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MINISTRY OF WATER, LAND AND AIR PROTECTION - 2002

Environmental Indicator: Habitat in British Columbia

Primary Indicator: ***Trends in road density in British Columbia.***

Selection of Indicator: The trend in density of roads is a *pressure* indicator. It shows the impact of human activities in the landscape. Impacts of increasing road density have been found to include: changes to species composition, increases in the percentages of exotic species, reduced populations of some native species and altered local hydrological patterns (Demarchi et al. 1990, Trombulak 1997). In forested areas, certain densities of roads have been shown to affect wildlife populations (Baxter et al. 1999, Horejsi 1999). In urban areas, road density provides a rough estimate of imperviousness, which is an indicator of general watershed and in-stream conditions (Zandbergen et al. 1999). Under the Coastal and Interior Watershed Assessment Procedure, road density, in conjunction with other measures, is used to assess the impact of timber harvesting on stream channels (MOF 1999).

Both historic and current information about roads and road building were available in provincial data sheets (see text box, below, for definitions of road types used in this indictor). The Terrain Resource Information Management program has data for the entire province to 1988 (TRIM I) and for approximately 40 percent of the province to 1999 (TRIM II). By comparing the overlapping areas between these two data sets, it was possible to determine trends in road building that have occurred during this period.

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Road Definitions Used in this Indicator

Road–includes paved, unpaved and rough roads; includes features such as tunnels, bridges and snow sheds.

Main and secondary roads – includes roads in the main provincial transportation system as documented by Ministry of Transportation on 1:600,000 maps; ca. 50% are on forest land, 50% on non-forest land.

Paved road –designed for the passage of non-rail vehicles with a surface of concrete, asphalt or tar-gravel.

Loose road –designed for passage of non-rail vehicles with a surface of aggregate, soil or clay.

Rough road –unimproved logging or secondary road (4-wheel drive only).

Skid road –random pathway traveled by ground-skidding equipment while moving trees or logs to a landing.

Forest Service Roads –built and maintained by the BC Ministry of Forests.

Other forest roads – all non-Forest Service roads on forest land, including main and secondary roads and roads built and maintained by logging companies.

Other non-forest roads – All roads on non-forest land that are not main and secondary roads.

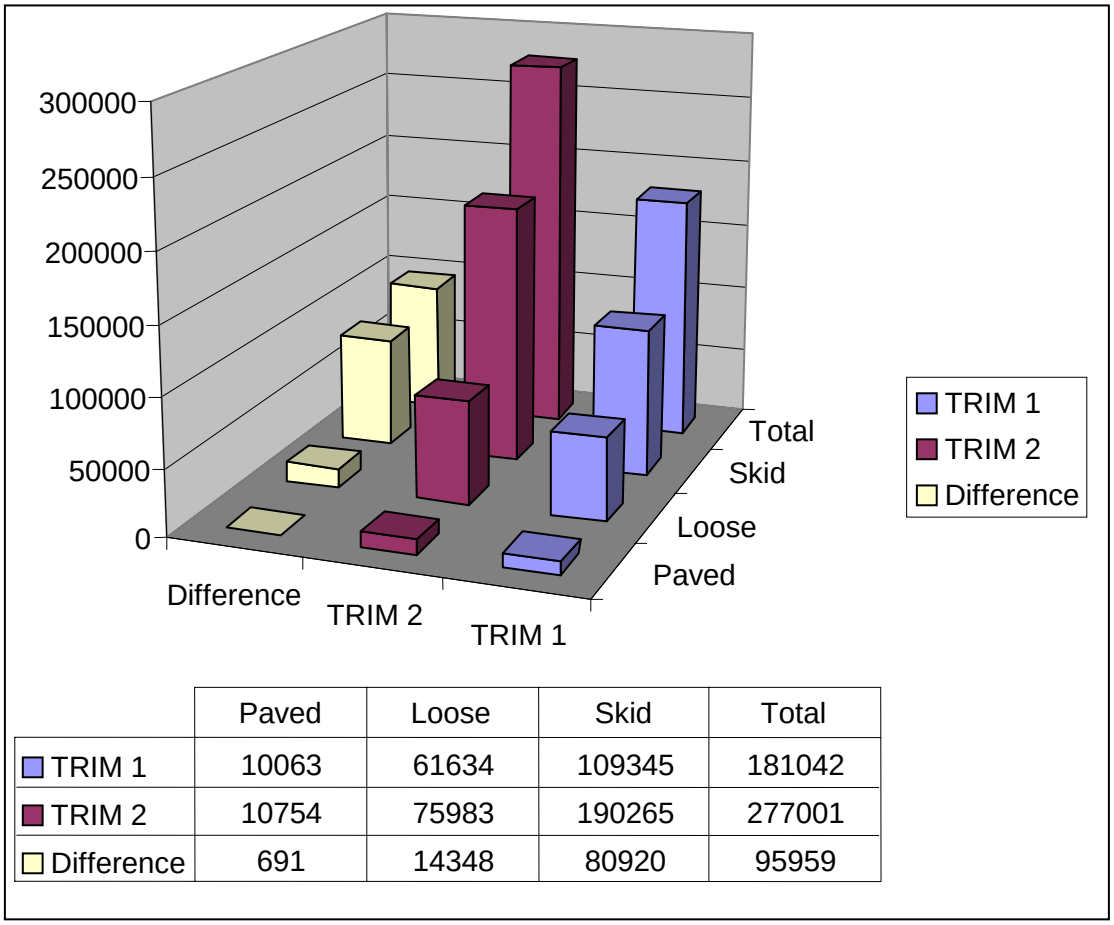
Deactivation – Deactivation of logging roads may be permanent (i.e., road bed is removed and replanted) or semi-permanent (i.e., road bed is not removed, but access is restricted).

Data and Sources:

Table 1. Number of watershed groups in each road density class in British Columbia for the entire province (late 1980's) and for only the area (ca. 40% of the total) mapped in both 1980's and 1990's.

	Mapped Late 1980's: Total area of province		Mapped Late 1980's: Same area as mapped in late 1990's		Mapped Late 1990's	
Road density (km/km^2)	Number of watershed groups	Percentage of total watershed groups	Number of watershed groups	Percentage of total watershed groups	Number of watershed groups	Percentage of total watershed groups
>2.0	4	1.6	1	0.6	10	6.4
1.0-2.0	26	10.6	21	13.5	36	23.1
0.5-1.0	46	18.7	35	22.4	42	26.9
0.25-0.5	46	18.7	35	22.4	19	12.2
0.1-0.25	47	19.1	28	17.9	26	16.7
<0.1	77	31.3	36	23.2	23	14.7

Source: Geographic Data BC, 1998; Decision Support Services, Ministry of Sustainable Resource Management, 2002.
Note**: Appendix A** contains a complete listing of all watershed groups in British Columbia.



	Paved	Loose	Skid	Total
TRIM 1	10063	61634	109345	181042
TRIM 2	10754	75983	190265	277001
Difference	691	14348	80920	95959

Figure 1. Comparisons of road length totals (kms) between late 1980s and late 1990s for the 40% of British Columbia that was mapped by both phases of the TRIM Program.
Source: Decision Support Services, Ministry of Sustainable Resource Management.
Note: TRIM 1 shows the landscape up until the late 1980s; TRIM 2 until the late 1990s.

Table 2. Estimated road length on forest and non-forest land in British Columbia.

Length (km) of roads in BC based on figures from c. 1988 (% of total road length)				
Total road length (TRIM 1986-88)	**Main and secondary roads (on forest and non-forest land) (c. 1990)**	**Estimated other roads on non-forest land**	**Forest Service roads (1987/88)**	**Estimated other roads on forest land**
387,021 (100%)	21,924 (6%)	70,820 (18%)	30,340 (8%)	263,937 (68%)

Source: Geographic Data BC, 1999; British Columbia Ministry of Transportation and Highways, 1996; British Columbia Ministry of Forests, 1987/88.

Table 3. Number of kilometres of Forest Service roads built and deactivated since 1988.

Year	Total Forest Service road length (km)	New Forest Service roads built (km)		Roads deactivated/repaired under Watershed Restoration Program (km)
		By Licensee	By Ministry	
1988/89	32502.0	230.0	611	-
1989/90	33733.8	160.9	667	-
1990/91	34952.1	246.0	550.7	-
1991/92	35182.3	110.0	601.0	-
1992/93	37280.3	121.2	575.7	-
1993/94	38319.9	160.7	647.7	-
1994/95	40203.5	287.1	726.7	>2500
1995/96	41480.8	218.8	741.6	2358
1996/97	42458.8	61.6	942.7	3468
1997/98	43649.0	59	738	11300
1998/99	43939.0	70	707	
Total	-	1596.3	6064.1	19626
Grand total	-	7660.4		19626

Source: B.C. Ministry of Forests, 1988-1999; Forest Renewal British Columbia, 1999.

Methodology and Reliability:

Estimated total road length and density: (see Table 1; also **Appendix A** for road length summarized by watershed group). The data for estimated total road length and road density on all forested land were extracted from the provincial Watersheds BC: Watershed Ranking and Assessment Product, using amalgamation software developed by Geographic Data BC. The database was released for use in October 1999. The product is a compilation of province-wide GIS databases summarized on a watershed basis. Sources of the data were:

- Watershed Atlas (Fisheries BC 1998): Watershed and watershed group boundaries were taken from the Atlas. Boundaries are derived from paper Federal NTS 1:50,000 base mapping. Watersheds that are third order or higher (e.g., headwaters, which are defined as first order watershed) have been delineated and assigned a code; some lower order watersheds are included where low order streams drain directly into a major river, lake or ocean. The average size of a watershed is 3,000 hectares and there are about 18,000 watershed in BC. All watersheds smaller than 50 hectares were excluded. Watersheds were grouped to facilitate data management (Aquatic Information Branch, BC Ministry of Sustainable Resource Management, pers. comm.).

- Terrain Resource Information Management (TRIM) – Roads were taken from the TRIM base map database. The TRIM program consists of 7,027 map sheets covering the province at a scale of 1:20,000, mapped to an accuracy of +/-10 m horizontally using photogrammetric technique. It is based upon aerial photography collected between 1982 and 1988. The TRIM II program is a selective update using photos from 1994 to present. The data snapshot used for this analysis encompassed approximately

40 % of the province. Data were divided into 18,481 watersheds, which were amalgamated into 246 watershed groups.

- Baseline Thematic Mapping (BTM): The source of data for urban and residential/agricultural mixed use was the BTM Land Use/Ground Cover interpretation of satellite imagery. Positional accuracy is +/- 300 m and captures areas as small as 15 hectares.

When compiling the data it was necessary to determine the differences between the TRIM I and TRIM II datasets. For example, the TRIM I dataset used 3D lengths, while TRIM II used 2D lengths. An analysis of the two datasets suggested that the 2D data underestimated the total road length of the TRIM II area by 6,500 km or 2.3%. Changes in TRIM specifications between TRIM I and II programs also resulted in new classes of roads and the capture of road segments in TRIM II that had been below the threshold length for capture in TRIM I (Table 4).

Table 4. Comparison of minimum lengths (metres) of roads captured in TRIM I and TRIM II.

	Rough	Loose	Paved	Overgrown	Cutline / Seismic	Trail	Skid Trail
TRIM 1	400	400	400	n/a	400	400	n/a
TRIM 2	50	50	50	50	400	100	100

n/a – road type not mapped in TRIM I

An assessment of the changes between TRIM I and TRIM II road data was performed using a sampling system based on 1:20,000 map sheets (Berry and Iles, 2002). It was found that the explanation of changes between datasets could be broken down as follows:

+2% Error in interpretation.
+7% Changes in TRIM specifications (i.e., summarized in Table 4).
+86% Legitimate change, mainly from addition of new roads and seismic lines.
+5% Legitimate type changes as roads are upgraded, overgrown, etc.

From the above list it was inferred that 9% of the change between TRIM I and II did not represent true road building, but captured methodological differences and errors. Therefore, a discount rate of 9% was applied to the summed road lengths and road densities.

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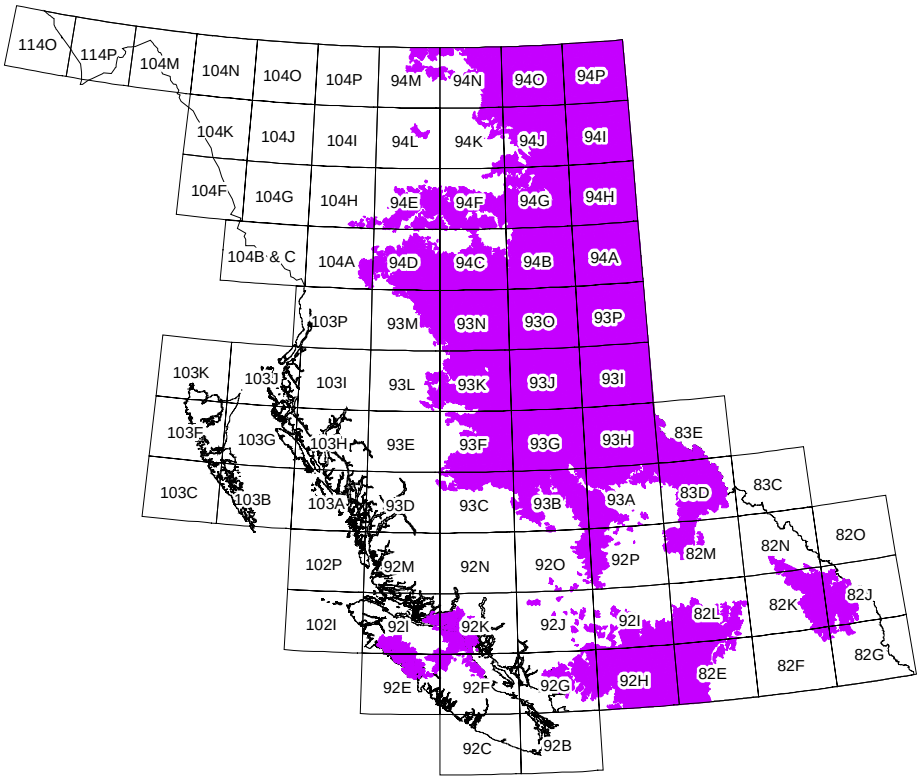

Figure 2. Watersheds with more than 75 percent TRIM II area coverage as of February 2001.

Source: Decision Support Services, Ministry of Sustainable Resource Management.

Estimated road lengths on forest and non-forest land (see Table 2 and Table 3). Data for road lengths on all forest and non-forest land were obtained from:

- Ministry of Transportation and Highways: The main provincial transportation system of primary and secondary road is maintained by the Ministry of Transportation and Highways. These roads have been recorded on 1:600,000 scale maps. Six map sheets are required to cover the entire province. The 1990 estimate of road lengths was taken from 1992–1993 series. Road distances were measured using a map-measuring tool made by Eschenbach, Germany. The percentage of the primary and secondary road network that occurs on forest land was roughly estimated at 50% (M. Gray, pers. comm.)

- Ministry of Forests: The extent of Forest Service roads is recorded annually. Data were taken from the Ministry of Forests 1987/88 annual report and are considered accurate. From the MOF annual reports, it is estimated that the Forest Service builds about 800 km of new roads per year. No official data are available for roads built by forest companies, however, it is generally assumed that they build about ten times the

distance of roads built by the Forest Service, for an estimated 8,000 km/year (M. Gray, pers. comm.). Although Ministry of Forests regional offices may have data for roads built by forest companies, resources were not available to pursue this information.

- Road deactivation Watershed Restoration Program, Forest Renewal British Columbia (FRBC): Data for deactivation of roads were found in the MOF annual reports for 1994/95 to 1996/97 under the Forest Renewal British Columbia section. Estimates for 1997/98 and 1998/99 came from the FRBC Five Year report. The length of roads deactivated by the Watershed Restoration Program represents the majority of roads deactivated in the province. Roads are also deactivated by the Forest Service (at a rate of 200 km/year) and by some forest companies under the Small Business Program. Data for the latter were not available, however, potential reduction in road length from this source was considered minimal. See Table 3 for kilometres of Forest Service roads built and deactivated since 1988.

Road type calculation methodology:
The estimations for length of road in each category were made using the following data sources and logic:

- Total road length (from Geographic Data BC) = 387,021 km
- Forest Service roads (from MOF 1987/88) = 30,340 km
- Main and secondary roads (from Ministry of Highways) = 21,924 km
- Total forest roads = 79% of 387,021 km = 305,239 km
- Non-forest roads = Total road length – total forest roads = 387,021 – 305,239 = 81,782 km
- Estimated other roads on forest land was calculated by subtraction: Total forest roads – Forest Service roads – 0.5 (main and secondary roads*) = 305,239 – 30,340 – 0.5(21,924) = 263,937 km
- Estimated other roads on non-forest land = Non-forest roads + 0.5 (main and secondary roads*) = 81,782 –10,962 = 70,820 km.

*as described above, 50% of main and secondary roads was estimated to be on forest land.

Supplementary Information: *Effects of road density on wildlife.*

Literature reporting effects of road density on wildlife is summarized in Table 5.

Table 5. Reported effects of road density on selected wildlife species.

Species	Road density at which effect observed	Effect	Reference
Grizzly Bear	0.5 km/km^2	Population declines in area	Horejsi 1999
Wolf	0.6 km/km^2	Population declines in area?	Jalkozy, et al. 1998
Black Bear	1.25 km/km^2	Population declines in area?	Jalkozy, et al. 1998
Bull Trout	0.1 km/km^2	Number of redds (spawning sites) decreases.	Baxter, et al. 1999

Seismic/Cutline Roads: This class of roads was not part of the original Watersheds BC data set and therefore was not included in this indictor. As collected by the TRIM program this class includes some non-road features, such as cutlines defining property boundaries. For the 40% of the province mapped by both TRIM I and TRIM II the changes in seismic roads is of interest in showing the extent of human intrusion into forested areas. Between the late 1980's and 1990s, the total length of seismic roads increased from 159,747 km to 207,441 km. This was an increase of 47,694 km.

References:

Baxter, C., C.A. Frissell, and F.R. Hauer. 1999. *Geomorphology, logging roads, and the distribution of bull trout spawning in a forested river basin: Implications for management and conservation.* Transactions of the American Fisheries Society 128:854-867.

Berry, J., and K. Iles. 2002. *Road Accuracy Assessment*. Forest Information Systems report for Decision Support Services, Ministry of Sustainable Resource Management, Victoria, BC.

Canadian Association of Petroleum Producers, Arc Wildlife Services Ltd, M.G. Jalkotzy, P.I. Ross, and M.D. Nasserden. 1998. *The effects of linear development on wildlife: A review of selected literature*. Canadian Association of Petroleum Producers.

Demarchi, D., 1993. *Ecoregions of British Columbia*. British Columbia Ministry of Environment, Lands and Parks, Victoria, BC.

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Demarchi, D.A., R.D. Marsh, A.P. Harcombe, and E.C. Lea., 1990. The Environment. pp 55-144, In: *The Birds of British Columbia, Vol. I*. R.W. Campbell, N.K. Dawe, I. McTaggart-Cowen, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall (eds.). Royal BC Museum, Victoria, BC.

Fisheries BC. *The Watershed Atlas*. Available on an ftp site from the Ministry of Sustainable Resource Management from: http://www.bcfisheries.gov.bc.ca/fishinv/basemaps.html

Forest Renewal BC. 1999. *Five Year Report 1994-1999*.

Geographic Data BC. 1999. *Watersheds: BC user's guide*. Environmental statistics draft users guide, May 1999. BC Ministry of Environment, Lands and Parks.

Horejsi, B.L. 1999. *The endangered Granby-Gladstone grizzly bear population: A conservation biology analysis for recovery.* Western Wildlife Environments Consulting Ltd., Calgary Alberta. (sections 5.0 and 5.2).

Ministry of Forests. 1988-1999. Annual Reports.

Ministry of Forests. 1999. *Coastal and Interior Watershed Assessment Procedure Guidebook.* 2nd Ed.. British Columbia Ministry of Forests. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/Guidetoc.htm

Trombulak, S.C. 1997. *Edge effects and roads: A review of the literature*. Unpublished paper presented at the Annual Meeting of the Society for Conservation Biology, June, 1997, Victoria, BC.

Zandbergen, P. 1998. *Urban watershed assessment: Linking watershed health indicators to management.* PhD dissertation. University of British Columbia.

Zandbergen, P., Houston, J., and H. Shreier. 1999. *Comparative analysis of measuring imperviousness of watersheds in the Georgia Basin.* Report for Fisheries and Oceans Canada, Habitat and Enhancement Branch prepared by Institute for Resources and Environment, Univ. of British Columbia. October 1999. 44 pp.

Secondary Indicator: ***Percentage lost of selected habitat types.***

Selection of the Indicator: The percentage of selected habitats lost is a *state* or *condition* indicator that provides a direct measure of loss of ecosystem integrity. The five habitats selected for this indicator are each important for the protection of biodiversity in British Columbia because they are home to unique communities of plants and animals, including threatened or endangered species. As these critical habitats disappear, species that depend on them may also be lost.

All five selected habitats are under pressure from human activities. The Garry Oak woodlands on southern Vancouver Island and the Antelope-brush grasslands of the south Okanagan Valley are the two most endangered ecosystems in BC and are among the four most endangered ecosystems in Canada.

Garry Oak Woodlands on Southern Vancouver Island

Garry Oak ecosystems are found from southwestern British Columbia to southern California, within a distinctive climate zone characterized by moderate year-round temperatures, wet winters, and dry summers.

Garry Oak ecosystems typically have an understorey dominated by grasses and flowering plants, with shrubby understories patchily distributed throughout the landscape. The oaks may be scattered across the landscape or form groves with canopies ranging in density

from relatively open to closed. Garry Oak ecosystems are home to more plant species than any other terrestrial ecosystem in coastal BC, with many of these plants being peripheral species at the northern limits of their range. At least 800 species of mites and insects (including one rare butterfly) are associated with Garry Oak trees; approximately 140 of these feed on the oaks, including 48 that are dependent on this food source.

In BC, Garry Oak ecosystems are restricted primarily to low-elevation sites on the southeast coast of Vancouver Island as far north as Comox and the southern Gulf Islands. Two outlier stands are found in the Fraser Valley and one is on Savary Island. Current estimates suggest that only about 1–5 percent of the province's Garry Oak habitat remains in near-natural condition. Garry Oak ecosystems can be divided into those occupying rocky outcrops and other thin-soiled sites, and those in areas of deep soil. The deep-soil ecosystems have suffered the greatest proportion of loss, because these lands have been favoured for farming and development.

Agricultural, residential and industrial developments threaten Garry Oak ecosystems through direct habitat loss and by altering the conditions needed to sustain this habitat. Fires, both wild and human-set, originally played an important role in maintaining Garry Oak ecosystems; suppression of fires has allowed native conifers and shrubs to take over some sites. Invasive non-native plant and animal species have dramatically altered many Garry Oak ecosystem remnants.

Historically, the largest continuous occurrence of Garry Oak woodlands was in the area now occupied by Greater Victoria. The few remaining patches of this habitat in the Victoria area are now small and generally isolated from each other, preventing less-mobile species from moving between them. Introduced plants (e.g., Scotch Broom) increase the risk that these remnants will be unable to survive as functioning ecosystems.

The Garry Oak ecosystems that have some degree of protection in and around Victoria are mostly those in parks, such as Mount Douglas, Christmas Hill and Beacon Hill, as well as the Department of National Defence lands at Rocky Point. Outside of the Greater Victoria area, Garry Oak ecosystems are the primary focus of two ecological reserves – Mount Tzuhalem near Duncan and Mount Maxwell on Saltspring Island. Conservation and restoration of Garry Oak ecosystems is also being undertaken by individuals and organizations on private lands on southern Vancouver Island and the Gulf Islands. A multi-agency Garry Oak Ecosystems Recovery Team is developing a recovery plan dedicated to conserving the last of the Garry Oak ecosystems.

Data and Sources:

Table 6. Garry Oak Ecosystems on Southern Vancouver Island

	1800	1997
Municipality	**Area (ha)**	
Victoria	1,460	21
Oak Bay	850	25
Saanich	3,540	192
Central Saanich	740	7
Sidney	30	0
North Saanich	1,040	1
Esquimalt	470	20
Colwood	320	16
Langford	370	105
View Royal	270	39
Metchosin	1,180	49
Indian Reserves	240	37
Total	**10,510**	**512**

Source: Ministry of Sustainable Resource Management, 2002.

Methodology and Reliability: The BC Ministry of Sustainable Resource Management mapped historical Garry Oak ecosystems in Victoria and surrounding municipalities and Indian Reserves at a 1:20,000 scale (Lea 2002). These maps include areas where Garry Oak was a dominant component of the ecosystem. The understorey of these ecosystems included shrub-dominated and herb-dominated ecosystems, often referred to as Garry Oak Meadow. Garry Oak is currently, or has been, a minor component of other unmapped areas.

Garry Oak historical mapping was based on original land surveys done in the 1850s and 1860s, as well as ecosystem mapping done by the Canadian Forest Service in 1975. Additional information was collected in field studies in 2001 and 2002, using expert opinion to determine areas that likely supported Garry Oak ecosystems before urban, suburban and agricultural development took place in the Greater Victoria area.

Mapping for 1997 figures was extracted from Sensitive Ecosystem Inventory mapping done by the BC Conservation Data Centre, the Nanaimo office of the BC Ministry of Environment, Lands and Parks, and the Canadian Wildlife Service (BC Ministry of Environment, Lands and Parks and Environment Canada 1997).

References:

BC Ministry of Environment, Lands and Parks. 1993. Garry Oak Ecosystems (Ecosystems at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks and Environment Canada. 1997. Sensitive Ecosystem Inventory of Eastern Vancouver Island and the Gulf Islands. 1:20,000 maps.

Fuchs, M.A. 2001. Towards a Recovery Strategy for Garry Oak and Associated Ecosystems in Canada: Ecological Assessment and Literature Review. Technical Report GBEI/EC-00-030. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.

Lea, E.C. 2001. Historical (1800) Garry Oak Ecosystems of Greater Victoria and Saanich Peninsula. 1:20,000 Map. Terrestrial Information Branch, BC Ministry of Sustainable Resource Management.

Antelope-brush Grasslands of the South Okanagan

Antelope-brush ecosystems are widespread in the arid west of the United States, however, the dry, shrubby Antelope-brush grasslands of the Okanagan Valley are rare habitats found only on the lower bench lands south of Penticton and extending a short distance into northern Washington. They occur here because of a unique combination of climate and glacial soils in this area. The plants of these ecosystems include Antelope-brush (a yellow-flowering shrub that grows up to 3 metres tall), Big Sagebrush, Rabbitbrush, various bunchgrasses and forbs, Prickly-pear Cactus, Bitterroot, lichens and mosses.

British Columbia's endangered Antelope-brush ecosystems were never extensive. Since European settlement of the Okanagan Valley began in the 1800s, more than 60 percent of the original Antelope-brush habitat has been replaced by orchards, vineyards, houses and other urban development, golf courses and paved roads. Much of the remainder has been disturbed by livestock grazing and invaded by foreign plants. Less than one percent remains relatively undisturbed; most of this is severely fragmented and is extremely vulnerable to disturbance, particularly fire.

The Antelope-brush grasslands are the subject of research and management efforts by a number of government agencies and other organizations, including the multi-agency South Okanagan Conservation Strategy, established in 1990. Currently, about 7% (706 ha) of the historical area of South Okanagan Antelope-brush grasslands are protected in parks, wildlife areas and other conservation areas. Protected areas include the 100-hectare Haynes Lease Ecological Reserve (burned in the mid 1990's), a tiny (1–2 ha) ecological reserve on the west side of Osoyoos Lake, Canadian Wildlife Service lands near Vaseux Lake and various properties purchased by the Nature Trust of BC.

Data and Sources:

Table 7. Area of Antelope-brush Grasslands of the South Okanagan by Year.

Year	1860	1938	1995	2001
Ecosystem	**Area (ha)**			
Antelope-brush	10,053	7,425	4,438	3,898
Pine-Antelope-brush	1,864	1,637	852	816
Total	**11,917**	**9,062**	**5,290**	**4,714**

Source: Ministry of Water, Land and Air Protection, 2002.

Methodology and Reliability: Biophysical habitat units of the South Okanagan and lower Similkameen valleys were mapped at a 1:20,000 scale using biophysical and Terrestrial Ecosystem Mapping methods of the Resources Inventory Committee (1998). Lea (2001) used historical air photos from 1938 to map ecosystems and agricultural and urban areas at that time. As 1860 was the approximate date when substantial, permanent habitat disturbance began in the Okanagan Valley (R. Manuel, pers. comm.), a map for this year was extrapolated from the above 1938 map using expert opinion from the Ministry of Sustainable Resource Management (T. Lea, pers. comm.). Mapping took into account soil, slope, aspect and vegetation. At the time of this report, mapping was 95 percent complete, therefore the analyses in this report should be considered interim until mapping is finished.

References:

BC Ministry of Environment, Lands and Parks. 1995. Antelope-brush Ecosystems (Ecosystems at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

Lea, E.C. 2001. Historical ecosystems of the south Okanagan and Similkameen valley. 1:20,000 map. Ministry of Sustainable Resource Management.

Lea, E.C. 1996. Antelope-brush Ecosystems: Past, Present and Future.[unpublished paper]

Wetlands in the Lower Fraser Valley

Wetlands are ecosystems dominated by water-loving plants and having wet or saturated soils. Although they represent only a small percentage of the overall land base, they are an important element of British Columbia's biodiversity because they perform essential ecological and hydrological functions. They provide critical habitat for many plants and animals. Wetlands are usually concentrated in valley bottoms and lowland areas, where development pressures are greatest. Within BC, wetland alteration and destruction has been most significant in the Lower Mainland and the semi-arid Interior.

European settlement of the Lower Fraser Valley began in the early 1800s. At that time, flooding along the river occurred every spring, resulting in large tracts of swampy or

marshy land. Large areas of fen and other wetland types would have existed in the delta area and along the river. In the 1860s, settlers began building dykes along the river to reduce flooding and allow agricultural development of low-lying wetlands. By 1930, much of the area had been diked and drained, and farms and settlements had taken over much of the delta and Fraser River bottomlands.

Data and Sources:

Table 8. Area of Wetlands in the Lower Fraser Valley (LFV) by Year.

Land Cover	Pre-1827		1930		1990	
	Area (ha)	Percent of LFV	Area (ha)	Percent of LFV	Area (ha)	Percent of LFV
Fen	56,000	6.7	5,500	0.7	2,400	0.3
Swamp/bog/marsh	27,100	3.3	10,800	1.3	9,700	1.2
Total Wetlands	83,100	10.0	16,300	2.0	12,100	1.5

Source: Boyle et al., 1997.
Note: Total LFV study area = 828,200 hectares.

Methodology and Reliability: This study was done as part of a three-year interdisciplinary research project on the Lower Fraser Basin carried out by researchers from the University of British Columbia (Boyle et al. 1997). The study area encompassed the Fraser River basin from Hope to Vancouver, between the US border and the mountains north of the Fraser.

Land cover was determined for three time periods:
- prior to 1827 (when the land cover was considered to be primarily native);
- 1930 (when much of the initial logging and settling of the area had been completed);
- 1990 (providing a view of changes wrought by modern society).

Ten land cover types were defined, including four wetland types: *fen, swamp, bog* and *marsh* (the Canadian Wetland Classification System was not used since wetland descriptions were insufficient to distinguish among classifications).

Pre-1927 land cover was reconstructed by examining current soil types and correlating these with descriptions and data from historical and other accounts. Soils classified as gleysols and organics were assigned to the wetland cover types. The original configurations of Pitt, Alouette, Stave, Coquitlam and Sumas lakes were determined using 1905 maps from the New Westminster District. Land cover for 1930 was determined on the basis of an aerial photo mosaic from 1930, along with contemporary soil survey data, logging accounts and forest inventory data. Land cover for 1990 was determined by analyzing a Landsat photo, forest inventory data, a land-use map and an inventory of wetlands.

The boundary of each land cover class was transposed onto a copy of the Landsat image for each time period, then digitized using Terrasoft (GIS software). The approximate area of each type of land cover was then calculated for each time period.

References:

BC Ministry of Forests. 2000. The Ecology of Wetland Ecosystems. Extension Note 45. Research Branch, Ministry of Forests.

Boyle, C.A., L. Lavkulich, H. Schreier, and E. Kiss. 1997. Changes in land cover and subsequent effects on Lower Fraser Basin ecosystems from 1827 to 1990. Environmental Management 21(2):185-196.

Streams in the Lower Fraser Valley

Before European settlement and for some time after the first arrivals, the Lower Fraser Valley was a forested wetland crisscrossed by numerous streams. The Lower Fraser Valley is now the most densely populated region in British Columbia and has been under intense urban and rural development pressures for many decades. Many of the area's natural waterways have been altered in the process. The loss of stream habitat has contributed to the loss of biodiversity in the Lower Mainland.

The aquatic habitat within the streams and the riparian habitat along the banks support a wide range of plants and animals. In the Lower Fraser Valley, streams once hosted complex food webs involving invertebrates, fish, birds, mammals, amphibians and reptiles. By providing spawning habitat for salmon, the influence of streams in the Lower Fraser Valley extended into the marine environment. Salmon stocks once associated with these streams are now either extinct or reduced to a fraction of their former numbers.

Stream stewardship programs of the BC Ministry of Water, Land and Air Protection and Fisheries and Oceans Canada encourage individuals and community groups to help protect and restore streams in the Lower Fraser Valley through water quality monitoring, storm drain marking, stream clean-up and streamside planting.

Data and Sources:

Table 9. Number of Existing and Lost Streams in the Lower Fraser Valley by Class of Stream

Status	Number of streams	Percent of total existing streams (lost streams not included)	Percent of total, including lost streams
Wild	106	16	14
Threatened	181	27	23
Endangered	375	57	48
Total (existing)	662	100	85
Lost	117		15
Total (includes lost)	779		100

Source: Fraser River Action Plan, Fisheries and Oceans Canada 1998.

Notes: Identification of historic lost streams is uncertain; therefore the number of lost streams is an approximation. The Fraser River mainstem and lateral channels of the Fraser River were not included in the analysis.

Table 10. Summary of Impacts on Endangered and Threatened Streams in the Lower Fraser Valley.

	Number of streams in each category of stream health							
Status	Riparian removal	Channel-ization	Effective impermeable area	Water diversion	Water quality	Logging	Urban-ization	Other
Endangered	249	211	107	16	319	27	178	197
Threatened	10	9	0	1	2	111	27	20
Total	**259**	**220**	**107**	**17**	**321**	**138**	**205**	**217**

Source: Fraser River Action Plan, Fisheries and Oceans Canada, 1998.
Note: For definitions of stream classification and impact criteria see text boxes in Methodology section, below.

Methodology and Reliability: An evaluation of historical and existing streams in the Lower Fraser Valley was conducted by Precision Identification Biological Consultants for the Fraser River Action Plan (Fisheries and Oceans Canada, 1998). The study area included all streams from the Strait of Georgia, east to the Coquihalla Watershed (Hope), and from the North Shore mountains to the United States border. The Fraser River mainstem and the estuary area were not included.

Historical maps and survey field notes (circa 1860s) were compared with current National Topographic System maps to create a GIS database of streams. Of the 1,202 existing streams in the database, 662 were assessed for overall condition using the stream health impact criteria described in the text box, below.

Definition of Impact Criteria Used to Categorize Stream Health

Riparian removal – Significant loss of riparian vegetation along more than 50 percent of the fish-frequented length of the stream. The fish-frequented length may be a small proportion of the stream's length; however, a record of impact under this criterion will trigger classification of the entire stream.

Channelization/Dyking – Channelization, armourization or dyking of more than 50 percent of the fish-frequented length of the stream.

Effective Impermeable Area (EIA) – EIA covering approximately 10 percent or more of the stream's watershed. EIA is a measure of the total surface area that does not allow water to infiltrate the soil and that is connected directly to the drainage network. EIA is a useful indicator of development activity. Research shows that once a watershed is covered by more than 10 percent EIA, irreversible changes in hydrology and channel morphology occur, causing a significant loss of fish habitat features.

Water diversion – Diversion of greater than 50 percent of stream flow (i.e., diversion out of the water system) or significant manipulation of flow.

Water quality – Significant water quality (i.e., temperature, water chemistry) problems (e.g., pH, BOD, nutrients); includes urban impacts, but not impacts from logging.

Logging – Logging has been extensive in the watershed and direct or related impacts have been obvious. Logging can have multiple impacts, such as sedimentation (water quality), riparian removal, etc.

Urbanization – Settlement in the watershed has significantly affected the stream basin.

Other – Other impacts (e.g., agricultural/urban impacts and cumulative effects of these impacts); includes urban features such as linear and industrial development.

The following classifications were used in the stream assessment process:

- Wild: No significant threats to the stream;
- Threatened: Stream was affected by only one of the impact criteria;
- Endangered: Stream affected by more than one of the impact criteria;
- Lost: Stream has been directed into culverts, paved over, drained or filled, and generally no longer exists as a surface waterway.

Stream classifications were assigned after a thorough process involving map and literature reviews, interviews and Stream Information Workshops. The remaining 423 streams were not assessed for various reasons: they were unnamed, they lacked a watershed code, or they were minor tributaries unknown to workshop participants and not referenced in any of the review literature. Since the identification of historic streams that have been lost contains an element of uncertainty, the number of lost streams is considered an approximation.

References:

Fraser River Action Plan, Fisheries and Oceans Canada. 1998. Wild, Threatened, Endangered and Lost Streams of the Lower Fraser Valley, Summary Report, 1997. Prepared by Precision Identification Biological Consultants, Vancouver, BC. 27pp.

Coastal Forest Suitable for Nesting Marbled Murrelets

The Marbled Murrelet (*Brachyramphus marmoratus*) is a small seabird belonging to the auk family (Alcidae). It spends most of its life at sea, diving for small schooling fish in near shore waters. It is found from Alaska through to central California, but the bulk of the population breeds in Alaska and BC.

The Marbled Murrelet was selected as an indicator species because it has a widespread distribution across the coast of British Columbia and is dependent on old-growth forests for nesting. The Committee on the Status of Endangered Wildlife in Canada designated this species as Threatened in Canada. It is on the BC provincial Red List of species considered Endangered or Threatened. The murrelet is one of the Identified Wildlife species within the Forest Practices Code Act, and procedures for protecting its nesting habitat were included in the Identified Wildlife Management Strategy (IWMS; Anon. 1999). Loss of nesting habitat in coastal old-growth forests is recognized as the main threat to the species, with oil spills and gill nets, as additional threats (Ralph et al. 1995, Nelson 1997, Burger 2002).

Although there are estimated to be about 65,000 murrelets in BC, the concern is that the population is declining. Counts at sea, off southwest Vancouver Island, indicate declines of 20 to 40 percent from the early 1980s to the present. This decline is attributed largely to the loss of nesting habitat in old-growth forests, but the negative impacts of unusually warm oceans in the 1990s might also be responsible (Burger 2002). Since this species is dependent on old-growth forests within 30 to 50 km of the coast for nesting, the extent of suitable coastal forest for nesting may be used as an indicator of impacts on the its population.

Marbled Murrelets are extremely difficult to count. A few nests have been found on mossy cliff ledges, but the great majority of murrelets nest on large, mossy boughs high in tall, old conifers. Their nests are widely scattered and the birds fly to and from the nests in the dark twilight before dawn or after sunset. Their mottled brown plumage provides a perfect camouflage on the mossy platforms and they sit quietly on the nests. This secretive behaviour makes it extremely difficult to locate nests, therefore their populations cannot be censused directly by counting nest sites. Populations have been assessed indirectly by counting the birds on the water, but this gives highly variable results because the birds move about. Recently, techniques using radar have been developed that provide reliable counts of murrelets entering watersheds. Radar counts have only been done since 1995 which is too recent to assess population trends. Nests have been found by tracking radio-tagged murrelets caught on the ocean to their nest-sites, but this technique does not provide a measure of nest density or population trend.

Because of the difficulties in monitoring murrelet population changes by directly counting nests or birds, measuring the availability of their old-growth forest habitat has been used as an indicator. Intensive research in BC and the US over the past decade has shown the essential characteristics of Marbled Murrelet nesting habitat. In most cases, nesting is restricted to old forests (typically more than 250 years old) with several species of large trees that provide high, thick boughs topped with thick pads of moss and lichens. Old-growth forests also provide the variable canopy structure and gaps needed by murrelets to fly in and land at nest sites. The majority of murrelets nest within 30 km of the shoreline and below 900 m elevation.

Not all old-growth forests are suitable nesting habitat for Marbled Murrelets. In particular, they do not nest in the stunted old trees typically found in coastal bogs, windswept coastal plains, or subalpine areas near the tree-line. Research has also shown that large trees bordering exposed coastlines are also less suitable as murrelet nesting habitat. Finally, forests that are not within commuting distance of the ocean (i.e., beyond 30-50 km inland) are generally not considered as potential habitat. Although all of these forest types are important habitat for species other than murrelets, the changes in their area were not included in the trend analysis based on the Demarchi and Button (2001a,b) maps because they are not suited to nesting by murrelets.

Data and Sources:

Table 11. Likely Changes in The Availability Of Moderate to Very High Quality Marbled Murrelet Nesting Habitat (Habitat Classes 1–3 Combined) by Forest District.

Forest District	Percentage of the Area in Classes 1–3		Percent Change
	Capability[1]	Suitability[2]	
Port Alberni	64	34	46.9
Campbell River	61	36	41.0
Queen Charlotte Islands	53	45	15.1
Duncan	53	12	77.4
Port McNeil	46	30	34.8
Mid-Coast	29	26	10.3
Sunshine Coast	27	8	70.4
North Coast	26	24	7.7
Squamish	13	7	46.2
Chilliwack	13	6	53.8
Kalum	10	8	20.0
Cassiar	3	0	100.0
Chilcotin	3	0	100.0
Whole BC Coast	**26**	**17**	**34.6**

Source: Demarchi and Button 2001a,b.

Notes: Combined percent area within the top three habitat classes is shown, along with the percent drop in total area with capability to current areas of suitability.

[1] Capability represents the ability of the land base to produce habitat in which murrelets could nest. In this table, forest districts are ranked from highest to lowest percent capability.

[2] Suitability represents the current availability of habitat suitable for nesting.

Methodology and Reliability: Demarchi and Button (2001a,b) produced the first map and database to cover Marbled Murrelet habitat across the entire BC coast. Habitat ratings were developed by Demarchi (2001) in collaboration with wildlife biologists familiar with murrelets. Based on features known to be important to Marbled Murrelets (e.g., distance from ocean, elevation, tree size, moss cover) the quality of forest habitat types was classified as: 1) Very High; 2) High; 3) Moderate; 4) Low; 5) Very Low; and (6) Nil (RIC 1999). These classifications were then applied to habitat polygons derived from 1:250,000 Broad Ecosystem Inventory mapping. Two categories of habitat were derived and mapped:

- Habitat capability: indicating the likely pre-industrial distribution of nesting habitat in the past, based on biogeoclimatic conditions (Demarchi and Button 2001a).
- Habitat suitability: indicating the likely distribution and ranking of nesting habitat at the present time (Demarchi and Button 2001b).

The habitat capability map shows almost continuous distribution of habitat ranked Moderate, High or Very High through most of the BC coast. Comparisons between the capability mapping (predicted historical) and suitability mapping (present status) show

considerable changes in many areas, mainly due to industrial logging, urbanization and agriculture (Appendix B). The first three habitat categories (Very High, High and Moderate) were considered most likely to provide suitable nesting habitat for murrelets (Burger 2002). Changes in the availability of these categories were then assessed for each Forest District in BC and for the entire BC coast.

Recent research in four separate studies showed that murrelet numbers, counted with radar, were directly correlated with the areas of suitable forest available (Burger 2002). In areas affected by clearcut logging there was no evidence that the murrelets were concentrated in higher densities in the remaining old-growth patches. This suggests that the populations of murrelets are likely to decline roughly in proportion to the decline in nesting habitat.

This analysis represents a first step in mapping and monitoring suitable nesting habitat for the entire Marbled Murrelet range in BC. The only mapping system available to cover this entire range was the 1:250,000 Broad Ecosystem Inventory mapping. This scale allows only a coarse analysis of habitat availability. Field studies show that features important to murrelets often change over relatively short distances. Often only parts of areas mapped as suitable actually provide suitable trees. The existence of apparently suitable habitat does not necessarily indicate use by nesting murrelets; other factors such as availability of suitable foraging areas in nearby seas are also important.

In the analysis used for this indicator, the top three categories of habitat were considered adequate for murrelet nesting. There is some uncertainty in this decision, but in most forest districts the trend of declining habitat would be similar even if slightly wider or narrower ranges of habitat categories were considered (Appendix B). Field research and analysis with Geographical Information Systems (GIS) is constantly improving the models used to identify suitable habitat for murrelets. More refined estimates of habitat loss will be possible in future years.

These comparisons provide a meaningful illustration of the loss of habitat potential, but do not provide a measure of absolute habitat loss. The capability mapping assumes that all of the high-ranking habitats were actually old-growth and not in earlier stages of succession following blow-downs or fires. The effects might be underestimated, because the best murrelet habitat (large trees at low elevations) is most accessible for logging and has likely been disproportionately reduced. Some of the capable habitat that has been modified, but is now in protected areas such as parks, will become suitable in the future as the forest regenerates. Most of the logged areas will likely remain in short harvest rotations (e.g., 80 years), which does not allow development of old-growth features needed by murrelets. Some of the forest, particularly on the southern mainland and southeast Vancouver Island, has been permanently converted into cities, towns, roads and agricultural land.

References:

Anon. 1999. Managing Identified Wildlife: Procedures and measures. Forest Practice Code of British Columbia, Volume 1. Province of British Columbia, Victoria, BC.

Burger, A.E. 2002. Conservation assessment of Marbled Murrelets in British Columbia: Review of the biology, populations, habitat associations and conservation of this threatened species. Technical Report Series, Canadian Wildlife Service, Delta, BC.

Demarchi, D.A. 2001. Species account for Marbled Murrelet based on 1:250,000 Broad Ecosystem Inventory habitat mapping. Resources Inventory Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Demarchi, D.A., and A.A. Button. 2001a. Marbled Murrelet nesting habitat capability in British Columbia: Map 2 – weighted average capability; 1:300,000 map. Resource Inventory Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Demarchi, D.A., and A.A. Button. 2001b. Marbled Murrelet nesting habitat suitability in British Columbia: Map 3 – weighted average suitability; 1:300,000 map. Resource Inventory Branch, Ministry of Environment, Lands and Parks, Victoria, BC.

Nelson, S. K. 1997. Marbled Murrelet *Brachyramphus marmoratus*. *In* A. Poole and F. Gill, eds. The Birds of North America, No. 276. The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, DC.

Ralph, C. J., G. L. Hunt Jr., M. G. Raphael and J.F Piatt (eds.). 1995. Ecology and conservation of the Marbled Murrelet in North America. USDA Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-152, Albany, CA.

RIC (Resources Inventory Committee). 1999. British Columbia wildlife habitat rating standards, Version 2.0. BC Resources Inventory Committee, Victoria, BC.

Secondary Measure: ***Number of species on the British Columbia Red- and Blue-lists dependent on selected habitats.***

Selection of Indicator: The number of species of vertebrates and vascular plants on the provincial Red- and Blue- lists that are dependent on selected habitats shows how important these habitats are in maintaining biodiversity in the province. Invertebrates and non-vascular plants (mosses, liverworts, algae, fungi and lichens) were not included in this indicator because of the lack of complete species lists and uncertainty about the status of many taxa within these groups.

The Red List is an inventory of indigenous species and subspecies that have Extirpated, Endangered, or Threatened status in British Columbia, or are candidates for such status. The Blue List includes any indigenous species or subspecies considered to be special concern because of characteristics that make them particularly sensitive to human activities or natural event; they are at risk, but are not Extirpated, Endangered or Threatened.

For more detailed information on how species are classified in the province with respect to conservation risk, see the technical documents for the indicator or Species at Risk in British Columbia.

Each of the four habitats selected for this indicator is limited in area and has diminished over the past century. As a result, many of the specialized plants and animals associated with these habitats are also at risk (endangered, threatened or vulnerable). Many of these species occur nowhere else in Canada; some occur nowhere else in the world. Although some species associated with these habitats also occur elsewhere, their existence within these selected habitats contributes to regional biodiversity. If they disappeared from the selected habitats, the genetic diversity of the species could be affected.

It should be noted that the presence of any species in a habitat does not necessarily mean that the population is viable. The population must be able to persist and be resilient to changing conditions over time.

Garry Oak Woodlands on Southern Vancouver Island
The number of species at risk in Garry Oak ecosystems (Appendix C), especially Red-listed vascular plants, is disproportionate to the ecosystem's land area on a provincial scale. Garry Oak ecosystems occupy only a small fraction of the Coastal Douglas-fir biogeoclimatic zone, which itself comprises only 0.3 percent of the land area of BC. Red-listed vascular plants found in Garry Oak ecosystems represent 18 percent of all threatened and endangered vascular plants in the province. Twelve of plant species, including Golden Paintbrush, Sulphur Lupine and White Meconella, are at risk globally.

Garry Oak woodlands provide nest-holes, acorns and open habitat for the wildlife species associated with them. Loss of Garry Oak habitat likely contributed to the disappearance of the Lewis' Woodpecker from southern Vancouver Island.

Although invertebrates are not included in the data for this indicator, it should be noted that insects are generally dependent on specialized food sources. The larvae of the Blue-listed Propertius Duskywing butterfly, for example, feed exclusively on oak leaves.

Wetlands in the Lower Fraser Valley
Wetlands are areas of high biodiversity within larger terrestrial ecosystems, therefore, declining populations of wetland plants and animals in the Lower Fraser Valley can affect the food webs of the entire region.

Eleven percent of BC vertebrates at risk and six percent of vascular plants at risk in the province are associated with wetlands in the Lower Fraser Valley (Appendix E). Some, like the Red-listed Pacific Water Shrew, are found nowhere else in Canada. The Pacific Water Shrew's preferred habitat is valley bottom forestland, along streams and wetlands. In the Lower Fraser Valley most of this habitat has been converted to farms, urban areas and industrial developments.

Dyking, drainage and filling of wetlands along the lower Fraser have also eliminated habitat for young White Sturgeon, another Red-listed species. The Lower Mainland nesting population of Sandhill Cranes has been reduced to fewer than 10 pairs, which nest at Pitt Polder, Burns Bog and Langley Bog.

Antelope-brush Grasslands of the South Okanagan
Fourteen percent of all Red- and Blue-listed vertebrates in BC are found in South Okanagan Antelope-brush ecosystems (Appendix D). Counting species that have been ranked by the Conservation Data Centre of the Ministry of Sustainable Resources as well as species that have not been ranked, it is estimated that 104 species of British Columbia's rare invertebrates are confined to South Okanagan Antelope-brush ecosystems (O. Dyer, pers. comm.). Within Canada, 72 of these rare invertebrates are found only in South Okanagan Antelope-brush ecosystems and six are not known to occur anywhere else in the world. For example, Behr's Hairstreak – a Red-listed butterfly found in Canada only in the South Okanagan – is completely dependent on Antelope-brush ecosystems because its larvae feed exclusively on antelope-brush leaves.

Both the Pigmy Short-horned Lizard and the White-tailed Jack Rabbit used to live in this habitat but are now apparently extirpated from BC.

Coastal Forest Suitable for Nesting Marbled Murrelets
Along the BC coast, Marbled Murrelets nest almost exclusively in old forests, typically more than 250 years old. These forests also provide critical habitat for a number of other Red- and Blue-listed species (Appendix F). The forest attributes used by those species are often different from the ones that murrelets require, but they share a common dependence on this forest type.

This analysis is limited to old-growth forests used by nesting Marbled Murrelets (i.e., generally within 30-50 km of the ocean and below 900 m elevation), therefore, does not encompass old-growth dependent species and subspecies whose range does not overlap with the murrelet's nesting range.

Data and Sources:

Table 12. Number of Red-listed (Endangered and Threatened) and Blue-listed (Vulnerable) vertebrate and vascular plant taxa in selected ecosystems. Percentages of total Red- and Blue-listed taxa in British Columbia are shown in parentheses.

Ecosystem	Vertebrates			Vascular Plants			Vertebrates & Vascular Plants
	Red-listed	Blue-listed	Total	Red-listed	Blue-listed	Total	Total
Garry Oak Woodlands on Southern Vancouver Island	9 (8)	5 (4)	14 (6)	45 (18)	13 (4)	58 (9)	72 (9)
Wetlands in the Lower	13	12	25	10	29	39	64

Fraser Valley	(12)	(11)	(11)	(4)	(8)	(6)	(8)
Antelope-brush Grasslands in the South Okanagan Valley	16 (14)	16 (14)	32 (14)	17 (7)	6 (2)	23 (4)	55 (7)
Coastal Forest Suitable for Nesting Marbled Murrelets	7 (6)	8 (7)	15 (7)	–	–	–	15 [vertebrates only]

Sources: For Garry Oak woodlands: Garry Oak Ecosystems Recovery Team, 2002; for other ecosystems: Ministry of Sustainable Resource Management and Conservation Data Centre, 2002.
Notes: A list of old-growth-dependent plant species has not been compiled for BC. Total number of Red- and Blue-listed taxa in BC: vascular plants = 619 (257 Red list + 362 Blue list species); vertebrates = 223 (111 Red list + 112 Blue list species).

Methodology and Reliability: Lists tracking the status of species are maintained by the BC Conservation Data Centre (CDC). These are the basis for the BC Ministry of Water, Land and Air Protection's Red and Blue lists. These lists include taxa with population characteristics, population trends or distributions that indicate they require special attention if they are to be maintained as part of British Columbia's biodiversity. The lists of Red- and Blue-listed vertebrates and vascular plants dependent on each of the selected habitats were compiled by various experts (as detailed below) based on the CDC species tracking lists. See Appendices C–F for complete listings of the dependent species and subspecies.

Because the CDC tracks taxa by forest district, the Chilliwack Forest District was chosen to represent the Lower Fraser Valley when determining which species are dependent on Lower Fraser Valley wetlands. For the plants, Red- and Blue-listed species on the Chilliwack Forest District list were compared to the CDC provincial list of Rare Wetland Vascular Plants, and wetland-dependent plants were singled out. CDC staff identified the wetland-dependent vertebrates.

The species list for Garry Oak woodlands was compiled by the Garry Oak Ecosystems Recovery Team.

The species list for the Antelope-brush grasslands was compiled by BC Ministry of Water, Land and Air Protection wildlife biologist from the Okanagan region.

The species list for coastal forest suitable for nest Marbled Murrelets was taken from Fenger and Harcombe (1990). Using this list, CDC staff determined which Red-listed, old-growth dependent vertebrates have ranges that coincide with the Marbled Murrelet's nesting range. No lists of old-growth-dependent plant or invertebrate species were available to make the same comparison for plants.

References:

BC Ministry of Environment, Lands and Parks. 1995. Antelope-brush Ecosystems (Ecosystems at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks. 1993. Garry Oak Ecosystems (Ecosystems at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks. 1995. Pacific Water Shrew (Wildlife at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks. 1999. Rare Butterflies of Southeastern Vancouver Island and the Gulf Islands (Wildlife at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Environment, Lands and Parks. 1999. Sandhill Crane (Wildlife at Risk brochure series). Wildlife Branch, Ministry of Environment, Lands and Parks.

BC Ministry of Sustainable Resource Management.2001. Species lists available: http://srmwww.gov.bc.ca/atrisk/

Fenger, M.A., and A.P. Harcombe. 1990. Biodiversity, Old-Growth Forests and Wildlife in British Columbia. BC Ministry of Environment, Lands and Parks, Integrated Management Branch. [unpublished document]

Fuchs, M.A. 2001. Towards a Recovery Strategy for Garry Oak and Associated Ecosystems in Canada: Ecological Assessment and Literature Review. Technical Report GBEI/EC-00-030. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.

Garry Oak Ecosystems Recovery Team. 2002. Recovery Strategy for Garry Oak and Associated Ecosystems and Their Associated Species at Risk in Canada, 2001-2006. Garry Oak Ecosystems Recovery Team, Victoria, BC.

Secondary Measure: *Percentage of ecosections that are roadless.*

Selection and Use of Indicator: Areas without roads are generally found in the most remote parts of the province. These areas are the least altered by human development or activities and provide opportunities for both habitat protection and wilderness recreation.

In most cases, the larger the contiguous area without roads, the greater the degree of ecosystem integrity. As discussed in the primary indicator, roads can have a negative impact on species and ecosystem health by increasing habitat fragmentation, degradation and stream sedimentation, by allowing access by commercial and recreational resource users, and by increasing the chance of vehicle collisions with wildlife.

Data and Sources:

Table 13: Number of ecosystems in British Columbia classed by percentage of ecosystem that is roadless.

Percentage of ecosection that is roadless	Number of ecosections
0-10	27
11-30	22
31-60	28
61-85	17
86-100	27

Source: Ministry of Sustainable Resource Management, 2002.

Methodology and Reliability: Roadless areas were determined using the Recreation Opportunity Spectrum (ROS) Inventory, which characterizes and represents recreation opportunities as mixes or combinations of settings and probable experience opportunities arranged along a continuum or spectrum of classes.

The spectrum has seven ROS classes, differentiated from each other in terms of differing degrees or types of remoteness, naturalness and social experience. From most remote and natural to least remote and natural, they are as follows: Primitive (P); Semi-primitive Non-Motorized (SPNM); Semi-primitive Motorized (SPM); Roaded Natural (RN); Roaded Modified (RM); Rural (R); and Urban (U).

For this indicator, roadless areas were defined as those falling within the first three ROS classes: Primitive; Semi-primitive Non-Motorized; and Semi-primitive Motorized. The standards for applying the delineation factors to delineate polygons in all ROS classes are set out in the following table. Motorized use includes off-road, boat and air access vehicles. The “Roaded” classifications include active water transportation routes.

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Table 14: Descriptions of classes used in the British Columbia Recreation Opportunity Spectrum Inventory.

ROS Class	Factors					
	Remoteness		Naturalness		Social Experience	
	Distance from road (km)	Size (ha)	Motorized Use	Evidence of Humans	Solitude/Self-reliance	Social Encounters
Primitive (P)	> 8	> 5000 ha	• occasional air access, otherwise no motorized access or use in the area.	• very high degree of naturalness; • structures are extremely rare • generally no site modification • little on-the-ground evidence of other people • evidence of primitive trails	• very high opportunity to experience solitude, closeness to nature; self-reliance and challenge.	• very low interaction with other people; • very small party sizes expected;
Semi-Primitive Non-Motorized (SPNM)	≥ 1	≥ 1000 ha	• generally very low or no motorized access or use • may include primitive roads and trails if usually closed to motorized use.	• very high degree of naturalness; • structures are rare and isolated except where required for safety or sanitation • minimal or no site modification. • little on-the-ground evidence of other people.	• high opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• low interaction with other people; • very small party sizes expected;
Semi-Primitive Motorized (SPM)	≥ 1	≥ 1000 ha	• a low degree of motorized access or use.	• high degree of naturalness in the surrounding area as viewed from access route; • structures are rare and isolated • minimal site modification. • some on-the-ground evidence of other people • evidence of motorized use	• high opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• low interaction with other people; • small party sizes expected;
Roaded Natural (RN)	≤ 1	N/A	• moderate amount of motorized use within the area. • may have high volume of traffic through the main travel corridor.	• moderate degree of naturalness in surrounding area • structures may be present and more highly developed; • moderate site modification. • some on-the-ground evidence of other people, • some on-site controls. • typically represent main travel corridors and recreation areas that have natural-appearing surroundings	• moderate to high opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• moderate interaction with other people; • small to large party sizes expected;
Roaded Modified (RM)	≤ 1	N/A	• moderate to high degree of motorized use for both access and recreation.	• low degree of naturalness; • moderate number of more highly developed structures; • highly modified in areas; generally dominated by resource extraction activities. • on-the-ground evidence of other people and on-site controls.	• low to moderate opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• moderate to high interaction with other people; • moderate to large party sizes expected;
Rural (R)	≤ 1	N/A	• high degree of motorized use for both access and recreation.	• very low degree of naturalness; • complex and numerous structures, high concentrations of human development and settlements associated with agricultural land. • obvious on-the-ground evidence of other people and on-site controls.	• low opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• high interaction with other people; • large party sizes expected;
Urban (U)	≤ 1	N/A	• very high degree of motorized use for both access and recreation.	• very low degree of naturalness; • highly developed and numerous structures associated with urban development; • very high site modification. • obvious on-the-ground evidence of other people and on-site controls.	• very low opportunity to experience solitude, closeness to nature, self-reliance and challenge.	• very high interactions with other people; • very large party sizes expected;

Note: ROS classes are based on the US Forest Service ROS classes, with modifications to adapt these standards to British Columbia conditions. Although the USA and BC use the same ROS classes and class names, the BC standards require greater remoteness and naturalness with fewer social encounters to achieve the 'Primitive' and 'Semi-primitive' ratings.

ROS polygons are closed-line boundaries representing discrete, non-overlapping, irregularly shaped areas of land and water encircling a recreation opportunity class. Polygons are delineated using the following two procedures:

1) Pertinent information, such as location of roads or structures, is transferred to a 1:50,000-scale Recreation Base Map. For this work, a road is defined as any surface designed for use by conventional 2- or 4-wheel-drive automobiles that is either:
    a) linked to a highway through a continuous network of roads and has not been decommissioned, or
    b) not linked to a highway because it is accessible only by water or air, but is presently being used for access purposes.

2) Additional information that may not have been identified during information assembly, such as location of seismic lines, is identified using air photos and the working map.

The data analysis was done by ecosection. The 133 polygons used for the analysis comprise 124 ecosections, because 8 ecosections had multiple spatial entities (i.e., 7 had 2 pieces and 1 had 3 pieces). These 8 were each modified to a single combined area before the data were processed. Three ocean ecosystems did not contain any ROS data.

References:

BC Ministry of Forests. 1998. Recreation Opportunity Spectrum Procedures and Standards Manual. Version 3.0. October 9, 1998.

Clark, R.N., and G.H. Stankey. 1979. The Recreation Opportunity Spectrum: A Framework for Planning and Management and Research. USDA Forest Service. General Technical Report PNW-98.

Secondary Measure: *Percentage of key coastal estuaries under license or managed for conservation.*

Selection of the Indicator: An estuary is a water body where a river meets the ocean so that freshwater and saltwater mix and river level is affected by tides. Estuaries are among the richest and the most imperiled of British Columbia's ecosystems. They comprise less than 3 percent of the entire BC shoreline, yet are used by 80 percent of all coastal wildlife. They are also heavily used by people. With coastal BC experiencing rapid population growth, the biological productivity of the province's estuaries is threatened by industrial, commercial, residential and recreational development.

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Data and Sources:

Table 15a: Area of key coastal estuaries licensed, under tenure or managed for conservation.

	Licensed or under Tenure		Managed for Conservation	
Year	Area (ha)	Percent of total estuarine area	Area (ha)	Percent of total estuarine area
1986	600.5	2	6,688.6	23.0
1991	1,197.7	4	7,775.1	26.7
1996	1,311.3	5	19,110.8	65.7
2001	1,375.5	5	20,273.7	69.7

Table 15b: Uses of licensed and tenured estuarine areas in 2001.

Type of activity*	Area (ha)	Percent of total estuarine area
Log Storage	603.855	44
Aquaculture	186.415	14
Other Commercial/Industrial	165.9096	12
Public/Private Use	419.3226	30
Mineral Use	0	0
Total tenured area	**1,375.5022**	**100**

* See Methodology section for detailed descriptions of activities.

Table 15c. Estuarine areas managed for conservation in 2001

Conservation management designation	Area (ha)	Percent of total estuarine area
Parks	828.543	3.9
Recreation Reserves	121.6	0.6
Notations of Interest	4,652.3	22.0
Wildlife Management Areas and other conservation reserves	15,502.22	73.5
Total area managed for conservation	**21104.663**	**100**

Sources for Table –a, b, c: Ministry of Sustainable Resource Management, 2002; Crown Land Registry, 2002; Ministry of Energy and Mines, 2002; Laracorp Land and Resource Analysis, 2002.

Methodology and Reliability: The list of 51 estuaries used for this analysis was developed by the Pacific Estuary Conservation Program (PECP), a partnership between government bodies and conservation groups dedicated to conserving wetlands in British Columbia. The current PECP partners include the Canadian Wildlife Service, Department of Fisheries and Oceans, BC Ministry of Water, Land and Air Protection, Habitat Conservation Trust Fund , Ducks Unlimited Canada, The Nature Trust of British Columbia and Nature Conservancy of Canada.

An initial list of estuaries was derived from Hunter, et al. (1983) and then refined by the PECP partners. The priority list of estuaries developed by the PECP partners was based on the importance of each area to wildlife, which habitats are limited, and which are threatened.

Tenures – Land Act
Data on *Land Act* tenures were provided by the BC Assets and Land Corporation, with some historical information provided by Crown Land Registry Services of the Ministry of Sustainable Resource Management (MSRM). Tenured uses captured in the statistics include only those within the defined estuary boundaries. For resource tenures or claims that cross estuary boundaries or are located on the adjacent upland, only the portion of the area that fell within the estuary was included in the statistics. Tenures issued under the *Land Act* in the selected estuary areas have been grouped into the following categories:

- log storage and handling;
- aquaculture, which includes shellfish, finfish, and other fishery facilities;
- other commercial or industrial uses, including marinas, commercial wharves, commercial type a and type b, heavy industrial and light industrial uses; and
- public/private use, which includes residential, private moorage, public wharf, roadway, utilities (electric power, sewer, water, telecommunications), ferry terminal and military reserves.

In addition to standard forms of tenure, such as leases, licences, permits and rights-of-way, lands transferred to, or held in reserve for, other agencies for resource management (e.g., for quarrying) have been included in the statistics. Notations of interest, such as for planning purposes or for treaty negotiations, however, were not included. The portion of telecommunications, electric power or road corridors was not counted if the amount passing through an estuary area was incidental.

The Nanaimo Harbour is tenured by the Province to the Nanaimo Port Authority (NPA). An estimation of the area tenured by the NPA for the various uses was incorporated into the statistics instead of simply indicating the head lease issued by the Province to the Authority. Information on tenures issued by the NPA was accurate to January, 2000, and is not expected to have changed since that time.

Mineral Tenures and Claims
Data on mineral tenures and claims were provided by the Ministry of Energy and Mines. Mineral use includes mineral, placer and coal authorizations issued by the Ministry of Energy and Mines. Both tenures and registered claims are included. No mineral uses were captured by the above statistics, since mineral activity almost always occurs in upland areas that are not included within estuary boundaries.

Reserves – Land Act
Data on *Land Act* reserves were provided by the then BC Assets and Land Corporation, with some historical information provided by Crown Land Registry Services of the Ministry of Sustainable Resource Management. Reserves include land designated under the

Land Act for protection status, such as map reserves, Order-in-Council reserves and transfers of administration (the latter are used to create Wildlife Management Areas), as well as long-term notations of interest documented in the Crown land tenure database.

As with tenures, reserves captured in the above statistics include only those areas used within the defined estuary boundaries. For resource tenures or claims that cross estuary boundaries or are located on the adjacent upland, only the portion of the area that fell within the estuary was included in the statistics.

Other Protection/Conservation Designations
In addition to reserves created under the *Land Act*, the data include federal and provincial parks, and all Wildlife Management Areas. This information was provided by Parks Canada, Decision Support Services Branch of the Ministry of Sustainable Resource Management, and the Parks Branch of the Ministry of Water, Land and Air Protection, respectively.

The data do not include private land held for conservation purposes by organizations such as the Nature Trust and Ducks Unlimited.

References:

Hunter, R.A., L.E. Jones, M.M. Wayne, and B.A. Pendergast. 1983. Estuarine Habitat Mapping and Classification System Manual. British Columbia Ministry of Environment. Victoria, BC 33 pp.

Appendix A:
Estimated Road Length and Road Density in British Columbia, Summarized by Watershed Group.

Appendix B:
Percent of the Total Area of BC Coast and of Each Forest District That Falls Within Each Class of Marbled Murrelet Habitat.

Appendix C:
Species Dependent on Garry Oak Habitats.

Appendix D:
Species Dependent on Antelope-brush Habitats.

Appendix E:
Species Dependent on Lower Fraser Valley Wetlands.

Appendix F: Species Dependent on Coastal Forest Suitable for Nesting Marbled Murrelets.

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Appendix A: Estimated Road Length and Road Density in British Columbia Summarized by Watershed Group.

Watershed Group	Total land area of watershed group (ha)	Total road length TRIM 1 (km)	Total road length density TRIM 1 (km/km^2)	Area of watershed group covered by TRIM 2 (ha)	% of watershed group total	Total road length TRIM 2 (km)	Total road length density TRIM 2 (km/km^2)	Average interval between TRIM photography (years)
Adams River (ADMS)	318999	2259.55	0.71	79751	25%	820.51	1.03	10.0
Alberni Inlet (ALBN)	366902	4390.47	1.20					
Atlin Lake (ATLL)	461990	972.58	0.21					
Atnarko River (ATNA)	247101	188.37	0.08					
Babine Lake (BABL)	597918	3177.74	0.53	210290	35%	1402.78	0.67	10.9
Babine River (BABR)	386956	205.23	0.05	47577	12%	79.34	0.17	10.7
Barrington River (BARR)	517848	0.00	0.00					
Beaver River (BEAV)	607646	526.55	0.09	322098	53%	596.94	0.19	11.1
Bella Coola River (BELA)	282051	369.47	0.13					
Big Bar Creek (BBAR)	360486	2937.32	0.81	135478	38%	2116.23	1.56	12.8
Big Creek (BIGC)	240623	1053.68	0.44	3171	1%	0.00	0.00	9.7
Blackwater River (BLAR)	404522	1629.91	0.40	404522	100%	2942.83	0.73	8.4
Blue River (BLUR)	169703	125.91	0.07					
Bonaparte River (BONP)	389218	3657.69	0.94	4780	1%	6.31	0.13	12.9
Bowron (BOWR)	354774	2484.95	0.70	354774	100%	4592.56	1.29	11.9
Bridge Creek (BRID)	143496	2141.15	1.49	834	1%	10.50	1.26	13.8
Brooks Peninsula (BRKS)	196892	1689.52	0.86	28287	14%	246.26	0.87	8.8

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Bulkley River (BULK)	773436	5085.12	0.66	81054	10%	793.96	0.98	11.5
Bull River (BULL)	375769	4283.87	1.14					
Campbell River (CAMB)	162714	1430.29	0.88	30978	19%	411.54	1.33	8.9
Canoe Reach (CANO)	306040	426.70	0.14	305995	100%	958.94	0.31	11.5
Cariboo River (CARR)	316574	1306.21	0.41	303004	96%	2335.47	0.77	11.2
Carp Lake (CARP)	168677	528.34	0.31	168677	100%	1114.57	0.66	10.4
Cheslatta River (CHES)	201134	801.02	0.40	118443	59%	743.93	0.63	8.0
Chilako River (CHIL)	153905	1005.53	0.65	153905	100%	1363.63	0.89	8.0
Chilko River (CHIR)	335062	727.53	0.22					
Chilliwack River (CHWK)	118067	1933.05	1.64	31572	27%	271.33	0.86	6.8
Chukachida River (CHUK)	124892	0.00	0.00	28890	23%	0.00	0.00	13.6
Clayoquot (CLAY)	314475	1427.72	0.45	3226	1%	33.23	1.03	8.8
Clearwater River (CLWR)	309488	914.60	0.30	43547	14%	61.17	0.14	11.4
Coal River (COAL)	486872	169.99	0.03	54521	11%	69.89	0.13	12.4
Columbia Reach (CLRH)	756836	1637.95	0.22	24046	3%	23.57	0.10	11.6
Columbia River (COLR)	438781	4084.15	0.93	404842	92%	5394.70	1.33	9.3
Comox (COMX)	231283	4000.48	1.73	115255	50%	3203.96	2.78	9.5
Cottonwood River (COTR)	464029	3789.75	0.82	464029	100%	7757.48	1.67	11.5
Cowichan (COWN)	272633	6725.82	2.47					
Crooked River (CRKD)	213487	1389.80	0.65	213487	100%	2548.81	1.19	12.0
Cry Lake (CRYL)	203369	0.00	0.00					

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Deadman River (DEAD)	149474	1208.58	0.81					
Dease Lake (DEAL)	403391	501.82	0.12					
Dease River (DEAR)	272443	349.41	0.13					
Dog Creek (DOGC)	297649	2106.52	0.71	97185	33%	1505.38	1.55	11.4
Driftwood River (DRIR)	175070	181.07	0.10	175070	100%	330.57	0.19	10.6
Duncan Lake (DUNC)	465195	1413.65	0.30	1122	0%	0.00	0.00	8.8
Dunedin River (DUNE)	562733	371.69	0.07	512323	91%	929.25	0.18	11.1
Elk River (ELKR)	587957	5241.59	0.89					
Euchiniko Lake (EUCL)	268361	314.66	0.12	268270	100%	498.65	0.19	8.7
Euchiniko River (EUCH)	139577	644.46	0.46	139577	100%	1026.32	0.74	8.1
Finlay Arm (FINA)	641334	1833.02	0.29	476474	74%	3202.63	0.67	10.8
Finlay River (FINL)	547601	194.73	0.04	436586	80%	877.47	0.20	14.6
Firesteel River (FIRE)	426298	52.63	0.01	197087	46%	206.74	0.10	13.1
Fontas River (FONT)	387032	373.66	0.10	387032	100%	556.27	0.14	11.2
Fox River (FOXR)	427398	79.08	0.02	115212	27%	44.97	0.04	14.0
Francois Lake (FRAN)	604978	5295.76	0.88	288416	48%	3905.82	1.35	11.1
Fraser Canyon (FRCN)	510043	3432.72	0.67	416132	82%	4067.70	0.98	7.4
Frog River (FROG)	488635	10.72	0.00					
Gataga River (GATA)	366523	0.00	0.00	27258	7%	0.00	0.00	10.9
Gladys River (GLAR)	238674	70.00	0.03					
Gold Rliver (GOLD)	274180	2144.04	0.78	189713	69%	2443.24	1.29	9.0

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Graham Island (GRAI)	647701	1934.75	0.30					
Green Lake (GRNL)	126030	1316.17	1.04					
Guichon Creek (GUIC)	122221	2094.87	1.71	42269	35%	1079.96	2.55	9.0
Harrison River (HARR)	274960	2933.96	1.07	223946	81%	2623.36	1.17	7.9
Hay River (HAYR)	156893	115.26	0.07	156893	100%	128.94	0.08	10.8
Herrick Creek (HERR)	204485	61.83	0.03	204485	100%	192.11	0.09	10.9
Holberg (HOLB)	118937	1088.34	0.92					
Homathco River (HOMA)	783433	1050.24	0.13					
Horsefly River (HORS)	264782	1996.78	0.75	71825	27%	898.80	1.25	11.2
Ingenika River (INGR)	530746	302.04	0.06	184656	35%	275.43	0.15	13.8
Inklin River (INKR)	473657	23.34	0.00					
Iskut River (ISKR)	313060	83.00	0.03					
Jennings River (JENR)	204272	0.00	0.00					
Jervis Inlet (JERV)	468078	4652.23	0.99					
Kahntah River (KAHN)	277270	588.36	0.21	277270	100%	825.15	0.30	12.0
Kakiddi Creek (KAKC)	182457	112.45	0.06					
Kalum River (KLUM)	486452	1809.58	0.37					
Keecha Creek (KEEC)	87616	4.11	0.00					
Kettle River (KETL)	811943	10976.61	1.35	139913	17%	2854.50	2.04	8.3
Khutze River (KHTZ)	339760	23.14	0.01					
Kicking Horse River (KHOR)	561402	3026.83	0.54	119508	21%	1148.73	0.96	10.3

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Kinskuch River (KINR)	205813	210.51	0.10					
Kiskatinaw River (KISK)	408679	2445.40	0.60	408679	100%	4019.05	0.98	11.3
Kispiox River (KISP)	514951	1999.00	0.39					
Kitasu Bay (KTSU)	88697	16.09	0.02					
Kitimat River (KITR)	392760	1315.44	0.33					
Kitlope River (KITL)	424112	142.67	0.03					
Klappan River (KLAR)	356762	64.68	0.02					
Klinaklini River (KLIN)	655560	734.55	0.11					
Knight Inlet (KNIG)	587252	2286.24	0.39	134013	23%	1782.96	1.33	8.5
Kootenay Lake (KOTL)	893827	7962.20	0.89					
Kootenay River (KOTR)	534527	2554.58	0.48	313205	59%	2614.15	0.83	10.9
Kotcho Lake (KCHL)	407044	444.91	0.11	407044	100%	736.23	0.18	10.8
Kshwan River (KSHR)	383309	226.33	0.06					
Kumowdah River (KUMR)	285434	44.24	0.02					
Kusawa River (KUSR)	352233	152.49	0.04					
Lakelse (LKEL)	57450	473.33	0.82					
Laredo Inlet (LRDO)	215230	13.50	0.01					
Liard River (LIAR)	757730	754.31	0.10	165103	22%	136.74	0.08	12.5
Lillooet (LILL)	594369	1961.92	0.33	73555	12%	273.71	0.37	8.3
Little Rancheria River (LRAN)	269426	207.70	0.08					
Lower Arrow River (LARL)	638482	6123.35	0.96	6300	1%	132.70	2.11	9.6

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Lower Beatton River (LBTN)	712256	5222.38	0.73	712256	100%	7678.54	1.08	9.5
Lower Bell-Irving River (LBIR)	354058	134.39	0.04					
Lower Chilako River (LCHL)	304514	3995.98	1.31	304514	100%	5305.46	1.74	9.2
Lower Chilkotin River (LCHR)	578317	4124.09	0.71	59819	10%	985.57	1.65	12.9
Lower Dean River (LDEN)	417355	167.15	0.04	27823	7%	2.85	0.01	9.3
Lower Eutsuk River (LEUT)	179624	198.36	0.11	3880	2%	7.28	0.19	8.8
Lower Fort Nelson River (LFRT)	486308	321.87	0.07	486308	100%	969.64	0.20	10.9
Lower Fraser (LFRA)	445944	10066.95	2.26	163761	37%	1288.11	0.79	8.0
Lower Halfway River (LHAF)	559656	2764.46	0.49	559656	100%	4266.16	0.76	11.8
Lower Iskut River (LISR)	249216	0.00	0.00					
Lower Kechika River (LKEC)	395383	62.00	0.02					
Lower Muskwa River (LMUS)	332244	937.97	0.28	332224	100%	1536.82	0.46	11.0
Lower Nass River (LNAR)	613561	1238.57	0.20					
Lower Nechako Reservoir (LNRS)	252510	855.02	0.34	225272	89%	1348.23	0.60	8.3
Lower Nicola River (LNIC)	365598	4314.97	1.18	337818	92%	5512.52	1.63	8.8
Lower North Thompson River (LNTH)	482465	5594.61	1.16	3409	1%	36.07	1.06	10.1
Lower Omineca River (LOMI)	397115	480.93	0.12	397115	100%	1258.04	0.32	10.5
Lower Peace River (LPCE)	323247	3733.83	1.16	323247	100%	5649.20	1.75	10.9
Lower Petitot River (LPET)	406539	278.55	0.07	406539	100%	473.57	0.12	10.9
Lower Prophet River (LPRO)	156910	555.92	0.35	151795	97%	764.82	0.50	11.0

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Lower Salmon River (LSAL)	174608	1861.35	1.07	174608	100%	3204.95	1.84	12.0
Lower Sikanni Chief River (LSIK)	464776	871.72	0.19	464776	100%	1446.18	0.31	11.8
Lower Skeena River (LSKE)	518966	564.17	0.11					
Lower Stikine River (LSTR)	422594	39.16	0.01					
Lower Trembleur Lake (LTRE)	156243	697.41	0.45	156243	100%	1144.97	0.73	8.9
Mahood Lake (MAHD)	307405	2071.80	0.67	19955	6%	127.79	0.64	13.2
McGregor River (MCGR)	344141	994.33	0.29	344141	100%	1767.73	0.51	10.9
Mesillinka River (MESI)	328597	467.34	0.14	328597	100%	1104.34	0.34	13.2
Mess Creek (MESC)	230131	92.83	0.04					
Middle Banks Island (MBNK)	42356	7.30	0.02					
Middle Dease River (MDEA)	402710	557.82	0.14					
Middle Fort Nelson River (MFRT)	299987	789.09	0.26	299987	100%	1613.69	0.54	10.9
Middle Fraser (MFRA)	248850	3016.62	1.21	98973	40%	1936.86	1.96	12.2
Middle Muskwa River (MMUS)	423367	305.11	0.07	63192	15%	114.59	0.18	10.5
Middle Prophet River (MPRO)	274536	898.04	0.33	224319	82%	1068.05	0.48	11.2
Middle River (MIDR)	169391	507.24	0.30	169391	100%	1128.14	0.67	9.1
Middle Skeena River (MSKE)	482269	67.22	0.01	238521	49%	39.00	0.02	11.4
Middle Stikine River (MSTR)	667945	646.34	0.10					
Milligan Creek (MILL)	262581	1001.40	0.38	262581	100%	1388.92	0.53	11.9
Morice River (MORR)	415828	852.08	0.20					
Morkill River (MORK)	812109	3193.64	0.39	812109	100%	5557.63	0.68	11.4

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Morsby Island (MORI)	338844	1438.12	0.42					
Murray River (MURR)	644488	2265.90	0.35	644488	100%	3909.80	0.61	11.0
Murtle Lake (MURT)	236105	26.61	0.01	16543	7%	8.70	0.05	10.6
Muskeg River (MUSK)	80984	379.66	0.47	80984	100%	785.34	0.97	11.6
Nahlin River (NAHR)	379599	0.00	0.00					
Nakina River (NAKR)	400188	40.57	0.01					
Narcosli Creek (NARC)	408983	3961.78	0.97	307356	75%	5556.86	1.81	10.7
Naskall River (NASC)	387437	34.88	0.01					
Nass River (NASR)	241802	277.56	0.11					
Nation River (NATR)	667677	1621.58	0.24	667677	100%	3035.17	0.45	9.3
Nazko River (NAZR)	413744	2262.46	0.55	311485	75%	2914.52	0.94	8.9
Nechako River (NECR)	404127	4192.86	1.04	404127	100%	6399.01	1.58	9.1
Necleetsconnay River (NECL)	306101	97.88	0.03					
Nicola River (NICL)	224104	1909.69	0.85	224104	100%	2942.95	1.31	8.6
Niel Creek (NIEL)	342740	237.75	0.07					
Nimpkish River (NIMP)	213743	2126.85	1.00	5518	3%	14.75	0.27	9.1
North Banks Island (NBNK)	20759	0.00	0.00					
Northeast Vancouver Island (NEVI)	104138	422.22	0.41					
Okanagan River (OKAN)	752001	14364.14	1.91	749743	100%	19138.08	2.55	7.7
Ospika River (OSPK)	297154	44.71	0.02	151466	51%	128.20	0.08	12.6
Owikeno River (OWIK)	787068	620.19	0.08					

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Parksville (PARK)	164480	3946.28	2.40	293	0%	12.57	4.29	9.0
Parsnip Arm (PARA)	335932	1555.14	0.46	335932	100%	2159.82	0.64	9.5
Parsnip River (PARS)	556799	1437.30	0.26	556799	100%	2087.09	0.37	11.5
Peace Arm (PCEA)	554416	737.50	0.13	554416	100%	1601.39	0.29	10.1
Pine River (PINE)	698843	2653.02	0.38	698843	100%	4384.34	0.63	11.2
Pitman Rikver (PITR)	270138	5.92	0.00					
Porcher Island (PORI)	73532	96.00	0.13					
Quesnel River (QUES)	558928	3604.95	0.64	294004	53%	3685.99	1.25	11.3
Revelstoke Lake (REVL)	552623	1626.75	0.29	2078	0%	0.00	0.00	10.2
Sahdoanah Creek (SAHD)	234044	476.35	0.20	234044	100%	652.18	0.28	11.1
Sahtaneh River (SAHT)	410599	756.76	0.18	410599	100%	1466.64	0.36	11.1
Salmon River (SALM)	214814	2807.87	1.31	158112	74%	2953.39	1.87	9.1
Salmon River (SALR)	174524	507.25	0.29	174524	100%	1094.89	0.63	10.3
San Jose River (SAJR)	240505	3929.82	1.63	144508	60%	3589.07	2.48	13.0
San Juan River (SANJ)	312256	5590.82	1.79					
Seton Lake (SETN)	858194	3248.46	0.38	105933	12%	222.37	0.21	9.9
Seymour Inlet (SEYM)	376798	484.93	0.13					
Shekilie River (SHEK)	235929	148.36	0.06	235929	100%	213.61	0.09	11.0
Sheslay River (SHER)	394513	75.29	0.02					
Shushwap Lake (SHUL)	491507	4657.09	0.95					
Similkameen River (SIML)	754348	7443.23	0.99	754348	100%	9081.77	1.20	7.4

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Skagit River (SKGT)	105071	372.63	0.35	105071	100%	403.23	0.38	7.0
Slocan River (SLOC)	333462	2379.72	0.71					
Smoky River (SMOK)	506086	1224.83	0.24	506086	100%	1758.59	0.35	10.8
South Thompson River (STHM)	360250	5733.20	1.59	142139	39%	3722.76	2.62	9.6
Spatzizi River (SPAT)	348760	41.81	0.01	3976	1%	0.00	0.00	15.1
Squamish (SQAM)	527248	4774.30	0.91	103535	20%	1136.48	1.10	8.1
St. Mary River (SMAR)	656182	5757.81	0.88	193986	30%	1423.35	0.73	11.0
Stikine River (STIR)	257885	201.77	0.08					
Stuart River (STUR)	192829	1638.68	0.57	192829	100%	2464.21	0.86	10.0
Stuwart Lake (STUL)	286874	1087.74	0.56	286874	100%	1782.09	0.92	12.1
Sustut River (SUST)	354354	156.62	0.04	354354	100%	281.23	0.08	9.9
Swift River (SWIR)	297196	139.91	0.05					
Tabor River (TABR)	198498	3185.32	1.60	198498	100%	4368.15	2.20	11.9
Tahltan River (TAHR)	187391	45.18	0.02					
Tahsis (TAHS)	138630	1086.28	0.78	138603	100%	1680.75	1.21	9.0
Takla Lake (TAKL)	322512	558.62	0.17	254571	79%	837.42	0.33	10.0
Taseko River (TASR)	324542	756.26	0.23					
Tatshenshini River (TATR)	933596	143.73	0.02					
Taylor River (TAYR)	137268	15.28	0.01					
Teslin River (TESR)	368917	31.04	0.01					
Thompson River (THOM)	349405	4495.19	1.29	72571	21%	1102.74	1.52	9.6

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Toad River (TOAD)	727891	597.69	0.08	17636	2%	1.89	0.01	10.0
Toba Inlet (TOBA)	695567	1900.54	0.27	30484	4%	261.89	0.86	8.7
Toodoggone River (TOOD)	477740	74.79	0.02	349946	73%	228.56	0.07	13.8
Tsaytis River (TSAY)	357304	191.49	0.05					
Tsea River (TSEA)	355621	444.90	0.13	355621	100%	651.99	0.18	11.0
Tsitika River (TSIT)	179022	1697.63	0.95	13986	8%	229.02	1.64	9.2
Turnagain River (TURN)	707221	589.79	0.08					
Tutshi River (TUTR)	446544	95.75	0.02					
Tuya River (TUYR)	350752	19.50	0.01					
Twan Creek (TWAC)	194300	2993.27	1.54	125338	65%	3487.87	2.78	12.4
Unuk River (UNUR)	188128	71.69	0.04					
Upper Arrow Lake (UARL)	615506	3006.00	0.49	12151	2%	26.77	0.22	10.1
Upper Beatton River (UBTN)	519203	2972.75	0.57	519203	100%	4443.41	0.86	11.3
Upper Bell-Irving River (UBIR)	177724	33.24	0.02					
Upper Chilkotin River (UCHR)	435021	1390.71	0.32	44375	10%	530.09	1.19	12.0
Upper Dean River (UDEN)	346365	1262.32	0.36	42278	12%	43.59	0.10	9.8
Upper Eutsuk River (UEUT)	476610	493.91	0.10	185725	39%	583.09	0.31	8.4
Upper Fort Nelson River (UFRT)	369582	537.81	0.15	369582	100%	765.70	0.21	10.9
Upper Fraser (UFRA)	673525	1525.46	0.23	673525	100%	1964.98	0.29	11.2
Upper Halfway River (UHAF)	378252	1273.66	0.34	376539	100%	2079.28	0.55	12.8

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Upper Iskut River (UISR)	376352	362.25	0.10					
Upper Jennings River (UJER)	165777	0.14	0.00					
Upper Kechika River (UKEC)	322366	252.20	0.08	3613	1%	0.00	0.00	11.1
Upper Liard River (ULRD)	406263	612.60	0.15					
Upper Muskwa River (UMUS)	425482	173.56	0.04	183797	43%	114.19	0.06	12.1
Upper Nass River (UNAR)	395138	0.00	0.00	40598	10%	0.00	0.00	16.1
Upper Nechako Reservoir (UNRS)	356174	1036.82	0.29					
Upper North Thompson (UNTH)	534908	3015.57	0.56	505847	95%	4202.23	0.83	11.2
Upper Onimeca River (UOMI)	391904	377.51	0.10	391904	100%	602.26	0.15	9.8
Upper Peace River (UPCE)	564986	3238.16	0.57	564986	100%	4679.72	0.83	10.8
Upper Petitot River (UPET)	195184	225.49	0.12	195184	100%	468.37	0.24	11.0
Upper Prophet River (UPRO)	410343	630.31	0.15	325087	79%	766.78	0.24	13.8
Upper Shushwap River (USHU)	510100	5590.01	1.10	272348	53%	4665.43	1.71	10.1
Upper Sikanni Chief River (USIK)	639993	2471.56	0.39	605649	95%	3079.10	0.51	13.3
Upper Skeena River (USKE)	416273	122.89	0.03	116326	28%	12.34	0.01	12.8
Upper Stikine River (USTK)	346181	9.55	0.00	6828	2%	1.77	0.03	14.4
Upper Trembleur River (UTRE)	134657	239.86	0.18	134657	100%	744.12	0.55	9.1
Victoria (VICT)	95439	3678.67	3.85					
Willow River (WILL)	315038	2805.15	0.89	315038	100%	5423.84	1.72	12.1
Work Channel (WORC)	320408	377.43	0.12					
Zymoetz River (ZYMO)	300640	512.37	0.17					

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Source: Geographic Data BC 1998, Decision Support Services, MSRM 2002.

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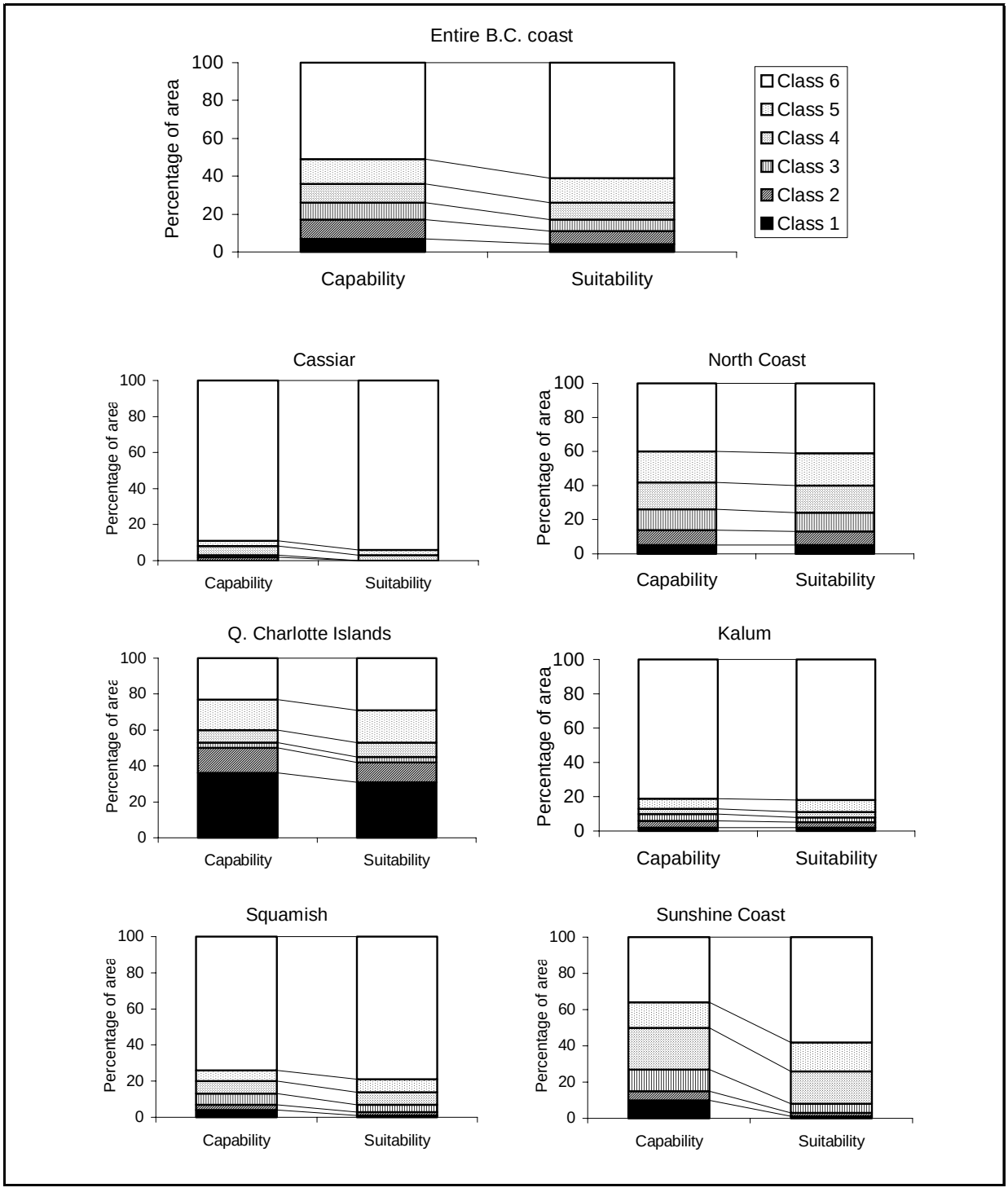
Appendix B: Percent of the Total Area of BC Coast and of Each Forest District That Falls Within Each Class of Marbled Murrelet Habitat (Demarchi and Button 2001a,b).
Habitat classes: 1 = Very High; 2 = High; 3 = Moderate; 4 = Low; 5 = Very Low; 6 = Nil (RIC 1999).
Note: The differences between habitat **capability** (based on biogeoclimatic characteristics) and habitat **suitability** (present conditions), reflect changes that have occurred in forest districts since the start of industrial logging and urbanization.



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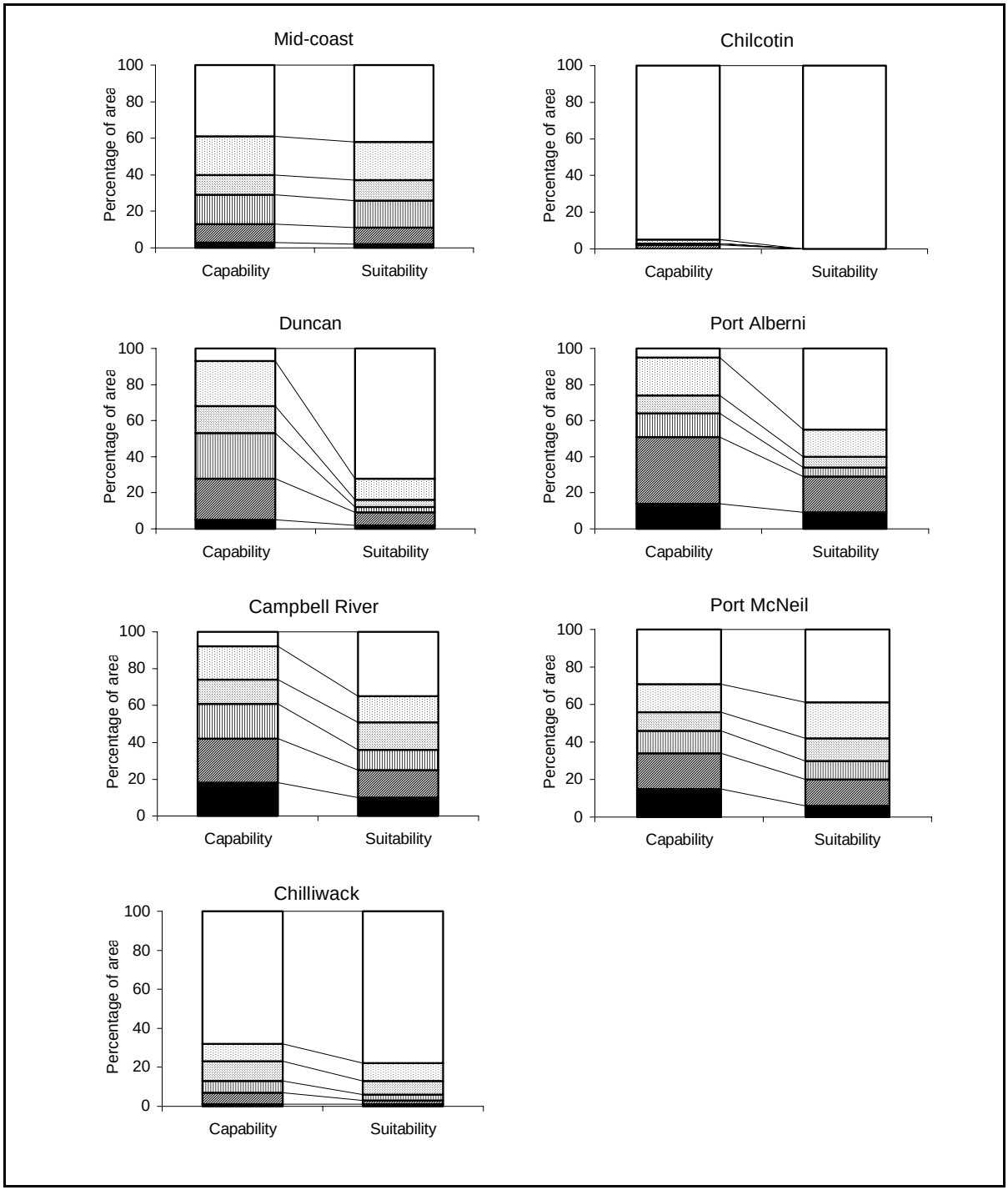

Appendix C: Species Dependent on Garry Oak Habitats.

Birds

Scientific Name	Common Name	Prov. Status
Coccyzus americanus	Yellow-Billed Cuckoo	Red-listed
Columba fasciata	Band-Tailed Pigeon	Blue-listed
Eremophila alpestris strigata	Streaked Horned Lark	Red-listed
Melanerpes lewis	Lewis' Woodpecker	Red-listed
Pooecetes gramineus affinis	Vesper Sparrow	Red-listed
Progne subis	Purple Martin	Red-listed
Sialia mexicana, Population 1	Western Bluebird, Georgia Depression Population	Red-listed
Sturnella neglecta, Population 1	Western Meadowlark, Georgia Depression Population	Red-listed
Tyto alba	Barn Owl	Blue-listed

Mammals

Scientific Name	Common Name	Prov. Status
Cervus elaphus roosevelti	Roosevelt Elk	Blue-listed
Corynorhinus townsendii	Townsend's Big-eared Bat	Blue-listed
Mustela erminea anguinae	Ermine, *anguinae* Subspecies	Blue-listed

Reptiles

Scientific Name	Common Name	Prov. Status
Pituophis catenifer catenifer	Gopher Snake, *catenifer* Subspecies	Red-listed
Contia tenuis	Sharp-Tailed Snake	Red-listed

Vascular Plants

Scientific Name	Common Name	Prov. Status
Sanicula arctopoides	Bear's foot Sanicle or Snake Root	Red-listed
Triphysaria versicolor ssp. *versicolor*	Bearded Owl-clover	Red-listed
Lotus pinnatus	Bog Birds's-foot Trefoil	Red-listed
Epilobium torreyi	Brook Spike-primrose	Red-listed
Ranunculus californicus	California Buttercup	Red-listed
Yabea microcarpa	California Hedge-parsley	Red-listed
Rupertia physodes	California-tea	Blue-listed
Alopecurus carolinianus	Carolina Meadow Foxtail	Red-listed
Microseris bigelovii	Coast Microseris	Red-listed
Dryopteris arguta	Coastal Wood Fern	Blue-listed
Trifolium cyathiferum	Cup Clover	Red-listed
Balsamorhiza deltoidea	Deltoid Balsamroot	Red-listed
Epilobium densiflorum	Dense Spike-primrose	Red-listed
Lupinus densiflorus var. *densiflorus*	Dense-flowered Lupine	Red-listed
Agrostis pallens	Dune Bentgrass	Blue-listed
Minuartia pusilla	Dwarf Sandwort	Red-listed
Crassula connata var. *connata*	Erect Pigmyweed	Red-listed
Carex tumulicola	Foothill Sedge	Red-listed
Plagiobothrys figuratus	Fragrant Popcorn-flower	Red-listed
Gilia capitata var. *capitata*	Globe Gilia	Red-listed

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Vascular Plants

Castilleja levisecta	Golden Paintbrush	Red-listed
Lomatium grayi	Gray's Desert-parsley	Red-listed
Carex feta	Greensheathed Sedge	Blue-listed
Triteleia howellii	Howell's Triteleia	Red-listed
Viola howellii	Howell's Violet	Blue-listed
Juncus kelloggii	Kellogg's Rush	Red-listed
Cheilanthes gracillima	Lace Fern	Blue-listed
Microseris lindleyi	Lindley's Microseris	Red-listed
Ranunculus lobbii	Lobb's Water-buttercup	Red-listed
Limnanthes macounii	Macoun's Meadowfoam	Blue-listed
Trifolium dichotomum	Macrae's Clover	Blue-listed
Marah oreganus	Manroot	Blue-listed
Helenium autumnale var. *grandiflorum*	Mountain Sneezeweed	Blue-listed
Myosurus apetalus var. *borealis*	Mousetail	Red-listed
Centaurium muehlenbergii	Muhlenberg's Centaury	Red-listed
Navarretia intertexta	Needle-leaved Navarretia	Red-listed
Castilleja ambigua	Paintbrush Owl-clover	Red-listed
Orobanche pinorum	Pine Broomrape	Red-listed
Toxicodendron diversilobum	Poison Oak	Blue-listed
Lupinus lepidus var lepidus	Prairie Lupine	Red-listed
Clarkia purpurea ssp. *quadrivulnera*	Purple Godetia	Red-listed
Sanicula bipinnatifida	Purple Sanicle	Red-listed
Orthocarpus bracteosus	Rosy Owl-clover	Red-listed
Idahoa scapigera	Scalepod	Red-listed
Silene scouleri ssp. *grandis*	Scouler's Campion	Red-listed
Lotus formosissimus	Seaside Birds-foot Lotus	Red-listed
Plagiobothrys tenellus	Slender Popcorn-flower	Red-listed
Psilocarphus tenellus var. *tenellus*	Slender Woolly-heads	Red-listed
Tonella tenella	Small-flowered Tonella	Blue-listed
Lotus unifoliolatus var. *unifoliolatus*	Spanish-clover	Blue-listed
Lupinus oreganus var. *kincaidii*	Sulphur Lupine	Red-listed
Psilocarphus elatior	Tall Woolly-heads	Red-listed
Ranunculus alismifolius var. *alismifolius*	Water-plantain Buttercup	Red-listed
Piperia candida	White Lip Rein Orchid	Red-listed
Meconella oregana	White Meconella	Red-listed
Seriocarpus rigidus = Aster curtus	White-top Aster	Red-listed
Callitriche marginata	Winged Water-starwort	Blue-listed
Viola praemorsa spp. *praemorsa*	Yellow Montane Violet	Red-listed

Endangered, Threatened, or Vulnerable Species Not Included in the Indicator Mosses

Scientific Name	**Common Name**	**Prov. Status**
Bartramia stricta	Apple Moss	Red-listed
Tortula laevipila var. *meridionalis*	Twisted Moss sp.	Red-listed

Appendix D: Species Dependent on Antelope-brush Habitats.

Birds

Scientific Name	Common Name	Prov. Status
Aeronautes saxatalis	White-Throated Swift	Blue-listed
Ammodramus savannarum	Grasshopper Sparrow	Red-listed
Athene cunicularia	Burrowing Owl	Red-listed
Buteo regalis	Ferruginous Hawk	Red-listed
Buteo swainsoni	Swainson's Hawk	Red-listed
Chondestes grammacus	Lark Sparrow	Red-listed
Falco mexicanus	Prairie Falcon	Red-listed
Falco peregrinus anatum	Peregrine Falcon (Anatum)	Red-listed
Melanerpes lewis	Lewis' Woodpecker	Blue-listed
Numenius americanus	Long-Billed Curlew	Blue-listed
Picoides albolarvatus	White-Headed Woodpecker	Red-listed

Mammals

Scientific Name	Common Name	Prov. Status
Antrozous pallidus	Pallid Bat	Red-listed
Corynorhinus townsendii	Townsend's Big-Eared Bat	Blue-listed
Euderma maculatum	Spotted Bat	Blue-listed
Lasiurus blossevillie	Western Red Bat	Red-listed
Lepus townsendii	White-Tailed Jackrabbit	Red-listed
Myotis ciliolabrum	Western Small-Footed Myotis	Blue-listed
Myotis thysanodes	Fringed Myotis	Blue-listed
Ovis canadensis	Bighorn Sheep	Blue-listed
Perognathus parvus	Great Basin Pocket Mouse	Blue-listed
Reithrodontomys megalotis	Western Harvest Mouse	Blue-listed
Sorex preblei	Preble's Shrew	Red-listed
Sylvilagus nuttallii	Nuttall's Cottontail Rabbit	Blue-listed
Taxidea taxus	Badger	Red-listed

Reptiles

Scientific Name	Common Name	Prov. Status
Coluber constrictor	Racer Snake	Blue-listed
Crotalus viridis	Western Rattlesnake	Blue-listed
Hypsiglena torquata	Night Snake	Red-listed
Phrynosoma douglasi	Pigmy Short-Horned Lizard	Red-listed
Pituophis catenifer deserticola	Gopher Snake (Deserticola)	Blue-listed

Amphibians

Scientific Name	Common Name	Prov. Status
Ambystoma tigrinum	Tiger Salamander	Red-listed
Chrysemys picta	Painted Turtle	Blue-listed
Spea intermontana	Great Basin Spadefoot Toad	Blue-listed

Vascular Plants

Scientific Name	Common Name	Prov. Status
Allium validum	Swamp Onion	Blue-listed
Apocynum x floribundum	Western Dogbane	Blue-listed
Arabis sparsiflora	Sickle-Pod Rockcress	Red-listed

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Vascular Plants

Astragalus sclerocarpus	Dalles Milk-Vetch	Red-listed
Astragalus spaldingii Ssp *spaldingii*	Spalding's Milk-Vetch	Red-listed
Carex vulpinoidea	Fox Sedge	Blue-listed
Castilleja minor Ssp *minor*	Annual Paintbrush	Red-listed
Cryptantha celosioides	Cockscomb Cryptantha	Red-listed
Epilobium halleanum	Hall's Willowherb	Blue-listed
Erigeron poliospermus Var *poliospermus*	Cushion Fleabane	Blue-listed
Halimolobos whitedii	Whited's Halimolobos	Red-listed
Hutchinsia procumbens	Hutchinsia	Red-listed
Ipomopsis minutiflora	Small-Flowered Ipomopsis	Red-listed
Lappula occidentalis Var *cupulata*	Western Stickseed	Red-listed
Linanthus septentrionalis	Northern Linanthus	Blue-listed
Orobanche corymbosa Ssp *mutabilis*	Flat-Topped Broomrape	Red-listed
Orthocarpus barbatus	Grand Coulee Owl-Clover	Red-listed
Pectocarya penicillata	Winged Combseed	Red-listed
Pyrrocoma carthamoides Var *carthamoides*	Columbia Goldenweed	Red-listed
Sphaeralcea coccinea	Scarlet Globe-Mallow	Red-listed
Sphaeralcea munroana	Munroe's Globe-Mallow	Red-listed
Sporobolus compositus Var *compositus*	Rough Dropseed	Red-listed
Verbena hastata Var *scabra*	Blue Vervain	Red-listed

Endangered, Threatened, or Vulnerable Species Not Included in the Indicator Invertebrates

Scientific Name	**Common Name**	**Prov. Status**
Anoplius depressipes	Spider Wasp / Spider Hunter	Red-listed
Apiocera barri	Apiocerid Fly	Red-listed
Botocudo modestus	Seed Bugs	Red-listed
Danaus plexippus	Monarch Butterfly	Blue-listed
Efferia albibarbis	Robber Flies	Red-listed
Eleodes extricatus	Darkling Beetles	Red-listed
Eleodes nigrinus	Darkling Beetles	Red-listed
Eremobates gladiolus	Sun Spiders or Wind/Sun Scorpions	Red-listed
Eremobates scaber	Sun Spiders or Wind/Sun Scorpions	Red-listed
Erythemis collocata	Western Pondhawk (Dragonfly)	Blue-listed
Eucerceris vittatifrons	Digger Wasps	Red-listed
Euphoria rufobrunnea	Scarab Beetles	Red-listed
Gastrodes intermedius	Seed Bugs	Red-listed
Gomphus graslinellus	Pronghorn Clubtail Butterfly	Blue-listed
Hemerotrecha denticulata	Sun Spiders or Wind/Sun Scorpions	Red-listed
Heterogaster behrensii	Seed Bugs	Red-listed
Holopyga hora	Spider Wasps	Red-listed
Hoplistoscelis heidemanni	Damselbugs	Red-listed
Libellula pulchella	Twelve-Spotted Skimmer (Dragonfly)	Blue-listed
Litaneutria minor	Ground Mantis	Red-listed
Machimus vescus	Robber Flies	Red-listed
Macromia magnifica	Western River Cruiser (Dragonfly)	Blue-listed

Invertebrates

Megaphorus willistoni	Robber Flies	Red-listed
Nemomydas pantherinus	Black Flies	Red-listed
Neosuris castanea	Seed Bugs	Red-listed
Ospriocerus aecus	Mydas Flies	Red-listed
Pachydiplax longipennis	Blue Dasher	Blue-listed
Satyrium behrii	Behr's Hairstreak	Red-listed
Satyrium californicum	California Hairstreak Butterfly	Blue-listed
Satyrium fuliginosum	Sooty Gossamer Wing Butterfly	Red-listed
Stylurus olivaceus	Olive Clubtail Butterfly	Red-listed
Sympetrum vicinum	Yellow-Legged Meadowhawk (Dragonfly)	Blue-listed
Synageles leechi	Jumping Spiders	Red-listed

Appendix E: Species Dependent on Lower Fraser Valley Wetlands.

Birds

Scientific Name	Common Name	Prov. Status
Recurvirostra americana	American Avocet	Red-listed
Botaurus lentiginosus	American Bittern	Blue-listed
Ardea herodias fannini	Great Blue Heron, *Fannini* Subspecies	Blue-listed
Butorides virescens	Green Heron	Blue-listed
Progne subis	Purple Martin	Red-listed
Grus canadensis Population 1	Sandhill Crane, Georgia Depression Population	Red-listed

Mammals

Sorex bendirii	Pacific Water Shrew	Red-listed

Reptiles

Chrysemys picta	Painted Turtle	Blue-listed
Clemmys marmorata	Western Pond Turtle	Red-listed

Amphibians

Scientific Name	Common Name	Prov. Status
Ascaphus truei Population 2	Tailed Frog, Coastal Population	Blue-listed
Dicamptodon tenebrosus	Pacific Giant Salamander	Red-listed
Rana aurora	Red-Legged Frog	Blue-listed
Rana pretiosa	Oregon Spotted Frog	Red-listed

Freshwater Fish

Scientific Name	Common Name	Prov. Status
Acipenser medirostris	Green Sturgeon	Red-listed
Acipenser transmontanus Population 4	White Sturgeon (Fraser River Population)	Red-listed
Catostomus platyrhynchus	Mountain Sucker	Blue-listed
Catostomus Species 4	Salish Sucker	Red-listed
Cottus Species 2	Cultus Lake Sculpin	Red-listed
Hybognathus hankinsoni	Brassy Minnow	Blue-listed

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Freshwater Fish

Oncorhynchus clarki clarki	Cutthroat Trout, *Clarki* Subspecies	Blue-listed
Rhinichthys Species 4	Nooksack River Dace	Red-listed
Salvelinus confluentus	Bull Trout	Blue-listed
Salvelinus malma	Dolly Varden	Blue-listed
Spirinchus Species 1	Pygmy Longfin Smelt	Red-listed
Thaleichthys pacificus	Eulachon	Blue-listed

Vascular Plants

Scientific Name	**Common Name**	**Prov. Status**
Alopecurus carolinianus	Carolina Meadow Foxtail	Red-listed
Bidens amplissima	Vancouver Island Beggarticks	Blue-listed
Callitriche heterophylla Ssp. *heterophylla*	Two-Edged Water-Starwort	Blue-listed
Caltha palustris Var. *palustris*	Yellow Marsh-Marigold	Blue-listed
Carex amplifolia	Bigleaf Sedge	Blue-listed
Carex comosa	Bearded Sedge	Blue-listed
Carex feta	Green-Sheathed Sedge	Blue-listed
Carex interrupta	Green-Fruited Sedge	Red-listed
Carex scoparia	Pointed Broom Sedge	Blue-listed
Carex vulpinoidea	Fox Sedge	Blue-listed
Coleanthus subtilis	Northern Coleanthus	Red-listed
Elatine rubella	Three-Flowered Waterwort	Blue-listed
Eleocharis parvula	Small Spike-Rush	Blue-listed
Eleocharis rostellata	Beaked Spike-Rush	Blue-listed
Elodea nuttallii	Nuttall's Waterweed	Blue-listed
Glyceria leptostachya	Slender-Spike Manna Grass	Blue-listed
Glyceria occidentalis	Western Mannagrass	Blue-listed
Hypericum majus	Canadian St. John's-Wort	Blue-listed
Juncus oxymeris	Pointed Rush	Blue-listed
Juncus regelii	Regel's Rush	Blue-listed
Leersia oryzoides	Rice Cutgrass	Blue-listed
Lilaea scilloides	Flowering Quillwort	Blue-listed
Lindernia dubia Var. *anagallidea*	False-Pimpernel	Red-listed
Lupinus rivularis	Stream-Bank Lupine	Red-listed
Myriophyllum pinnatum	Pinnate Water-Foil	Red-listed
Myriophyllum ussuriense	Ussurian Water-Milfoil	Blue-listed
Navarretia intertexta	Needle-Leaved Navarretia	Red-listed
Platanthera dilatata Var. *albiflora*	Fragrant White Rein Orchid	Blue-listed
Polygonum douglasii Ssp. *johnstonii*	Sachaline Knotweed	Red-listed
Polygonum hydropiperoides	Water-Pepper	Blue-listed
Polygonum punctatum	Dotted Smartweed	Blue-listed
Potamogeton oakesianus	Oake's Pondweed	Blue-listed
Potamogeton strictifolius	Stiff-Leaved Pondweed	Blue-listed
Salix sessilifolia	Sessile-Leaved Sandbar Willow	Blue-listed
Sanguisorba menziesii	Menzies' Burnet	Blue-listed
Sparganium fluctuans	Water Bur-Reed	Blue-listed
Stellaria obtusa	Blunt-Sepaled Starwort	Blue-listed
Verbena hastata Var. *scabra*	Blue Vervain	Red-listed
Wolffia borealis	Northern Water-Meal	Red-listed

Appendix F: Species Dependent on Coastal Forest Suitable for Nesting Marbled Murrelets

Birds

Scientific Name	Common Name	Prov. Status
Accipiter gentilis	Northern Goshawk	Red-listed
Ardea herodias	Great Blue Heron	Blue-listed
Brachyramphus marmoratus	Marbled Murrelet	Red-listed
Strix occidentals caurina	Spotted Owl	Red-listed
Synthliboramphus antiquus	Ancient Murrelet	Blue-listed

Mammals

Scientific Name	Common Name	Prov. Status
Aplodontia rufa rufa & A.r. rainieri	Mountain Beaver	Red-listed
Cervus elaphus roosevelti	Roosevelt Elk	Blue-listed
Gulo gulo luscus	Wolverine	Blue-listed
Martes pennanti	Fisher	Blue-listed
Myotis keenii	Keen's Long-Earred Myotis	Red-listed
Sorex trowbridgii	Trowbridge's Shrew	Blue-listed
Ursus arctos horribilis	Grizzly Bear	Blue-listed

Amphibians

Scientific Name	Common Name	Prov. Status
Ascaphus truei	Tailed Frog	Blue-listed
Contia tenuis	Sharp-Tailed Snake	Red-listed
Dicamptodon tenebrosus	Pacific Giant Salamander	Red-listed