern	43
MAP 20.	Species richness: species with a majority of their global range in B.C.	45
MAP 21.	Species richness: amphibians	47
MAP 22.	Species richness: perching birds	49
MAP 23.	Species richness: freshwater fishes	51
MAP 24.	Species richness: mammals	53
MAP 25.	Species richness: reptiles and turtles	55
MAP 26.	Species richness: insects	57
MAP 27.	Species richness: butterflies	59
MAP 28.	Species richness: dragonflies and damselflies	61
MAP 29.	Species richness: selected freshwater crustaceans (diaptomid copepods)	63
MAP 30.	Species richness: vascular plants	65
MAP 31.	Species richness: mosses	67
MAP 32.	Species richness: lichens	69
MAP 33.	Selected special elements: species	73
MAP 34.	Selected special elements: ecosystems	75
MAP 35.	Human footprint index	77
MAP 36.	Human population density	79

MAP 37.	Terrestrial ecosystem conversion	81
MAP 38.	Number of terrestrial and freshwater alien species	83
MAP 39.	Number of terrestrial alien species	85
MAP 40.	Number of freshwater alien species	87
MAP 41.	Absolute rate of change in minimum temperature (average of all months) from 1971 to 2000	89
MAP 42.	Relative rate of change in minimum temperature (average of all months) from 1971 to 2000	91
MAP 43.	Absolute rate of change in maximum temperature (average of all months) from 1971 to 2000	93
MAP 44.	Relative rate of change in maximum temperature (average of all months) from 1971 to 2000	94
MAP 45.	Absolute rate of change in precipitation (average of all months) from 1971 to 2000	96
MAP 46.	Relative rate of change in precipitation (average of all months) from 1971 to 2000	97
MAP 47.	Seasonal trends in minimum temperature from 1971 to 2000	99
MAP 48.	Seasonal trends in maximum temperature from 1971 to 2000	100
MAP 49.	Seasonal trends in precipitation from 1971 to 2000	101
MAP 50.	Area of forests more than 10% impacted by mountain pine beetle	103
MAP 51.	Logged since the 1970s	105
MAP 52.	Density of roads and other linear development features	107
MAP 53.	Density of road crossings on fish-bearing streams	109
MAP 54.	Water diversion index	111
MAP 55.	Areas upstream of a dam	113
MAP 56.	Oil and gas sites density	115
MAP 57.	Contaminated sites and landfills density	117
MAP 58.	Nitrogen oxides emissions density	119
MAP 59.	Sulphur oxides emissions density	121
MAP 60.	Water pollution index	123

List of Tables

TABLE 1.	Size distribution for biodiversity spatial analysis units.	3
TABLE 2.	Areal extent of biogeoclimatic zones in B.C.	20
TABLE 3.	Conservation status of biogeoclimatic zones in B.C.	22
TABLE 4.	Classification system for proportion of global range: ecosystems.	24
TABLE 5.	Provincial conservation status of ecological communities in B.C. by biogeoclimatic zone.	26
TABLE 6.	Provincial conservation status of Major Drainage Areas in B.C.	30

TABLE 7.	Protected areas in B.C.	32
TABLE 8.	Native terrestrial and freshwater species in B.C. assessed for species richness.	36
TABLE 9.	Summary of B.C. native species by global and provincial conservation status.	40
TABLE 10.	Classification system for proportion of global range: species.	44
TABLE 11.	Native amphibians of conservation concern in B.C.	46
TABLE 12.	Native perching birds of conservation concern in B.C.	48
TABLE 13.	Endemic freshwater fishes in B.C. currently without formal scientific species names.	50
TABLE 14.	Native reptiles and turtles of conservation concern in B.C.	54
TABLE 15.	B.C. native insect groups included on Map 26.	56
TABLE 16.	Native butterfly and skipper species of global conservation concern in B.C.	58
TABLE 17.	Diaptomid copepods found in saline lakes in B.C.	62
TABLE 18.	Native vascular plants in B.C. included on Map 30.	64
TABLE 19.	Conservation status of some endemic mosses in B.C.	66
TABLE 20.	Some B.C. lichen species endemic to the Pacific Northwest region.	68
TABLE 21.	Selected special elements of biodiversity related to species in B.C.	72
TABLE 22.	Selected special elements of biodiversity related to ecosystems in B.C.	74
TABLE 23.	Area of terrestrial ecosystem conversion in B.C. since European contact.	80
TABLE 24.	Alien species in B.C. included on Maps 38 to 40.	82
TABLE 25.	Terrestrial alien species richness for biogeoclimatic zones in B.C.	84
TABLE 26.	Freshwater alien species richness for Major Drainage Areas in B.C.	86
TABLE 27.	Percentage of land logged in B.C. since the 1970s by biogeoclimatic zone.	104
TABLE 28.	Density and presence of roads or other linear features for B.C.'s biogeoclimatic zones.	106
TABLE 29.	Surface water allocation in B.C. by Major Drainage Area.	110
TABLE 30.	Density of oil and gas sites in B.C. by biogeoclimatic zone.	114
TABLE 31.	Water pollution index values for Major Drainage Areas in B.C.	122



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.



Snow geese (*Chen caerulescens*)

PHOTO: LAUREN NICHOLL

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.



Garibaldi Provincial Park.

PHOTO: DAVID P. LEWIS



Grizzly bear (*Ursus arctos*) with salmon.

PHOTO: STEPHEN SCHWARTZ



Sandhill cranes (*Grus canadensis*).

PHOTO: FRANK LEUNG

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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.



The variety of life in all its forms is termed biodiversity.

PHOTO: RICK JONES

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.,^a) 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 km².² 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 ecosections³(p.18), biogeoclimatic subzones and variants⁴ (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 processing 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

AREA	NUMBER OF POLYGONS
1 – 10	50,209
11 – 20	11,218
21 – 30	4,319
31 – 40	2,156
41 – 50	1,221
51 – 60	735
61 – 70	540
71 – 80	340
81 – 90	261
91 – 100	199
101 – 110	147
111 – 120	121
121 – 130	89
131 – 140	98
141 – 150	75
151 – 160	55
161 – 170	48
171 – 180	44
181 – 190	47
191 – 200	37
201 – 210	28
211 – 220	27
221 – 230	19
231 – 240	15
241 – 250	12
251 – 260	10
261 – 270	12
271 – 280	19
281 – 290	12
291 – 300	10
301 – 1,530	212
Total	72,335

MAP 1
Example of biodiversity spatial analysis units

Legend

- Road
- ~ River/Stream
- ☪ Lake
- 🟢 Ecosections
- 🟡 Watersheds
- 🟠 Biogeoclimatic Ecosystem Classification Variant



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

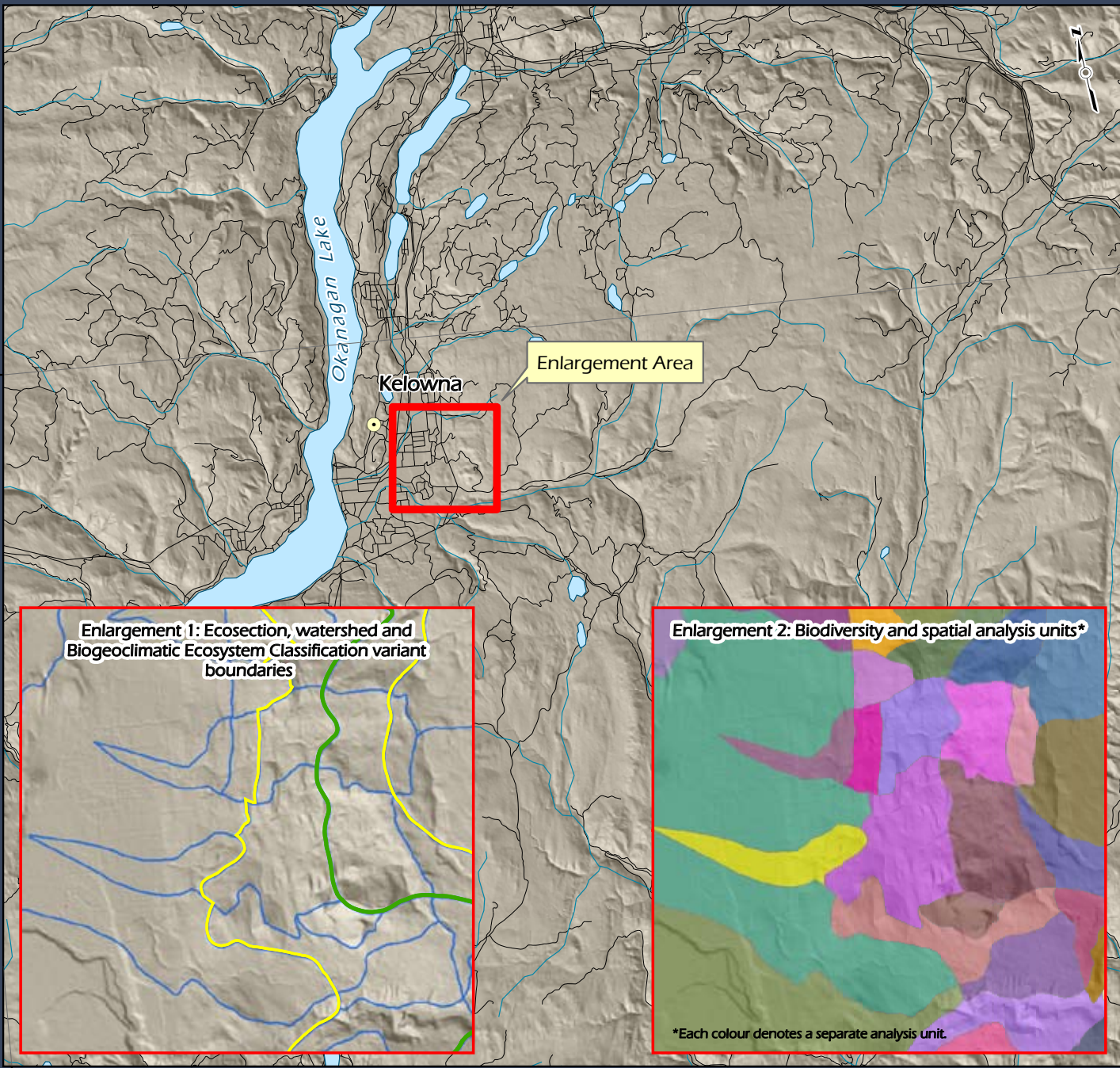
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



January 29, 2009



50°N

120°W

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,^{b,c} each of which generally incorporates the same number of analysis units.^d In effect, one-tenth of the analysis units are in each percentile class no matter what range of values are represented.^e 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. In some cases, the data is grouped into categories based on regular breaks in the data rather than equal spacing. For example, breaks for the equal interval classes used for the species richness map (p.37) were approximately 93 species per category (4-98; 99-191 etc). Equal interval classification often results in a significantly different spatial distribution of the data than when classed by percentile.

^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.

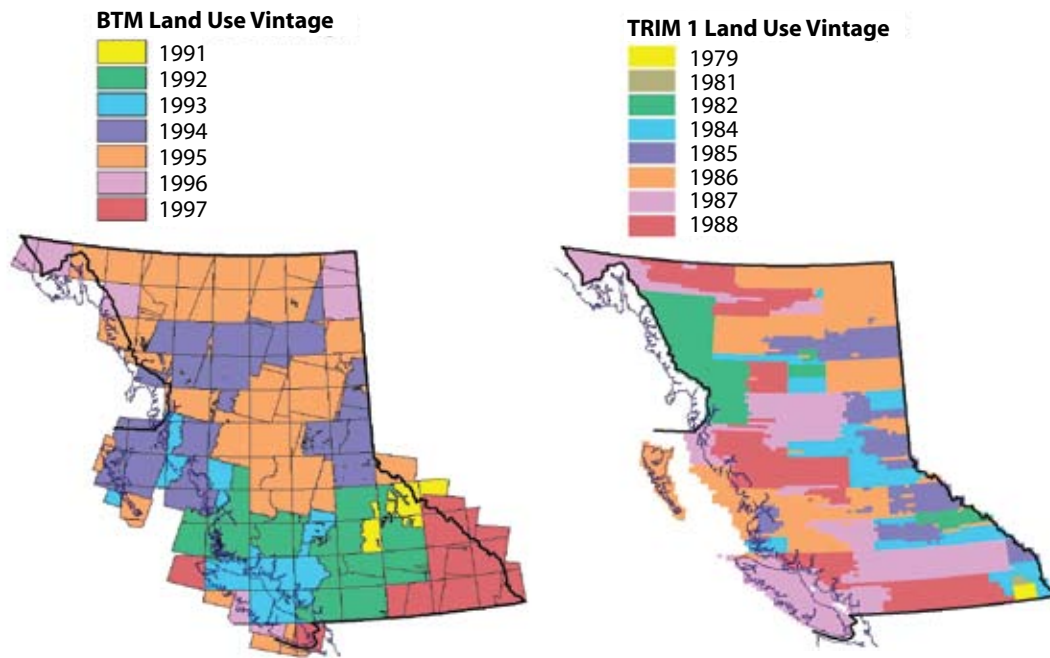


FIGURE 1: Vintage of Baseline Thematic Mapping (version 1 & 2 merged) and Terrain Resources Information Management Mapping.

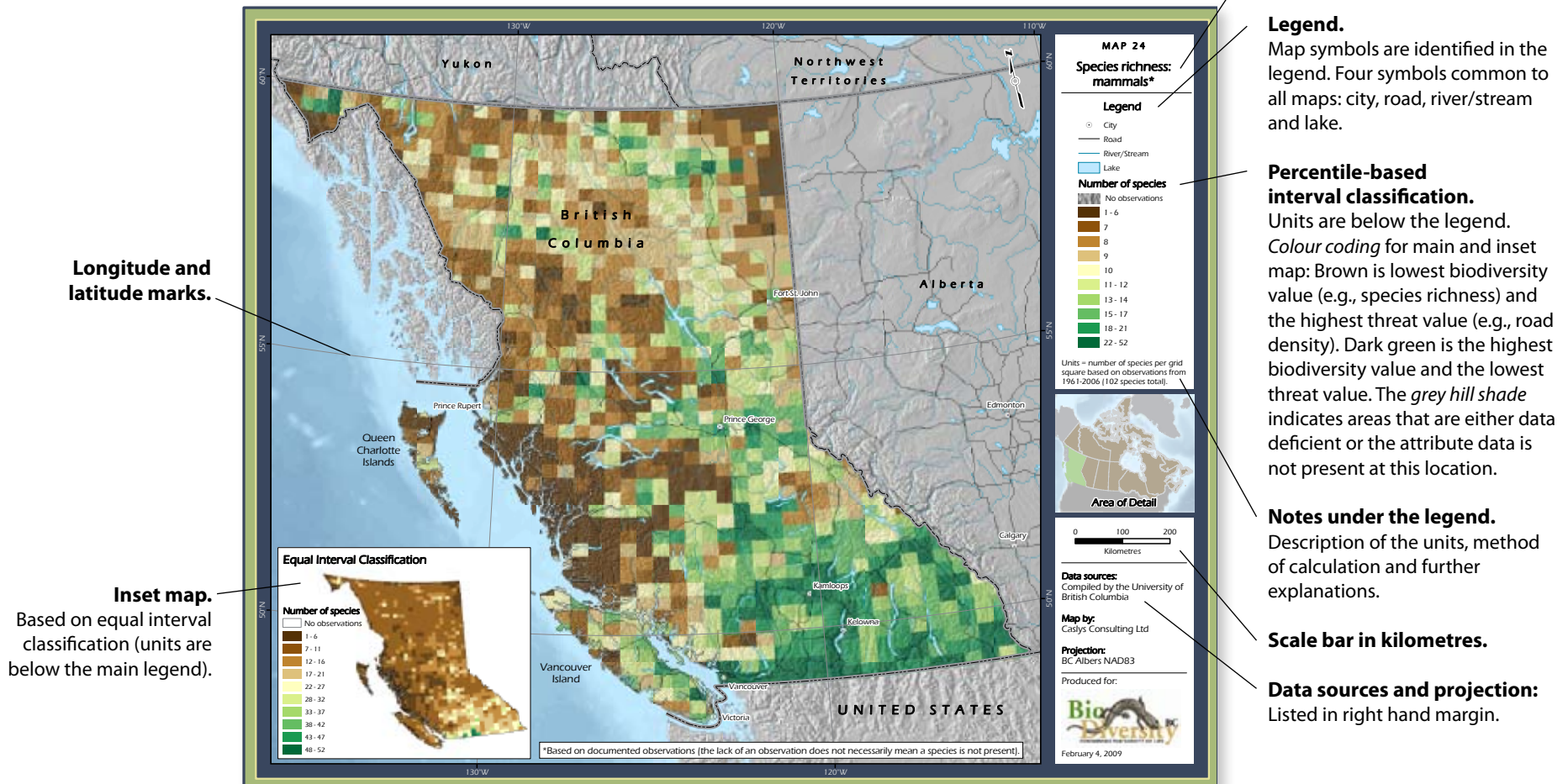
SOURCE: B.C. Integrated Land Management Bureau. Baseline Thematic Mapping. Available at: ilmbwww.gov.bc.ca/cis/initiatives/ias/btm/index.html; B.C. Integrated Land Management Bureau. Terrain Resources Information Management Mapping. Available at: ilmbwww.gov.bc.ca/bmgs/products/mapdata/trim_enhanced_map.htm.

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.⁸ 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)⁹ and Terrain Resources Information Management Mapping (TRIM).¹⁰ 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



Title of map.

Legend.

Map symbols are identified in the legend. Four symbols common to all maps: city, road, river/stream and lake.

Percentile-based interval classification.

Units are below the legend. *Colour coding* for main and inset map: Brown is lowest biodiversity value (e.g., species richness) and the highest threat value (e.g., road density). Dark green is the highest biodiversity value and the lowest threat value. The *grey hill shade* indicates areas that are either data deficient or the attribute data is not present at this location.

Notes under the legend.

Description of the units, method of calculation and further explanations.

Scale bar in kilometres.

Data sources and projection:

Listed in right hand margin.

Longitude and latitude marks.

Inset map.

Based on equal interval classification (units are below the main legend).

Note: It is important to read the exact specifications sited in the legend to each map, as they may differ even on similar maps.



ECOSYSTEMS



An ecosystem can be as small as a single log.

PHOTO: TORY STEVENS.





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.

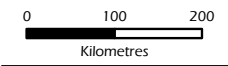
The latitude, coastline and **topography** of B.C., and the resulting climatic variation have created a wide diversity of ecosystems from intertidal areas to forests to grasslands to alpine ice and snow. The province stretches from the 48° north latitude at its most southerly point on Vancouver Island 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.¹¹ 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 km¹² 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.

MAP 2
Major topographic features

Legend

-  City
-  Road
-  River/Stream
-  Lake



Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



January 29, 2009



*The Cariboo, Monashee, Selkirk and Purcell mountains are collectively known as the Columbia Mountains.

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,



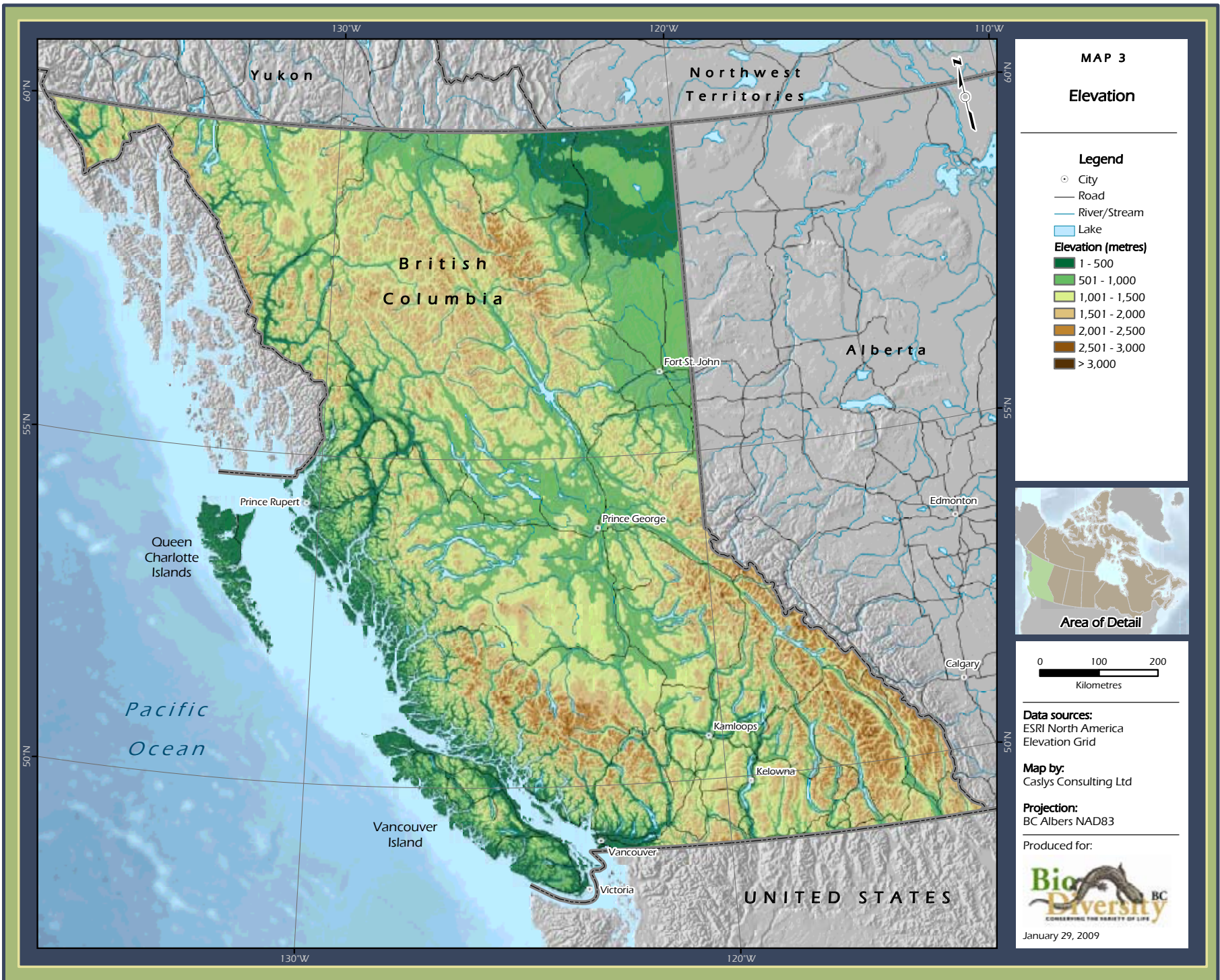
The Bugaboos.

PHOTO: KAREN WIPOND.

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).



Yukon

Northwest Territories

British Columbia

Alberta

Queen Charlotte Islands

Pacific Ocean

Vancouver Island

UNITED STATES

Prince Rupert

Prince George

Fort St. John

Edmonton

Calgary

Kamloops

Kelowna

Vancouver

Victoria

60°N
55°N
50°N

130°W 120°W 110°W
130°W 120°W

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



The Canadian Rockies.

PHOTO: NETA DEGANY.



Mountains, producing the highest rainfall and some of the most productive forests in Canada.¹³ 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

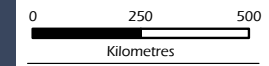
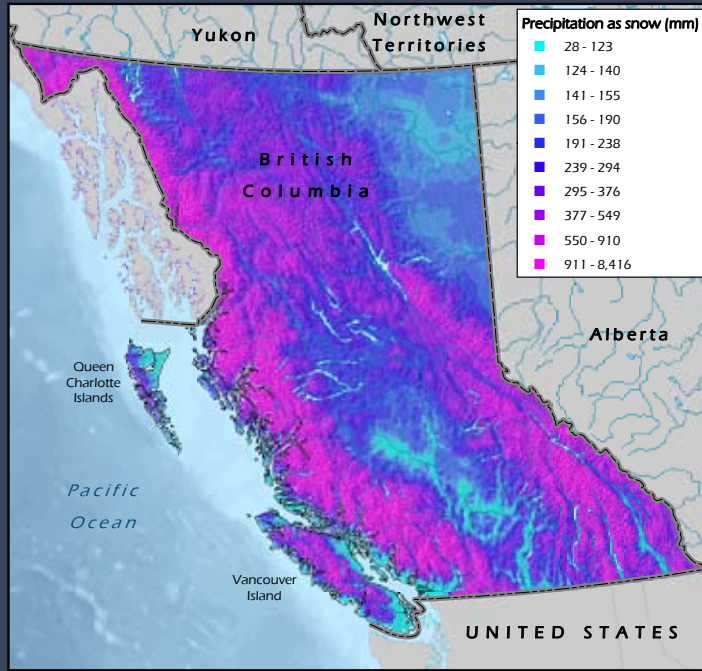
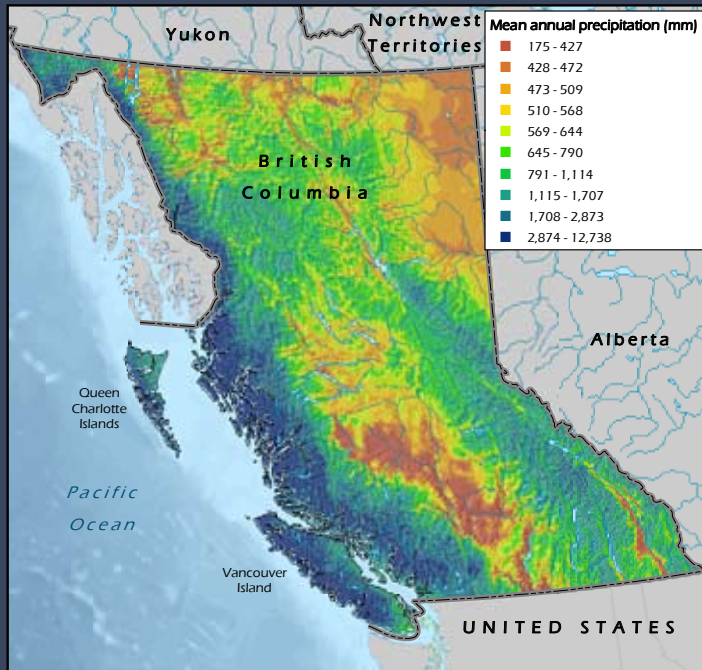
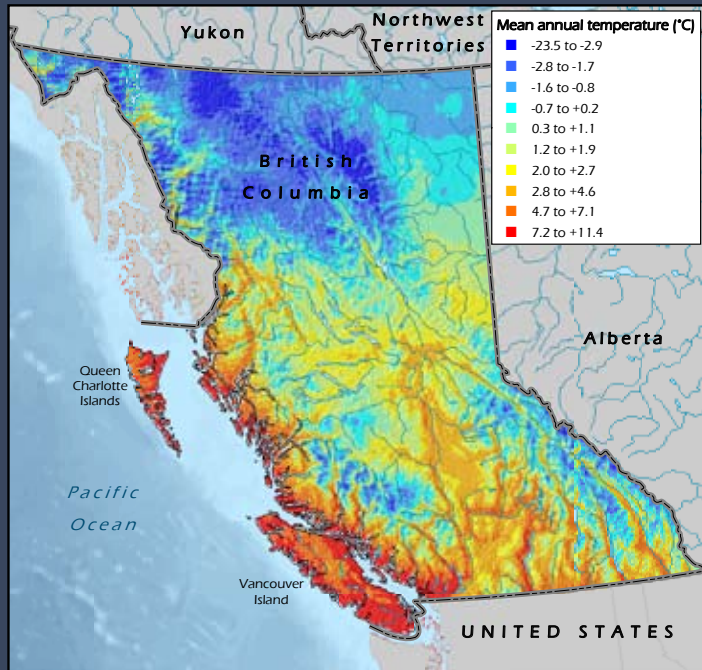
west of, and within parts of, the Rockies. The Peace region in the northeast, an extension of the Interior Plains of Alberta, is characterized by low elevation rolling hills and a cold northern climate in winter. Climate in the province is also influenced in the summer by warm or hot air from the Great 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).

MAP 4
Standard climate variables

Legend

-  River/Stream
-  Lake



Data sources:
Pacific Climate Impacts Consortium (University of Victoria): 1961 - 1990 averages

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



February 5, 2009

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).^f 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.¹⁴

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.¹⁵ More than

one-third of B.C.'s vertebrates of conservation concern depend on grasslands for their survival.^{16,17}

Similarly, more than 30% of species of conservation concern depend on wetlands.^{8,18} 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).

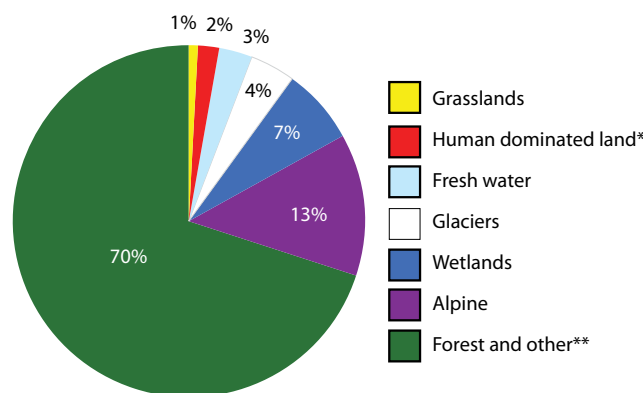


FIGURE 3: Land cover types in B.C. as percentage of total area of province.

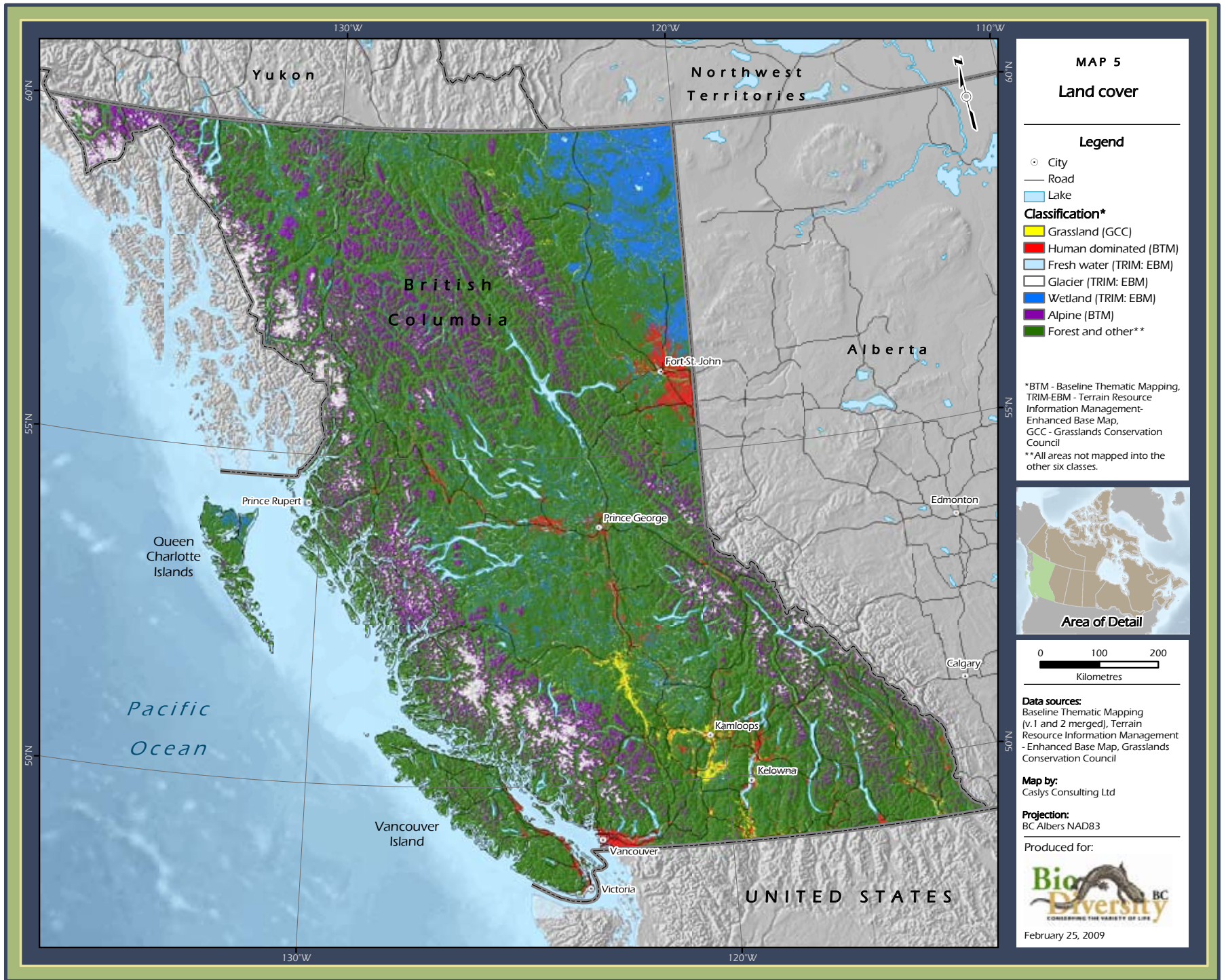
SOURCE: Produced for this report.

*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.

^fSources: 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.

^gWetlands include freshwater wetlands but not estuarine areas on the coast.



Net Primary Productivity

The net primary productivity (NPP) of an ecosystem is the difference between total **photosynthesis** by plants and total plant respiration.¹⁹ 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.²⁰ 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 indi-



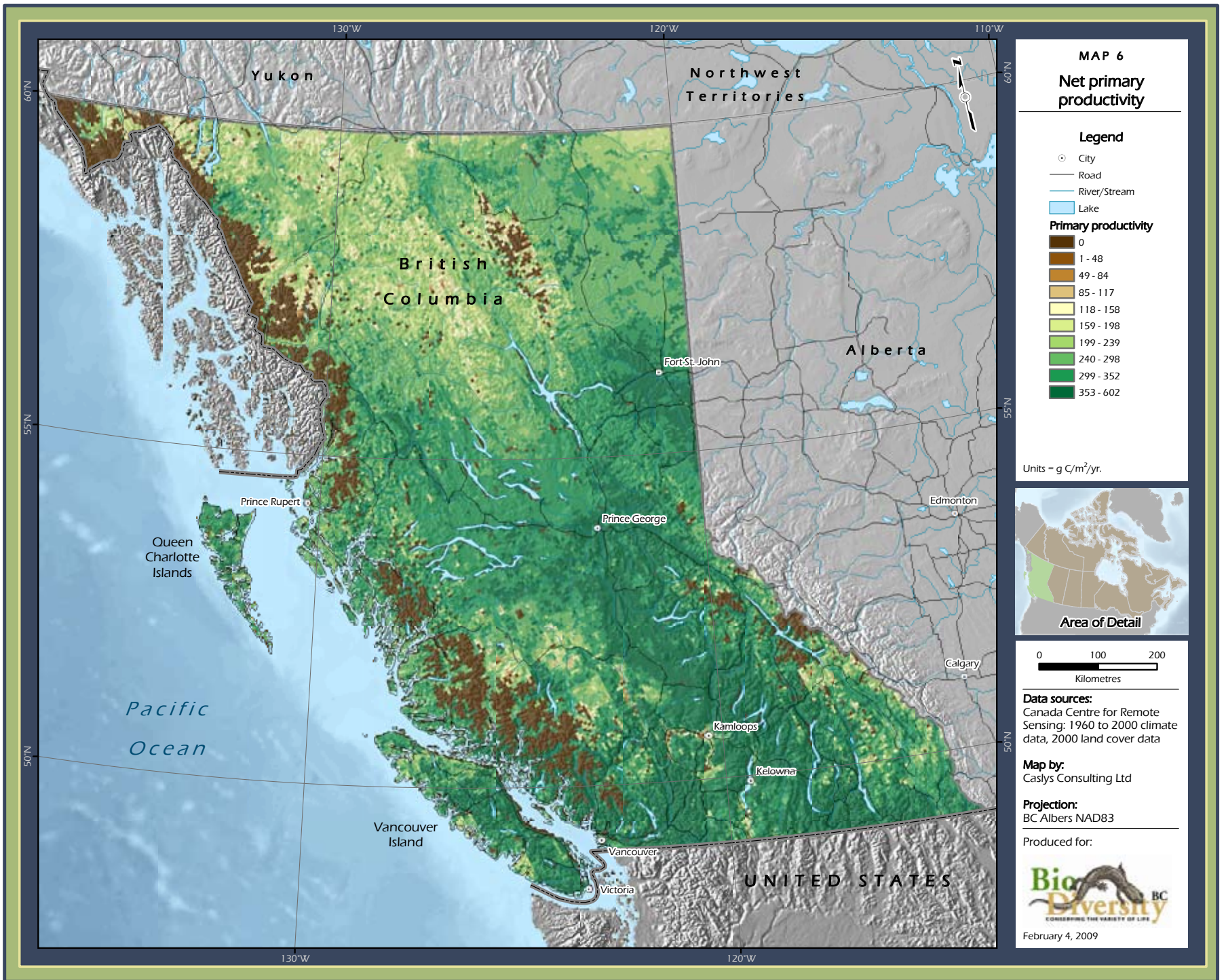
West coast British Columbia rainforest.

PHOTO: ROBERT KOOPMANS.

rectly 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).²¹

Net primary productivity in terrestrial ecosystems is most often measured as mass of carbon fixed per unit area per year ($\text{g C/m}^2/\text{yr}$) and is a major component of the carbon cycle.²² NPP is useful in climate science to calculate how much carbon is removed from the atmosphere by plants.²³

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.^{24,25,26,27}



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.²⁸ The system is organized



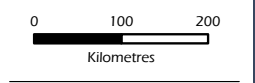
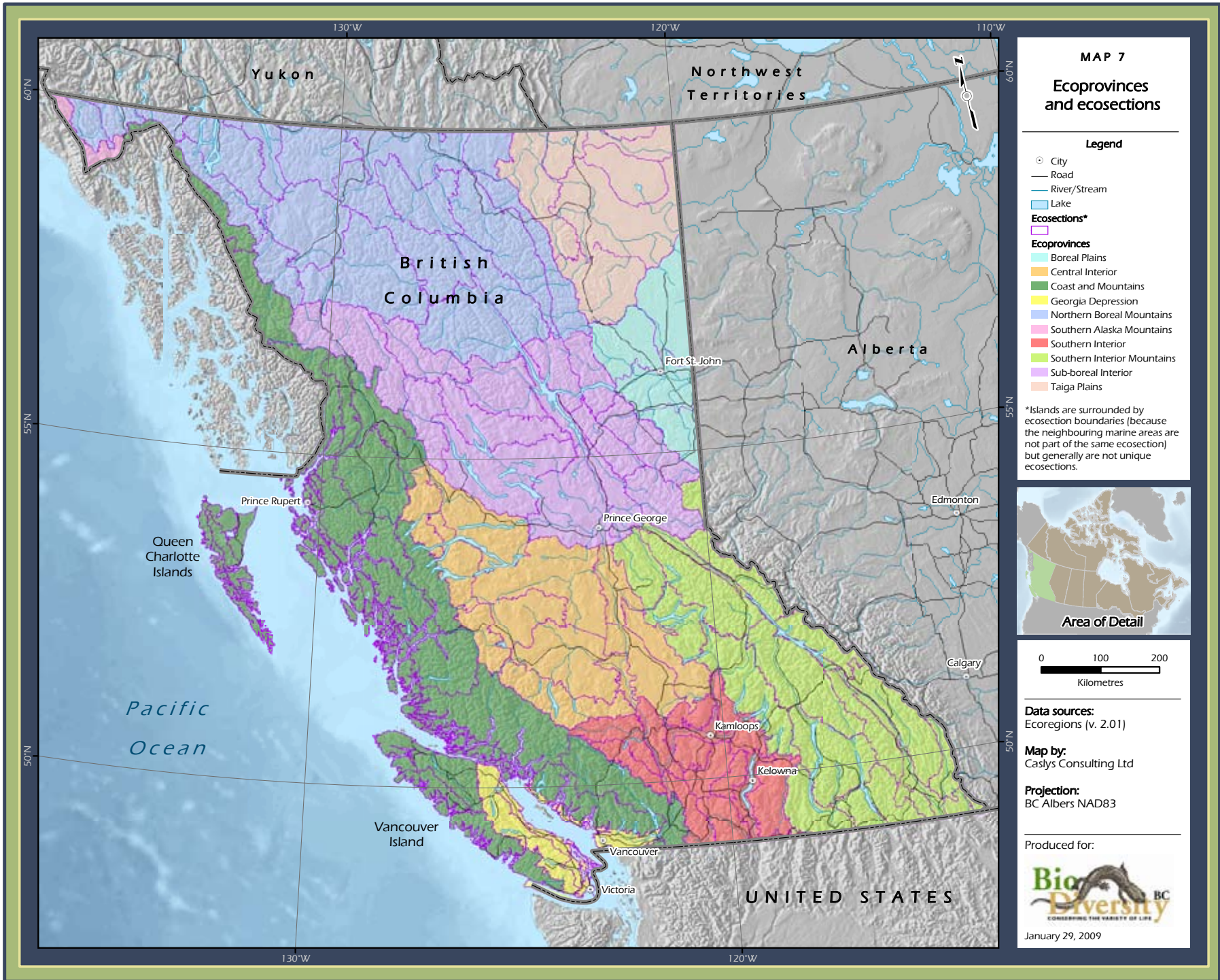
Near Kamloops.

PHOTO: MAREK SLUSARCZYK.

according to five hierarchical levels: Ecodomain, Ecodivision, Ecoprovince, Ecoregion and Ecosection. The highest two levels of this classification, Ecodomain and Ecodivision, are very broad and place British Columbia in a global context. Ecoprovinces, Ecoregions, and Ecosections, 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 Ecosection 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. Ecosections 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 Ecoprovinces and the 139 Ecosection divisions for the province (Map 7).



January 29, 2009

Biogeoclimatic Ecosystem Classification

Biogeoclimatic Ecosystem Classification (BEC) zones, commonly referred to as biogeoclimatic zones, are large geographical areas sharing similar climate and vegetation.^{h,29} 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 Ecosections (p.18), form the basis of the biodiversity spatial analysis units (pp.4) used to produce the maps pre-

sented 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.

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

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.

^hThe BEC system was developed independently of Ecoregion Classification (p.18). In order to provide a place of intersection for the two systems, ecosection boundaries were moved to the nearest biogeoclimatic variant boundary so that an ecosection always shares a boundary with a variant.

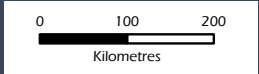
MAP 8
Biogeoclimatic ecosystem classification - zones

Legend

- City
- Road
- River/Stream
- Lake

Zone

- Boreal Altai Fescue Alpine
- Coastal Mountain-heather Alpine
- Interior Mountain-heather Alpine
- Spruce – Willow – Birch
- Boreal White and Black Spruce
- Sub-Boreal Pine – Spruce
- Sub-Boreal Spruce
- Mountain Hemlock
- Engelmann Spruce – Subalpine Fir
- Montane Spruce
- Bunchgrass
- Ponderosa Pine
- Interior Douglas-fir
- Coastal Douglas-fir
- Interior Cedar – Hemlock
- Coastal Western Hemlock



Data sources:
 Biogeoclimatic Ecosystem Classification (v. 6.0)

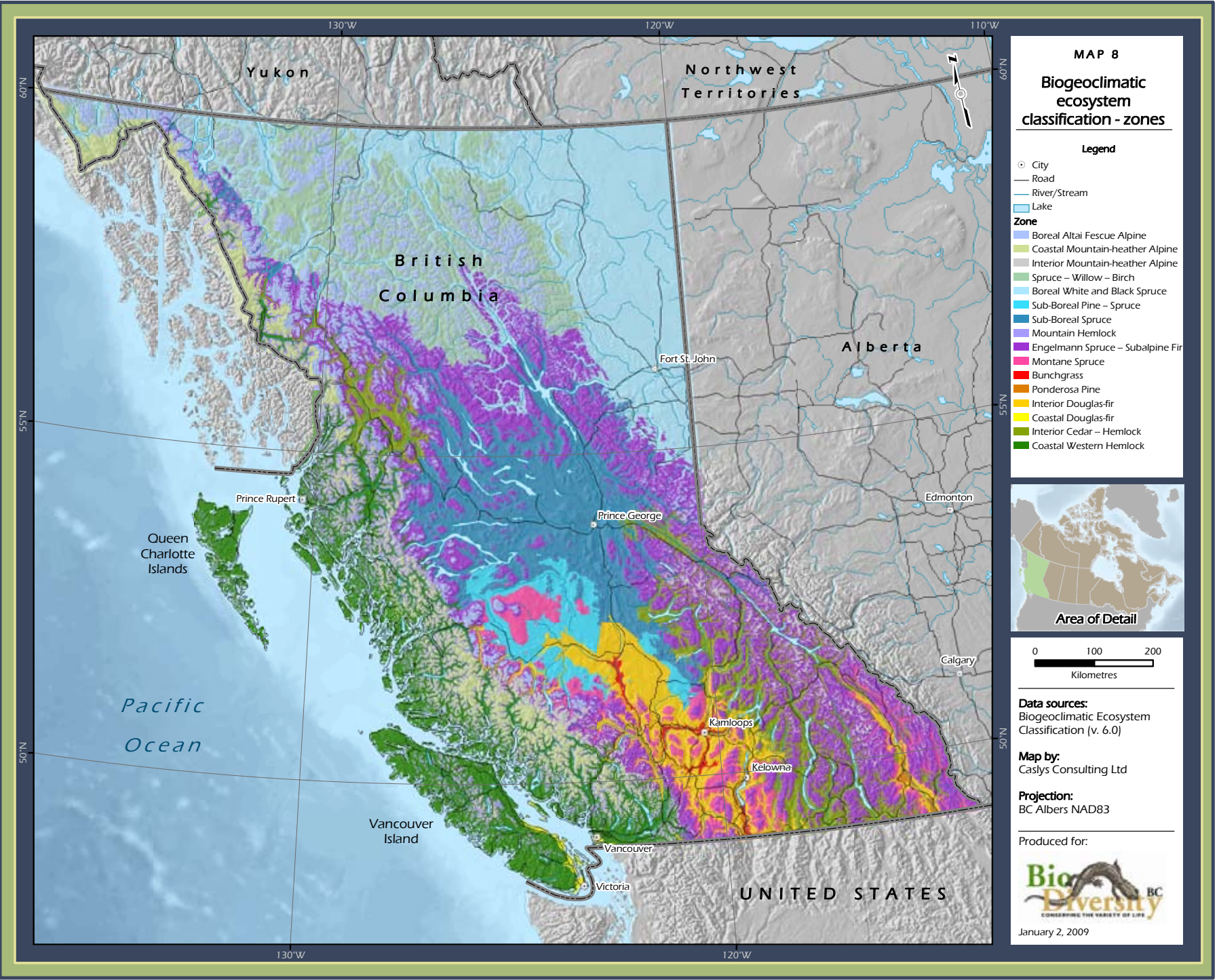
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



January 2, 2009



BIOGEOCLIMATIC ZONES OF CONSERVATION CONCERN

The **conservation status** of each of the biogeoclimatic zones was determined using a modification of NatureServe¹ 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.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),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.

BIOGEOCLIMATIC ZONE	CONSERVATION STATUS
Bunchgrass	Imperilled (S2)
Coastal Douglas-fir	Imperilled (S2)
Ponderosa Pine	Imperilled/Vulnerable (S2/S3)
Interior Douglas-fir	Vulnerable (S3)
Coastal Western Hemlock	Apparently secure (S4)
Interior Cedar–Hemlock	Apparently secure (S4)
Sub-Boreal Pine–Spruce	Apparently secure (S4)
Boreal White and Black Spruce	Apparently secure (S4)
Spruce–Willow–Birch	Apparently secure (S4)
Sub-Boreal Spruce	Apparently secure (S4)
Montane Spruce	Apparently secure (S4)
Mountain Hemlock	Apparently secure (S4)
Engelmann Spruce–Subalpine Fir	Secure (S5)
Coastal Mountain-heather Alpine	Secure (S5)
Boreal Altai Fescue Alpine	Secure (S5)
Interior Mountain-heather Alpine	Secure (S5)

SOURCE: Kremsater, L. 2007. Draft S Ranks and Surrogate G Ranks for BEC Zones and Draft S Ranks for Ecoprovinces and Major Drainage Areas of B.C.: Preliminary Rankings for Informing the Biodiversity Status Report and Action Plan. Biodiversity BC, Victoria, BC. 64pp. Available at: www.biodiversitybc.org.

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.

¹ NatureServe is an international network that includes the B.C. Conservation Data Centre. For more information see www.natureserve.org/explorer.

MAP 9
Biogeoclimatic zones of conservation concern

- Legend**
- City
 - Road
 - River/Stream
 - ▭ Lake
- Zone**
- ▭ Bunchgrass
 - ▭ Ponderosa Pine
 - ▭ Interior Douglas-fir
 - ▭ Coastal Douglas-fir

Status assessment from:
 Kremsater, L. 2007. Draft S Ranks and Surrogate G Ranks for BEC Zones and Draft S Ranks for Ecoprovinces and Major Drainage Units of B.C.: Preliminary Rankings for Informing the Biodiversity Status Report and Action Plan. Biodiversity B.C., Victoria, B.C. 64pp.



Data sources:
 Biogeoclimatic Ecosystem Classification (v. 6.0)

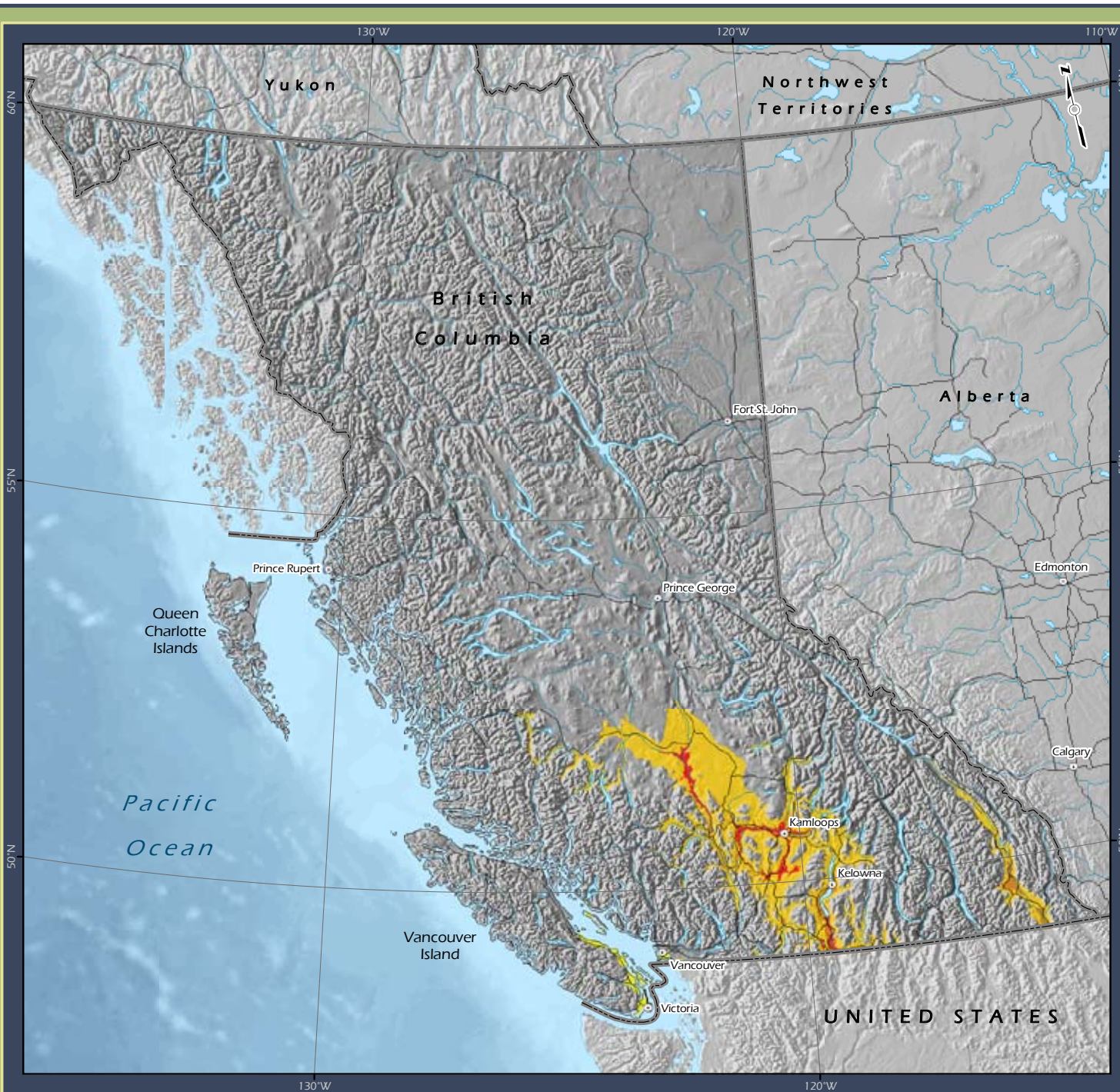
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009



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.^{j,32} 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.³³ 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.

GLOBAL RANGE CLASS		PERCENT OF GLOBAL RANGE THAT OCCURS IN B.C.
1	Endemic	100% of global range
2	Very High	75–99% of global range
3	High	51–74% of global range
4	Moderately High	30–50% of global range
5	Intermediate	11–29% of global range
6	Low and Widespread	less than 10% of global range, and occurs over more than 30% of the province
7	Low and Localized	less than 10% of global range, and occurs over more than 30% of the province

SOURCE: Adapted from Bunnell, F., L. Kremsater and I. Houde. 2006. Applying the Concept of Stewardship Responsibility in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 188pp. Available at: www.biodiversitybc.org.

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

^j 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:
 Kreamsater, L. 2007. Draft S Ranks
 and Surrogate G Ranks for BEC
 zones and Draft S Ranks for
 Ecoprovinces and Major Drainage
 Units of B.C.: Preliminary Rankings
 for Informing the Biodiversity Status
 Report and Action Plan.
 Biodiversity B.C., Victoria, B.C. 64pp.



Data sources:
 Biogeoclimatic Ecosystem
 Classification (v. 6.0)

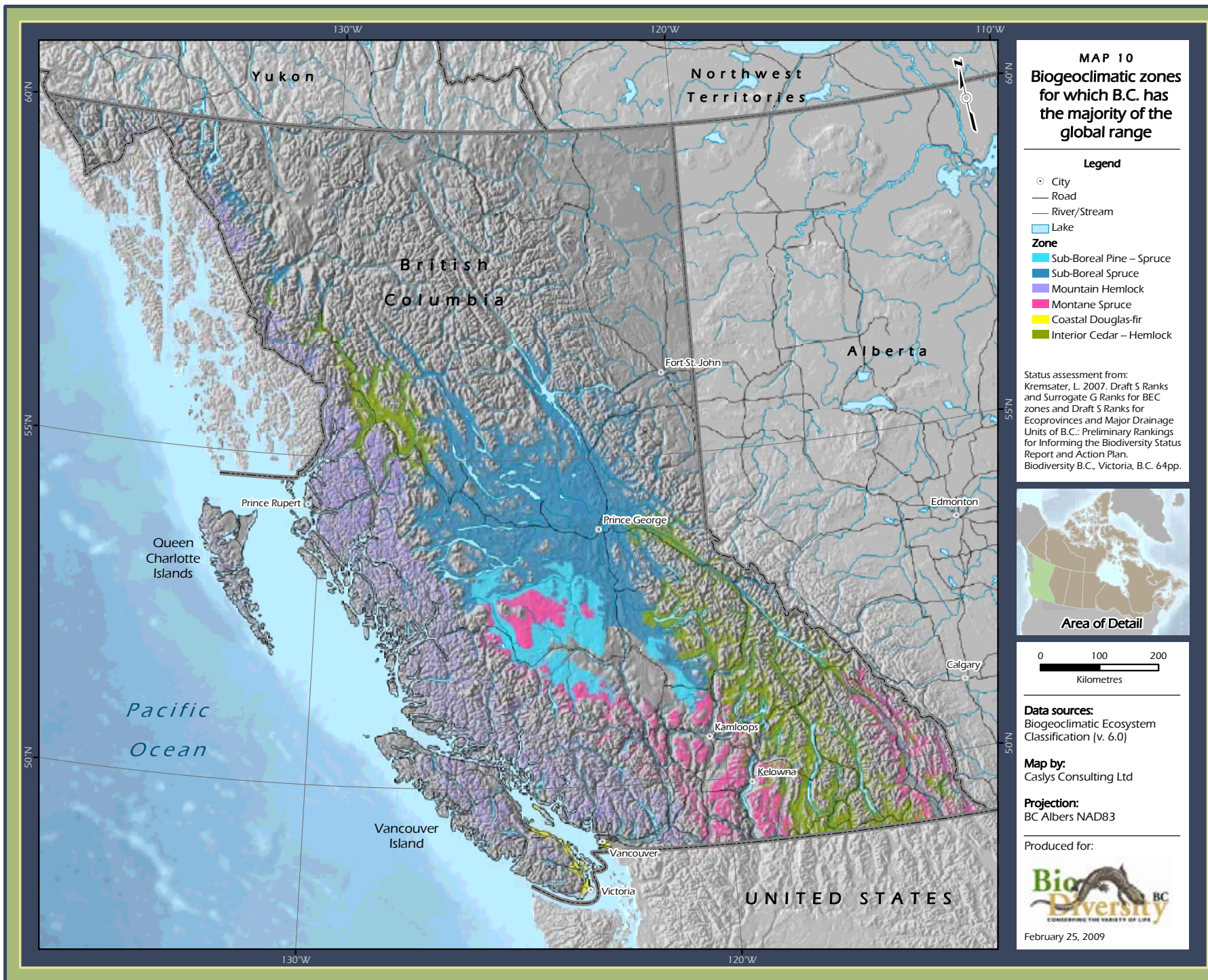
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



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).³⁴ Although not all ecological communities in the province have been described, the current list represents a majority of the province's ecological communities.³⁵ Ecological community classification is the most incomplete for alpine ecosystems, but this is a focus of current classification work.³⁶

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.^{37,38} 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.³⁹ 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.⁴⁰ 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 ECOLOGICAL COMMUNITIES IN B.C. BY BIOGEOCLIMATIC ZONE.









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

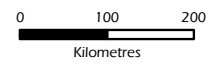
SOURCE: Prepared for this report with data from the B.C. Conservation Data Centre.

NOTES: **Boldface** indicates biogeoclimatic zone is of conservation concern. Some ecological communities occur in more than one biogeoclimatic zone.

MAP 11
Ecosystem mapping
as of 2006

Legend

-  City
-  Road
-  River/Stream
-  Lake
-  Predictive Ecosystem Mapping (1:50,000)
-  Terrestrial Ecosystem Mapping (1:50,000)
-  Terrestrial Ecosystem Mapping (1:20,000)
-  Sensitive Ecosystem Inventory



Data sources:
 B.C. Ministry of Environment

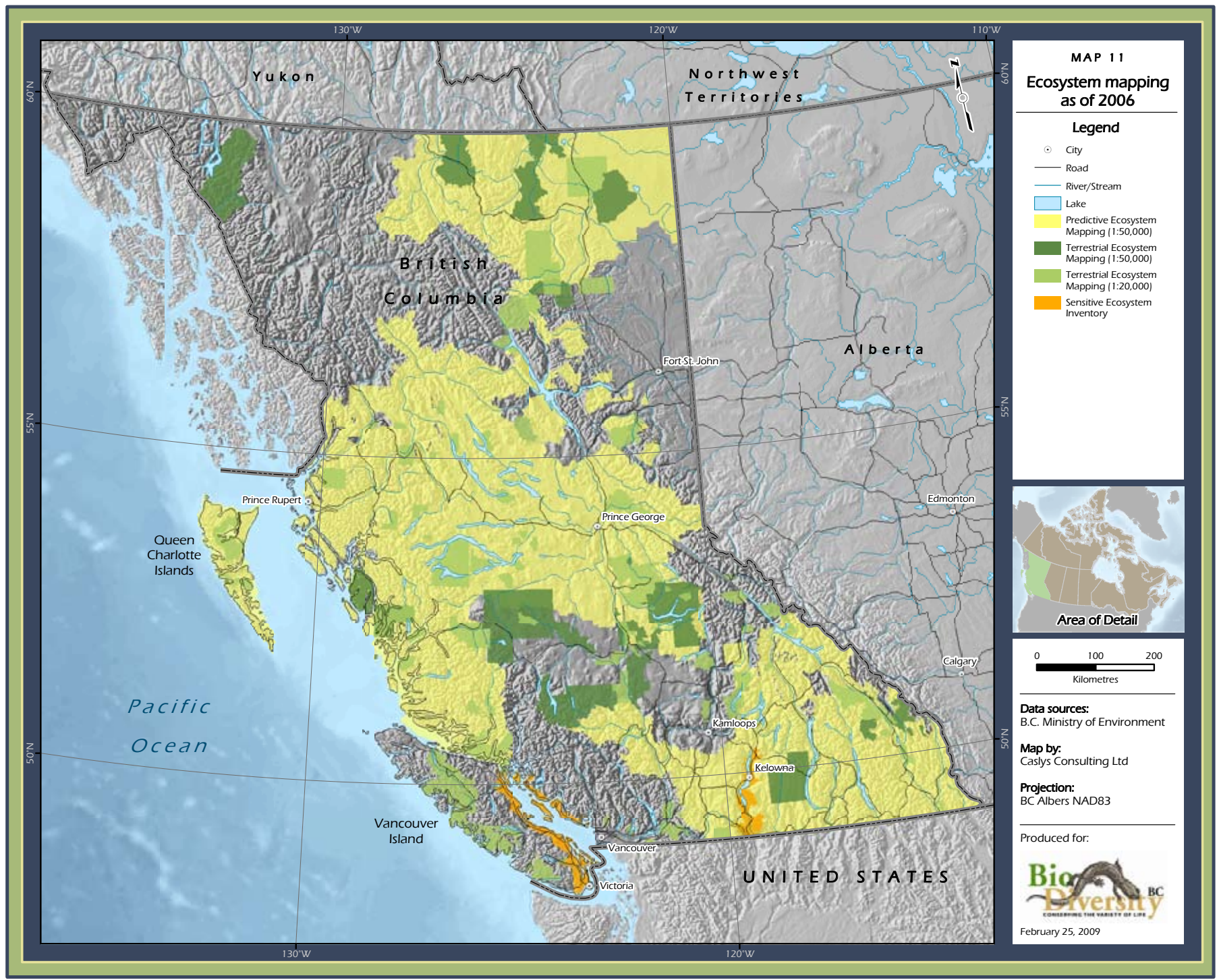
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009



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.⁴¹ 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).^{42,43} British Columbia holds 25% of Canada's freshwater supply⁴⁴ and 5% of the world's supply⁴⁵.

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, microorganisms, 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.⁴⁶ 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).⁴⁷ 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.

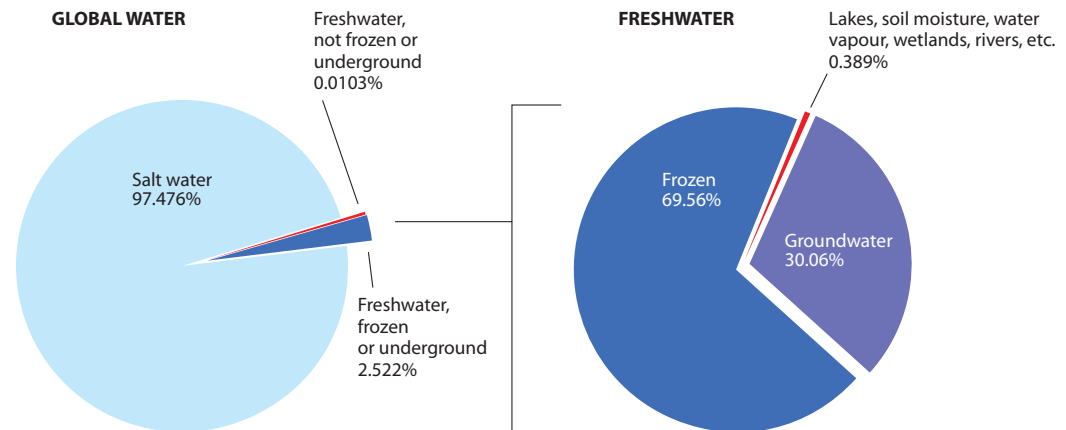
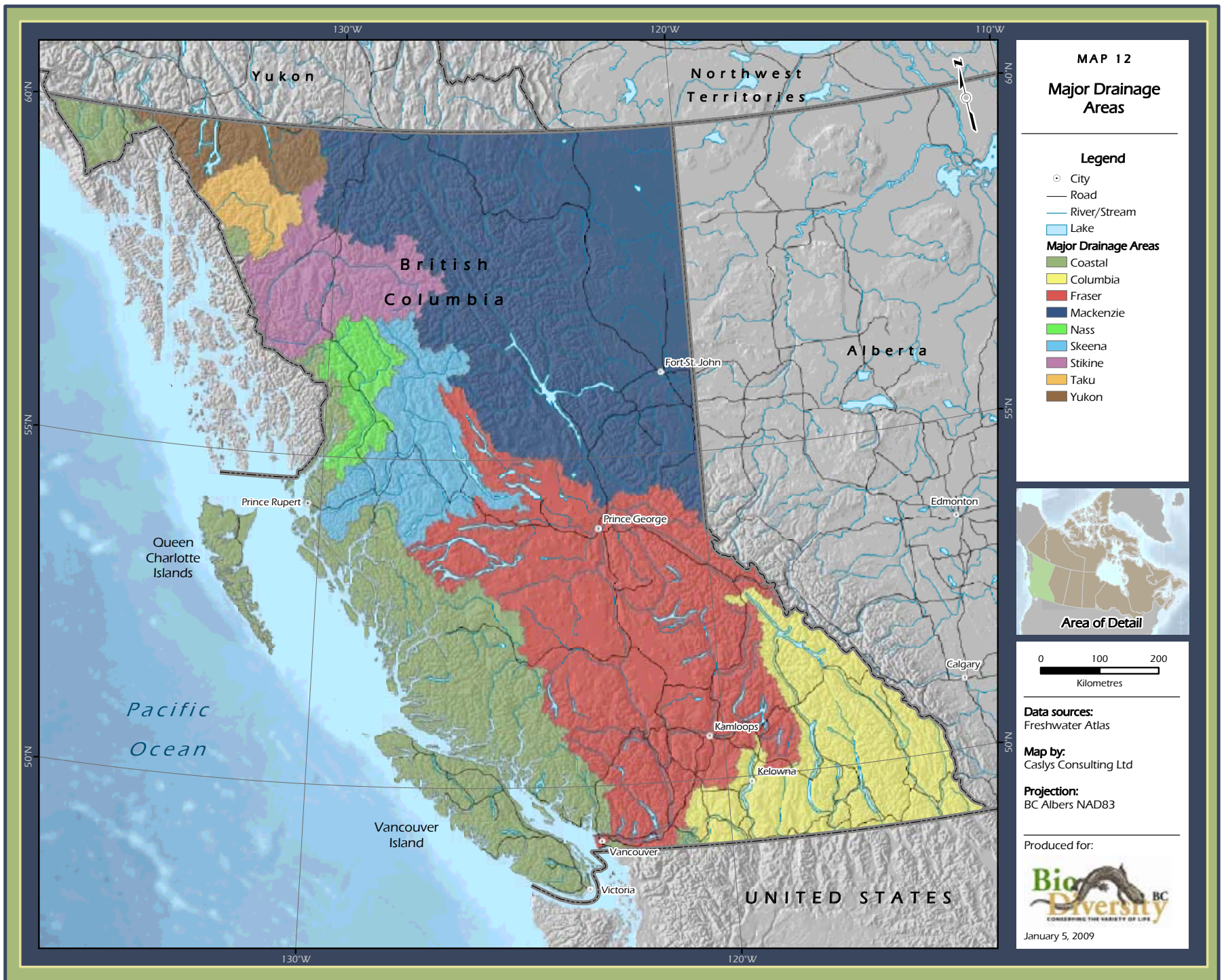


FIGURE 4: The world's water supply.

SOURCE: Adapted from Gleick, P.H. 2000. *The World's Water 2000-2001*. Washington, B.C. Island Press.



MAP 12
Major Drainage Areas

Legend

- City
- Road
- River/Stream
- Lake

Major Drainage Areas

- Coastal
- Columbia
- Fraser
- Mackenzie
- Nass
- Skeena
- Stikine
- Taku
- Yukon



Data sources:
 Freshwater Atlas

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



January 5, 2009



Columbia wetlands.

PHOTO: KAREN WIPOND.

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 6. PROVINCIAL CONSERVATION STATUS OF MAJOR DRAINAGE AREAS IN B.C.

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

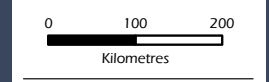
SOURCE: Kremsater, L. 2007. Draft S Ranks and Surrogate G Ranks for BEC Zones and Draft S Ranks for Ecoprovinces and Major Drainage Areas of B.C.: Preliminary Rankings for Informing the Biodiversity Status Report and Action Plan. Biodiversity BC, Victoria, BC. 64pp. Available at: www.biodiversitybc.org.

NOTES: **Boldface** indicates the Major Drainage Area is of conservation concern.

MAP 13
Major Drainage
Areas of conservation
concern

- Legend**
- City
 - Road
 - River/Stream
 - Lake
- Major Drainage Areas**
- Coastal
 - Columbia
 - Fraser
 - Mackenzie

Status assessment from:
 Kreamsater, L. 2007. Draft S Ranks
 and Surrogate G ranks for BEC
 zones and draft S ranks for
 Ecoprovinces and Major Drainage
 Units of B.C.: Preliminary rankings
 for Informing the Biodiversity Status
 Report and Action Plan.
 Biodiversity BC, Victoria, BC. 64pp.

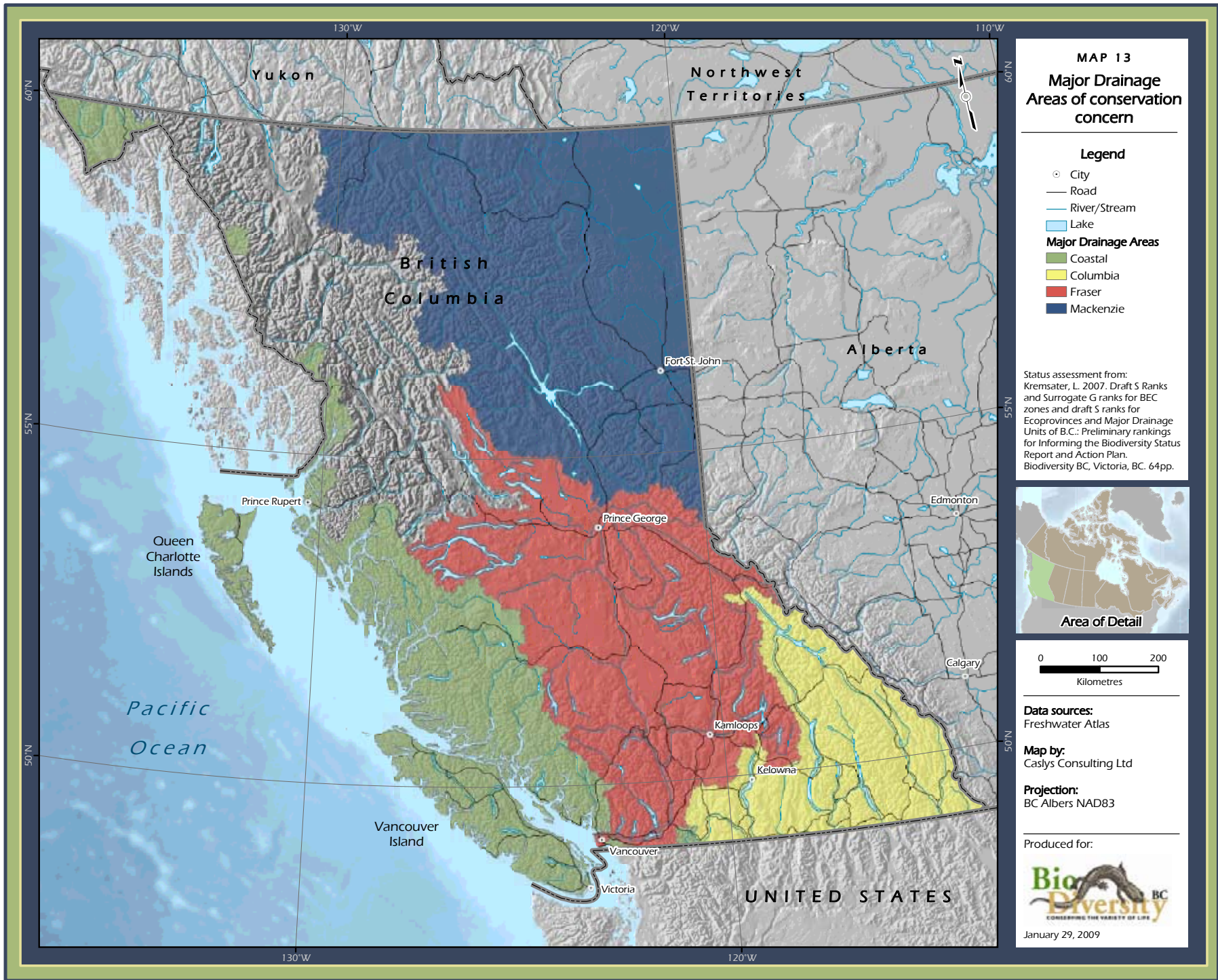


Data sources:
 Freshwater Atlas

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



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) des-

ignations. 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.

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

SOURCE: Ken Morrison and Karen Wipond, Parks and Protected Areas Division, Ministry of Environment. 2008.

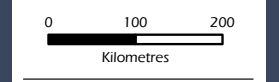
NOTE: Federally designated marine protected areas are not included.

*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**
- City
 - Road
 - River/Stream
 - Lake
 - National park*
 - Provincial park/protected area
 - Regional park**
- Conservation lands**
- Wildlife Management Area
 - All other conservation land***

* 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

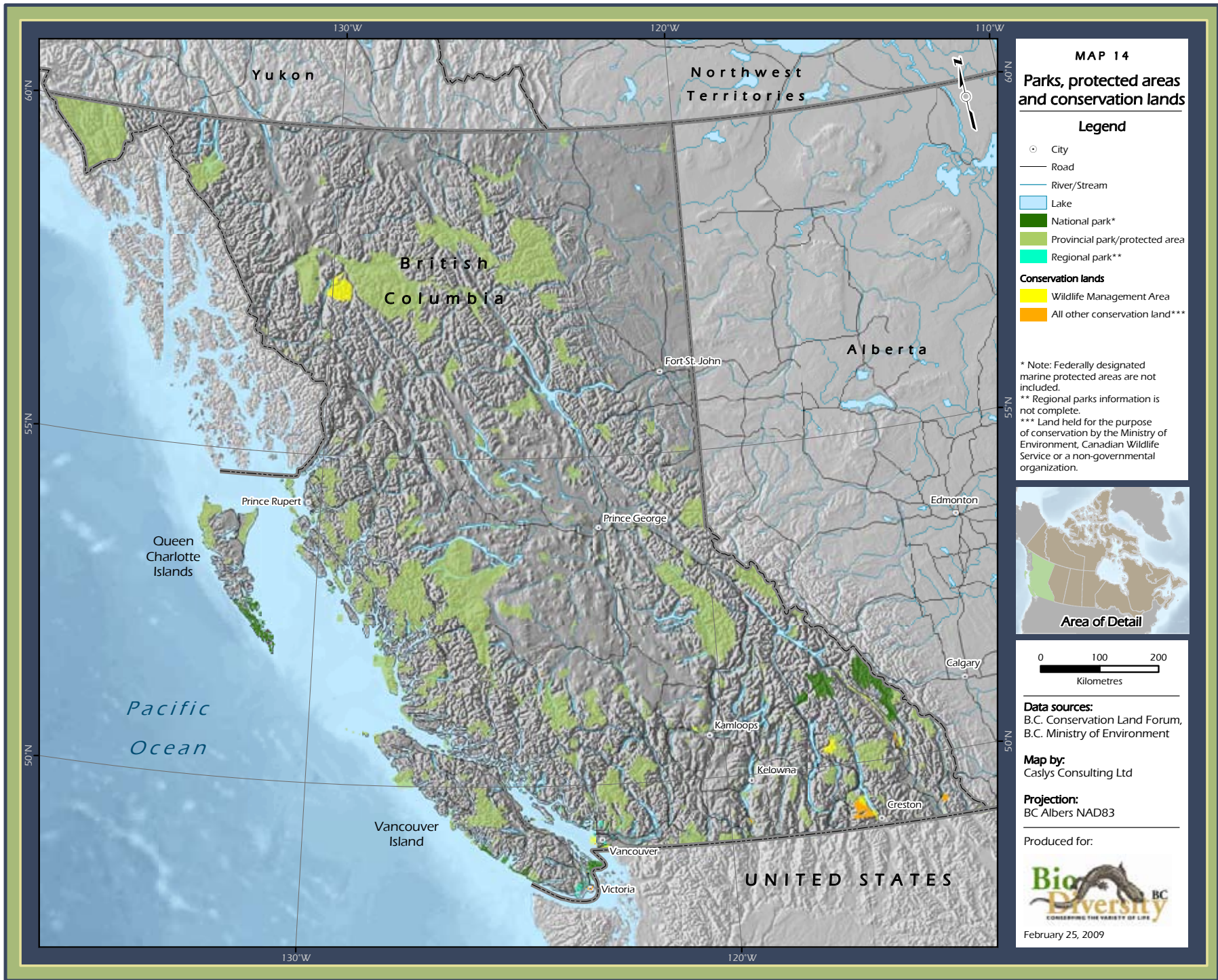
Map by:
 Caslys Consulting Ltd

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February 25, 2009





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.⁵⁸ More than 50,000 **native species** are thought to live here,⁵⁹ 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.⁶⁰

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.⁶¹

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 richness⁶² are Ponderosa Pine, Coastal Douglas-fir, Bunchgrass and Interior Douglas-fir, all zones of conservation concern (p.22).⁶³

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.

SPECIES GROUP	NUMBER OF NATIVE SPECIES MAPPED		
	ALL SPECIES	TERRESTRIAL	FRESHWATER
Vertebrates	391	319	109
Amphibians	20	20	17
Birds	187	185	18
Freshwater Fishes	70	0	70
Mammals	102	102	3
Reptiles and Turtles	12	12	1
Invertebrates	257	257	85
Butterflies and Skippers	172	172	0
Dragonflies and Damselflies	85	85	85
Vascular Plants	1,992	1,718	400
Ferns and Fern Allies	103		
Conifers	25	Not differentiated	Not differentiated
Flowering Plants (Monocots)	525	576	194
Flowering Plants (Dicots)	1,339		
TOTAL	2,640	2,294	594

SOURCE: Warman, L. and G.G.E. Scudder. 2007. Species Richness and Summed Irreplaceability in B.C. Biodiversity BC, Victoria, BC. 36pp. Available at: www.biodiversitybc.org.

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).



Data sources:
Compiled by the University of British Columbia

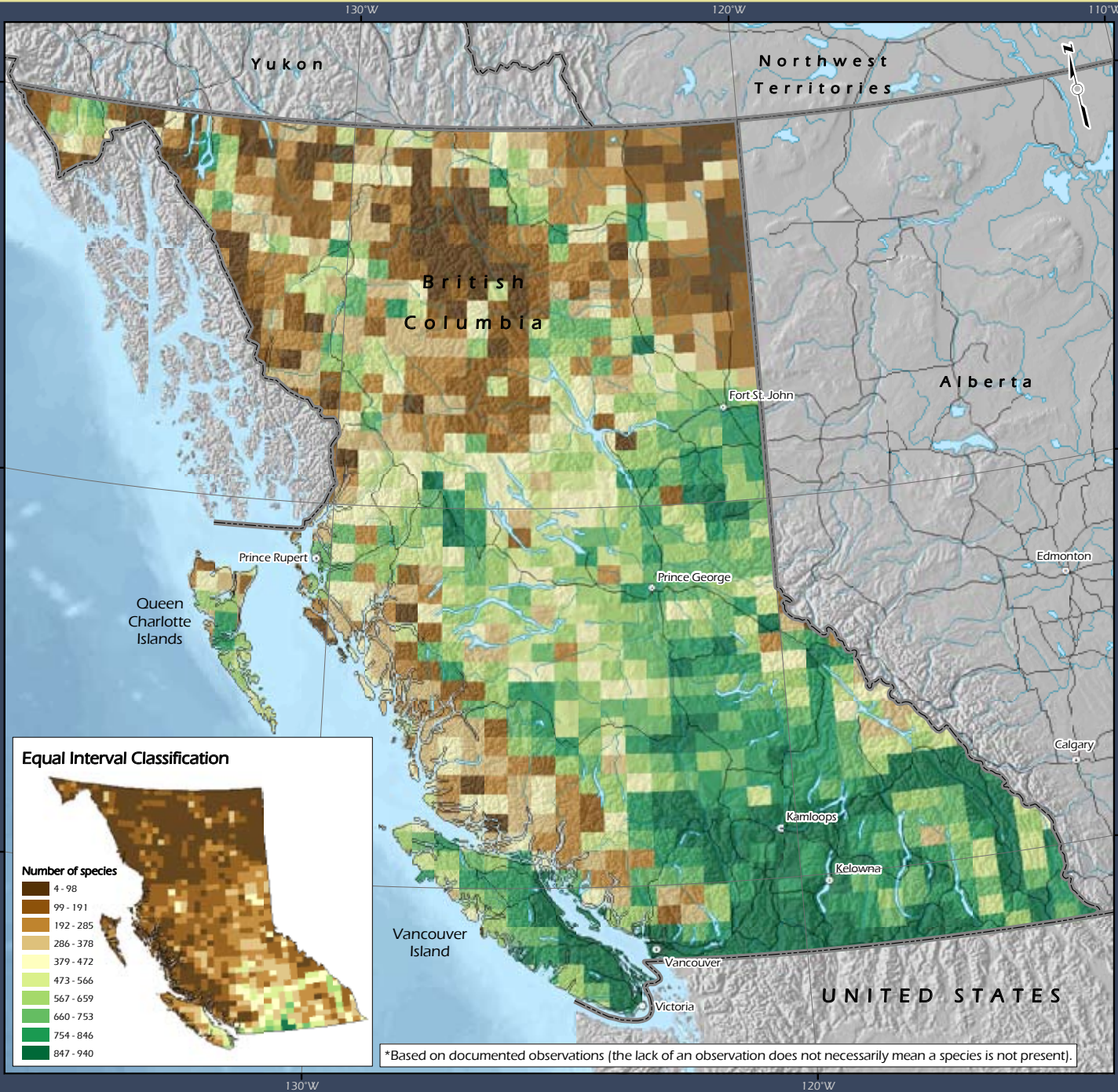
Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



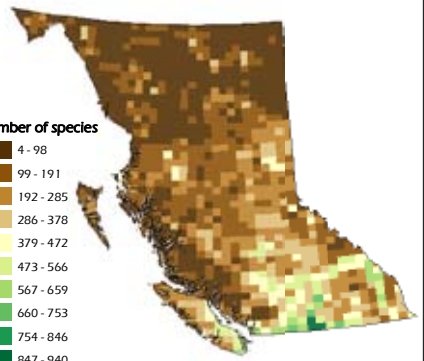
February 4, 2009



Equal Interval Classification

Number of species

- 4 - 98
- 99 - 191
- 192 - 285
- 286 - 378
- 379 - 472
- 473 - 566
- 567 - 659
- 660 - 753
- 754 - 846
- 847 - 940



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

MAP 16
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).



Data sources:
 Compiled by the University of British Columbia

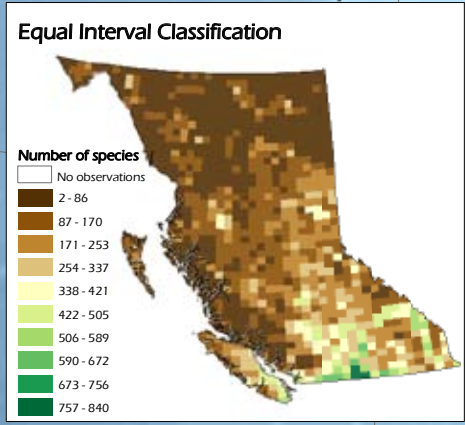
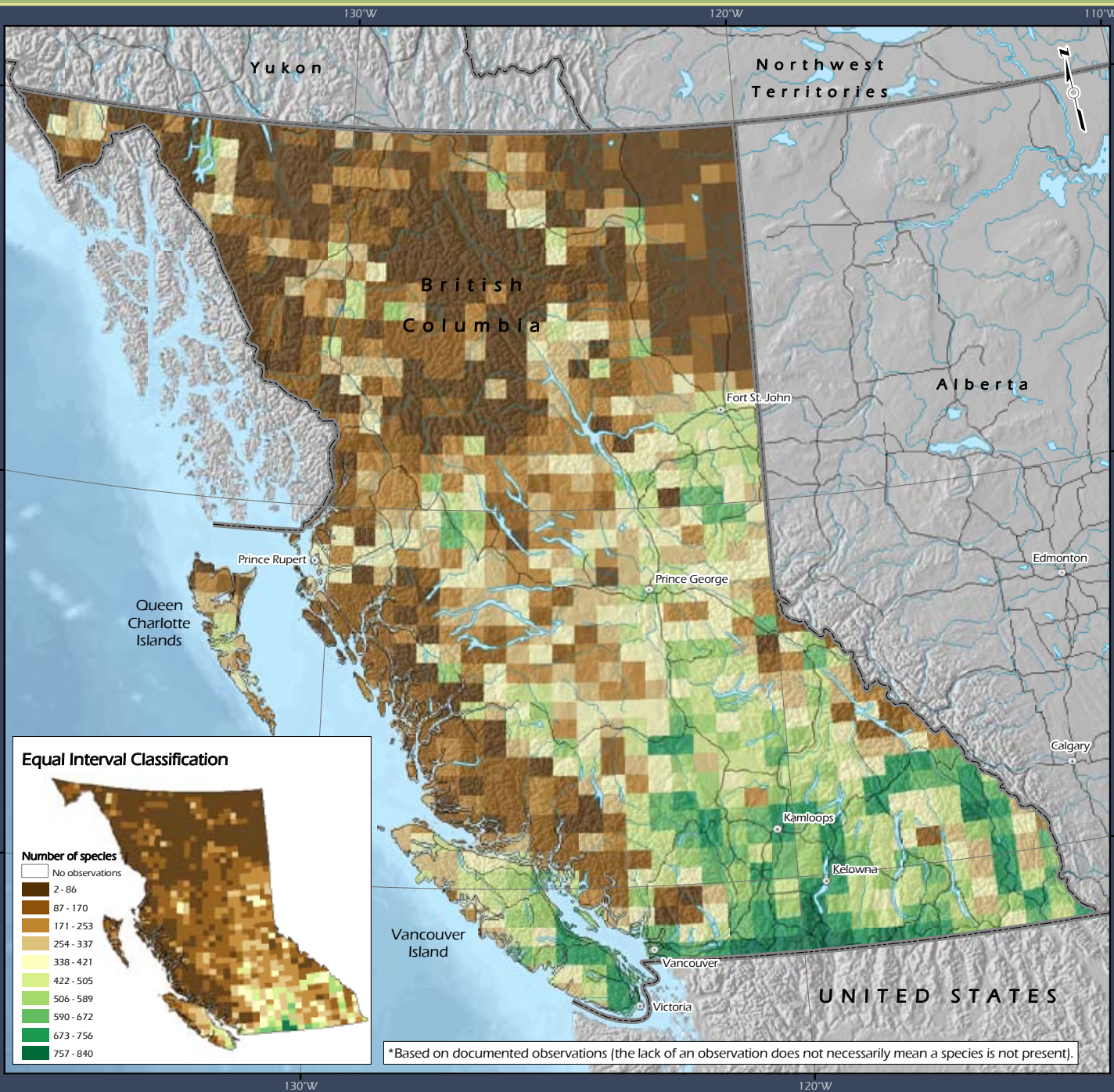
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

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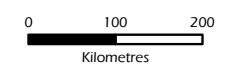


*Based on documented observations (the lack of an observation does not necessarily mean a species is not present).

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).



Data sources:
 Compiled by the University of British Columbia

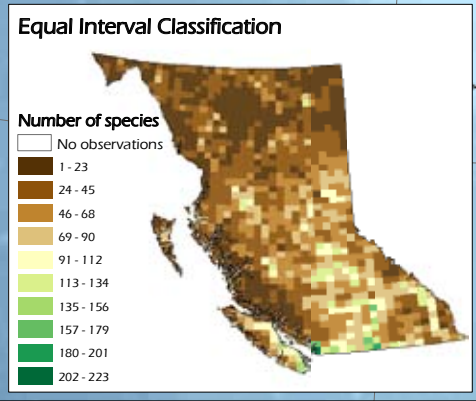
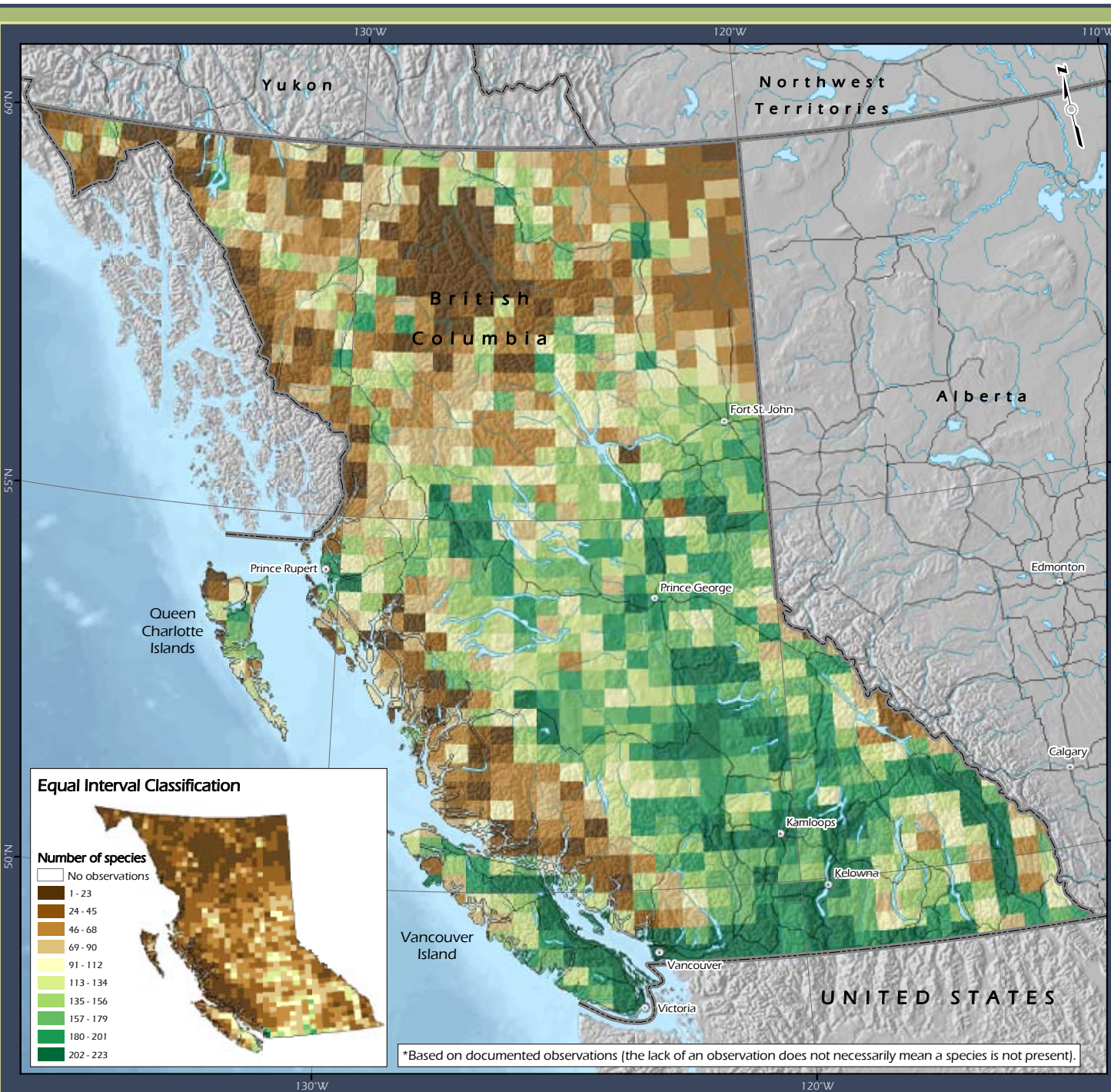
Map by:
 Caslys Consulting Ltd

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

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^k 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.⁶⁴ 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.



Burrowing owl.

PHOTO: BRIAN KLINKENBERG.

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.⁶⁵ 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.

CONSERVATION STATUS RANK	GLOBAL (G RANK)		PROVINCIAL (S RANK)	
	TOTAL SPECIES	PERCENTAGE OF SPECIES	NUMBER OF SPECIES	PERCENTAGE OF SPECIES
Extinct or Extirpated (GX, SX)	1	<1%	14	<1%
Historical* (GH, SH)	1	<1%	28	<1%
Critically Imperilled (G1, S1)	19	<1%	301	8%
Imperilled (G2, S2)	40	<1%	629	17%
Vulnerable (G3, S3)	172	5%	668	18%
Total species of conservation concern	233	6%	1,640	43%
Apparently secure or secure (G4, S4, G5,S5)	3,475	91%	2,055	54%
Not ranked or unrankable (GNR,SNR or GU,SU)	100	3%	100	3%
Total number of species assessed	3,808			

SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

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

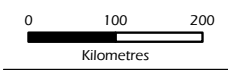
^kNatureServe Canada, part of an international NatureServe Network, provides scientific information about Canada's species and ecosystems.

MAP 18
Species richness:
species of global
conservation concern*

Legend

- City
 - Road
 - River/Stream
 - ▭ Lake
- Number of species**
- ▭ No observations
 - ▭ 1
 - ▭ 2
 - ▭ 3
 - ▭ 4
 - ▭ 5
 - ▭ 6
 - ▭ 7
 - ▭ 8
 - ▭ 10 - 13
 - ▭ 14 - 24

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

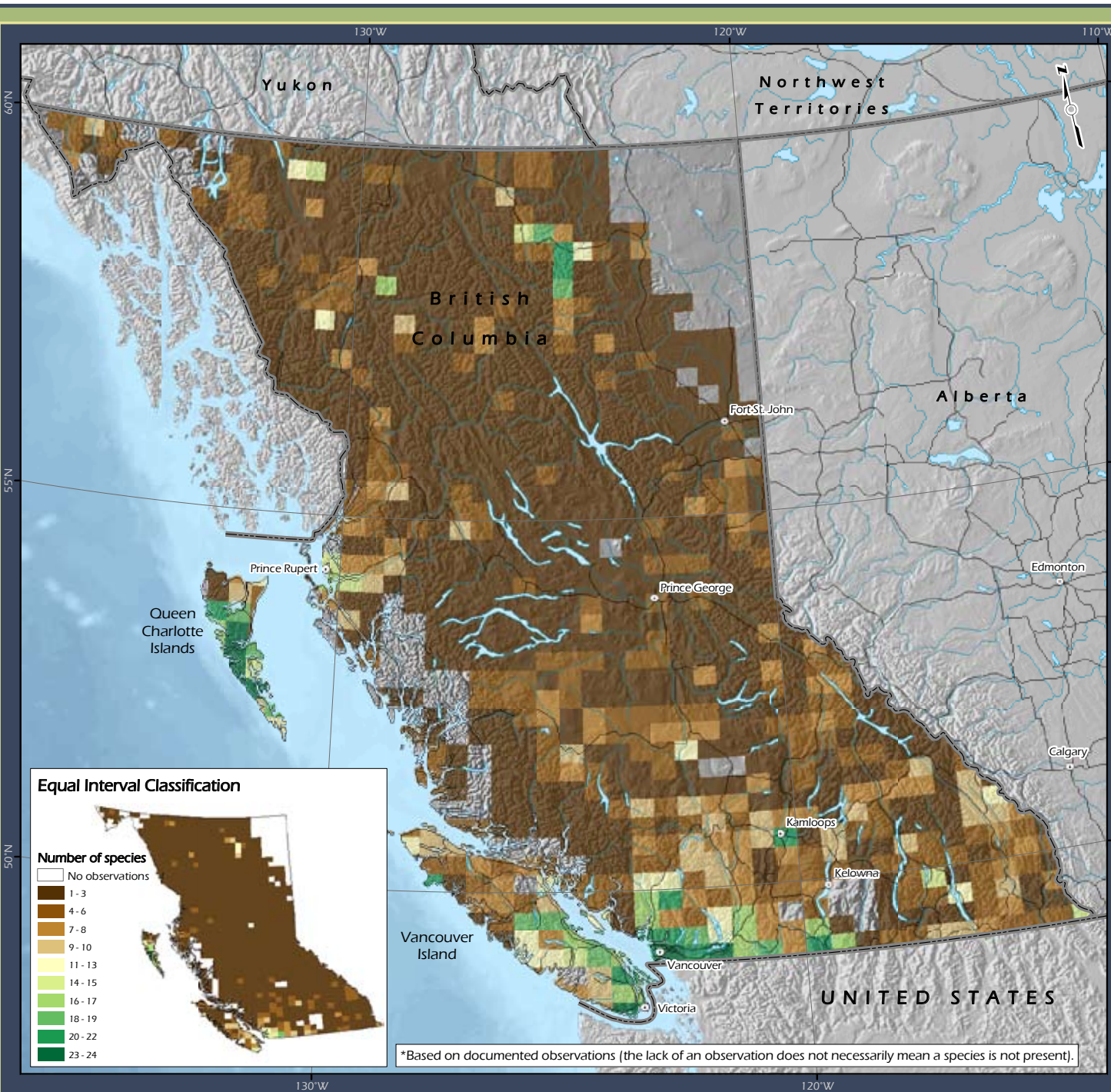
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:

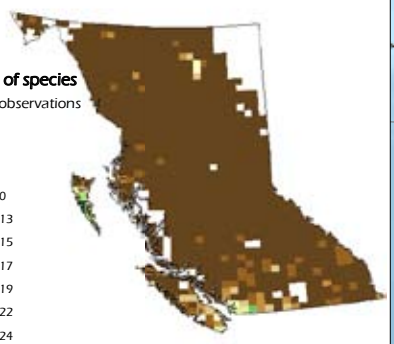


February 4, 2009



Equal Interval Classification

- Number of species**
- ▭ No observations
 - ▭ 1 - 3
 - ▭ 4 - 6
 - ▭ 7 - 8
 - ▭ 9 - 10
 - ▭ 11 - 13
 - ▭ 14 - 15
 - ▭ 16 - 17
 - ▭ 18 - 19
 - ▭ 20 - 22
 - ▭ 23 - 24



*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,⁶⁶ 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.⁶⁷ 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.⁶⁸ 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.^{69,70}



Sharp-tailed snake (*Contia tenuis*).

PHOTO: KRISTIINA OVASKA.

MAP 19
Species richness:
species of provincial
conservation concern*

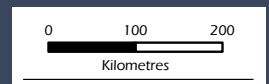
Legend

- 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).



Data sources:
 Compiled by the University of British Columbia

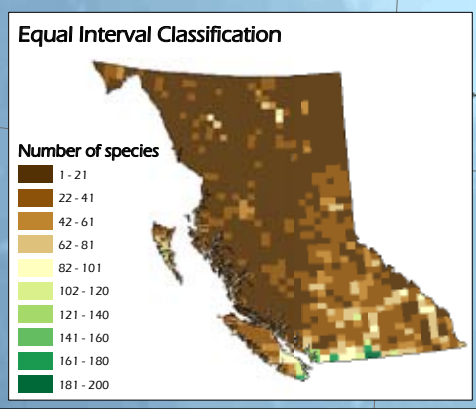
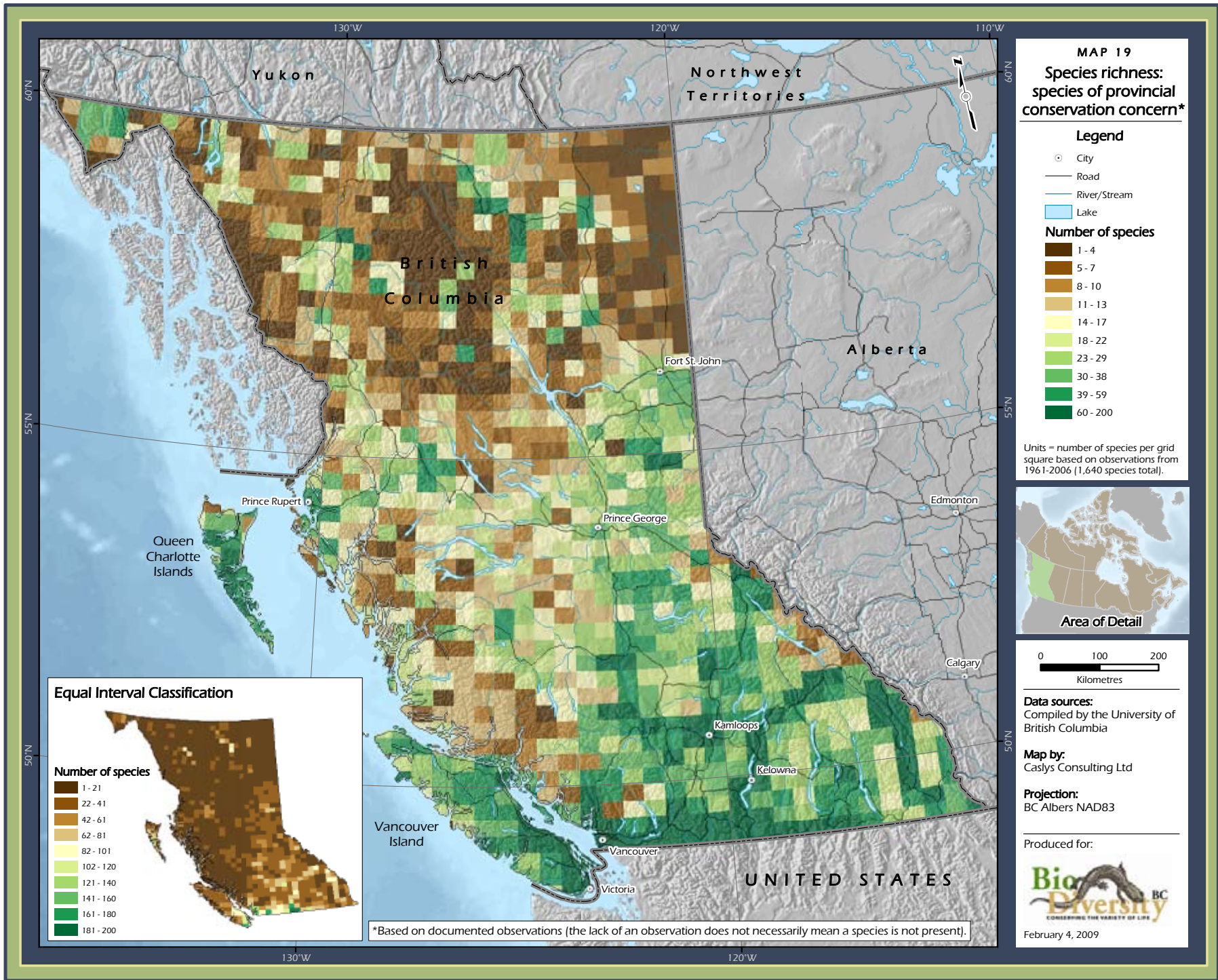
Map by:
 Caslys Consulting Ltd

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).

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



Townsend's vole (*Micotus townsendii*).

PHOTO: DAVID SHACKLETON.

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.⁷¹ 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 wide-

spread 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.⁷² 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.

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

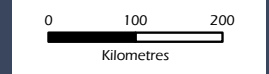
SOURCE: Bunnell, E. L. Kremsater and I. Houde. 2006. Applying the Concept of Stewardship Responsibility in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 188pp. Available at: www.biodiversitybc.org.

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

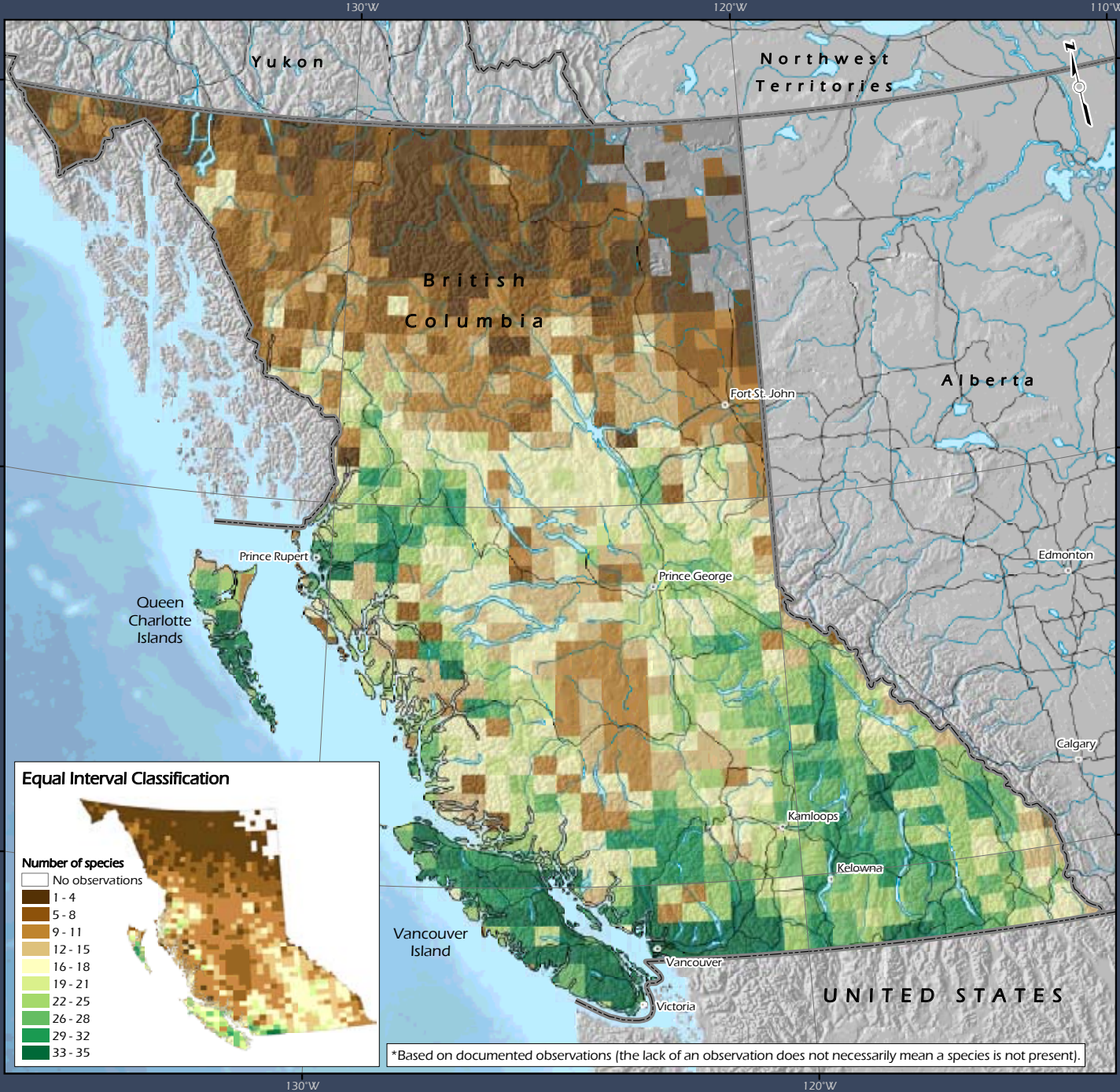
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

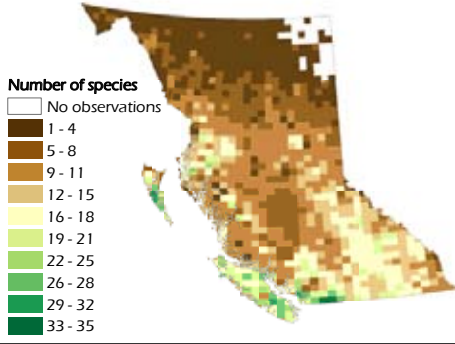
Produced for:



February 4, 2009



Equal Interval Classification



*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.⁷³ 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 freshwa-



Columbia spotted frog (*Rana luteiventris*).

PHOTO: WERNER EIGELSREITER.

ter 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.⁷⁴ 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).⁷⁵ 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.,⁷⁶ however none are endemic to the province.





TABLE 11. NATIVE AMPHIBIANS OF CONSERVATION CONCERN IN B.C.

SPECIES NAME, COMMON NAME	CONSERVATION RANK	
	GLOBAL	PROVINCIAL
<i>Ambystoma tigrinum</i> , tiger salamander	Secure (G5)	Imperilled (S2)
<i>Ascaphus montanus</i> , Rocky Mountain tailed frog	Apparently secure (G4)	Critically imperilled (S1)
<i>Ascaphus truei</i> , coastal tailed frog	Apparently secure (G4)	Vulnerable/apparently secure (S3S4)
<i>Dicamptodon tenebrosus</i> , Pacific giant salamander	Secure (G5)	Imperilled (S2)
<i>Plethodon idahoensis</i> , Coeur d'Alene salamander	Apparently secure (G4)	Vulnerable (S3)
<i>Rana aurora</i> , red-legged frog	Apparently secure (G4)	Vulnerable/apparently secure (S3S4)
<i>Rana pipiens</i> , northern leopard frog	Secure (G5)	Critically imperilled (S1)
<i>Rana pretiosa</i> , Oregon spotted frog	Imperilled (G2)	Critically imperilled (S1)
<i>Spea intermontana</i> , Great Basin spadefoot	Secure (G5)	Vulnerable (S3)



SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

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

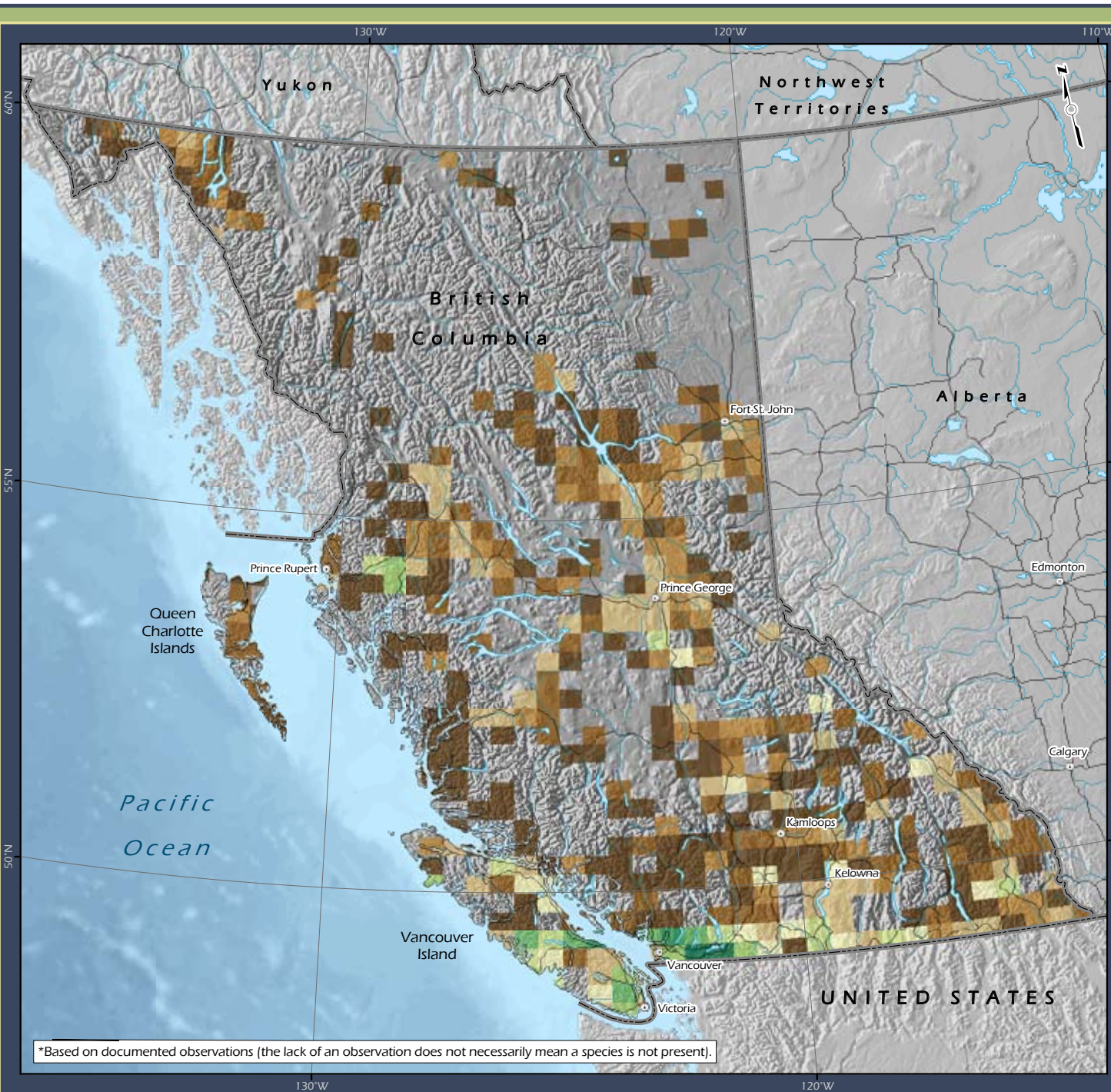
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 4, 2009



*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.⁷⁷ This is the most well-studied group in the province, surveyed yearly through programs such as the Christmas Bird Count⁷⁸ and the Breeding Bird Survey.⁷⁹ 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.¹ 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.

SPECIES NAME, COMMON NAME	CONSERVATION RANK	
	GLOBAL	PROVINCIAL
<i>Ammodramus leconteii</i> , Le Conte's sparrow	Apparently secure (G4)	Vulnerable/apparently secure (S3S4B)
<i>Ammodramus nelsoni</i> , Nelson's sharp-tailed sparrow	Secure (G5)	Imperilled (S2B)
<i>Ammodramus savannarum</i> , grasshopper sparrow	Secure (G5)	Imperilled (S2B)
<i>Calcarius pictus</i> , Smith's longspur	Secure (G5)	Vulnerable/apparently secure (S3S4B)
<i>Catherpes mexicanus</i> , canyon wren	Secure (G5)	Vulnerable (S3)
<i>Chondestes grammacus</i> , lark sparrow	Secure (G5)	Imperilled (S2B)
<i>Dendroica castanea</i> , bay-breasted warbler	Secure (G5)	Imperilled (S2B)
<i>Dendroica tigrina</i> , Cape May warbler	Secure (G5)	Imperilled (S2B)
<i>Dendroica virens</i> , black-throated green warbler	Secure (G5)	Vulnerable (S3B)
<i>Dolichonyx oryzivorus</i> , bobolink	Secure (G5)	Vulnerable (S3B)
<i>Empidonax wrightii</i> , gray flycatcher	Secure (G5)	Vulnerable (S3B)
<i>Euphagus carolinus</i> , rusty blackbird	Apparently secure (G4)	Vulnerable/apparently secure (S3S4B)
<i>Hirundo rustica</i> , barn swallow	Secure (G5)	Vulnerable/apparently secure (S3S4B)
<i>Icteria virens</i> , yellow-breasted chat	Secure (G5)	Critically imperilled/imperilled (S1S2B)
<i>Oporornis agilis</i> , Connecticut warbler	Apparently secure (G4)	Imperilled (S2B)
<i>Oreoscoptes montanus</i> , sage thrasher	Secure (G5)	Critically imperilled (S1B)
<i>Progne subis</i> , purple martin	Secure (G5)	Imperilled/vulnerable (S2S3B)
<i>Wilsonia canadensis</i> , Canada warbler	Secure (G5)	Vulnerable/apparently secure (S3S4B)

SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia. Biodiversity BC: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

NOTE: B indicates rank for breeding only.

¹Non-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).



Data sources:
Compiled by the University of British Columbia

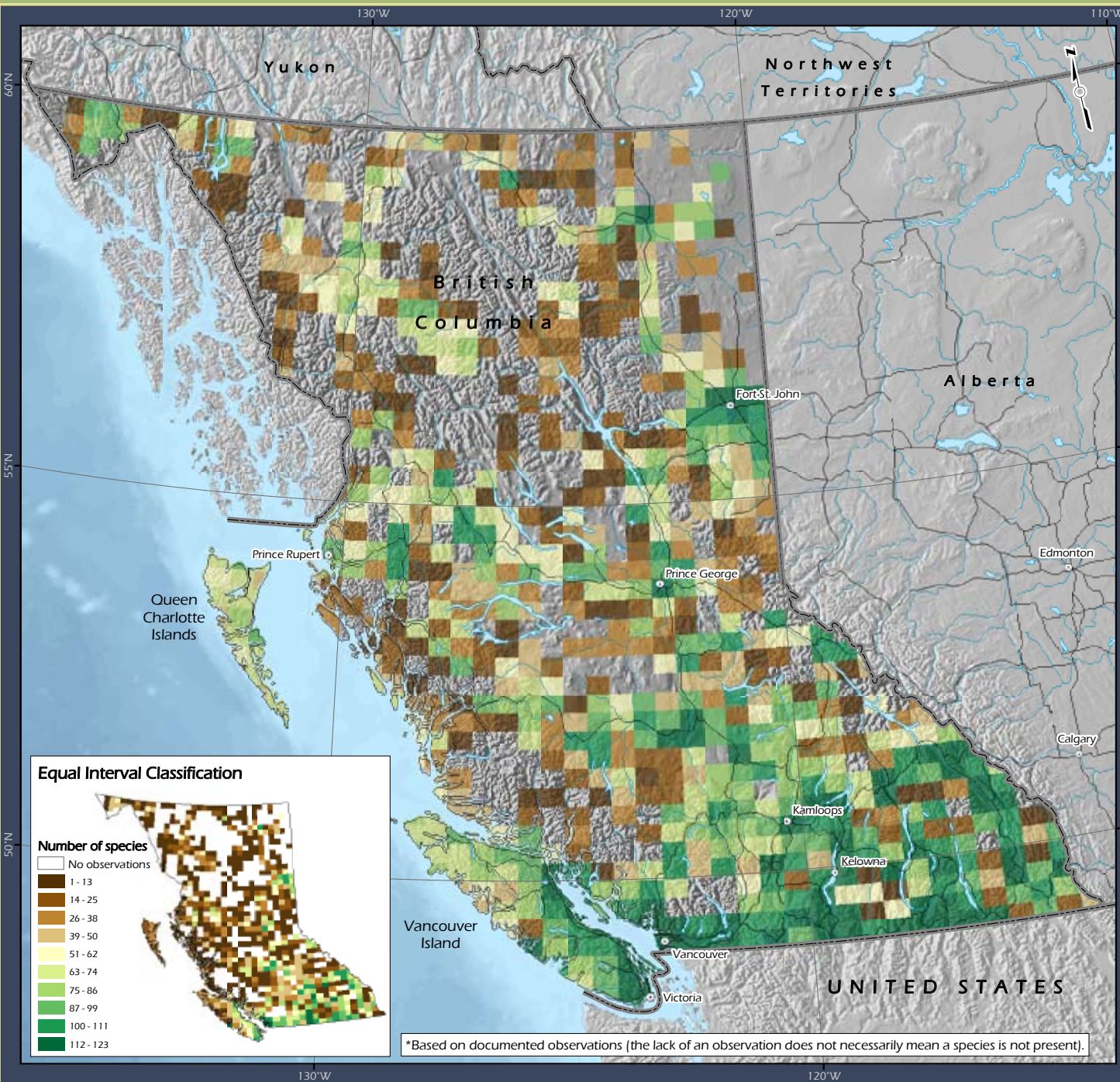
Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



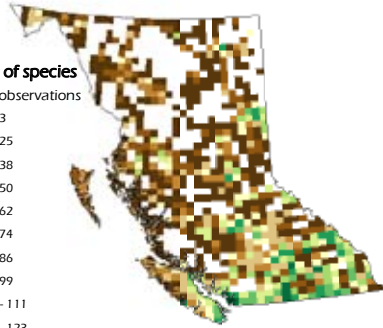
February 4, 2009



Equal Interval Classification

Number of species

- No observations
- 1 - 13
- 14 - 25
- 26 - 38
- 39 - 50
- 51 - 62
- 63 - 74
- 75 - 86
- 87 - 99
- 100 - 111
- 112 - 123



*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.⁸⁰ 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.⁸¹ 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.⁸²

Five freshwater fish species (7.5%) have the

majority of their global range in B.C. (p.44)⁸³ including bull trout (*Salvelinus confluentus*), and Cowichan Lake (or Vancouver Island)

lamprey (*Lampetra macrostoma*), both of which are critically imperilled in their global ranges.⁸⁴

TABLE 13. ENDEMIC FRESHWATER FISHES IN B.C. CURRENTLY WITHOUT FORMAL SCIENTIFIC SPECIES NAMES

SPECIES NAME, COMMON NAME	CONSERVATION RANK	
	GLOBAL	PROVINCIAL
<i>Cottus sp. 2</i> , Cultus, pygmy sculpin	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 1</i> , giant stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 16</i> , Vananda Creek limnetic stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 17</i> , Vananda Creek benthic stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 18</i> , Misty Lake "lake" stickleback	Not ranked (GNR)	Critically imperilled (S1)
<i>Gasterosteus sp. 19</i> , Misty Lake "stream" stickleback	Not ranked (GNR)	Critically imperilled (S1)
<i>Gasterosteus sp. 2</i> , Enos Lake limnetic sticklebackw	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 3</i> , Enos Lake benthic stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 4</i> , Paxton Lake limnetic stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Gasterosteus sp. 5</i> , Paxton Lake benthic stickleback	Critically imperilled (G1)	Critically imperilled (S1)
<i>Prosopium sp. 2</i> , McCleese Lake pygmy whitefish	Critically imperilled (G1)	Not ranked (SNR)
<i>Prosopium sp. 2</i> , McClure Lake pygmy whitefish	Critically imperilled (G1)	Not ranked (SNR)
<i>Spirinchus sp. 1</i> , pygmy longfin smelt	Critically imperilled (G1)	Critically imperilled (S1)

SOURCE: Anons, M. 2006. Global and Provincial Status of Species in British Columbia. Biodiversity BC: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

MAP 23
Species richness:
freshwater fishes*

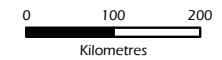
Legend

- 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).



Data sources:
 Compiled by the University of British Columbia

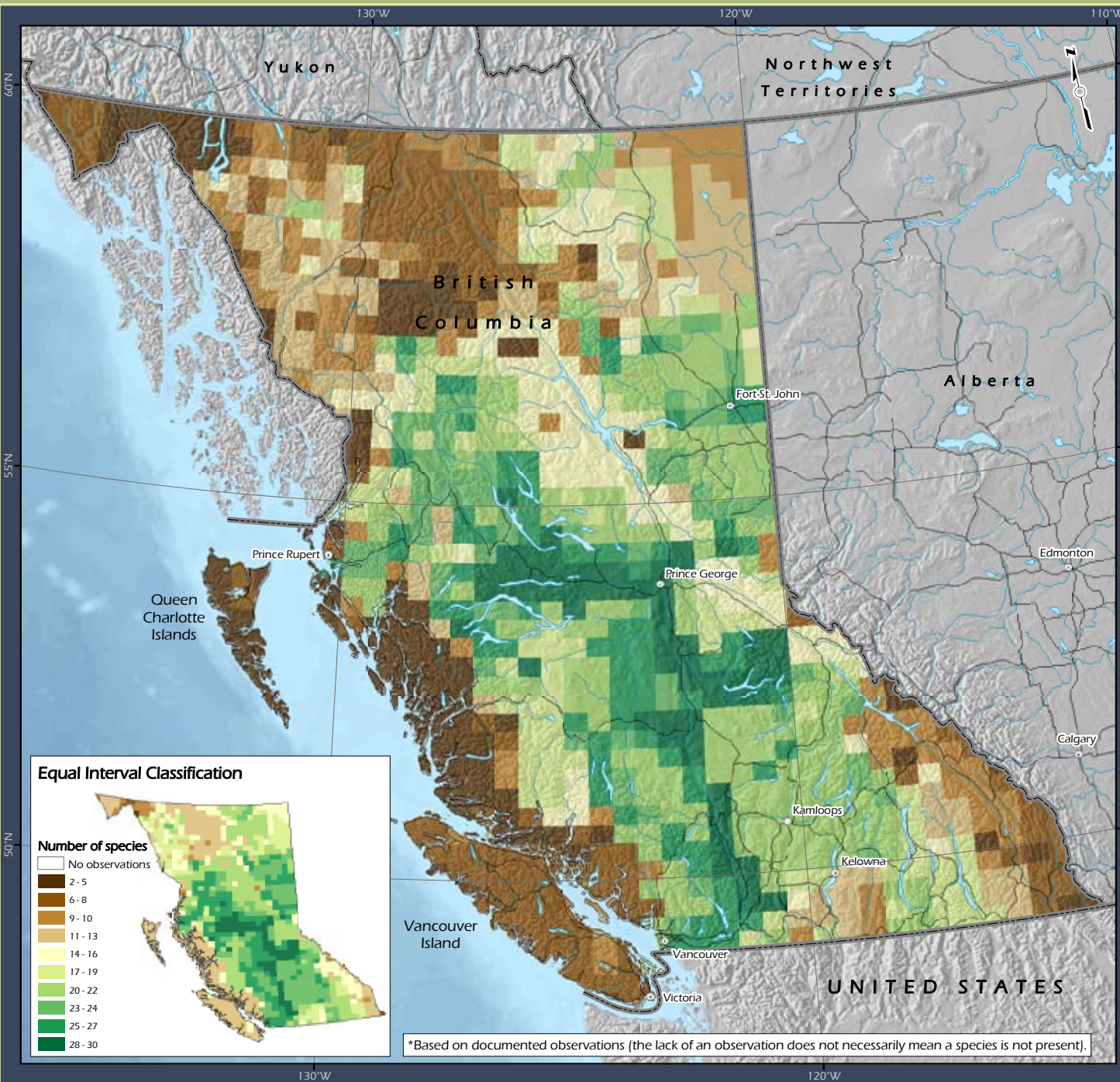
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



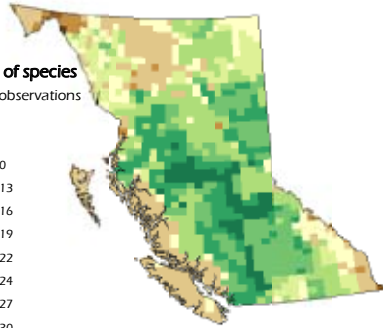
February 4, 2009



Equal Interval Classification

Number of species

- ▭ No observations
- ▭ 2 - 5
- ▭ 6 - 8
- ▭ 9 - 10
- ▭ 11 - 13
- ▭ 14 - 16
- ▭ 17 - 19
- ▭ 20 - 22
- ▭ 23 - 24
- ▭ 25 - 27
- ▭ 28 - 30



*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.^m 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 keenii*), 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.

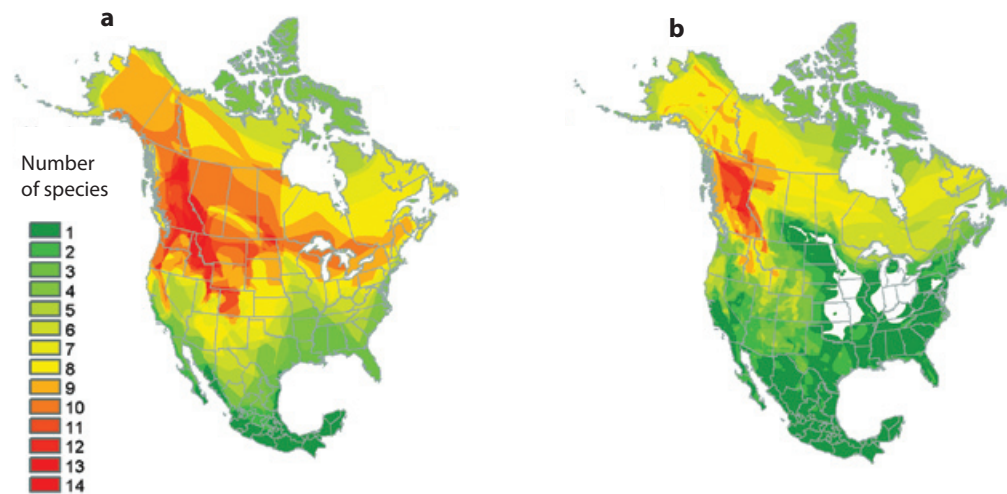


FIGURE 5: Historic (a) and current (b) species richness for 17 carnivore and ungulate species that have undergone significant range contractions in North America.

SOURCE: Laliberte, A.S. and W.J. Ripple. 2004. Range contractions of North American carnivores and ungulates. *Bioscience* 54(2): 123-138.

^m Map 24 does not include marine mammals.

MAP 24
Species richness:
mammals*

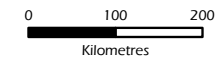
Legend

- 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).



Data sources:
 Compiled by the University of British Columbia

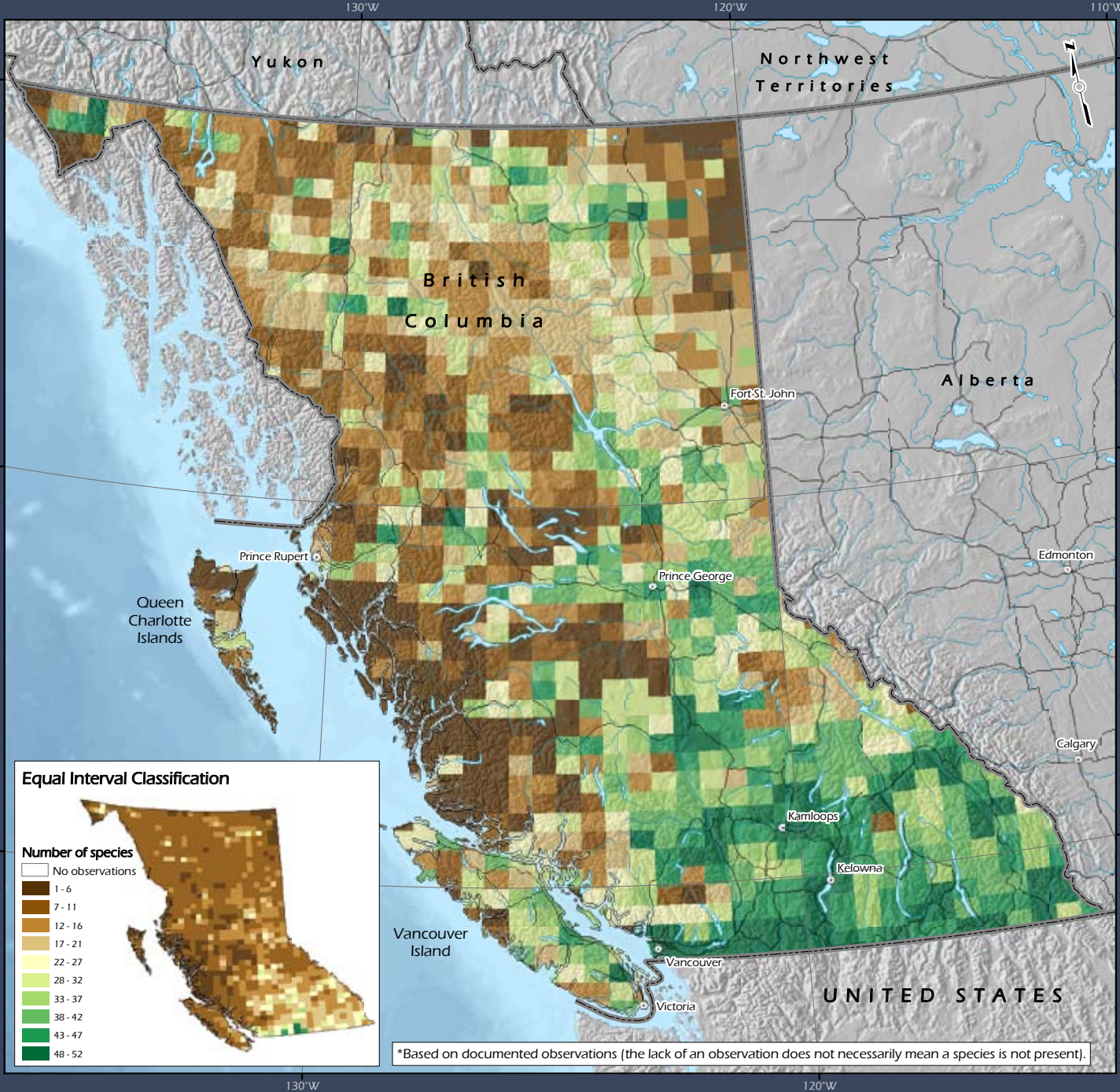
Map by:
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Projection:
 BC Albers NAD83

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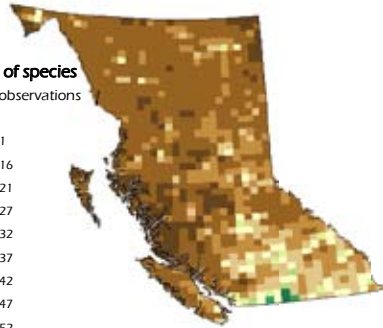
February 4, 2009



Equal Interval Classification

Number of species

- No observations
- 1 - 6
- 7 - 11
- 12 - 16
- 17 - 21
- 22 - 27
- 28 - 32
- 33 - 37
- 38 - 42
- 43 - 47
- 48 - 52



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

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 which live in tropical and subtropical regions.⁹¹ B.C. has 12 species: 9 snakes, 2 lizards and 1 turtle.⁹² 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.⁹³ 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.



Western painted turtle (*Chrysemys picta*).

PHOTO: IAN GARDINER.

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.

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

SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

MAP 25
Species richness:
reptiles and turtles*

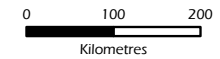
Legend

- 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).



Data sources:
 Compiled by the University of British Columbia

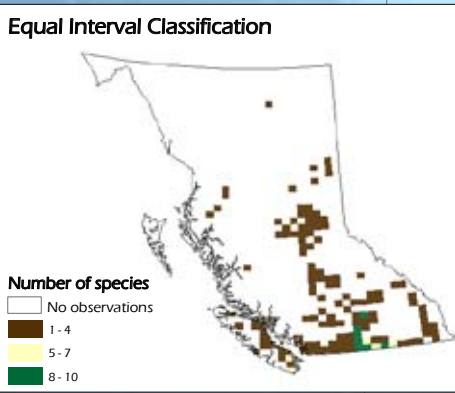
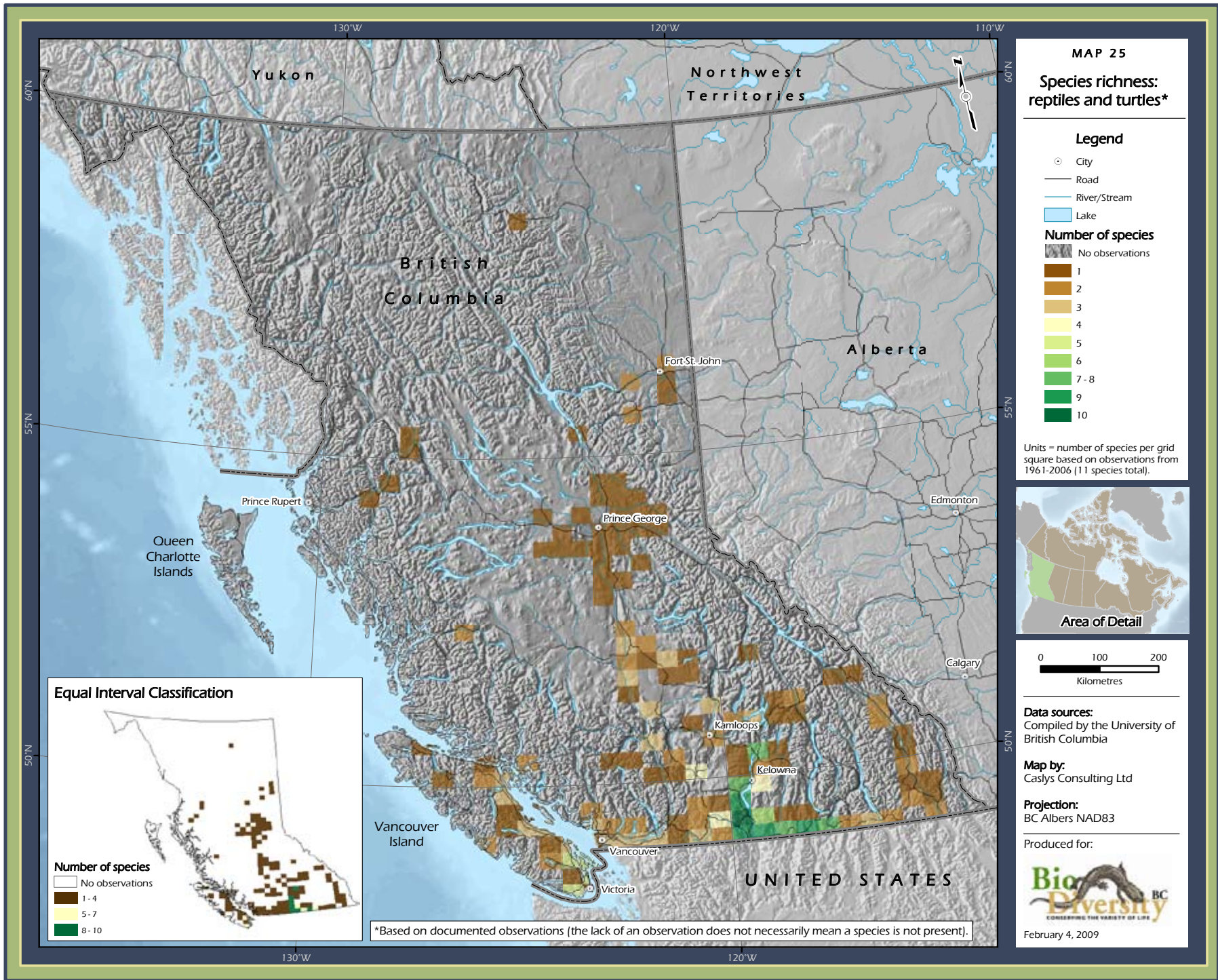
Map by:
 Caslys Consulting Ltd

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).

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 damselflies (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 damselflies 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.⁹⁴ 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.⁹⁵ Little is known about the global and provincial conservation concern of insect groups in B.C.

TABLE 15. B.C. NATIVE INSECT GROUPS INCLUDED ON MAP 26.

INSECT GROUP	NUMBER OF SPECIES MAPPED
Butterflies and skippers (order Lepidoptera)	172
Dragonflies and damselflies (order Odonata)	85
Stoneflies (order Plecoptera)	85
True bugs (order Hemiptera: Heteroptera)	581
Antlions, snakeflies, lacewings and allies (order Neuroptera)	74
Ground beetles (order Coleoptera, family Carabidae)	386
Total	1,383

SOURCE: Warman, L. and G.G.E. Scudder. 2007. Species Richness and Summed Irreplaceability in B.C. Biodiversity BC, Victoria, BC. 36pp. Available at: www.biodiversitybc.org.

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).



Data sources:
 Compiled by the University of British Columbia

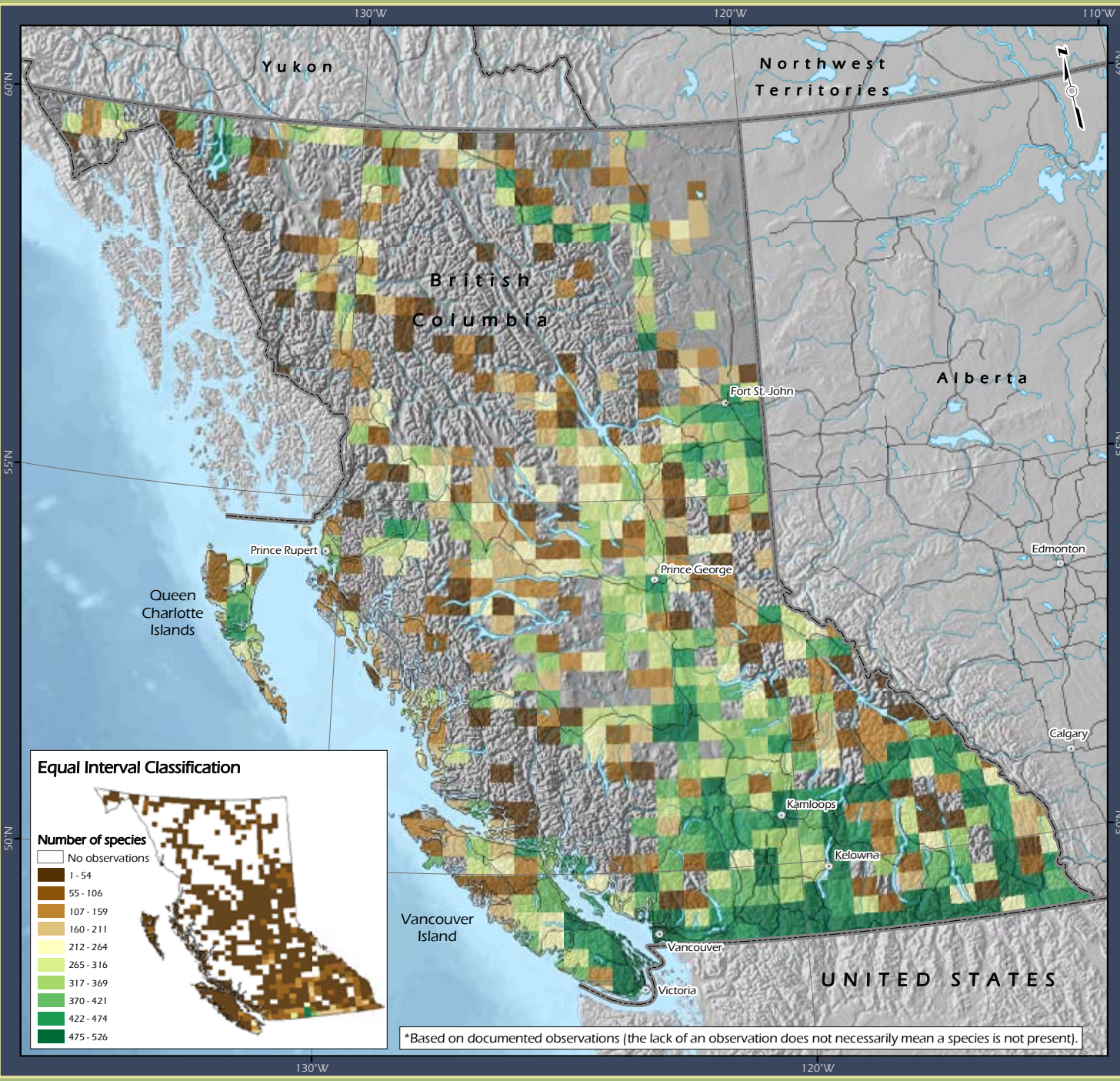
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



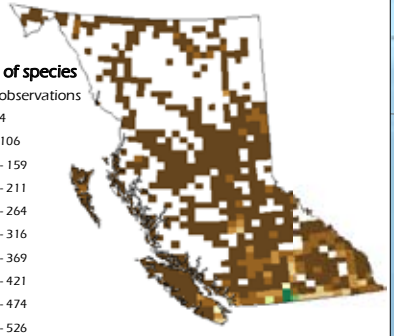
February 4, 2009



Equal Interval Classification

Number of species

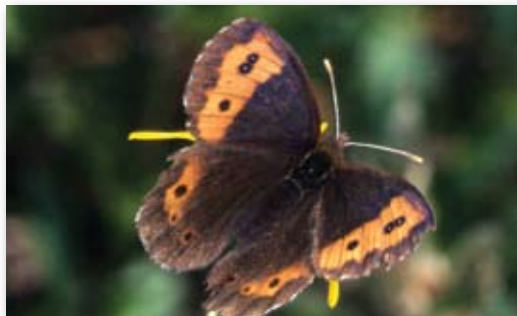
- No observations
- 1 - 54
- 55 - 106
- 107 - 159
- 160 - 211
- 212 - 264
- 265 - 316
- 317 - 369
- 370 - 421
- 422 - 474
- 475 - 526



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

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.⁹⁶ 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.



Vidler's alpine (*Erebia vidleri*).

PHOTO: IAN LANE.

British Columbia has 180 known native species of butterflies and skippers.⁹⁷ 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.⁹⁸ 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 16. B.C. NATIVE BUTTERFLY AND SKIPPER SPECIES OF GLOBAL CONSERVATION CONCERN IN B.C.

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

SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

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).



Data sources:
 Compiled by the University of British Columbia

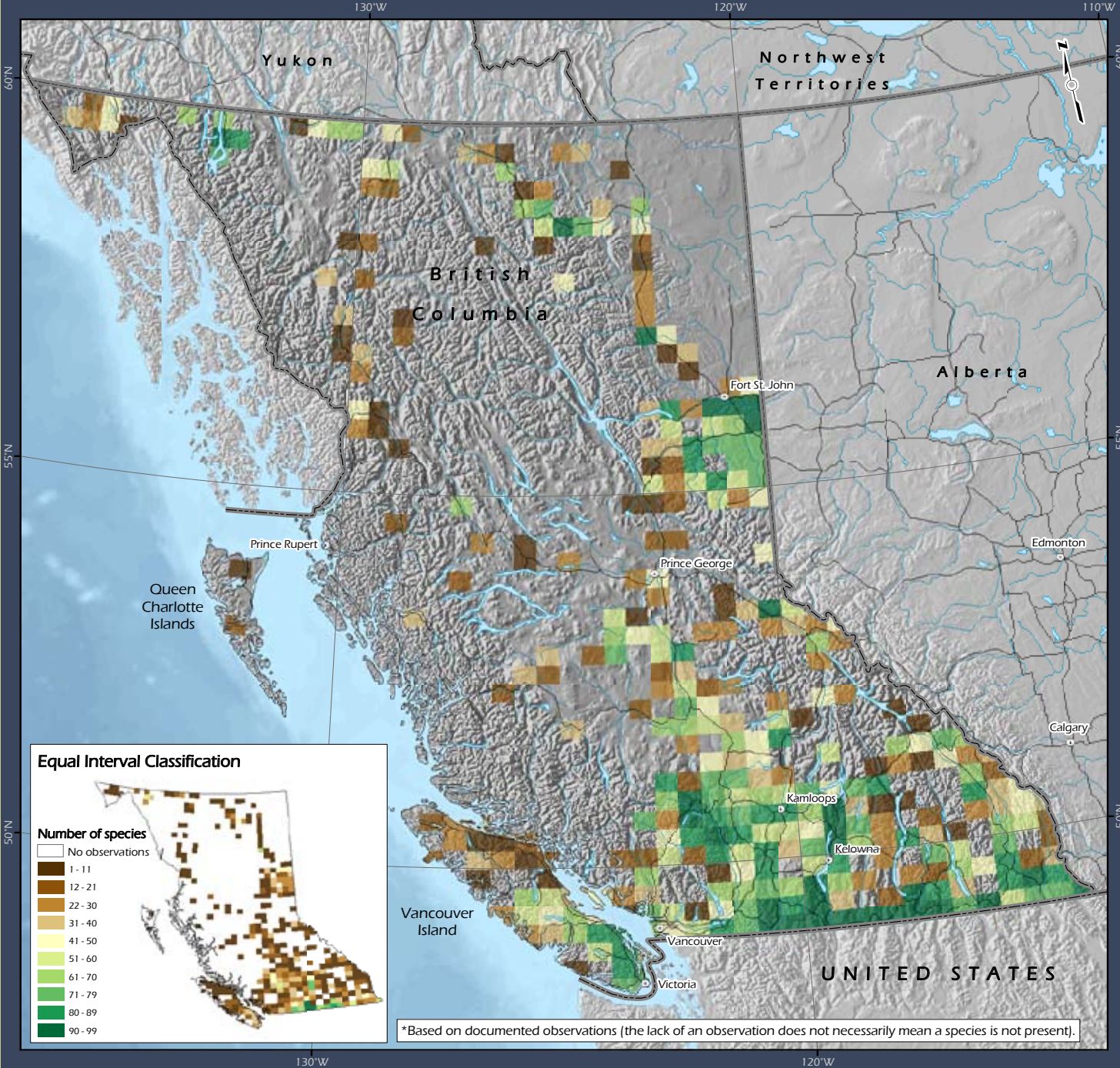
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



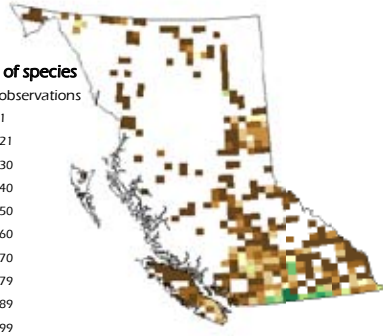
February 4, 2009



Equal Interval Classification

Number of species

- ▭ No observations
- ▭ 1 - 11
- ▭ 12 - 21
- ▭ 22 - 30
- ▭ 31 - 40
- ▭ 41 - 50
- ▭ 51 - 60
- ▭ 61 - 70
- ▭ 71 - 79
- ▭ 80 - 89
- ▭ 90 - 99



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

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



Quebec emerald (*Somatochlora brevicincta*).

PHOTO: SIDNEY DUNKLE.

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

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).



Data sources:
 Compiled by the University of British Columbia

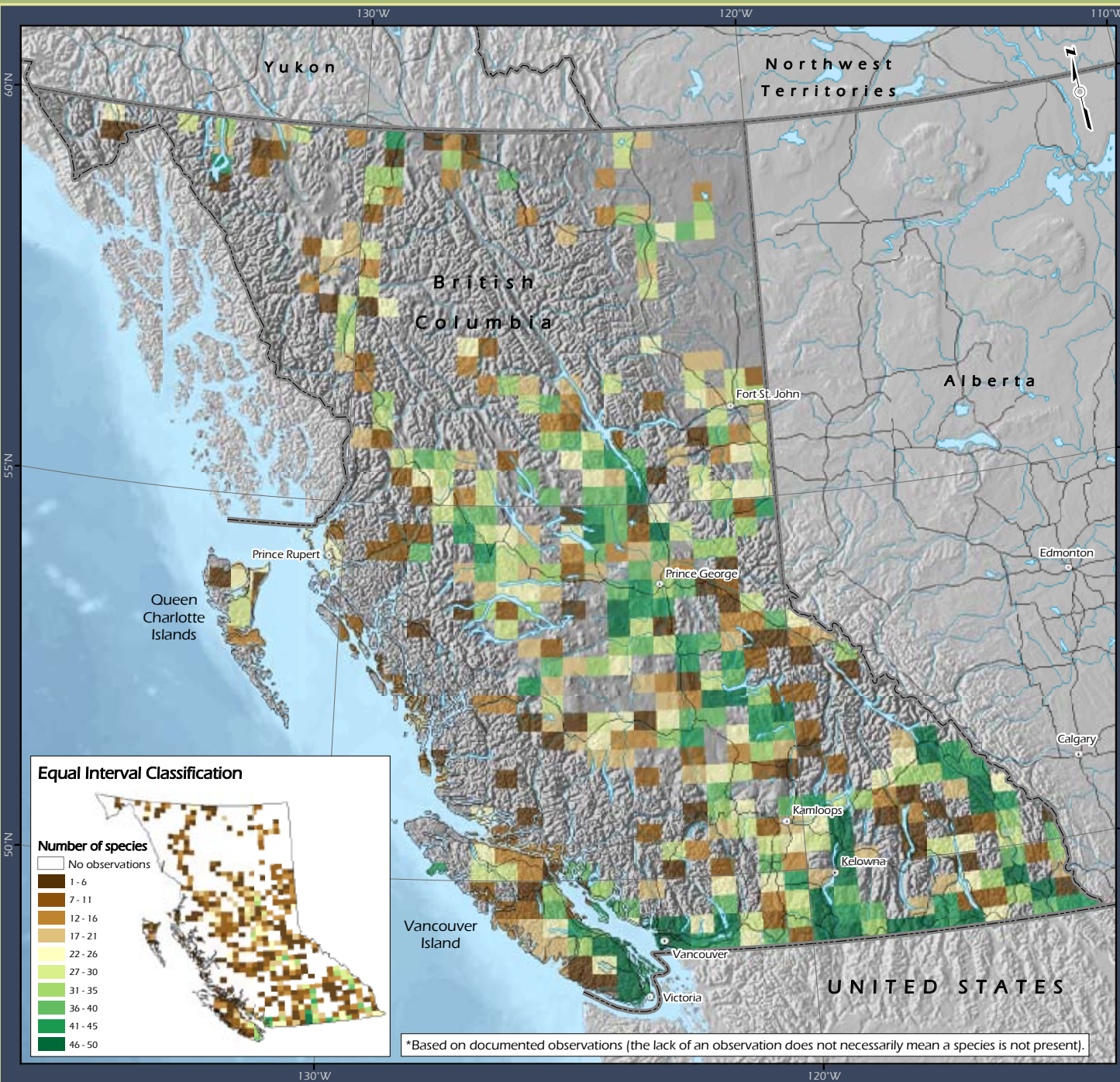
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



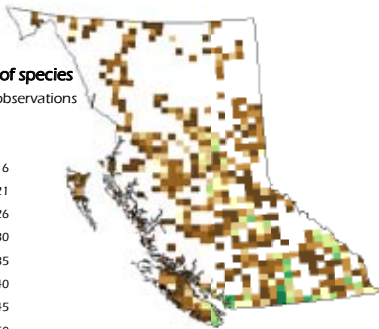
February 4, 2009



Equal Interval Classification

Number of species

- ▭ No observations
- ▭ 1 - 6
- ▭ 7 - 11
- ▭ 12 - 16
- ▭ 17 - 21
- ▭ 22 - 26
- ▭ 27 - 30
- ▭ 31 - 35
- ▭ 36 - 40
- ▭ 41 - 45
- ▭ 46 - 50



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

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.¹⁰³ 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.¹⁰⁴ The diaptomid copepods are a family within the Suborder Calanoida. The richness map includes

TABLE 17. DIAPTOMID COPEPODS FOUND IN SALINE LAKES IN B.C.

SPECIES NAME
<i>Aglaodiaptomus leptopus</i>
<i>Hesperodiaptomus kiseri</i>
<i>Hesperodiaptomus nevadensis</i>
<i>Hesperodiaptomus novemdecimus</i>
<i>Hesperodiaptomus sp.nr.hirsutus</i>
<i>Leptodiaptomus connexus</i>
<i>Leptodiaptomus sicilis</i>

SOURCE: G.G.E. Scudder, The Nature Trust of British Columbia, personal communication.

NOTE: These species do not have common names.

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.¹⁰⁵



Saline lake.

PHOTO: SARMA LIEPINS.

MAP 29
Species richness:
selected freshwater
crustaceans
(diaptomid copepods)*

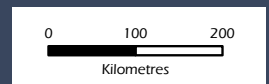
Legend

- 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).



Data sources:
 Compiled by the University of British Columbia

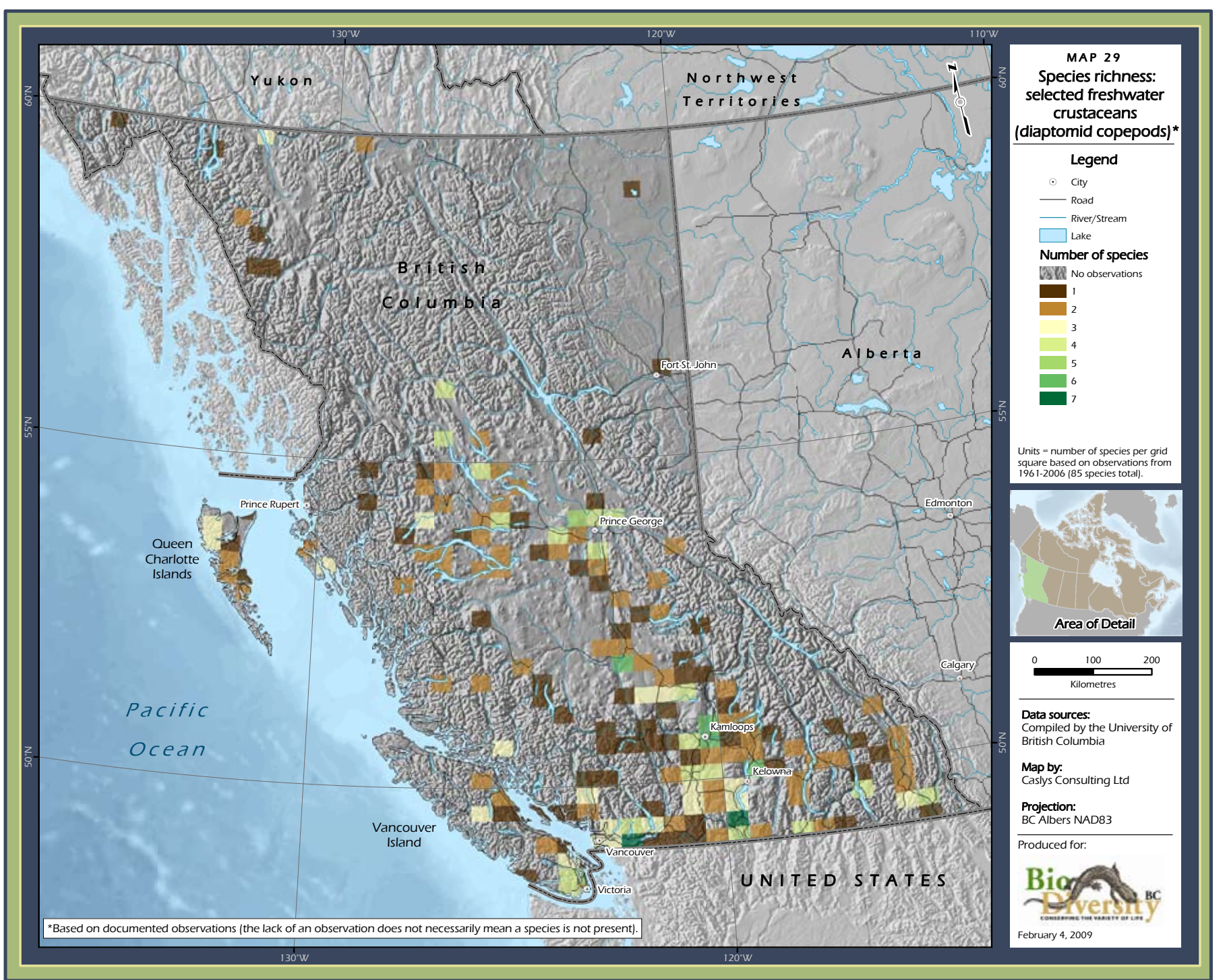
Map by:
 Caslys Consulting Ltd

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).

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 (p.16).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, includ-



Tiger lily (*Lilium columbianum*).

PHOTO: WERNER EIGELSREITER.

TABLE 18. NATIVE VASCULAR PLANTS IN B.C. INCLUDED ON MAP 30.

SPECIES GROUP	NUMBER OF SPECIES MAPPED
Ferns and Fern Allies	103
Conifers	25
Monocots	525
Dicots	1,339
Total	1,992

SOURCE: Warman, L. and G.G.E. Scudder. 2007. Species Richness and Summed Irreplaceability in B.C. Biodiversity BC, Victoria, BC. 36pp. Available at: www.biodiversitybc.org.

ing 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 na-

tive 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 (Potamogetonaceae). 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

MAP 30

**Species richness:
vascular plants***

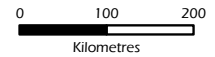
Legend

- 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 - 630

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



Data sources:
Compiled by the University of British Columbia

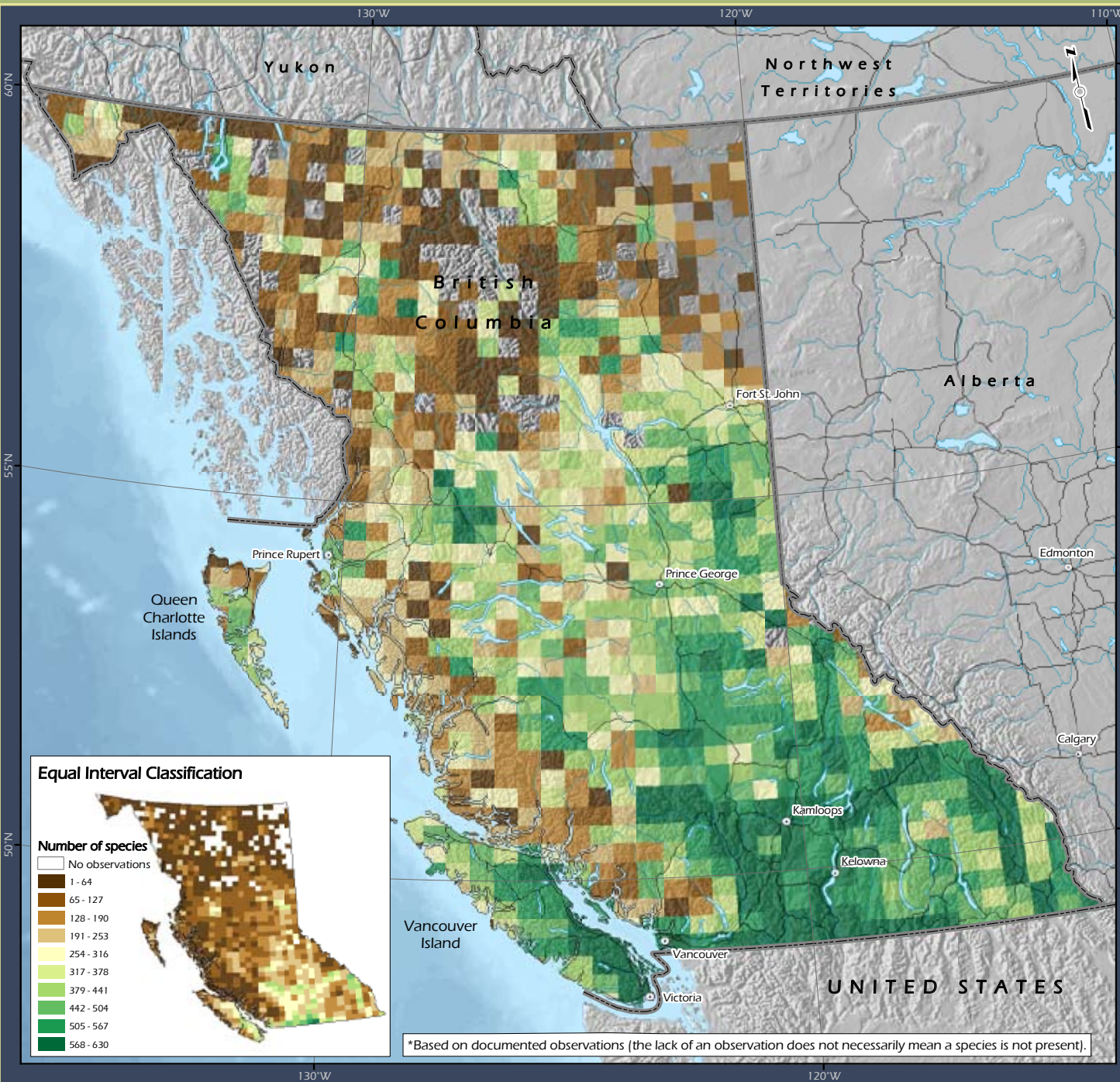
Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



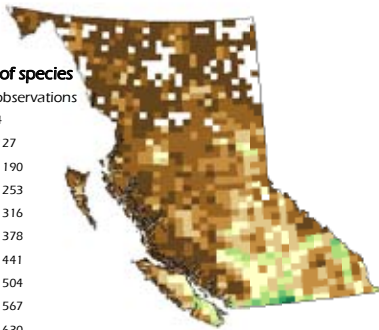
February 4, 2009



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.¹¹⁴ 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.¹¹⁵ 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



Roell's brotherella moss (*Brotherella roellii*).

PHOTO: STEVE JOYA.

concern (12%) and the highest percentage of species of provincial conservation concern (65%).¹¹⁶ The five moss species known to be endemic to B.C. are all of conservation concern both globally and provincially (Table 19).¹¹⁷

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.¹¹⁸

TABLE 19. CONSERVATION STATUS OF SOME ENDEMIC MOSSSES IN B.C.

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

SOURCE: Anions, M. 2006. Global and Provincial Status of Species in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 16pp. Available at: www.biodiversitybc.org.

MAP 31

**Species richness:
mosses***

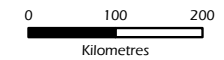
Legend

- 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).



Data sources:
Compiled by the University of British Columbia

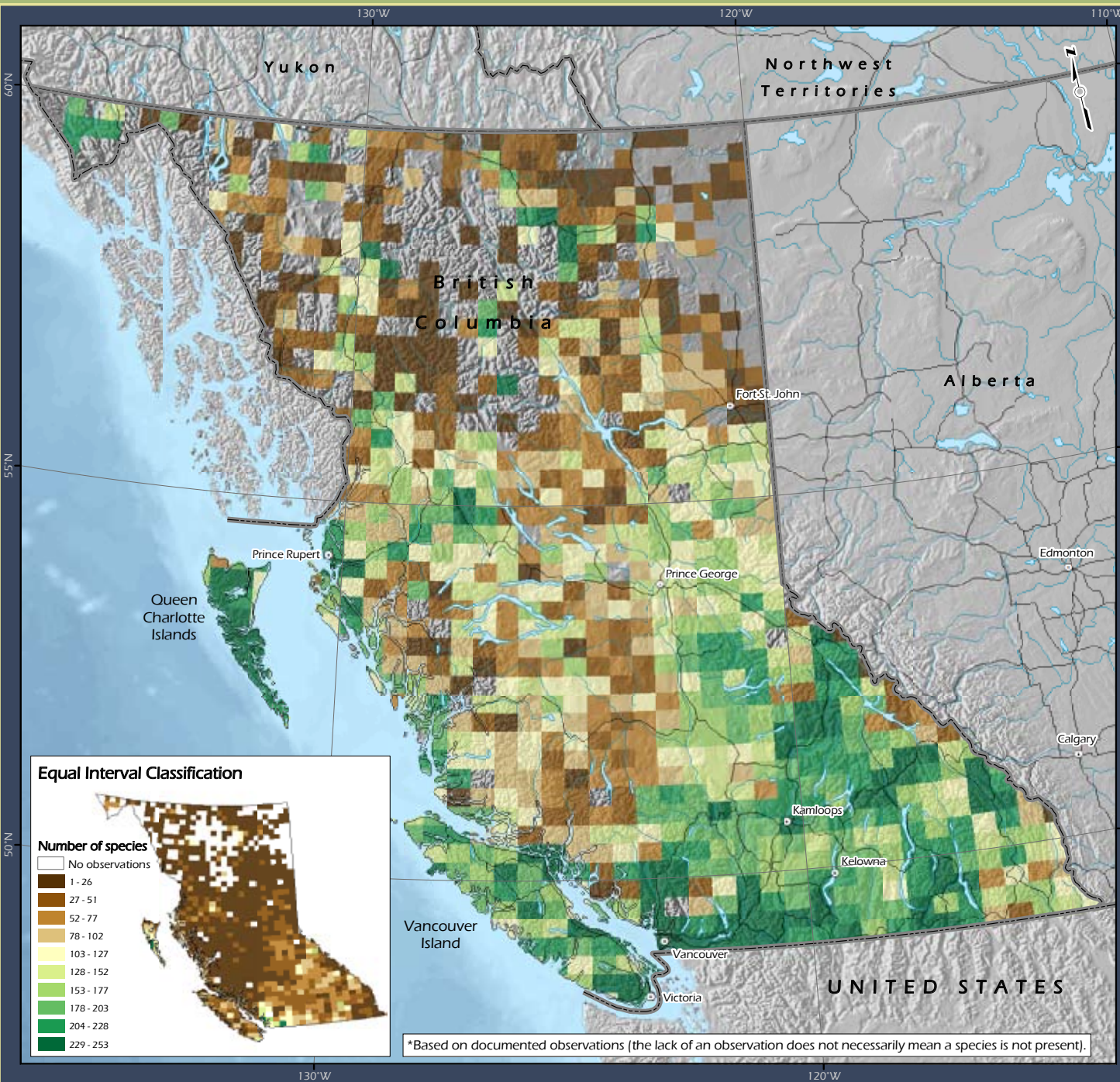
Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

Produced for:



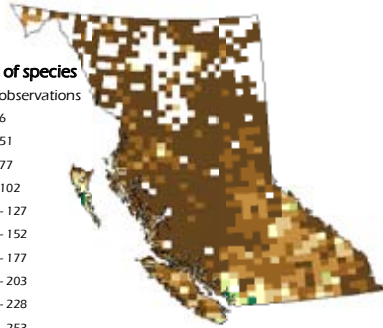
February 4, 2009



Equal Interval Classification

Number of species

- ▭ No observations
- ▭ 1 - 26
- ▭ 27 - 51
- ▭ 52 - 77
- ▭ 78 - 102
- ▭ 103 - 127
- ▭ 128 - 152
- ▭ 153 - 177
- ▭ 178 - 203
- ▭ 204 - 228
- ▭ 229 - 253



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

Lichens

Lichens are the result of a symbiosis between fungi and either green algae or a **cyanobacterium**.¹¹⁹ 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.



Oldgrowth specklebelly (*Pseudocyphallaria rainierensis*).

PHOTO: JIM RILEY.

Old forests are important to many species of lichens, and in turn, lichens make a significant contribution of nitrogen to forests.¹²⁰ Arboreal lichens are an important food source for woodland caribou.¹²¹ 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.¹²² 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 ENDEMIC TO THE PACIFIC NORTHWEST REGION.

SPECIES NAME, COMMON NAME
<i>Alectoria imshaugii</i> , Imshaug's witch's hair lichen
<i>Bryoria carlottae</i> , Carlott's horsehair lichen
<i>Bryoria cervinula</i> , horsehair lichen
<i>Cladonia schofieldia</i> , a lichen
<i>Fuscopannaria pacifica</i> , a lichen
<i>Fuscopannaria alaskana</i> , a lichen
<i>Hypogymnia heterophylla</i> , seaside bone
<i>Leptogium polycarpum</i> , a lichen
<i>Leptogium tacomae</i> , a lichen
<i>Lobaria silvae-veteris</i> , a lichen
<i>Massalongia microphylliza</i> , littlelobed lichen
<i>Neofuscelia subhosseana</i> , erupted camouflage lichen
<i>Nephroma occultum</i> , cryptic paw
<i>Physcia tribacia</i> , rosette lichen
<i>Pseudocyphellaria mallota</i> , a lichen
<i>Pseudocyphellaria perpetua</i> , a lichen
<i>Pseudocyphellaria rainierensis</i> , oldgrowth specklebelly

SOURCE: Bunnell, E, L. Kremsater and I. Houde. 2006. Applying the Concept of Stewardship Responsibility in British Columbia: 2007 Update. Biodiversity BC, Victoria, BC. 188pp. Available at: www.biodiversitybc.org.

MAP 32
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).



Data sources:
 Compiled by the University of British Columbia

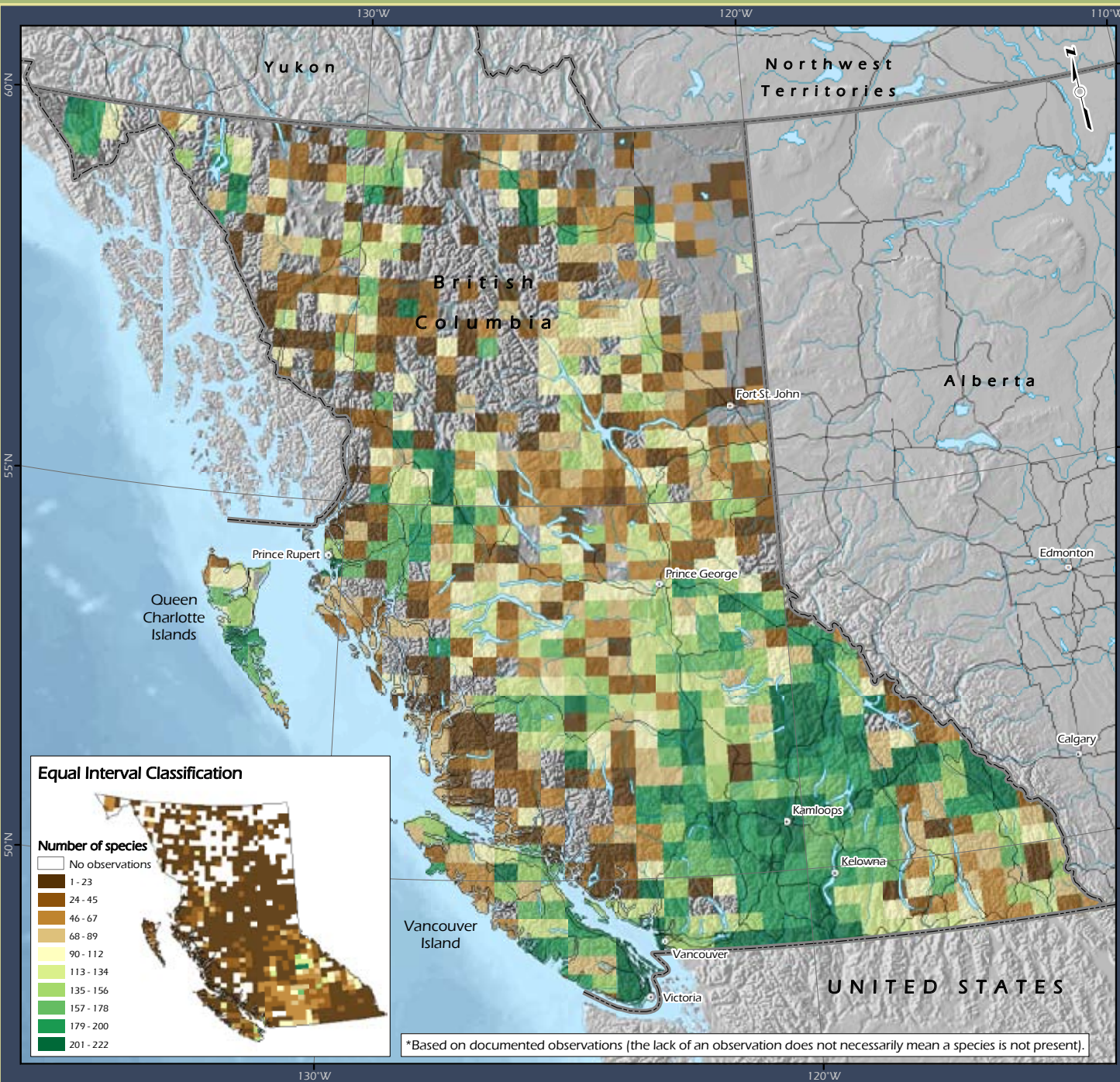
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



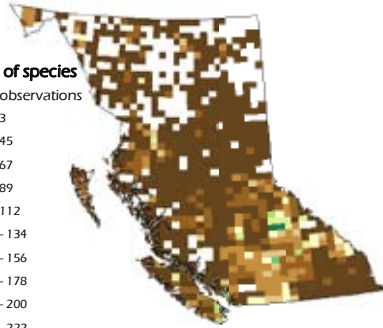
February 5, 2009



Equal Interval Classification

Number of species

- ▭ No observations
- ▭ 1 - 23
- ▭ 24 - 45
- ▭ 46 - 67
- ▭ 68 - 89
- ▭ 90 - 112
- ▭ 113 - 134
- ▭ 135 - 156
- ▭ 157 - 178
- ▭ 179 - 200
- ▭ 201 - 222



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



SPECIAL ELEMENTS OF BIODIVERSITY

BC 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.¹²³ 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).



Spotted Lake, Okanagan, British Columbia.

PHOTO: ORVILLE DYER.

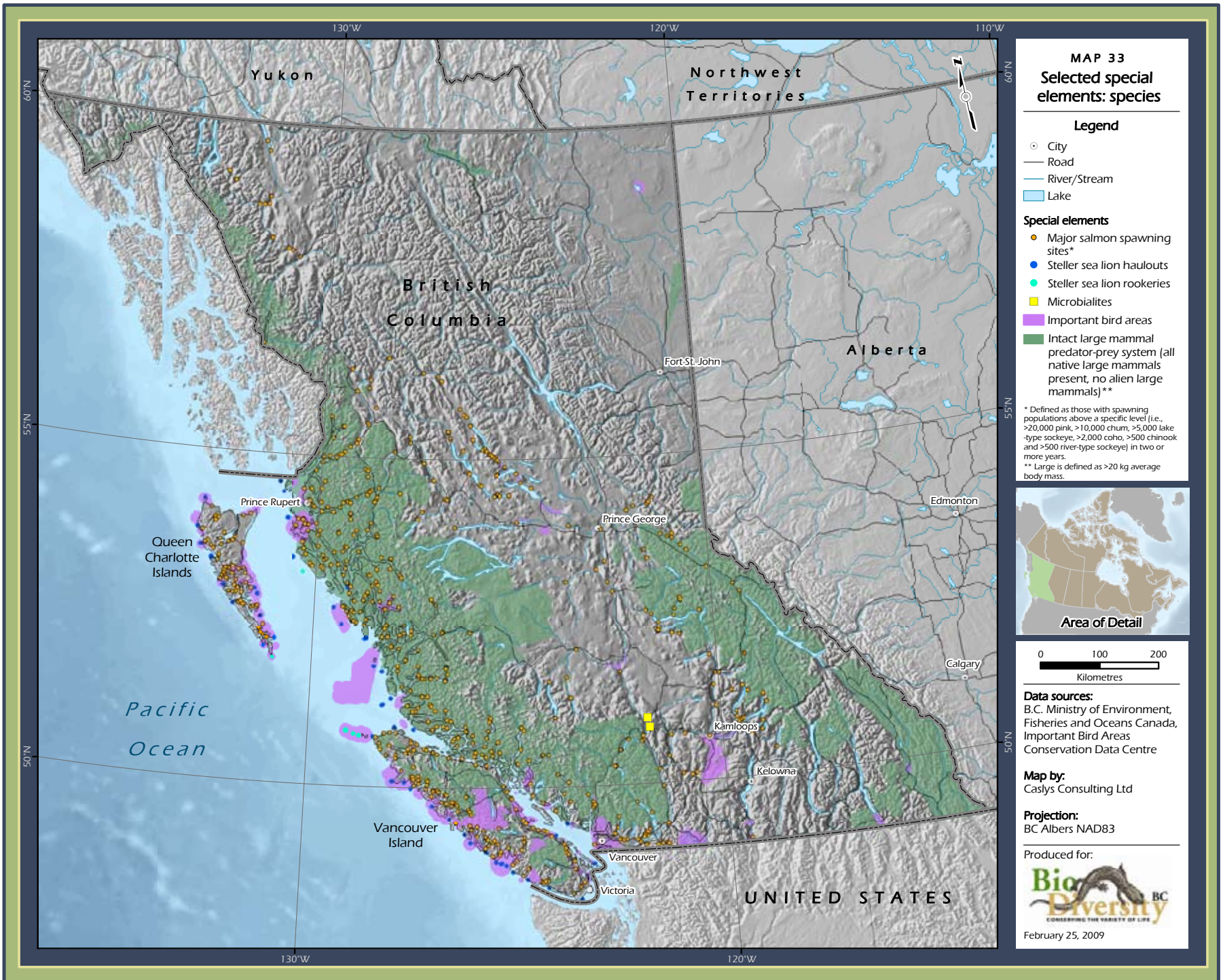
Special Elements: Species

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.

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

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..



MAP 33
Selected special
elements: species

Legend

- City
- Road
- River/Stream
- Lake

Special elements

- Major salmon spawning sites*
- Steller sea lion haulouts
- Steller sea lion rookeries
- Microbialites
- Important bird areas
- Intact large mammal predator-prey system (all native large mammals present, no alien large mammals)**

* Defined as those with spawning populations above a specific level (i.e. >20,000 pink, >10,000 chum, >5,000 lake-type sockeye, >2,000 coho, >500 chinook and >500 river-type sockeye) in two or more years.
 ** Large is defined as >20 kg average body mass.



Data sources:
 B.C. Ministry of Environment, Fisheries and Oceans Canada, Important Bird Areas Conservation Data Centre

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009

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 bed-

rock; serpentine soils formed from bedrock with high toxicity from heavy metals; and naturally fishless lakes.¹²⁴

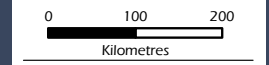
TABLE 22. SELECTED SPECIAL ELEMENTS OF BIODIVERSITY RELATED TO ECOSYSTEMS IN B.C.

REALM	SPECIAL ELEMENT	DESCRIPTION	STATUS	THREATS
Special Ecosystem Features	Saline lakes	Lakes or ponds with no outlet and a very high salt content. Home to invertebrate species not found in other water bodies.	Some are protected.	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.
	Hot springs	Hot springs are unique, self-contained habitats created from very hot water from deep within the earth.	Many are heavily used for recreation.	Vulnerable to pollution, disturbance and ecosystem conversion.
	Large Wetlands (Freshwater) • Burns Bog • Creston Valley Wetlands • Columbia Valley Wetlands	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.	Partially protected.	Large wetlands are threatened by pollution from agricultural and urban activities; motorized recreation; ecosystem conversion; and artificially managed water levels.
	Glacially influenced watersheds	Watersheds that have more than 5% of their area covered in glaciers are defined as glacially influenced.	Increasing temperatures over the past century have resulted in loss of glacial volume.	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.
Special Community	Old-growth temperate rainforests	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.	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.	Remaining low-elevation forests are often highly fragmented by roads and forest harvesting.

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..

MAP 34
Selected special
elements: ecosystems

- Legend**
- City
 - Road
 - River/Stream
 - Lake
- Special elements**
- Hot springs
 - ✦ Saline lakes
 - ▲ Burns Bog
 - ▲ Creston Valley Wetlands
 - ▲ Columbia Valley Wetlands
 - Glacially influenced watersheds (>5% of area covered by glaciers)
 - Old growth temperate rainforest (>250 years old in the Coastal Western Hemlock, Mountain Hemlock and Interior Cedar-Hemlock biogeoclimatic zones)



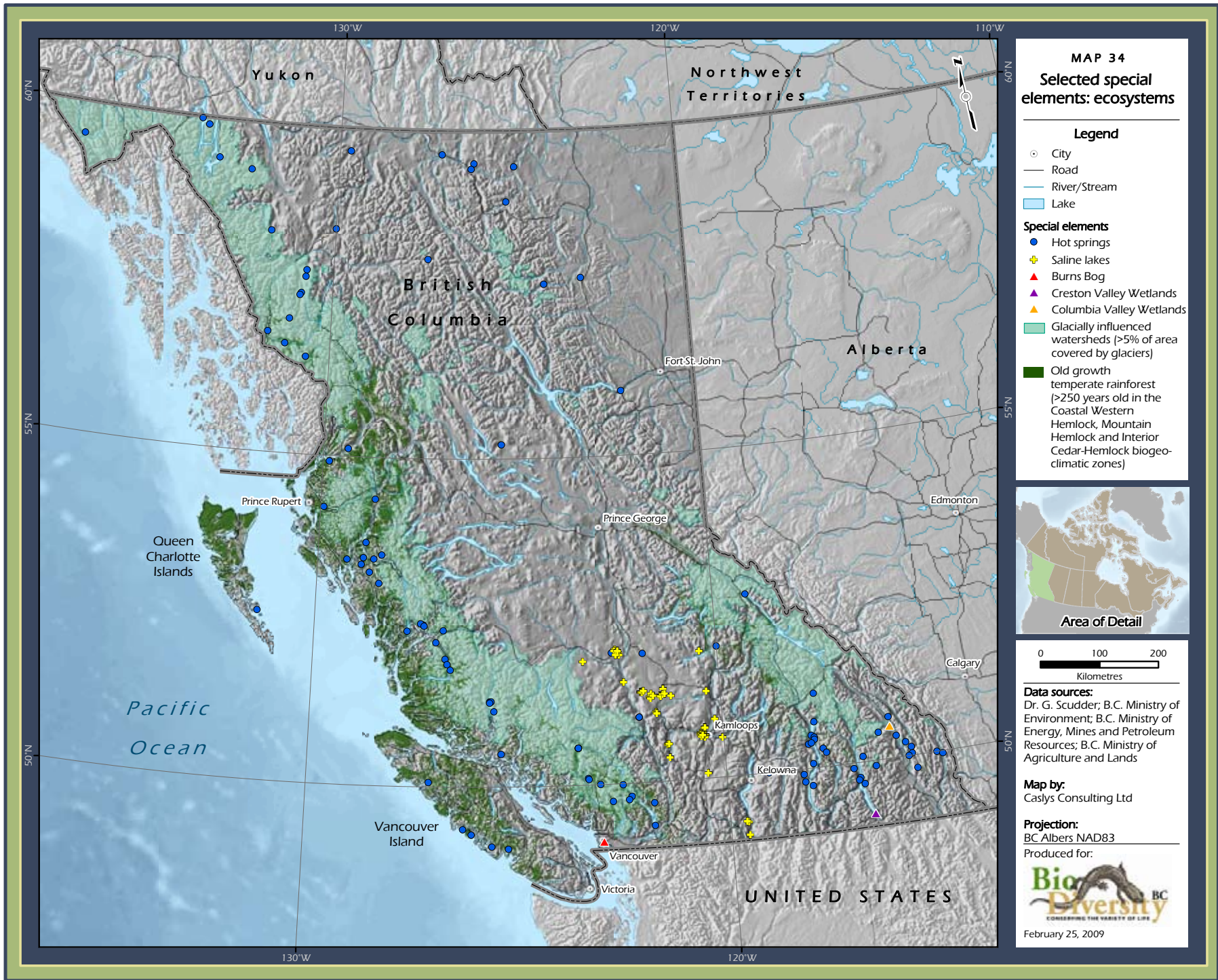
Data sources:
 Dr. G. Scudder; B.C. Ministry of Environment; B.C. Ministry of Energy, Mines and Petroleum Resources; B.C. Ministry of Agriculture and Lands

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83
 Produced for:



February 25, 2009



THREATS TO BIODIVERSITY



Cutleaf evergreen blackberry (*Rubus laciniatus*).

PHOTO: JIM RILEY.

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).¹²⁵ 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,¹²⁶ 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.^{127, 128} 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.¹²⁹

MAP 35

Human footprint index

Legend

- City
- Road
- River/Stream
- Lake

Human footprint index*

- 0 - 1
- 1.1 - 10
- 10.1 - 20
- 20.1 - 30
- 30.1 - 40
- 40.1 - 60
- 60.1 - 80
- 80.1 - 100

*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:

E.W. Sanderson, M. Jaiteh, M.A. Levy, K.H. Redford, A.V. Wannebo and G. Woolmer. 2002. The human footprint and the last of the wild. *BioScience* 52(10): 891-904.

Map by:

Caslys Consulting Ltd

Projection:

BC Albers NAD83

Produced for:



February 5, 2009



Area of detail:
British Columbia

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.^{130, 131, 132}

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 2001.¹³³ 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 im-

mediate 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 impervious surfaces, pollution (p.116), and facilitation of alien species introductions (p.82).¹³⁴ 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.

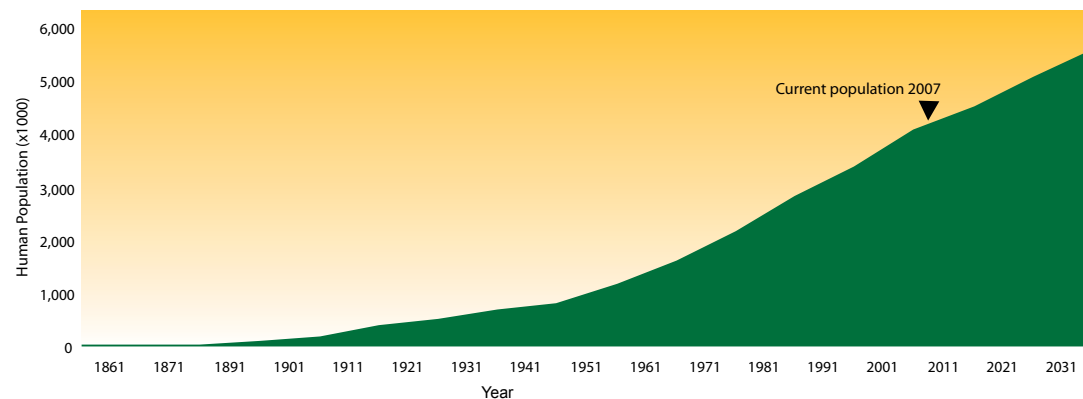


FIGURE 6: Population growth for B.C. (1861–2006) with a projection to 2031.

SOURCE: B.C. Stats. 2007. British Columbia Population 1867 to 2007. Available at: www.bccstats.gov.bc.ca

MAP 36
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)

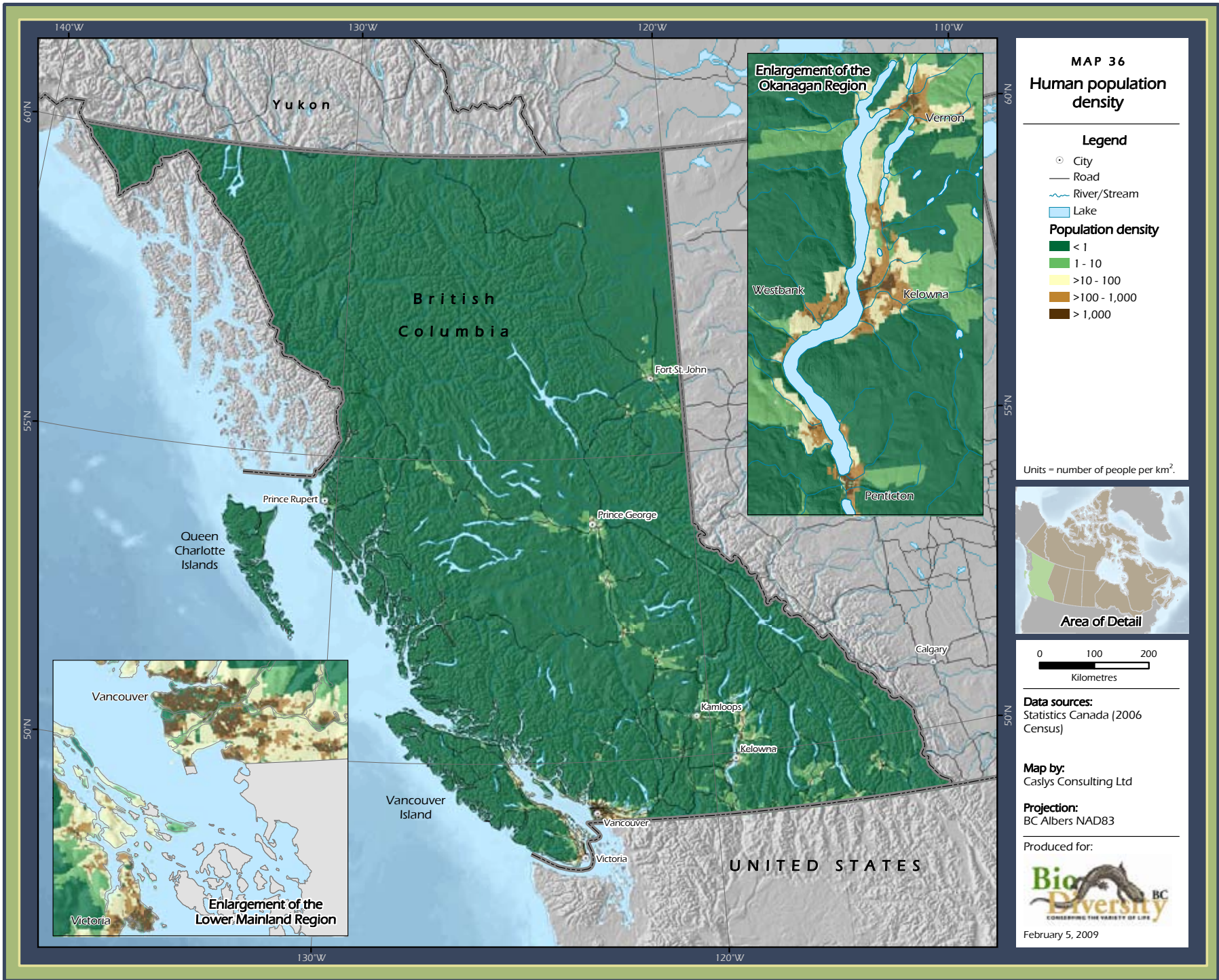
Map by:
Caslys Consulting Ltd

Projection:
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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).¹³⁵ 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, (p.20

has occurred in the Coastal Douglas-fir zone found on the south-eastern coast of Vancouver Island, and in the Bunchgrass and Ponderosa Pine zones in the Okanagan

(Table 23) all three of which are of conservation concern (p.22).¹³⁶ 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.

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

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.

MAP 37
Terrestrial ecosystem conversion*

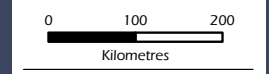
Legend

- City
- Road
- River/Stream
- Lake

Percentage

- 0.00
- 0.01 - 0.13
- 0.14 - 0.67
- 0.68 - 1.66
- 1.67 - 3.49
- 3.50 - 6.99
- 7.00 - 12.12
- 12.13 - 21.95
- 21.96 - 43.00
- 43.01 - 100.00

Units = percentage of land and reservoir area.



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

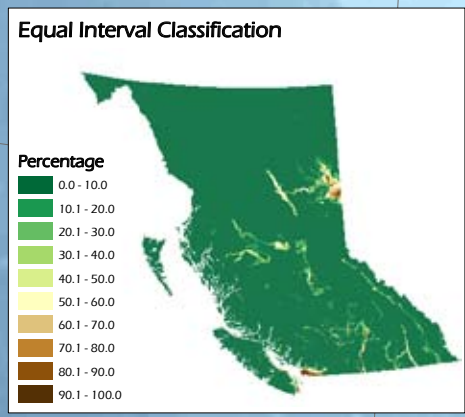
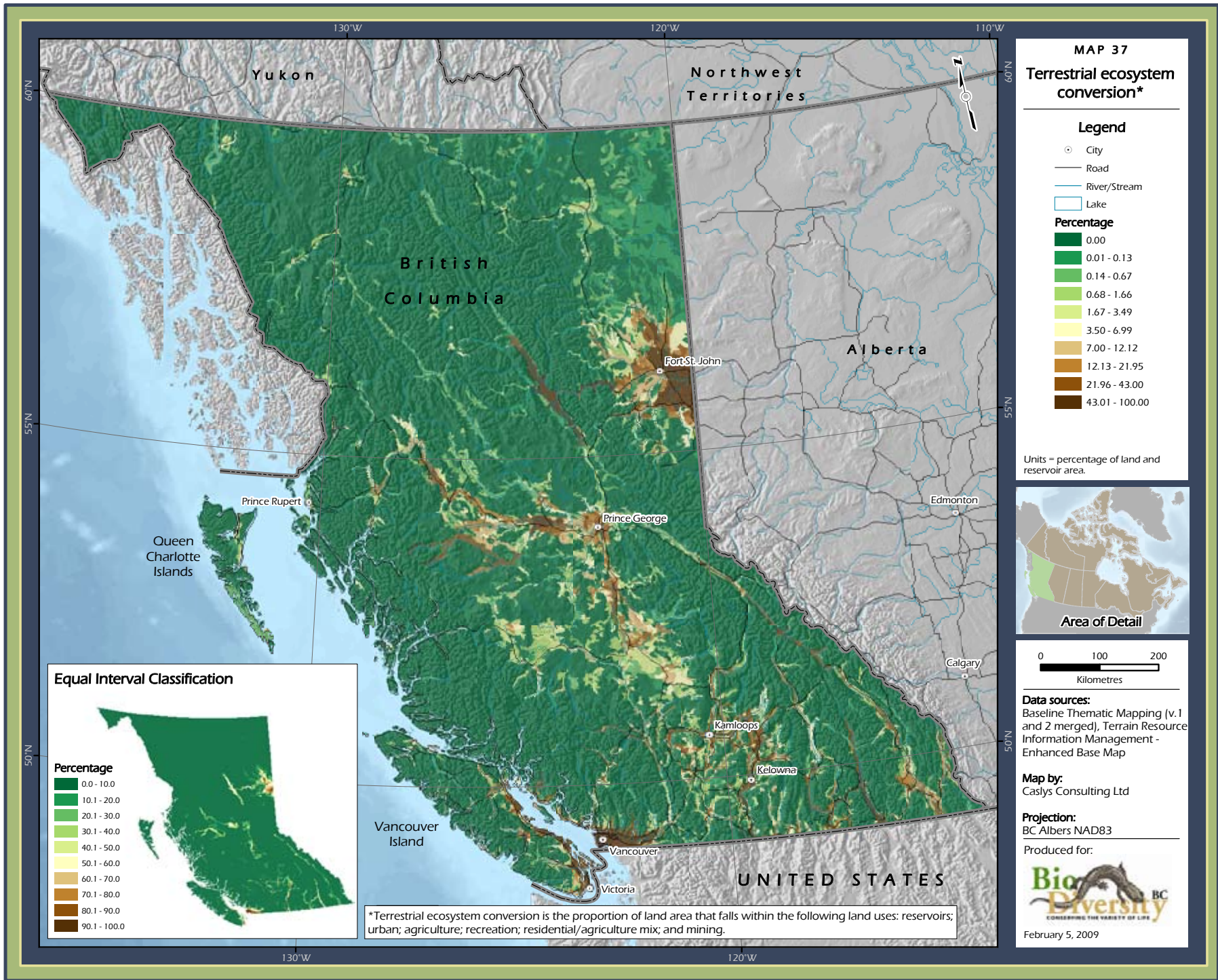
Map by:
 Caslys Consulting Ltd

Projection:
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*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.

Alien Species

Alien species are those that occur outside their native range owing to introduction by humans.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).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.¹³⁹ However, some species also exhibit a time lag between introduction and impact to biodiversity. For example, gorse (*Ulex europaeus*) was introduced to B.C. at least 90 years ago¹⁴⁰ 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.¹⁴¹ They

displace native populations of plants and animals by occupying habitat and competing for resources.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.¹⁴³

A total of 809 alien species are listed by the B.C. Conservation Data Centre (CDC).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.^{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).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

SPECIES GROUP	NUMBER OF ALIEN SPECIES MAPPED		
	FRESHWATER AND TERRESTRIAL	TERRESTRIAL	FRESHWATER
Amphibians	1	1	1
Birds	7	7	2
Freshwater Fishes	15	0	15
Mammals	17	17	3
Reptiles and Turtles	1	1	0
Invertebrates	55	55	0
Vascular Plants	680	637	43
TOTAL	776	718	64

SOURCE: Produced for this report.

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.

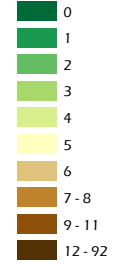
ⁿ Unlike the species richness maps (pp.36-67) where the analysis used data from point locations, the alien species maps were created by compiling lists of alien species for each Ecoregion (p.18) and biogeoclimatic variant (p.20) combination. This methodology has the effect of lowering spatial precision. Every polygon of a biogeoclimatic variant in an Ecoregion gets the same value whereas one may have a high road density (p.106) and many alien species while another may be relatively pristine.

MAP 38
Number of terrestrial and freshwater alien species*

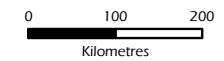
Legend

- City
- Road
- River/Stream
- Lake

Number of species



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



Data sources:
 B.C. Ministry of Environment

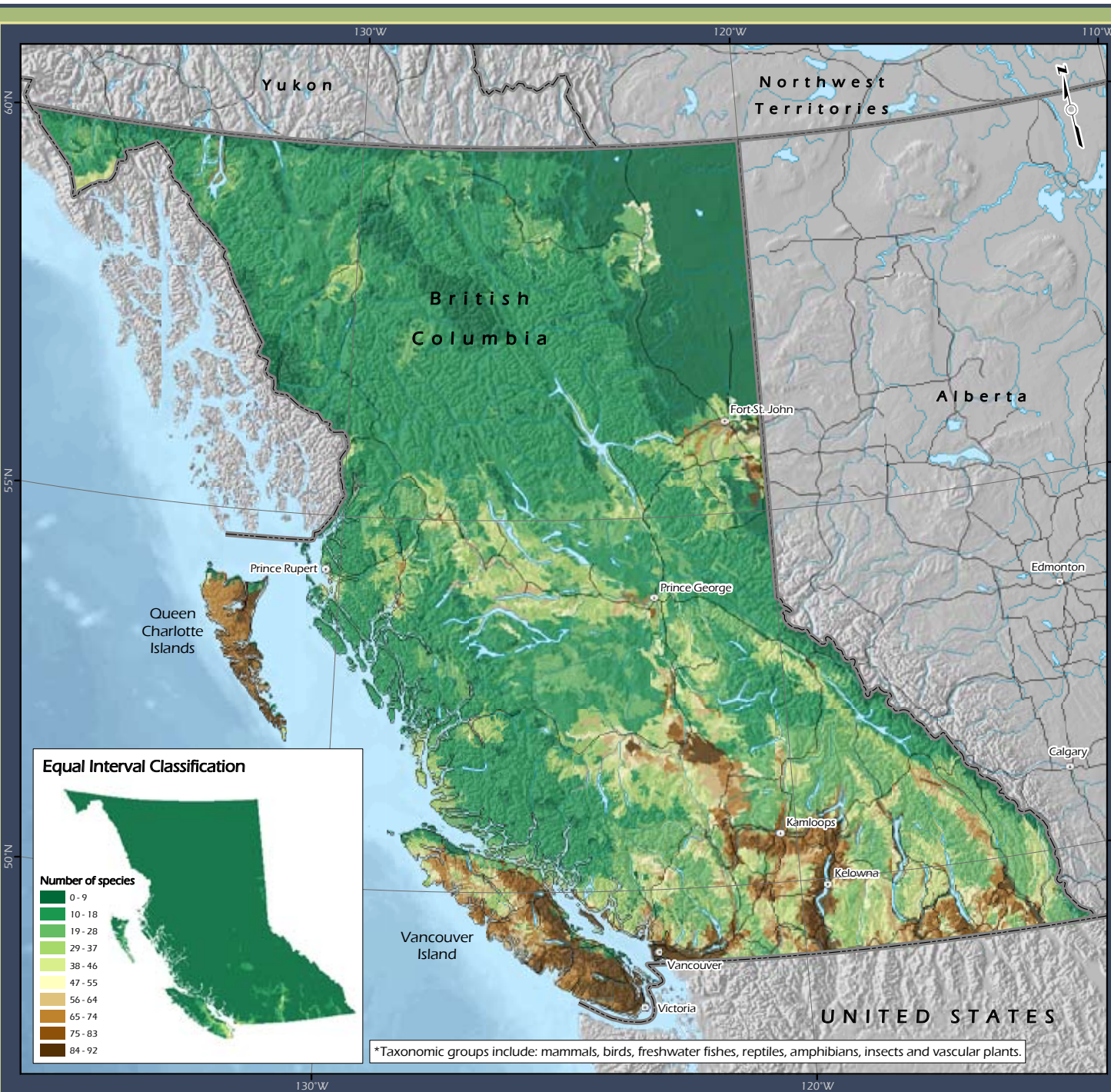
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

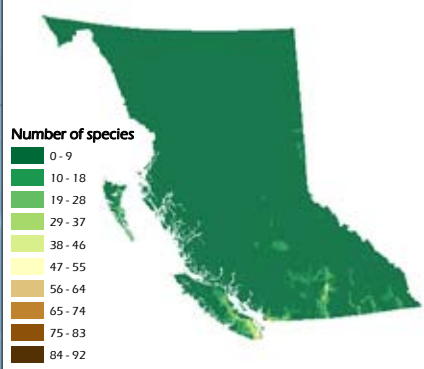
Produced for:



February 25, 2009



Equal Interval Classification



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

Alien species continued . . .

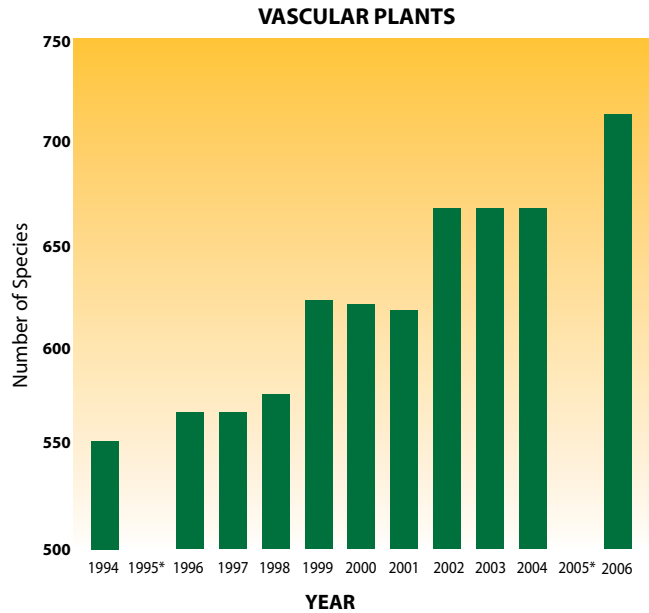


FIGURE 7: Trends in the number of alien vascular plant species established in B.C.

SOURCE: B.C. Ministry of Environment. 2007. Species Conservation. Technical Paper for Environmental Trends 2007. State of Environment Reporting Office, Victoria, BC. Available at: www.env.gov.bc.ca/soe/et07/07_species_conservation/technical_paper/species_conservation.pdf. Note: * Years with no data.

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%.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.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

TABLE 25. TERRESTRIAL ALIEN SPECIES RICHNESS FOR BIOGEOCLIMATIC ZONES IN B.C.

BIOGEOCLIMATIC ZONE	NUMBER OF SPECIES
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

SOURCE: Produced for this report.

130°W 120°W 110°W

60°N

55°N

50°N

130°W

120°W

60°N





55°N

50°N











MAP 39

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).



Data sources:
B.C. Ministry of Environment

Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

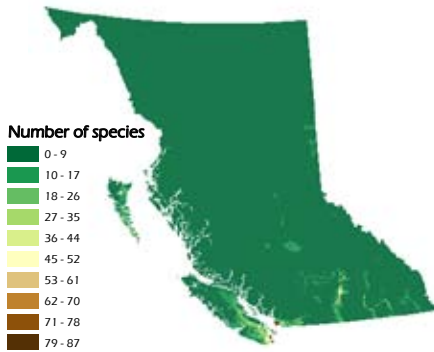
Produced for:



February 25, 2009



Equal Interval Classification



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

Alien species continued . . .

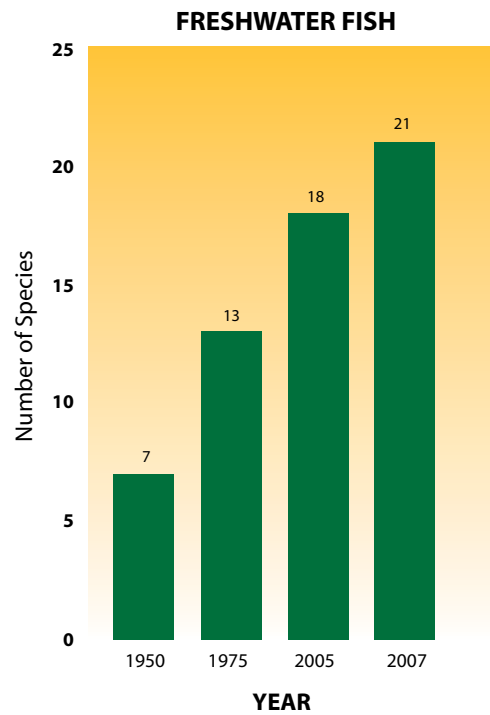


FIGURE 8: Trends in the number of alien freshwater fish species established in B.C.

SOURCE: B.C. Ministry of Environment. 2007. Species Conservation. Technical Paper for Environmental Trends 2007. State of Environment Reporting Office, Victoria, BC. Available at: www.env.gov.bc.ca/soe/et07/07_species_conserv/technical_paper/species_conservation.pdf and D. McPhail, University of British Columbia, Emeritus, personal communication.

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).^{151,152} 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).

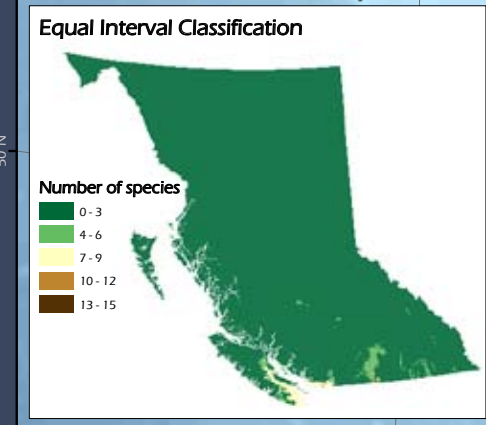
While the general pattern of alien species introductions following ecosystem degradation appears to hold for both terrestrial and aquatic species, in some cases, alien species are capable of invading apparently unaltered ecosystems such as islands and lakes, which often have significant genetic and species-level diversity.^{153,154}

TABLE 26. FRESHWATER ALIEN SPECIES RICHNESS FOR MAJOR DRAINAGE AREAS IN B.C.

MAJOR DRAINAGE AREA	NUMBER OF FRESHWATER ALIEN SPECIES
Coastal	25
Fraser	24
Columbia	22
Mackenzie	5
Skeena	2
Nass	1
Yukon	1
Stikine	0
Taku	0

SOURCE: Produced for this report.

MAP 40
Number of freshwater alien species



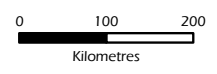
Legend

- 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).



Data sources:
 B.C. Ministry of Environment

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009

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

Climate Change

Climate is the primary factor enabling and shaping the distribution of organisms and the nature and character of ecosystems,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.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.^{157,158}

Rapid climate change is underway in response to human greenhouse gas (primarily CO₂) emissions¹⁵⁹ and biodiversity impacts are evident.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 2100.¹⁶¹ The resulting rate of change will be unprecedented in the last 750,000 years.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.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.¹⁶⁴ Based on measured changes in temperature and precipitation from weather stations between 1971 and 2000,^o 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 maximum temperature (1971-2000), and
 - 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).^p
- The *absolute* rate of change represents the average of the magnitudes^q 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.
- average rate of change in minimum temperature (1971-2000),

^o 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.

^p 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 41
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)

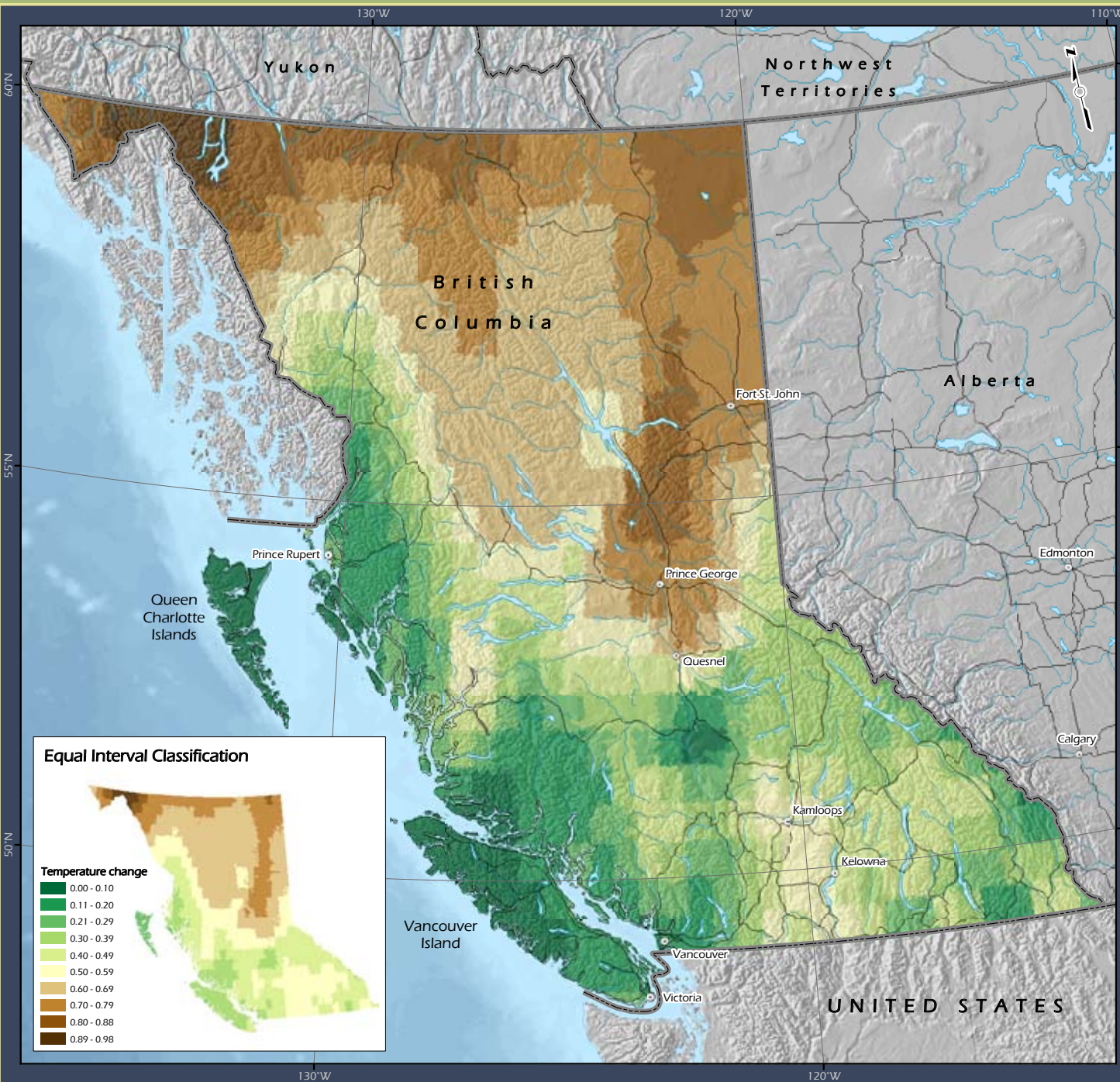
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

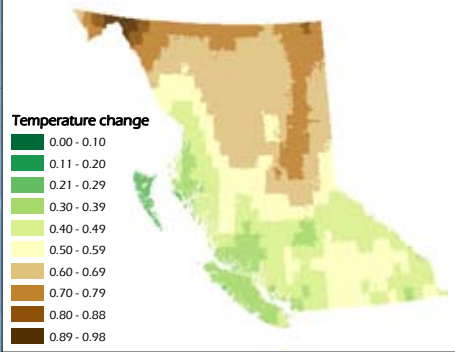
Produced for:

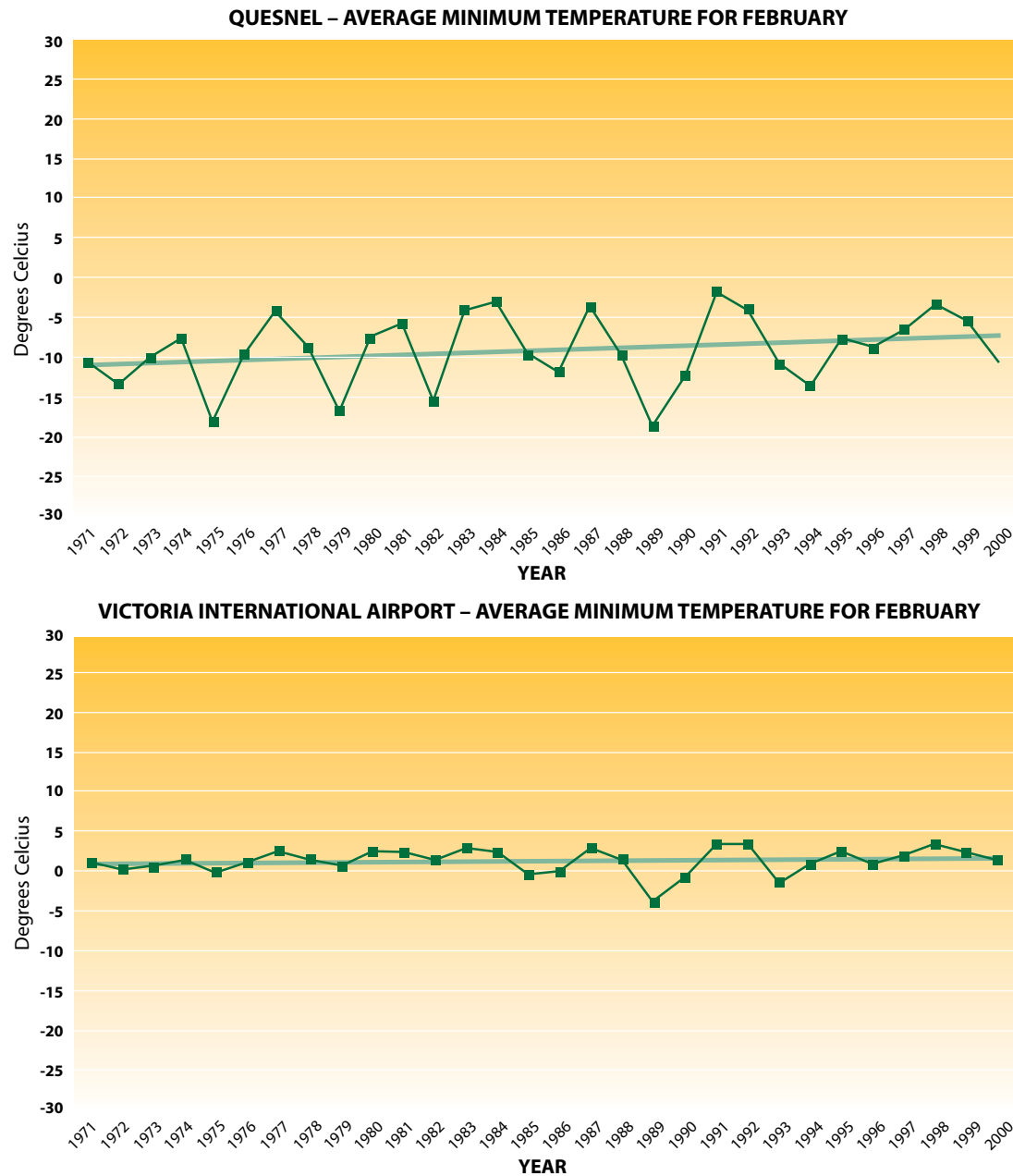


February 5, 2009



Equal Interval Classification





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.

MAP 42
Relative rate of change in minimum temperature (average of all months) from 1971 to 2000

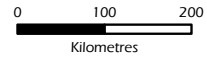
Legend

- City
- Road
- River/Stream
- Lake

Temperature change

- 0.000 - 0.252
- 0.253 - 0.273
- 0.274 - 0.283
- 0.284 - 0.293
- 0.294 - 0.306
- 0.307 - 0.315
- 0.316 - 0.324
- 0.325 - 0.336
- 0.337 - 0.354
- 0.355 - 0.475

Units = standard deviations per decade averaged for all months.



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

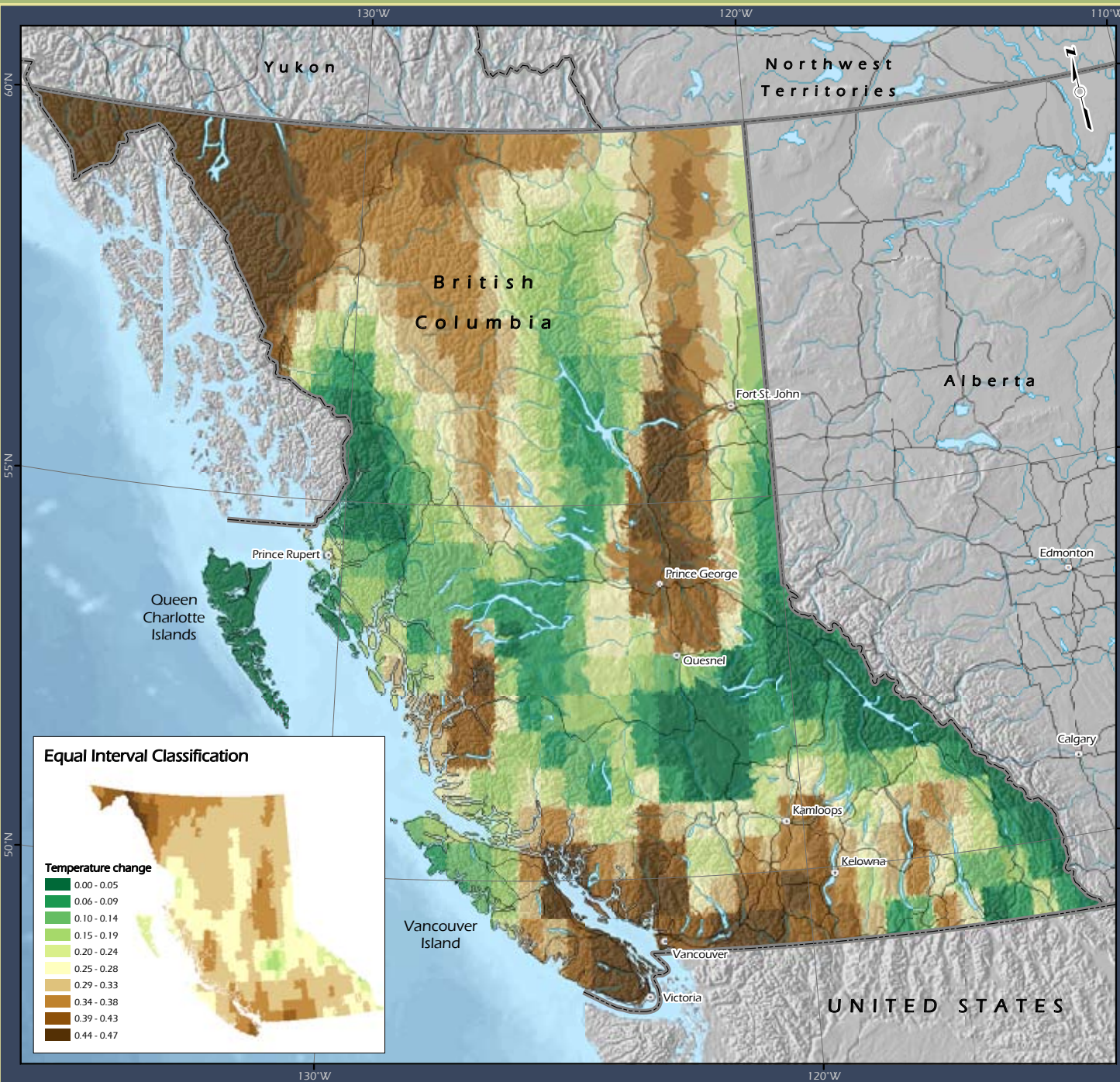
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

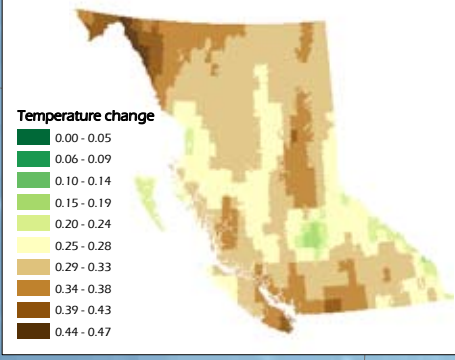
Produced for:



February 5, 2009



Equal Interval Classification



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



PHOTO: LUIS CAMARGO.

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.¹⁶⁵ 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.¹⁶⁶ Temperatures have been rising across the province with more rapid increases in winter and spring.¹⁶⁷ 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.

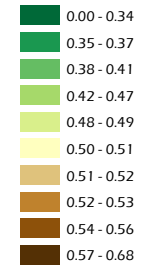
Maps 43 and 44 show absolute and relative rates of change for maximum temperature across the province. Maximum temperature changes have been smaller than changes in minimum temperature (e.g., highest changes of 0.68°C and 0.98°C per decade respectively). The highest absolute rates of change in maximum 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).

MAP 43
Absolute rate of change in maximum temperature (average of all months) from 1971 to 2000

Legend

- City
- Road
- River/Stream
- Lake

Temperature change



Units = °C per decade.



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

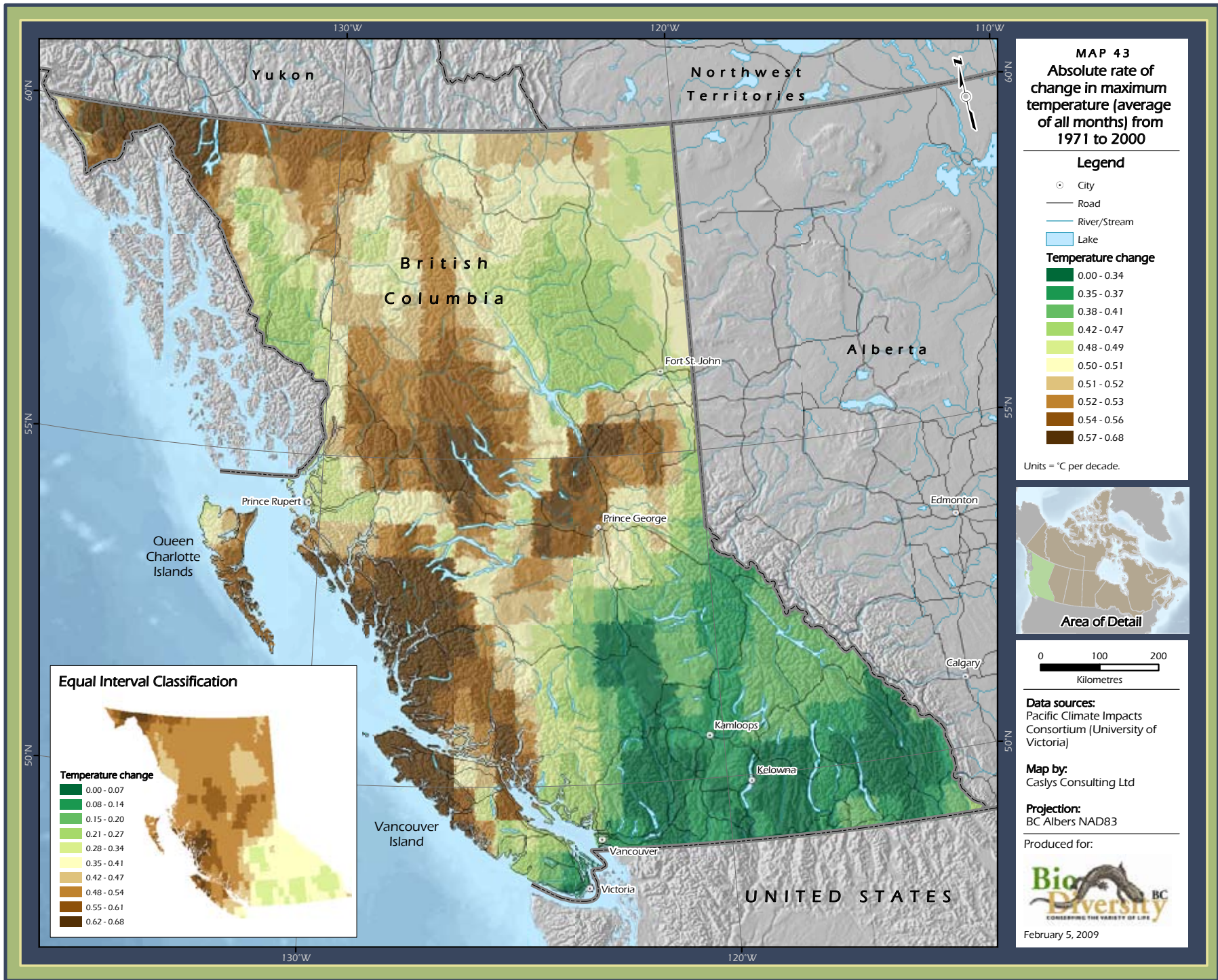
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

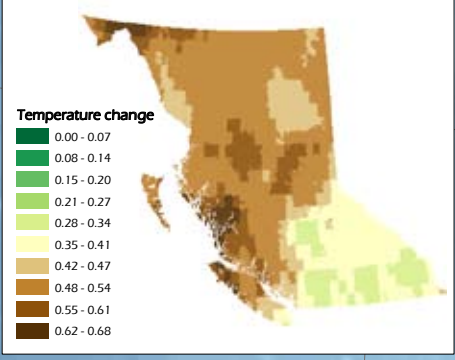
Produced for:



February 5, 2009







Equal Interval Classification













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
-  0.18 - 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)

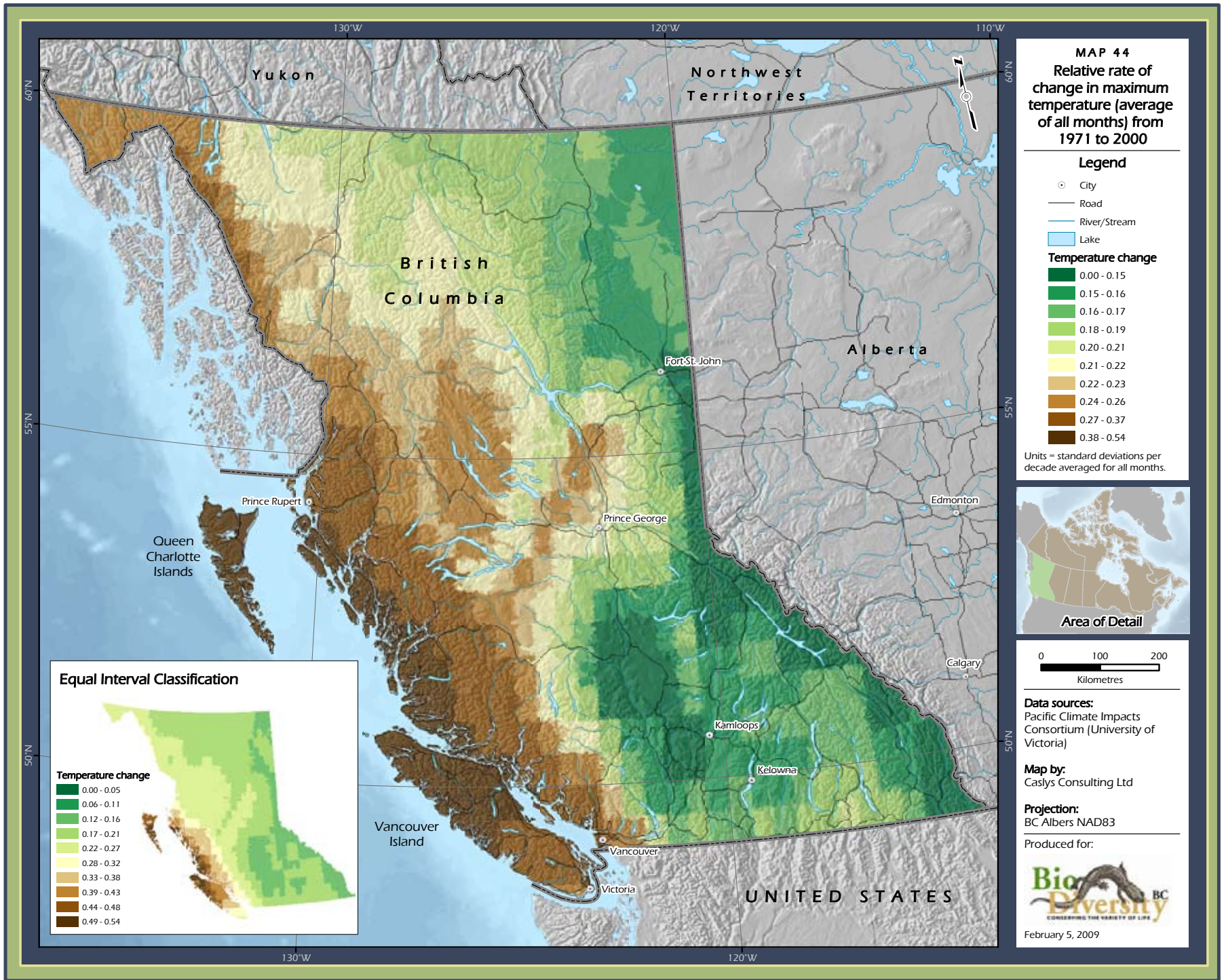
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

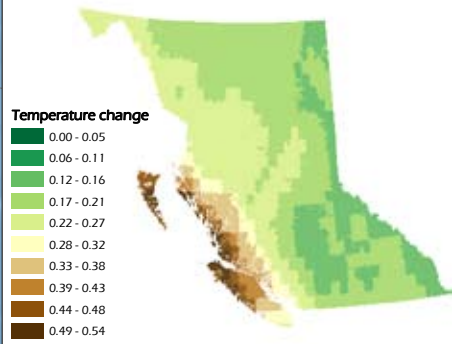
Produced for:



February 5, 2009



Equal Interval Classification



PRECIPITATION

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.^{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.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



PHOTO: GEOFFREY HOLMAN.

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.

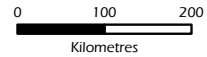
When natural variation is included in the analysis, it becomes apparent that the rates of change in precipitation are more significant in the south and central interior of the province where year to year variability in precipitation is less (Map 46).

MAP 45
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)

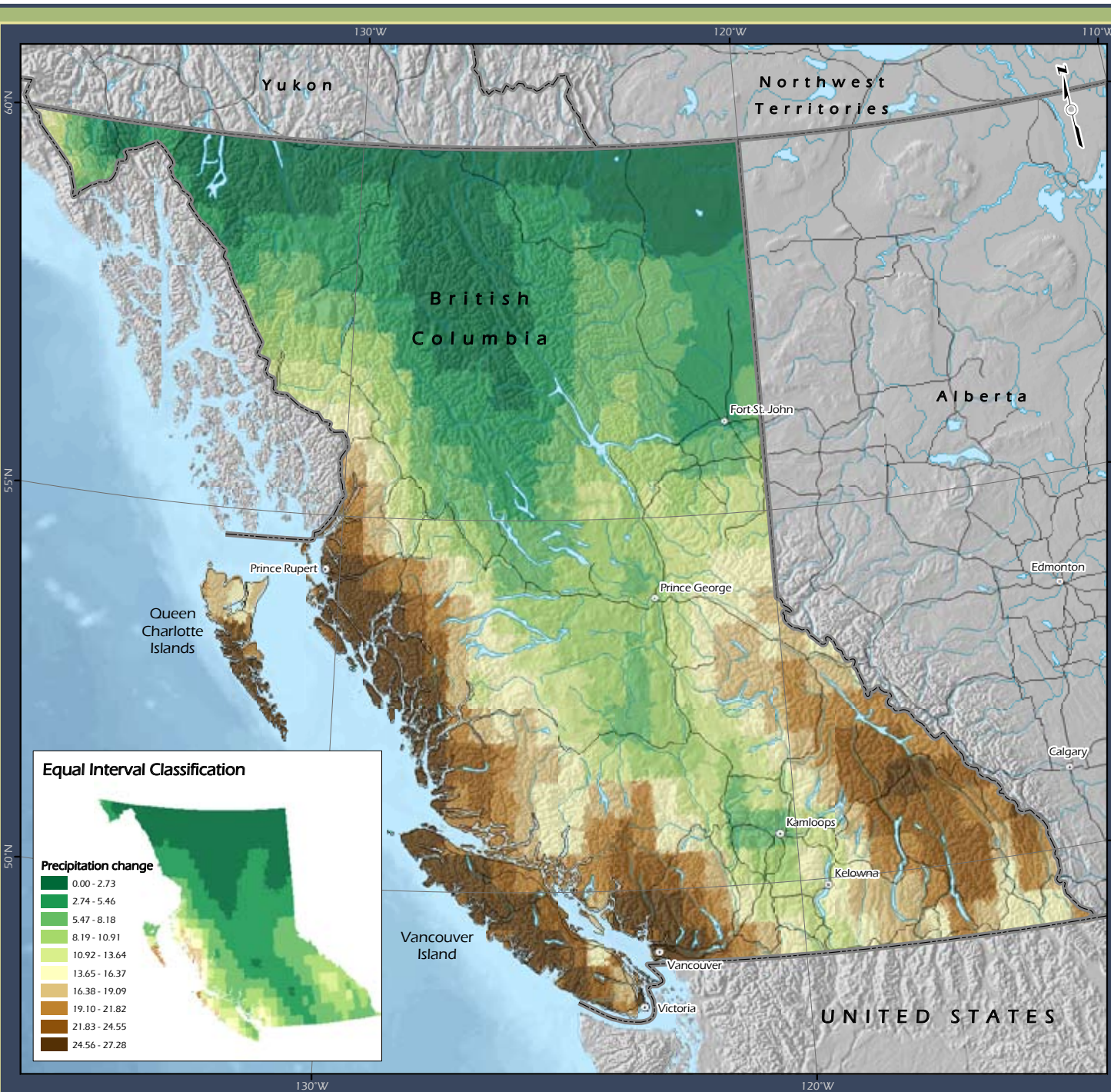
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

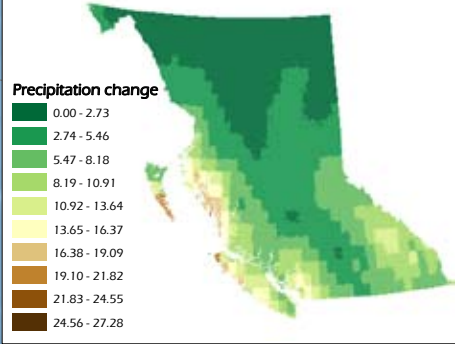
Produced for:



February 5, 2009



Equal Interval Classification



130°W

120°W

110°W

60°N

55°N

50°N

MAP 46
Relative rate of change in precipitation
(average of all months)
from 1971 to 2000

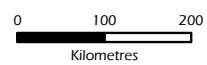
Legend

- 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)

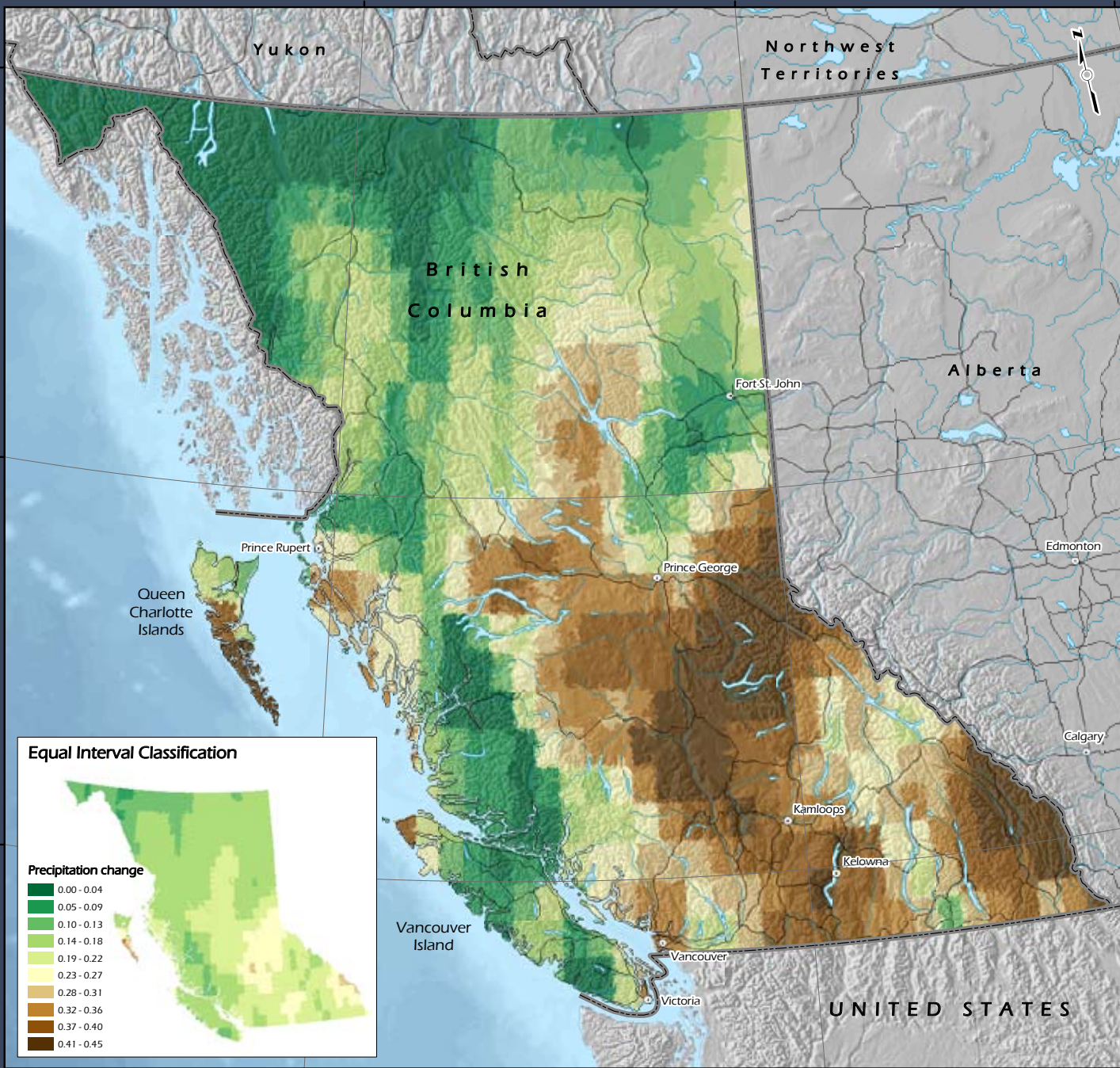
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

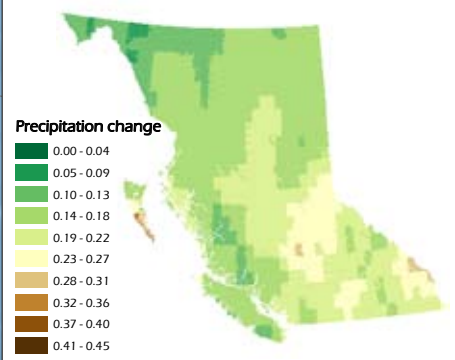
Produced for:



February 5, 2009



Equal Interval Classification



130°W

120°W

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 1971-2000.¹⁷¹ 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.



Dry stream bed in the Chilcotin Mountains.

PHOTO: CRAIG FARISH.

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.



MAP 47
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:
 Caslys 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:



February 4, 2009



MAP 49
Seasonal trends in precipitation from 1971 to 2000

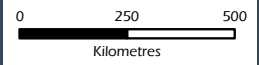
Legend

- River/Stream
- Lake

Precipitation trend

- 11.9 to -9.0
- 8.9 to -6.0
- 5.9 to -3.0
- 2.9 to 0.0
- +0.1 to +3.0
- +3.1 to +6.0

Units = 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:



February 4, 2009

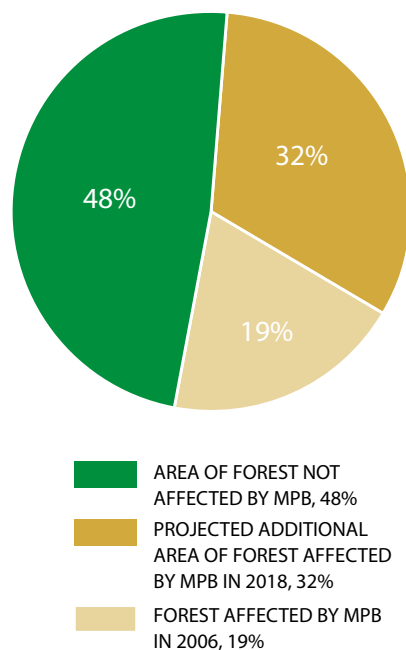


FIGURE 10: Forests in B.C. affected by mountain pine beetle (MPB), with projections to 2018.

SOURCE: Forest area is based on Baseline Thematic Mapping (BTM), Integrated Land Management Bureau from mid-1990s inventory data. Mountain pine beetle data is based on the Ministry of Forests and Range 1999 to 2006 Provincial Aerial Overview of Forest Health (<http://www.for.gov.bc.ca/hfp/health/overview/overview.htm>) and output from the BCMPB Projection Model (version 4) (www.for.gov.bc.ca/hre/BCMPB).

MOUNTAIN PINE BEETLE

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.¹⁷² 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.¹⁷³

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.^{174,175} 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.¹⁷⁶

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 2019.¹⁷⁷

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.¹⁷⁸ 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.¹⁷⁹ 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.^{180,181} The resulting increased run-off will have short-term effects on stream systems, including erosion. The effects of increased logging levels (p.104) from the salvage of beetle-killed timber may be significant.^{182,183,184,185} The risk of fire in beetle-killed forests is increasing.^{186,187}

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.¹⁸⁸ This trend is expected to continue.

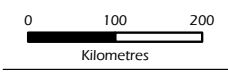
MAP 50
Area of forests
more than 10%
impacted by
mountain pine beetle

Legend

- City
- Road
- River/Stream
- Lake

Year

- 2007
- 2003
- 1999



Data sources:
 B.C. Ministry of Forests and Range

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009



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,⁴ 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^f of British Columbia has been logged since the 1970s (Table 27, Map 51). Logging prior

TABLE 27. PERCENTAGE OF LAND LOGGED IN B.C. SINCE THE 1970S BY BIOGEOCLIMATIC ZONE.

BIOGEOCLIMATIC ZONE	PERCENTAGE OF TOTAL LAND AREA LOGGED SINCE 1970s
Sub-Boreal Spruce	23%
Interior Douglas-fir	22%
Montane Spruce	22%
Interior Cedar–Hemlock	22%
Sub-Boreal Pine–Spruce	17%
Coastal Western Hemlock	14%
Ponderosa Pine	8%
Engelmann Spruce–Subalpine Fir	6%
Coastal Douglas-fir	6%
Boreal White and Black Spruce	5%
Mountain Hemlock	2%
Spruce–Willow–Birch	<0.5%
Bunchgrass	<0.5%
Interior Mountain-heather Alpine	<0.5%
Coastal Mountain-heather Alpine	<0.5%
Boreal Altai Fescue Alpine	<0.5%
Provincial	9%

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.

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.

⁴ A forest-associated species is one with a measurable dependence on a forest ecosystem for any aspect of its life history.

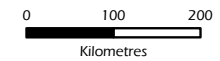
^f Area logged=Percent of land area.

MAP 51
Percentage logged since the 1970s

Legend

- City
 - Road
 - River/Stream
 - Lake
- Percentage**
- 0.00
 - 0.01 - 1.57
 - 1.58 - 4.58
 - 4.59 - 8.65
 - 8.66 - 13.84
 - 13.85 - 19.78
 - 19.79 - 27.42
 - 27.43 - 37.09
 - 37.10 - 51.21
 - 51.22 - 100.00

Units = percentage of land area.



Data sources:
 Baseline Thematic Mapping (v.1 and 2 merged), B.C. Ministry of Forests and Range (Results and Change Detection)

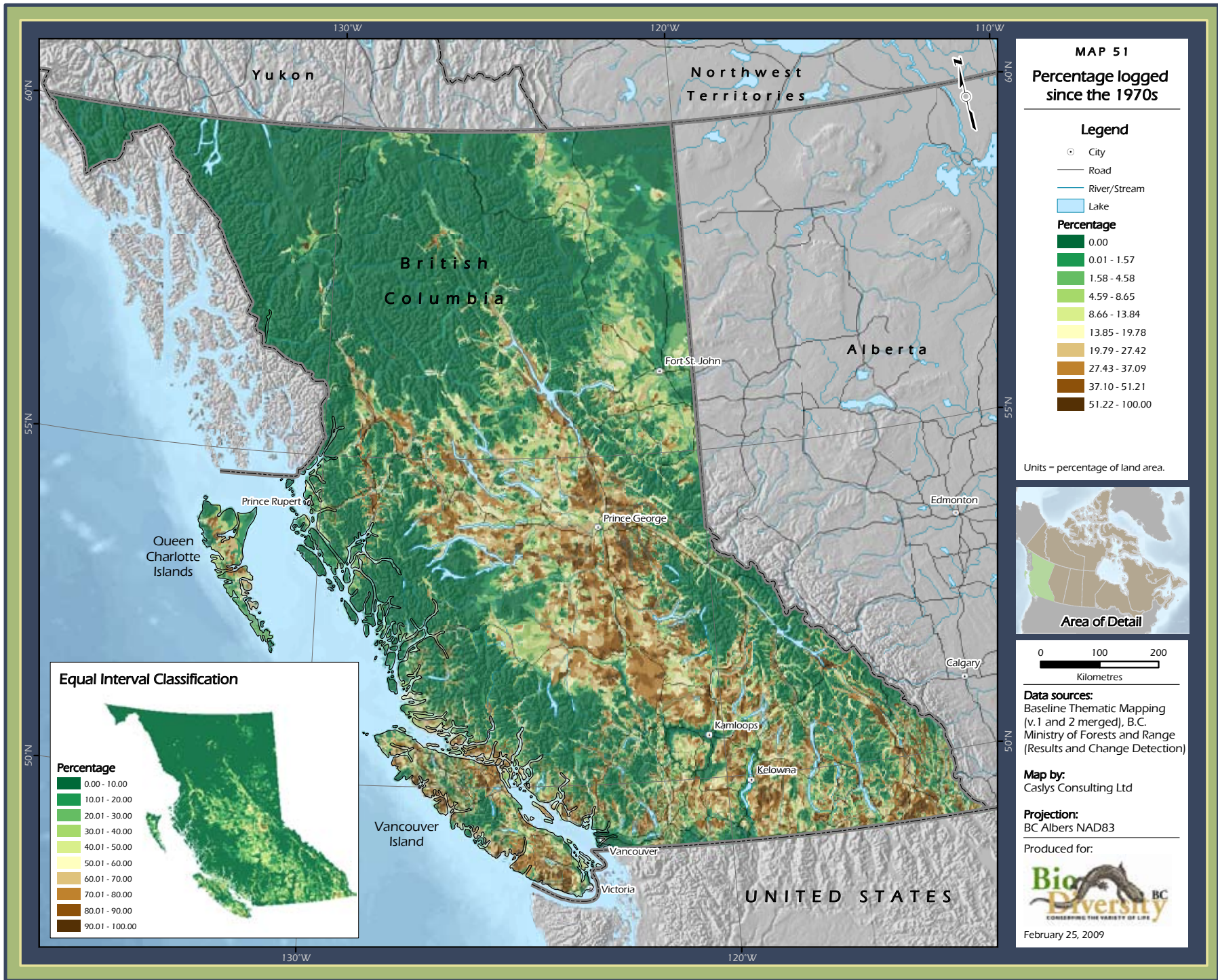
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

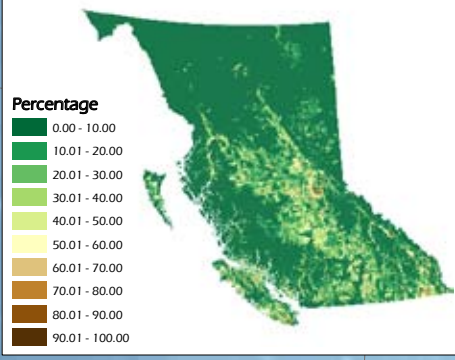
Produced for:



February 25, 2009



Equal Interval Classification



Transportation and Utility Corridors

Roads and other linear features include primary, secondary and forestry roads, trails, hydro transmission corridors, seismic lines,^s pipelines, and railways. Roads and other linear features impede the movement of native species, facilitate invasion by alien species and alter predator-prey relationships.^{198,199} Roads can fragment ranges, populations, habitats and ecosystems,^{200,201,202} and reduce gene flow, resulting in loss of genetic diversity.²⁰³ 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,²⁰⁴ 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.²⁰⁵ By 2005, total road length was 702,574 km, a 23% increase in five years, and an 82% increase since 1988.²⁰⁶

Table 28 compares the density of roads and other linear features (including seismic

lines) for B.C.'s biogeoclimatic zones (p.20). Highest densities of roads and other linear features are found in the Coastal Douglas-fir, Ponderosa Pine, Bunchgrass, and Interior Douglas-fir zones, all zones of conservation concern (p.22).²⁰⁷

TABLE 28. DENSITY AND PRESENCE OF ROADS OR OTHER LINEAR FEATURES FOR B.C.'S BIOGEOCLIMATIC ZONES

BIOGEOCLIMATIC ZONE	ROAD DENSITY (KM/KM ²)	PERCENTAGE OF 1 HECTARE UNITS WITH ROADS PRESENT
Coastal Douglas-fir	4.7	38%
Ponderosa Pine	3.0	28%
Bunchgrass	2.8	25%
Interior Douglas-fir	2.1	22%
Boreal White and Black Spruce	1.4	15%
Interior Cedar-Hemlock	1.3	14%
Sub-Boreal Spruce	1.3	13%
Montane Spruce	1.3	14%
Sub-Boreal Pine-Spruce	1.1	12%
Coastal Western Hemlock	0.9	9%
Engelmann Spruce-Subalpine Fir	0.3	3%
Mountain Hemlock	0.1	1%
Spruce-Willow-Birch	0.1	1%
Boreal Altai Fescue Alpine	<0.1	<1%
Interior Mountain-heather Alpine	<0.1	<1%
Coastal Mountain-heather Alpine	0.0	0%
Province		8%

SOURCE: Produced for this report.

NOTES: Density and percentage figures include other linear features.

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.²⁰⁸ 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.²⁰⁹ 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.²¹⁰

^s 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.

[†] 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).

MAP 52
Density of roads and other linear development features*

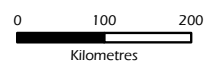
Legend

- City
- Road
- River/Stream
- Lake

Linear density

- 0.00
- 0.01 - 0.14
- 0.15 - 0.35
- 0.36 - 0.63
- 0.64 - 0.95
- 0.96 - 1.29
- 1.30 - 1.67
- 1.68 - 2.13
- 2.14 - 2.89
- 2.90 - 22.10

Units = km/km².



Data sources:
 Terrain Resource Information Management - Enhanced Base Map, Digital Road Atlas (v. 1.1), Oil and Gas Commission

Map by:
 Caslys Consulting Ltd

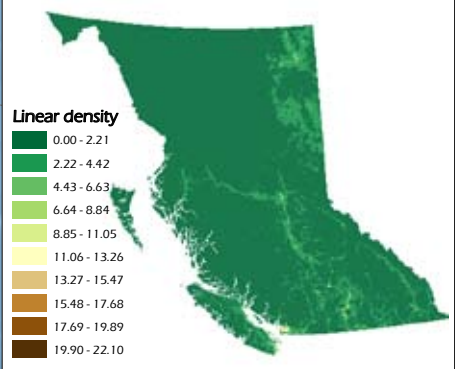
Projection:
 BC Albers NAD83

Produced for:

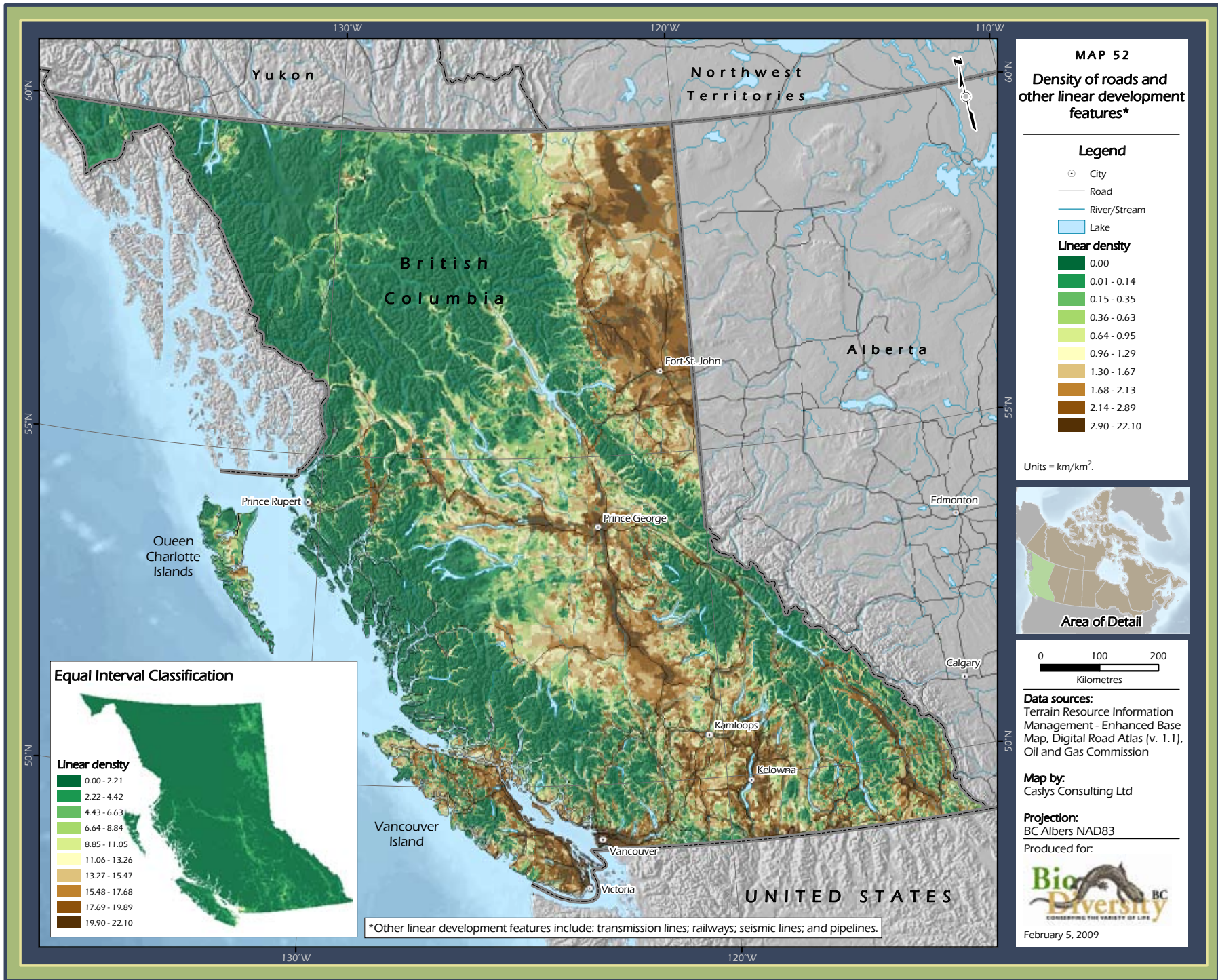


February 5, 2009

Equal Interval Classification



*Other linear development features include: transmission lines; railways; seismic lines; and pipelines.



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.^{211,212} 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 250,000.²¹³

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.²¹⁴ 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.²¹⁵ 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.^{216,217} 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.

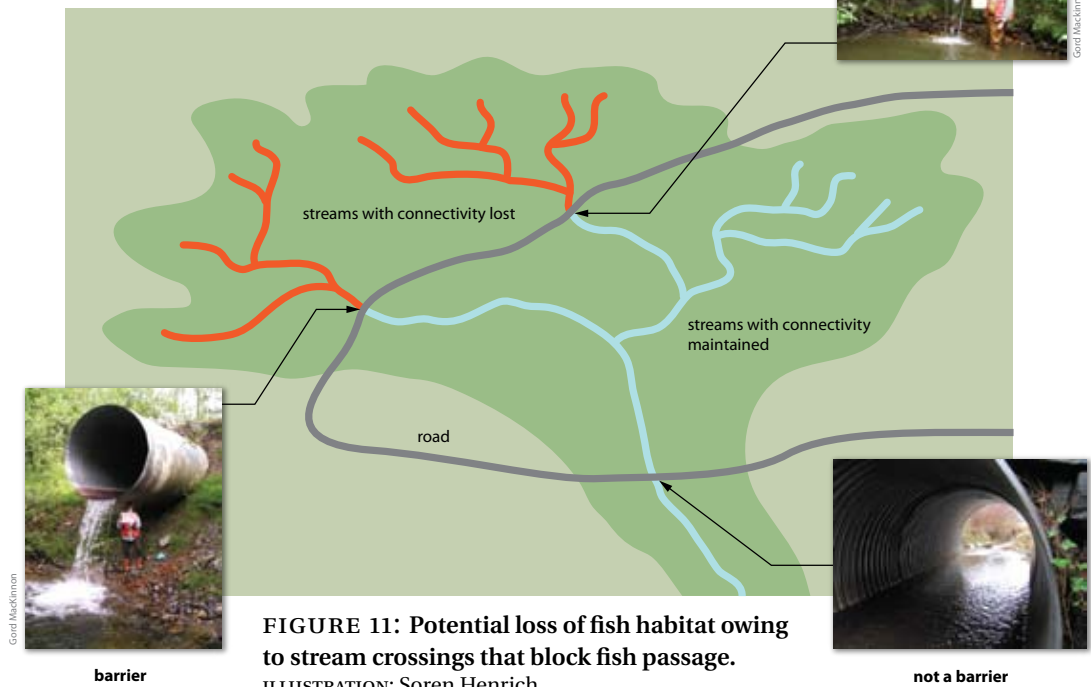
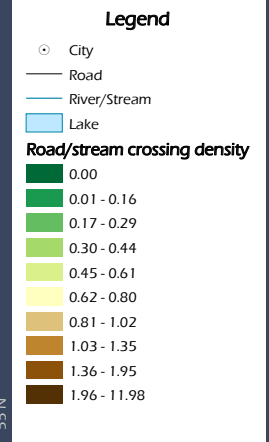
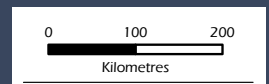


FIGURE 11: Potential loss of fish habitat owing to stream crossings that block fish passage.
ILLUSTRATION: Soren Henrich.

MAP 53
Density of road crossings on fish-bearing streams*



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



Data sources:
 Terrain Resource Information Management - Enhanced Base Map, Digital Road Atlas (v. 1.1), Forest Tenure Roads, Corporate Watershed Base, Fisheries Information Summary System [2006]

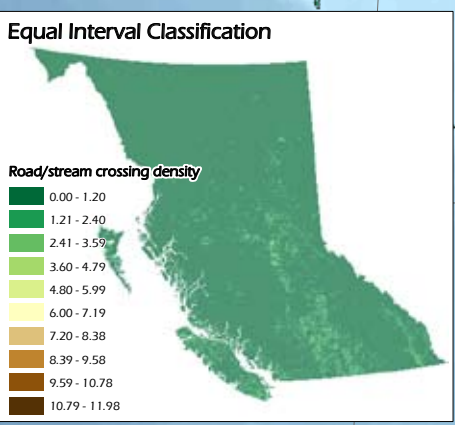
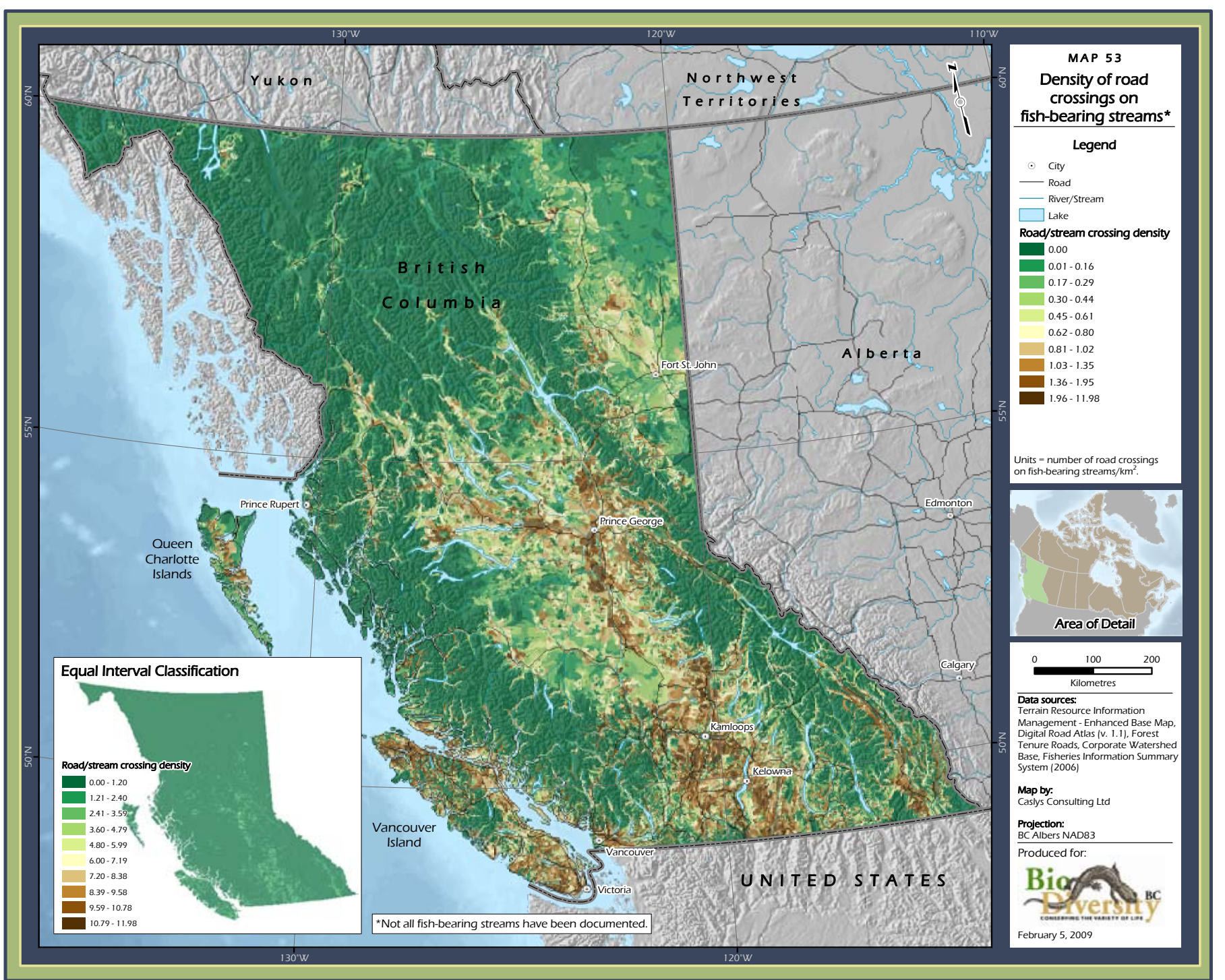
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



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*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



Cleveland dam.

PHOTO: KLAAS LINGBEEK-VAN KRANEN.

water sources with consequent disruption of aquatic and riparian habitat.²¹⁸ In rivers, water diversions reduce flow and lower water levels, which can create barriers to movement of fish and other aquatic species.^{219, 220} 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.^u A license does not mean that 100% of the permitted water is diverted by

TABLE 29. SURFACE WATER ALLOCATION IN B.C. BY MAJOR DRAINAGE AREA

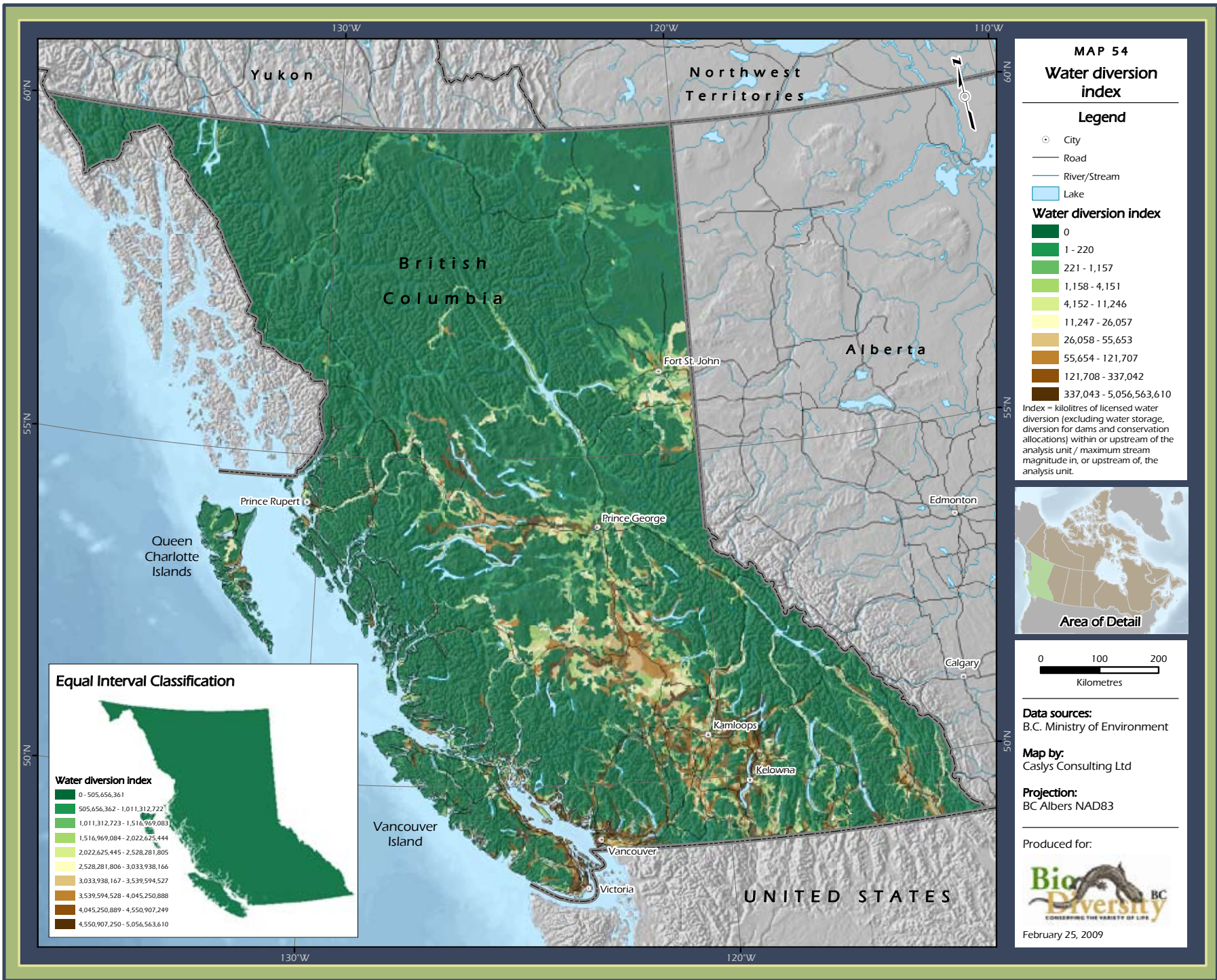
MAJOR DRAINAGE AREA	VOLUME OF LICENSE WATER ALLOCATION (KILOLITRES/YEAR)
Fraser	10,617,165,159
Coastal	6,960,674,550
Columbia	3,191,406,652
Skeena	547,689,512
Mackenzie	393,667,691
Stikine	1,002,531
Nass	816,950
Yukon	816,924
Taku	27,990
Provincial total	21,713,267,959

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.

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.²²¹ 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.²²² The majority of the restrictions are located in the southern Interior.

^u 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).



MAP 54
Water diversion index

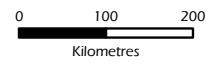
Legend

- City
- Road
- River/Stream
- Lake

Water diversion index

- 0
- 1 - 220
- 221 - 1,157
- 1,158 - 4,151
- 4,152 - 11,246
- 11,247 - 26,057
- 26,058 - 55,653
- 55,654 - 121,707
- 121,708 - 337,042
- 337,043 - 5,056,563,610

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.



Data sources:
 B.C. Ministry of Environment

Map by:
 Caslys Consulting Ltd

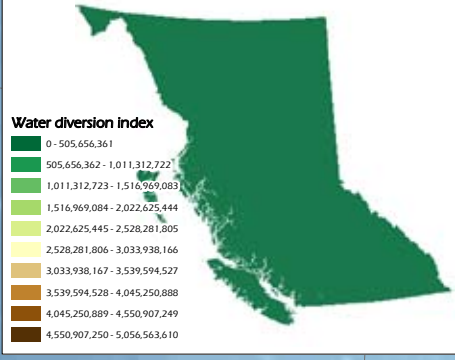
Projection:
 BC Albers NAD83

Produced for:



February 25, 2009

Equal Interval Classification



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

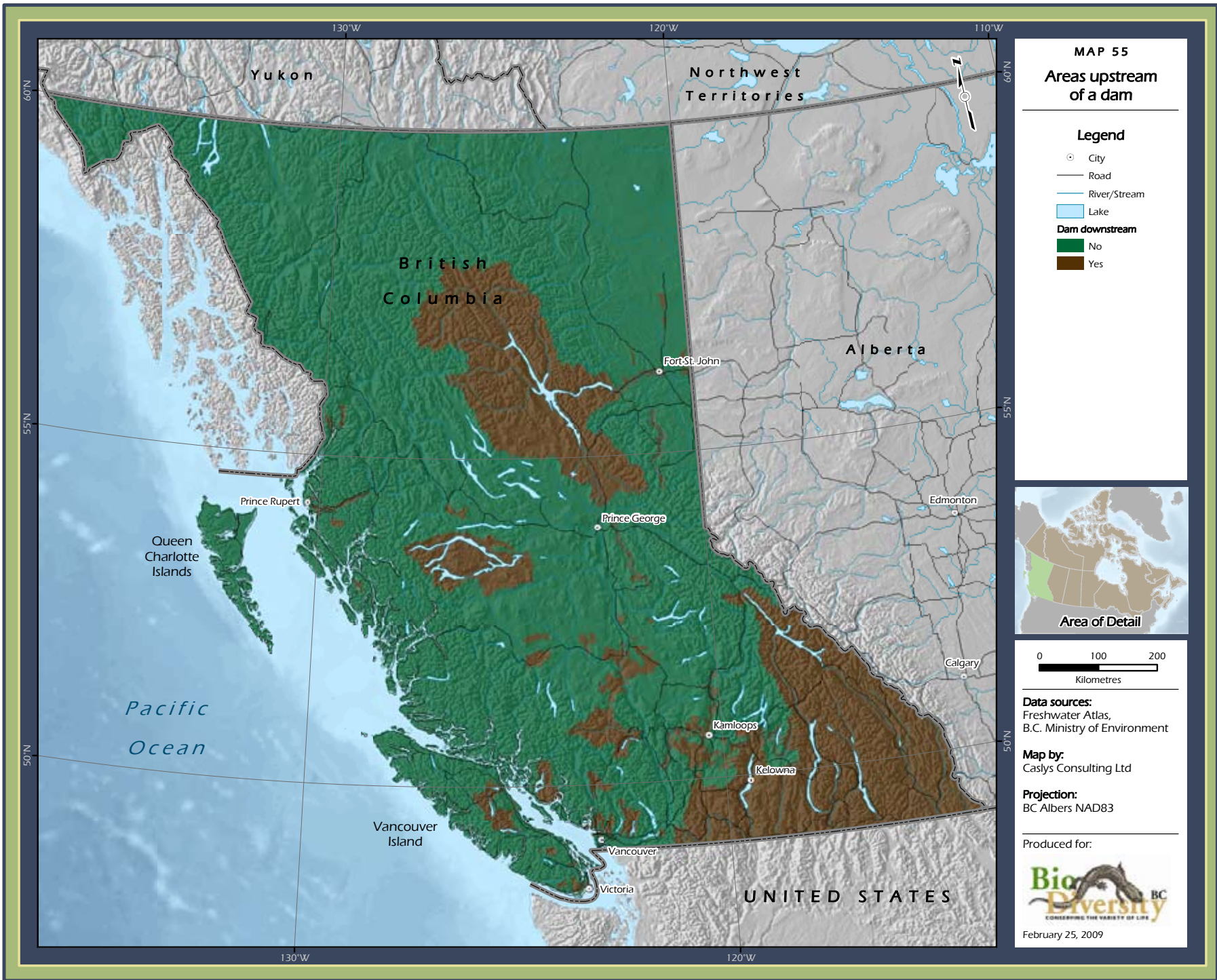
Dams can also create significant ecosystem degradation by hampering the movement of migratory fish species (which reduces the transfer of marine-derived nutrients into interior ecosystems) and some terrestrial species. Dams can change turbidity and sediment levels to which species and ecosystems are 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 down-

stream 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.

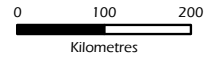
Dams have a functional lifespan and many hundreds of dams have been abandoned.²³² Dam decommissioning, modification, removal and water use planning have been used on some B.C. rivers to restore fish habitat and water flow regimes.²³³



MAP 55
Areas upstream of a dam

Legend

- City
- Road
- River/Stream
- Lake
- Dam downstream**
- No
- Yes



Data sources:
 Freshwater Atlas,
 B.C. Ministry of Environment

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009

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.^{234,235,236} At present, the majority of activities associated with petroleum or natural gas extraction in British Columbia take place in



Infrastructure relating to oil and gas development.

PHOTO: DON WILKIE.

the relatively flat Interior Plains in the north-east 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 30. DENSITY OF OIL AND GAS SITES IN B.C. BY BIOGEOCLIMATIC ZONE

BIOGEOCLIMATIC ZONE	DENSITY (NUMBER OF SITES / 1,000 KM ²)
Boreal White and Black Spruce	196
Engelmann Spruce–Subalpine Fir	3
Coastal Douglas-fir	2
Montane Spruce	2
Spruce–Willow–Birch	2
Sub-Boreal Spruce	1
Interior Douglas-fir	<1
Interior Cedar–Hemlock	<1
Sub-Boreal Pine–Spruce	<1
Coastal Western Hemlock	<1
Ponderosa Pine	<1
Mountain Hemlock	<1
Bunchgrass	<1
Interior Mountain-heather Alpine	<1
Coastal Mountain-heather Alpine	<1
Boreal Altai Fescue Alpine	<1

SOURCE: Prepared for this report.

MAP 56
Oil and gas site density

Legend

- City
 - Road
 - River/Stream
 - Lake
- Site density**
- 0.00
 - 0.01 - 0.04
 - 0.05 - 0.08
 - 0.09 - 0.13
 - 0.14 - 0.20
 - 0.21 - 0.30
 - 0.31 - 0.43
 - 0.44 - 0.62
 - 0.63 - 0.95
 - 0.96 - 14.73

Units = sites/km².



Data sources:
Oil and Gas Commission

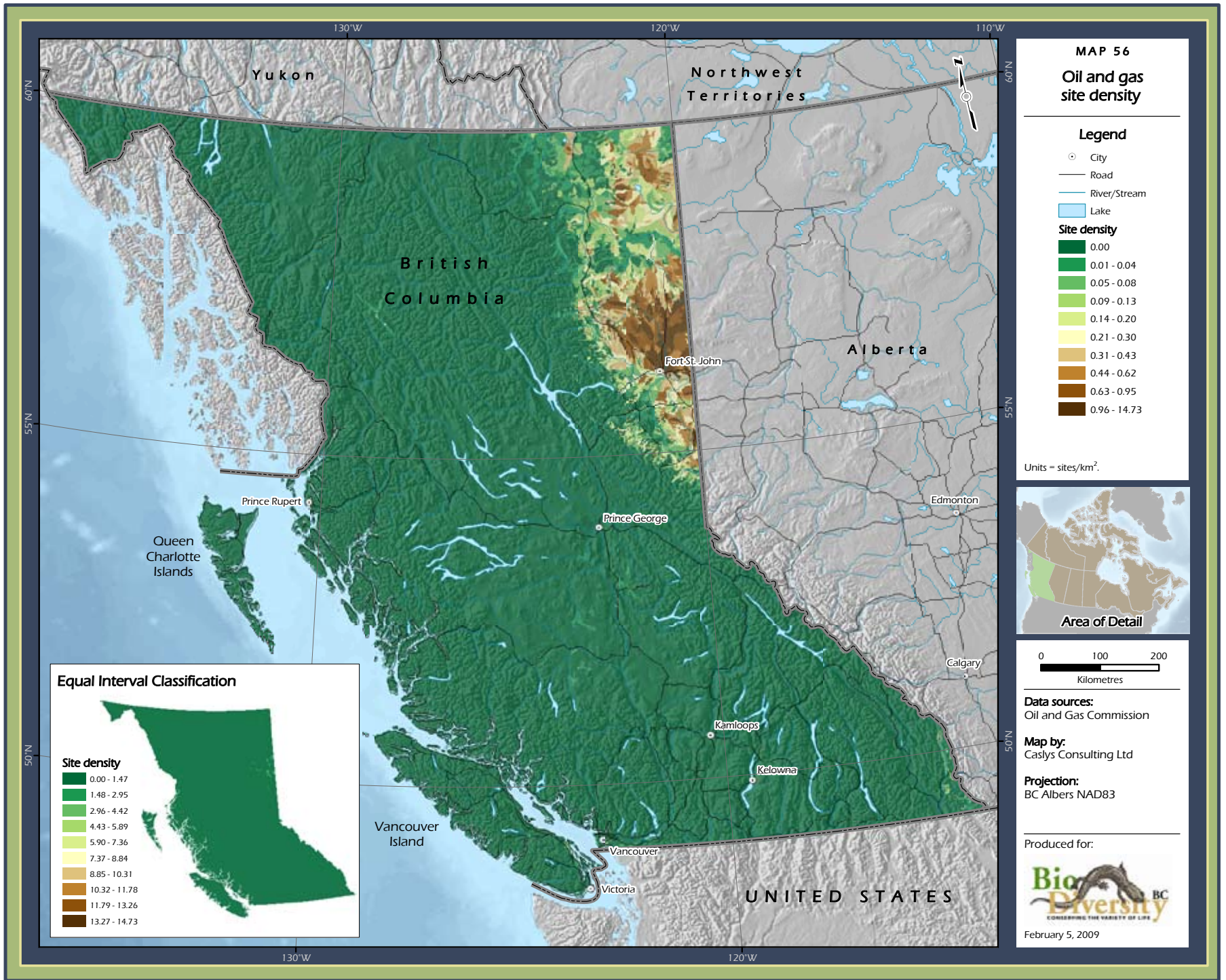
Map by:
Caslys Consulting Ltd

Projection:
BC Albers NAD83

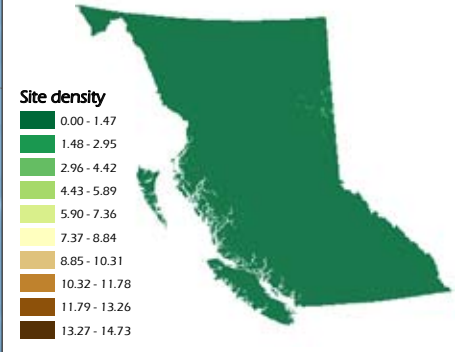
Produced for:



February 5, 2009



Equal Interval Classification



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.



Black bear (*Ursus americanus*).

PHOTO: CRAIG FARISH.

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.²³⁷ 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.²³⁸ 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.²³⁹ 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.²⁴⁰

Municipal landfills can be sources of ground and surface water pollution, as well as greenhouse gas emissions, primarily methane (CH₄) and carbon dioxide (CO₂).²⁴¹

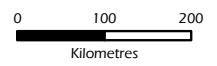
For example, groundwater contamination and gas emissions are a concern at Burns Bog, a 5,000-year-old, 30 km² raised bog in Delta, British Columbia near Vancouver (p.74).²⁴² Burns Bog is the site of Canada's largest landfill west of Toronto, and nine smaller landfills are situated adjacent to the bog.

As of 2008, over 9,000 sites were listed on the provincial registry.²⁴³ Note that 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/km² 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.

MAP 57
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

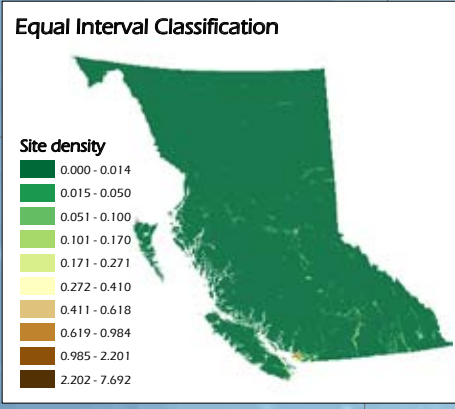
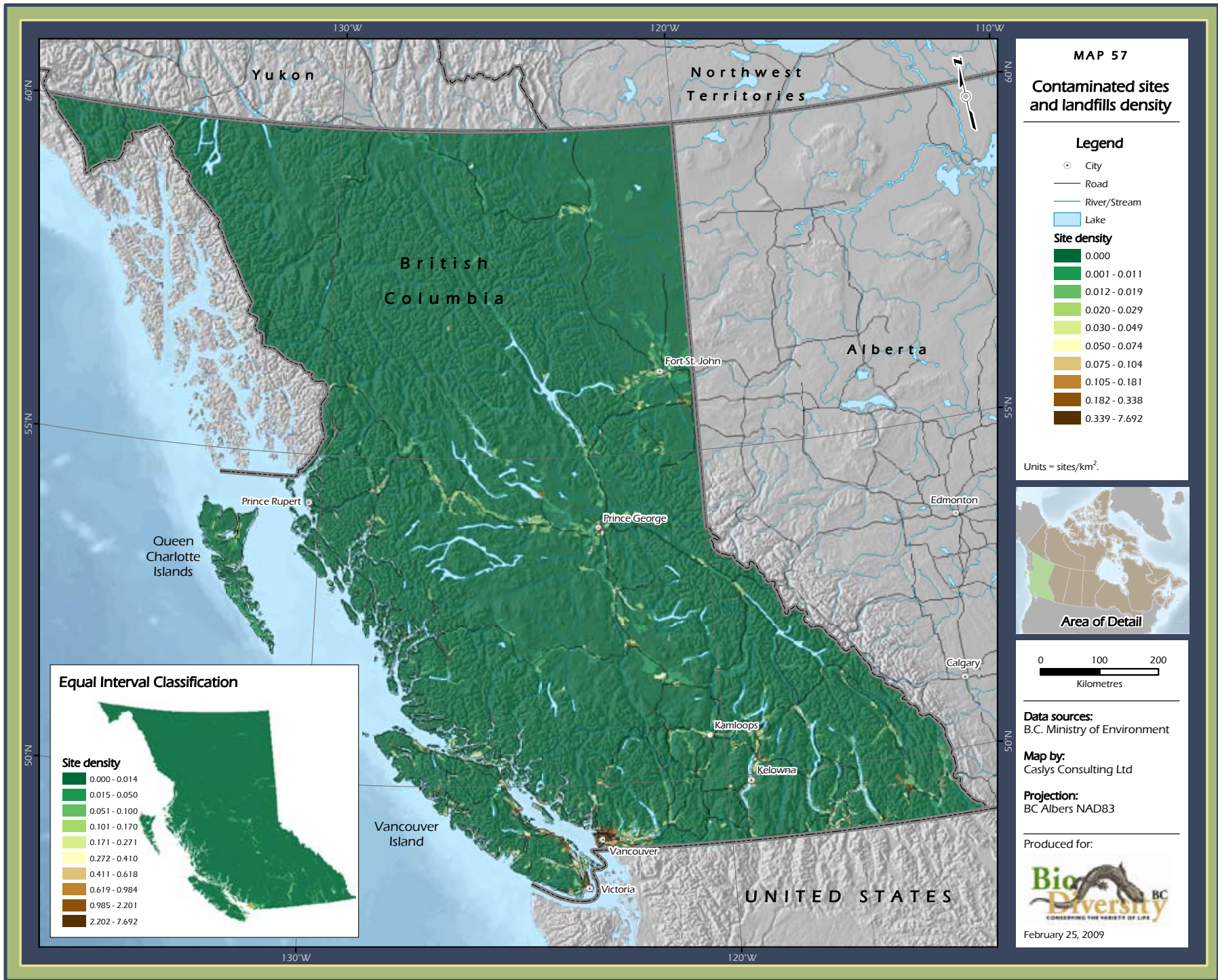
Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

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February 25, 2009



EMISSIONS OF NITROGEN OXIDES

Nitrogen oxides (NO_x) 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. NO_x 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 ($\text{kg}/\text{year}/\text{km}^2$) from human-initiated sources are shown on Map 58.^v Total NO_x 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 NO_x 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

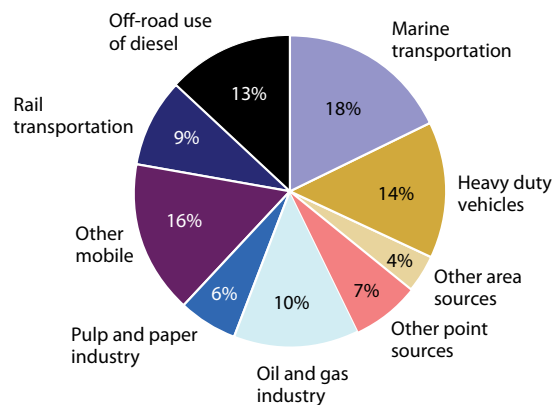


FIGURE 12: Human-initiated sources of nitrogen oxides in B.C.

SOURCE: B.C. Ministry of Water, Land and Air Protection (BCWLAP). 2005 (revision). 2000 British Columbia Emissions Inventory of Criteria Air Contaminants. Water, Air and Climate Change Branch. Available at: http://www.env.gov.bc.ca/air/airquality/pdfs/2000_inven_rep.pdf.

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 NO_x 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 $904 \text{ kg}/\text{year}/\text{km}^2$.

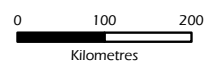
^v The data is based on models. The model for the Lower Mainland near Vancouver, which appears as a block of colour, was developed separately from the model used for the rest of the province.



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.



Data sources:
 B.C. Ministry of Environment

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



February 25, 2009

*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

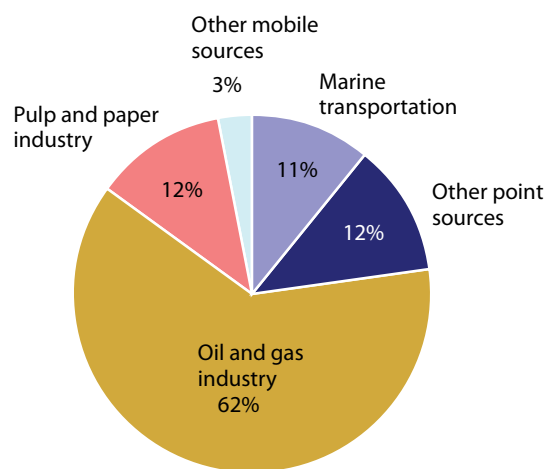


FIGURE 13: Human-initiated sources of sulphur oxides in B.C.

SOURCE: B.C. Ministry of Water, Land and Air Protection (BCWLAP). 2005 (revision). 2000 British Columbia Emissions Inventory of Criteria Air Contaminants. Water, Air and Climate Change Branch. Available at: http://www.env.gov.bc.ca/air/airquality/pdfs/2000_inven_rep.pdf.

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 north-east 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.

^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.



MAP 59
Sulphur oxides emission density

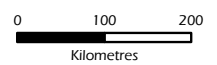
Legend

- City
- Road
- River/Stream
- Lake

SOx emission density*

- 0.00
- 0.01 - 0.50
- 0.51 - 1.00
- 1.01 - 100.00
- 100.01 - 453.10

Units = kg/year/km².



Data sources:
 B.C. Ministry of Environment

Map by:
 Caslys Consulting Ltd

Projection:
 BC Albers NAD83

Produced for:



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*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.^{251, 252, 253} 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^x 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 **main-stem** with a magnitude of 2, the value of the discharge will decrease proportionally as it moves downstream through a magnitude 4

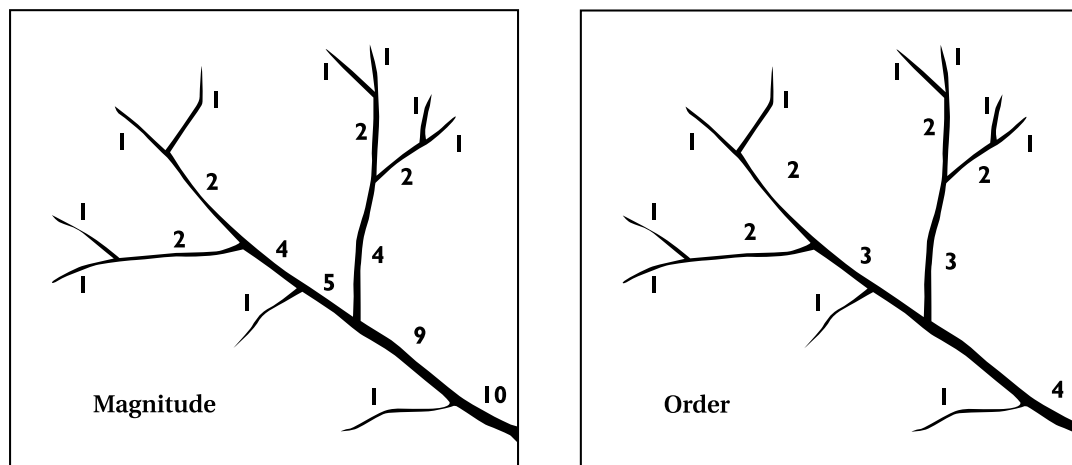


FIGURE 14: Comparison of stream magnitude and order.

SOURCE: Magnitude: Shreve, R.L. 1967. Infinite topologically random channel networks *J. Geology* 75:178-186. Order: Strahler, A.N. 1952. Hypsometric (area-attitude) analysis of erosional topography. *Bulletin of the Geological Society of America* 63:923-938.

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.

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

MAJOR DRAINAGE AREA	WATER POLLUTION INDEX
Coastal	372
Columbia	32
Fraser	24
Mackenzie	10
Skeena	1
Stikine	<1
Nass	<1
Yukon	<1
Taku	<1

SOURCE: Produced for this report.

^x The only case in which magnitude is higher upstream occurs on side channels that are low magnitude.

MAP 60
Water pollution index

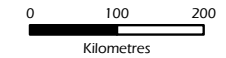
Legend

- 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

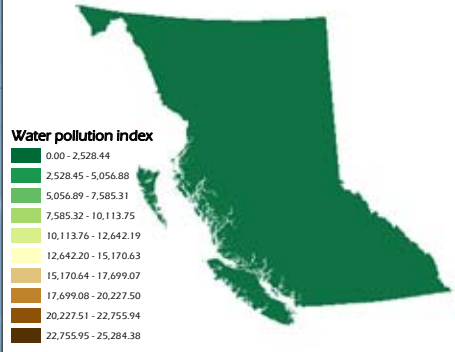
Produced for:



February 25, 2009



Equal Interval Classification



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).

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).

Notes

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