2.0 State of the Natural Environment

2.1 Landbase

Introduction

Forested landscapes define British Columbia. The Cowichan Valley Regional District (CVRD) is located in the coastal temperate rainforest – a globally unique ecosystem. The CVRD's forest-dominated ecosystems are very diverse, and range from some of the driest to some of the wettest in the province.

Measuring trends for the thousands of individual living species is impossible, and broader indicators are typically used to understand ecological health. A broad "state of the landbase" indicator is useful because it reflects population trends for many other species. The closer a landscape is to its "natural" condition, the more likely that the associated biodiversity values are maintained and that natural processes such as hydrologic cycles continue to function.

Forest harvesting and land clearing have historically been the major agents of change for forested ecosystems on Vancouver Island and within the Cowichan Valley Regional District. Significant harvesting of easily accessible stands started in the 1800s and has continued to the present day, with changes in harvest pattern and profile over time.

Accessibility is different for different areas of the Island, resulting in variations in remaining forest cover today. In addition, clearing by Europeans for agriculture and settlement has significantly impacted land conditions, primarily of the eastern and southern portion of the Island, including the CVRD.

Measuring the Condition of the Landbase

Landbase condition can be measured and assessed at many different scales. For example, although the CVRD region is large, forested landscapes and many associated species generally function at a much larger scale. It therefore becomes important to understand how conditions in the CVRD fit into the broader condition of forests on Vancouver Island.

This section focuses on the broader forest condition, and assesses its state primarily by measuring the amount of old forest present in different ecosystems for Vancouver Island and within the CVRD. An analysis of smaller ecosystems is provided in Section 2.2 (Sensitive Ecosystems). A secondary measure used is the level of land under protection, as it provides a general assessment of the potential future condition of the landbase.

Current land use also interacts with condition and levels of protection – for example, Crown land and private forest land are managed under different regulations. As a result future condition may be different. In addition, lands that are converted from forest to other uses (development lands) make a different ecological contribution into the future. These factors are relevant in the CVRD where a significant area of forest land is held as private holdings; however, this factor was not included in this first State of the Environment Report (see Summary).

Three indicators are provided in this report:

> Condition of Vancouver Island's forested landbase

> Condition of the CVRD's landbase

> Level of protected areas within the CVRD

Condition of Vancouver Island's Landbase

Indicator and Measure

This indicator examines the current forest condition for the different ecosections on Vancouver Island, as defined by the amount of forest >140 years in age. This indicator places information for the CVRD into an appropriate regional context.

Vancouver Island is classified into six ecosections, and the ecosystems within them are divided into a large number of "biogeoclimatic" units (Figure 2.1).[21] The eastern side of the Island – the Nanaimo Lowland and Leeward Island Mountains – are characterized by dry forests dominated historically by Douglas-fir and Garry oak, which historically burned relatively frequently by both natural and First Nation-driven fires. This "Coastal Douglas-fir" zone is one of the most diverse forested regions in BC, and under natural conditions had about 50% in old forest condition at any one time,[22] with many old fire-resistant trees scattered among younger forest stands.

21 A description of these zones can be found on the Ministry of Forest's Biogeoclimatic Ecosystem Classification (BEC) website: www.for.gov.bc.ca/HRE/becweb/resources/classificationreports/subzones/index.html

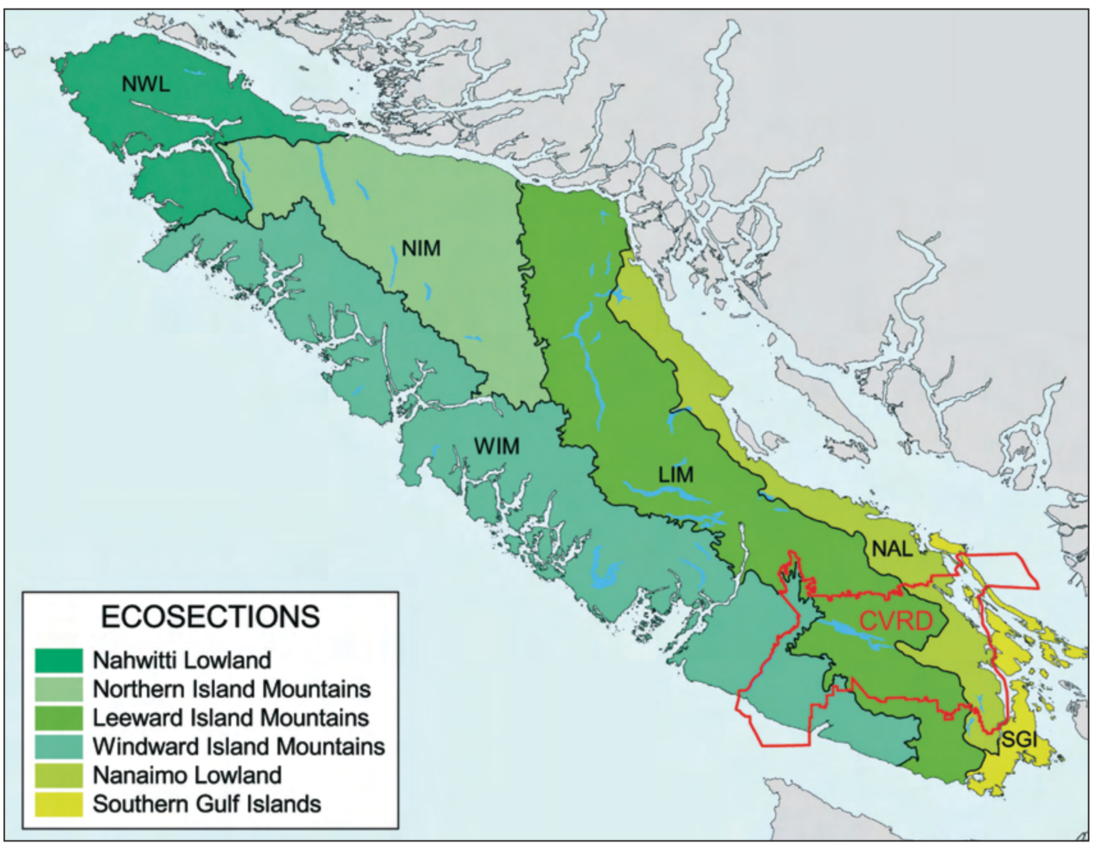
22 Percent in old forest condition is estimated based on stand-replacing fire interval estimates available from a variety of scientific studies for coastal ecosystems.

In contrast, the forests on the west side of Vancouver Island are some of the wettest in the province, and so burn very infrequently. As a result, they are characterized by huge-statured and often old or ancient western red-cedar, western hemlock and Sitka spruce forests, and under natural conditions typically had between 70–95% in old forest condition. These multi-storied canopy forests (forests with many layers) provide a home to a huge diversity of plants and animals and provide many natural functions.

British Columbia has some of the best forest classification systems and forest cover mapping available anywhere in the world, and this information is typically publicly available for Crown land. However, although the information exists for private forest land and tree farm licenses, it is sometimes not released by companies or is available only in summary form. This is the case for the CVRD, where much of the forest is held privately. In the absence of access to privately held information, this indicator relies on Baseline Thematic Mapping (BTM) data.[23] Although BTM data can provide an overview of general trends, the level of detail available in the data is relatively coarse and not as accurate as typical forest cover data.

The "age" of the forest stand is defined by air-photo interpretation, and presented by ecosection.

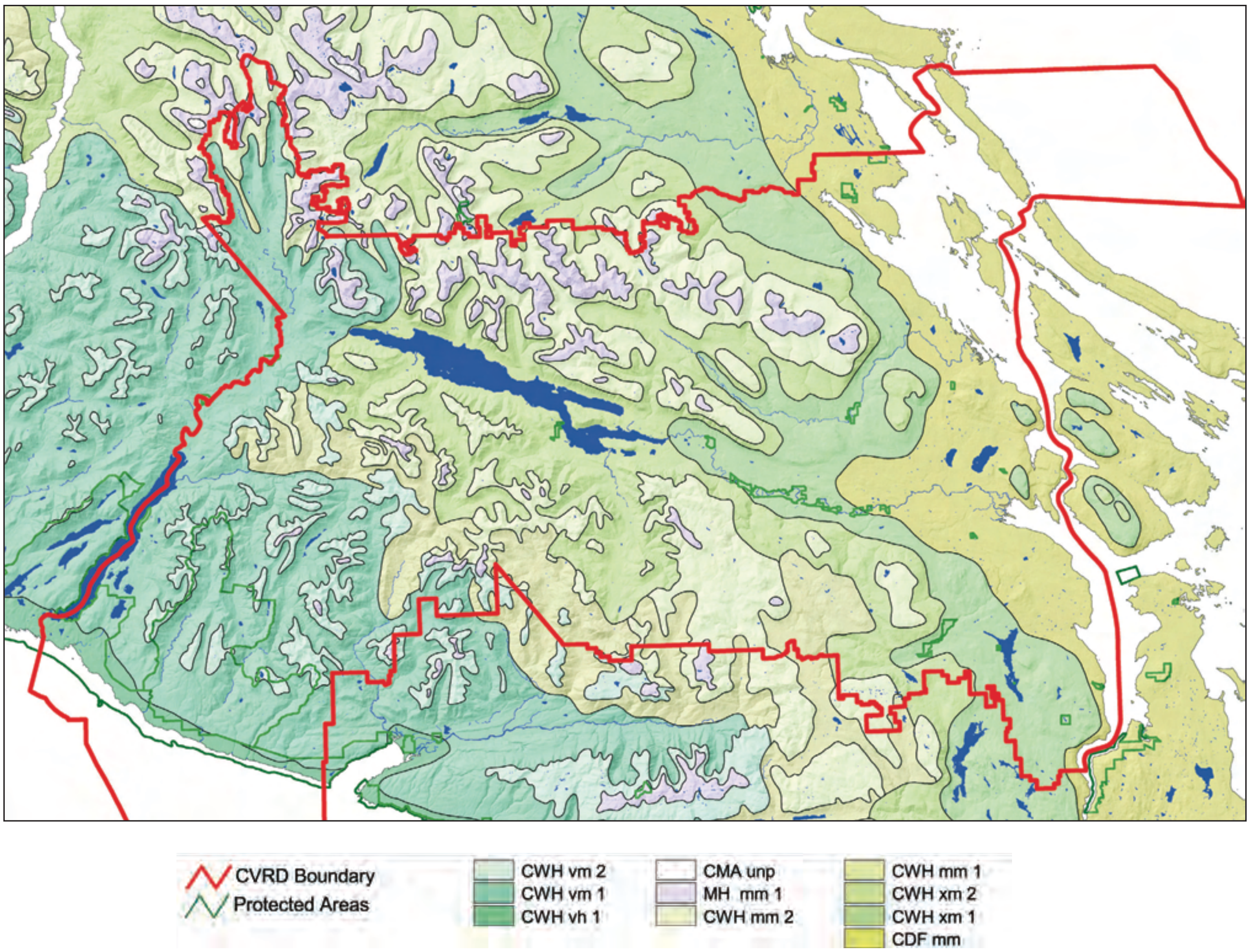
FIGURE 2.1: Distribution of ecosections on Vancouver Island, highlighting the CVRD



23 Baseline Thematic Mapping – available at: www.hectaresbc.org

In addition, the forests of the province are classified into biogeoclimatic zones, which provide a framework within which to categorize the condition of different "types" of forests. For example, Figure 2.2 shows the biogeoclimatic zones present within the CVRD. These forests differ in terms of their vegetation, soils and topography and span the range from dry Garry oak and arbutus woodlands in the east to wet cedar-dominated forests in the west.

FIGURE 2.2: Distribution of biogeoclimatic zones within the CVRD



CDF = Coastal Douglas-fir zone;

CWH = Coastal Western Hemlock zone;

MH = Mountain Hemlock zone.

The additional characters (e.g., vm1) describe the specific moisture and temperature regime within that specific region.

A detailed description of these biogeoclimatic zones is available online.[24]

24 See www.for.gov.bc.ca/hfd/library/documents/TREEBOOK/biogeo/biogeo.htm

Findings

Coastal temperate rainforests are defined by their old-growth forests, so assessing the amount of remaining old forest provides an indicator of the health of the ecosystem as a whole today. In addition, it likely reflects the ability of the ecosystem to resist, at least to some degree, the coming impacts of climate change into the future.

For Vancouver Island, the distribution of older forests remaining in different ecosystems is very uneven. The drier zones on the east side of the Island (the Nanaimo Lowlands ecosection) have extremely low levels of old forest remaining, with 2.5% of the forested landbase greater than 140 years in age. This is a fraction of what would have existed under natural disturbance conditions.

Levels of older forest are higher on the western/northern sections of the Island – ranging from 40–55%. However, although these percentages are much higher, they are still considerably lower than the amount of old forest present under natural disturbance conditions, when typically 70%– >90% of the landbase would have been older than 140 years in age.

Table 2.1 shows a breakdown of the amount of older forest (>140 years in age[25]) remaining in each of four ecosections (locations shown in Figure 2.1 and Figure 2.2).

A recent detailed mapping exercise for part of the area – the Coastal Douglas-fir (CDF) zone[26] – provides more accurate and fine-scale information about the amount of older forest cover. For the whole CDF zone (not just the section within the CVRD), more than 33% of the land area has been converted to urban, rural, agricultural and industrial use, while 2% is wetlands, 4% is natural non-forested areas and 60% remains forested. Of the forested portion only 610 ha (less than 1%) remains as old growth (structural stage 7), with 13% remaining as mature forest. Wetland and estuary ecosystems represent only 2% of the entire CDF area.

This context analysis is important for the CVRD because it highlights whether the condition within the regional district is mirrored in adjacent areas, or whether the condition within the CVRD is an anomaly in the broader forest landscape. The low level of old forest remaining, particularly in the eastern portion of Vancouver Island, suggests that ecological functions and values may not be being maintained at this scale. Where forest condition is poor at this scale, and also found to be to be poor within the CVRD, additional concern and action within the CVRD may be warranted. A more detailed analysis particular to sensitive ecosystems within this zone is presented in Section 2.2 (Sensitive Ecosystems).

25 Forests greater than 140 years in age are used to identify "natural older" forests for the ecosystems in this analysis. Typically, an age of greater than 250 years is used to identify old forests, particularly in wetter west coast ecosystems, where natural old growth can be in excess of many thousands of years in age. However, for simplicity of presentation, and because of data limitations, 140 years is used to define "older" forests in this analysis since these forests likely established naturally – rather than as a result of harvesting – so represent naturally mature or old forests.

26 Madrone, 2008. Even this analysis is out of date since it is based on air photos taken since 1993.

TABLE 2.1: Vancouver Island – amount of old growth remaining in broad forested zones, by ecosection[27]

Ecosection	ZONE	Area (ha) Forest > 140 years	Total Forest area (ha)	Percent >140 years	Estimated Percent of natural remaining	Total for Ecosection (%)
Nanaimo Lowland	CDF	245	86,626	0.3	<1%	
	CWH	7,145	211,559	3.4	6%	
Total		7,390	298,185			2.5%
Leeward Island Mountains	CWH	138,258	764,623	18.1	36%	
	MH	62,561	129,096	48.5		
Total		203,930	932,882			21.9%
Northern Island Mountains	CWH	167,044	421,928	39.6		
	MH	63,442	135,991	46.7		
Total		232,527	577,858			40.2%
Windward Island Mountains	CWH	555,907	992,004	56.0		
	MH	33,208	80,941	41.0		
Total		589,348	1,080,937			54.5%

CDF = Coastal Douglas-fir zone; CWH = Coastal Western Hemlock zone; MH = Mountain Hemlock zone.

27 From analysis of 2002 BTM data, available at www.hectaresbc.org

Condition of the CVRD's Landbase

Indicator and Measures

The amount of old forest >140 years in age (as above) is now analyzed within the CVRD. This focus allows for a more detailed analysis of the condition of individual biogeoclimatic zones, compared to the natural level of old forest expected under natural disturbance conditions.

Findings

The CVRD is about 360,000 ha in size. Of this total area, around 8% is identified as developed for agriculture, residential and urban (note this does not include forested areas that contain rural properties). The biodiversity values and ecological functions (e.g., provision of clean water, productive soil, native biodiversity) provided by these "converted" forest lands are typically much lower than those provided by remaining forests. Of the remaining broad landbase, almost 70% is young forest or recently logged, with 18% in forest >140 years in age (Table 2.2).

TABLE 2.2: Approximate land use within the Cowichan Valley Regional District[28]

Land Use Type	Area	Percent
Agriculture	9,164	2.6
Residential / Agricultural Mix	5,314	1.5
Urban	12,440	3.5
Freshwater	9,918	2.8
Recently Logged	91,917	25.8
Young Forest	156,234	43.9
Old Forest	65,302	18.4
Alpine	1,333	0.4
Wetlands	955	0.3

28 Analysis of Baseline Thematic Mapping (BTM) from statistics generated from HectaresBC (www.hectaresbc.org

Ecologically it is important to look in more detail at individual biogeoclimatic zones, especially given the diversity of ecosystems present within the CVRD. Figure 2.2 illustrates the diversity of forested biogeoclimatic zones present within the CVRD, as described above.

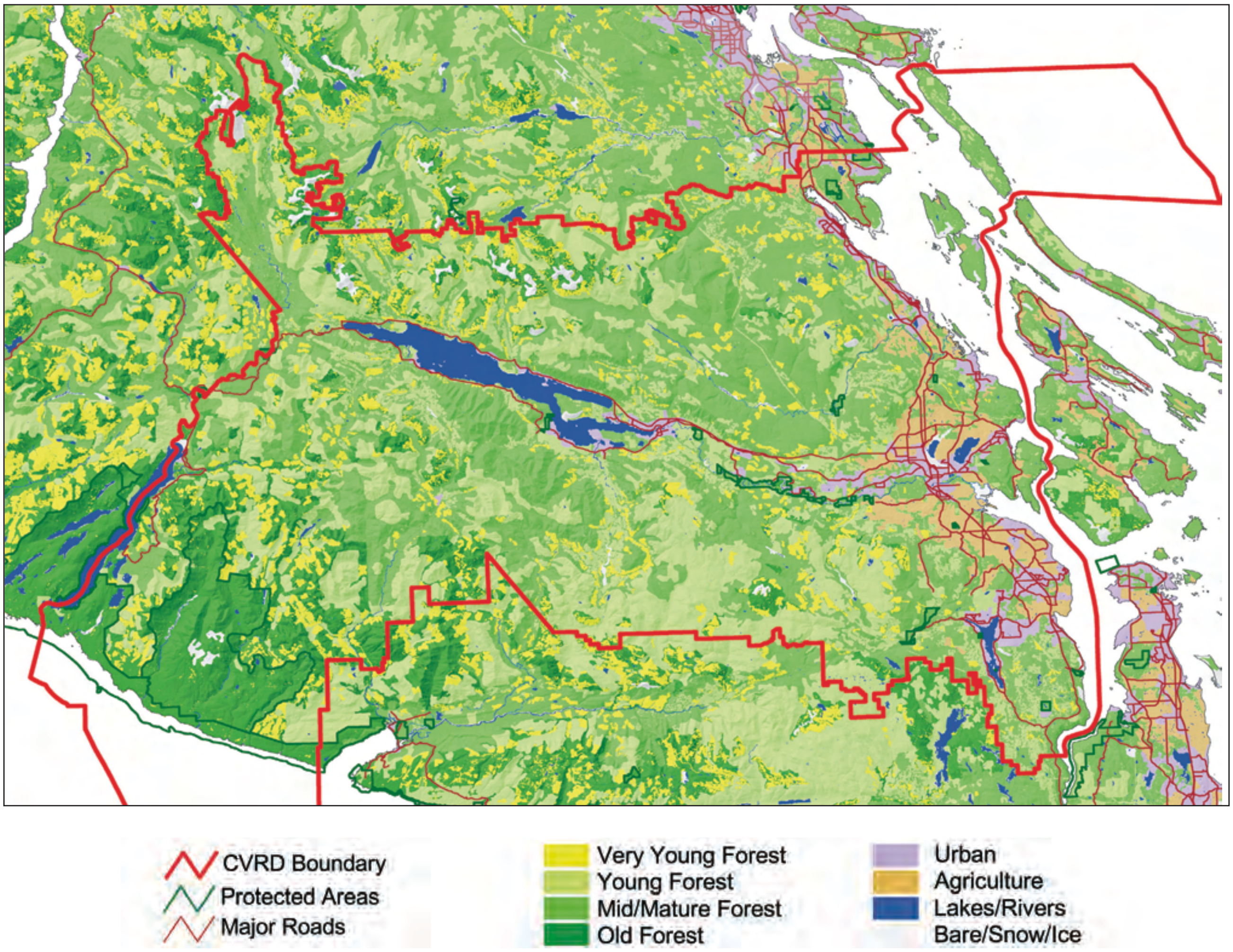
Figure 2.3 and Table 2.3 provide a more detailed illustration of the amount of old forest remaining in each zone within the CVRD, including the (largely) dry zone on the east coast, and the wettest zones on the west coast. The CDF zone has the highest percent of human settlement – almost 50% of the whole zone is agriculture/residential or urban. For the remaining forested portion within the CDF zone, no old forest remains.[29] Historically, around 50% of the CDF landscape would have been greater than 140 years in age.

The two drier Coastal Western Hemlock zones (adjacent to the Coastal Douglas-fir zone) also have extremely low levels of forest >140 years in age remaining (2% and 4% respectively), compared to an estimated historic level of around 50% or more, resulting in very poor forest condition today.

For this whole eastern portion of the CVRD, the vast majority of the landbase is in second growth forest less than 40 years in age. This is shown by the yellow and light green forests in Figure 2.3. The only significant areas of older forest remaining are within the Carmanah/Walbran valleys on the west coast of the region (shown by dark green).

29 Very small areas of "high structure" forest remain in this zone, but they are sufficiently small as to not be visible using these data. These small areas are highlighted in the "Sensitive Ecosystems Inventory" (Section 2.2).

FIGURE 2.3: The CVRD landbase coloured by broad age group categories[30] of forest and other land use (urban/agricultural)



Source: Data analysis based on BTM Data, 2002.

30 Approximate age group categories: Very young = less than 10 years old; Young = less than 40 years old; Mid / Mature = 41 – 140 years in age; Old = >140 years in age. Based on analysis of BTM data, current to 2002.

Land use and condition shifts towards the west, with the percentage of development declining and the percent of old forest increasing in general. However, the mid-elevation zones (CWHmm1 and CWHmm2) have some older forests remaining, but still very low levels of forest >140 years in age (7% and 12% respectively). Again, compared with the predicted historic level of old forest (around 50% old forest) this represents very low levels of older forest (Table 2.3).

As the higher elevation zones and west coast forests are reached, older forests are more prevalent (see dark green within the Carmanah/Walbran provincial park), but in general (except for the CWHvm1) at levels still considerably lower than the predicted levels of 70 – 95% forests > 140 years that would occur under natural disturbance conditions.

TABLE 2.3: Landbase condition data – area (in hectares) and percent in four broad age categories[31] for forested zones, and percent in urban/agriculture/mixed zones

			Forested						
Biogeoclimatic Zone	Forest type	Permanent Conversion Area and Percent	Area and Percent Less than 20 years		Area and Percent 20 – 140 years		Area and Percent > 140 years		Percent of natural forest > 140 years
CDF	Dry	20,000 (49%)*	1,280	6%	18,900	94%	0	0%	<1%
CWHxm1	Dry	3838 (7%)**	6,400	15%	34,300	82%	768	2%	4%
CWHxm2	Dry	1280 (2%)***	17,700	25%	49,900	71%	2,820	4%	8%
CWHmm1	Moist	-	11,000	42%	13,100	51%	1,790	7%	14%
CWHmm2	Moist	-	31,500	55%	18,900	33%	6,910	12%	24%
MHmm1	Moist/ Wet	-	4,610	37%	2,560	21%	5,120	42%	73%
CWHvm1	Wet	-	17,400	25%	16,600	24%	34,600	50%	61%
CWHvm2	Wet	-	5,890	37%	1,540	10%	8,450	53%	61%
CWHvh1	Wet	-	256	6%	0	0%	4,350	94%	98%

Note: This table is organized by biogeoclimatic zones (see Figure 2.2). The far right-hand column shows today's older forest as a percent of that occurring historically (red text indicates those below the "high risk to ecological integrity" threshold as defined below)

*CDF: 21% agriculture; 11% residential/agricultural mix, 17% urban.
** CWHxm1: 1% agriculture; 2% residential /agricultural mix; 4% urban
*** CWHxm2: 2% urban.

31 Note that these "age" cut-offs are approximate, and based on broad categories of photo-interpretation.

The estimated percent of natural forest remaining provides a more "ecosystem-specific" assessment of current condition – since naturally the levels of old forest differ across ecosystems. An analysis of science literature undertaken for the Coast Information Team[32] looked at how the levels of old forest relate to potential "risk" to ecological integrity, and recommended that more than 70% of natural levels represented low risk, while less than 30% of total level of old forest represented high risk to ecological integrity.[33]

For forest types within the CVRD, the wettest outercoast zone (CWHvh1) has a high proportion of its original old forest, so there is a high probability that ecological systems remain fully functioning. The other wetter zones have around 70% of the natural levels of old forest remaining – meaning there is reasonable probability that landscape-level ecological integrity is maintained.[34] However, east coast moist and dry zones all have considerably less than the "high risk threshold" of 30% of old forest remaining, meaning that there is a high probability that landscape level ecological integrity is not maintained.

Level of Protected Areas within the CVRD

Indicator and Measures

The level of "protection" for different ecosystems provides a general overview of the potential future condition for an area. Landscapes with high levels of "conservation focused" protected areas tend to have high-functioning ecosystems into the future irrespective of the condition today, as these areas are either maintained or allowed to restore back towards natural condition through time. Protected areas are often thought of as providing "core" areas within which biodiversity values can be maintained, which then help to maintain biodiversity and ecological functions in other non-protected parts of the landscape. However, for them to be effective in this role, there needs to be a relatively high percent of protection, and protected areas need to be large, well distributed and representative of the ecological diversity. The higher the level of core protection, the higher the likelihood of meeting these criteria.

There are a number of different ways in which lands can be "protected" and these can contribute towards conservation goals to varying degrees, including federal and provincial parks, ecological reserves, regional parks, municipal parks, and conservation lands.

32 www.citbc.org

33 Price, Holt and Kremsater, submitted.

34 This single indicator of course does not consider the implications of habitat fragmentation, road density, disturbance, etc., which may also result in increased risk, but which are not assessed here.

Findings

Table 2.4 shows a breakdown of the amount of protected area for each zone for each type of park. It does not include municipal parks, which are typically not managed specifically for conservation goals.

TABLE 2.4: Total area (hectares) and percent protected areas – by biogeoclimatic zone[35]

Type	CDF	CWHxm1	CWHxm2	CWHmm1	CWHmm2	CWHvm1	CWHvm2	CWHvh1	MHmm1	TOTAL
National Park	0			0		1,790		3,330		5,120
Provincial Park	1,020	2,300	256	0	256	15,400	1,540	256		21,000
Regional Park	256	768		0						1,020
Total Park	1,276	3,068	256	0	256	17,190	1,540	3,586	0	27,140
Total Area	41,200	47,100	78,600	25,000	57,000	70,400	16,100	4,610	13,800	
Percent Park	3.1%	6.5%	0.3%	0.0%	0.4%	24.4%	9.6%	77.8%	0%	7.7%

In the east, there are generally very low levels of protected areas – 3% or less for the drier zones, except for the CWHxm1, which incorporates the Cowichan River Park. Working westwards, higher levels of protection are found – but the overall level of representation in protected areas for the CVRD remains low at 7.7%.

There is no set level of protected area that is considered necessary to maintain core ecological functioning. However, politically set levels of 12% are well known to be inadequate.[36] More recent scientific analyses suggest that to be effective, levels closer to 50% of the landscape managed with an emphasis on conservation are required for effective maintenance of biodiversity and ecosystem services.[37]

35 From www.hectaresbc.org

36 Svancara et al., 2005.

37 See review in Holt, 2007 and Svancara et al., 2005.

Summary

The CVRD landbase has been continuously utilized by humans since glacial retreat, but this utilization has expanded dramatically in scale and scope since European settlement. The human footprint now covers approximately 275,000 ha of the CVRD's 360,000 ha – over 75% of the total landbase (including development and logging), and affects the ability of the landbase to supply and maintain ecological values and services.

Impacts are particularly severe on the east coast, where around 50% of the landbase has been converted from its historic forested condition, and the remaining forested landbase has very little or no older forest or older forest attributes remaining. At higher elevations, and towards the west coast, the condition of the forested landbase is better – but is still lower than levels of old forest under natural conditions. Most protected areas within the CVRD serve to protect west coast forests, with almost no ecological protection on the east coast. The total level of protection (<8%) for the CVRD is much lower than what is needed to maintain ecological values into the future.

Missing Information

This analysis provides broad landscape trends, but could be improved by gaining access to more detailed or up-to-date forest cover information. The southern part of Vancouver Island, including the CVRD, is unusual for British Columbia in having a high proportion of forest land held as privately owned forests. This makes data availability and analysis more difficult than in areas of the province which are primarily Crown land. Most of the eastern forests of the CVRD are privately owned, and most of the western portion is Crown land managed as tree farm licenses where data are also not freely available. Compiling a complete and up-to-date database with up-to-date data is therefore difficult.

The Baseline Thematic Mapping (BTM) data used in this analysis are current to about 2002. Continued forest harvesting and conversion is ongoing within this region. An important "next step" in this analysis would be to assess the potential impacts of recent and already-planned development within the region. The broad "age class" breaks inferred from the BTM data are estimates only, based on photo-interpretation, and are useful in providing information on broad trends, but inaccurate when it comes to determining forest stand ages. A comprehensive data layer for conservation lands was not available, so these areas – which tend to be relatively small but focus on very high value areas – are not included in this analysis.

References

Baseline Thematic Mapping data available through www.hectaresbc.org

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2.2 Sensitive Ecosystems

Introduction

Ecosystems are areas of similar soil, topography and climate – but can be defined at many different scales. Section 2.1 assesses broad landscape conditions across Vancouver Island and the CVRD in particular. This section examines the CVRD's ecosystems using a finer scale.

The diversity of ecosystems – unique combinations of plants, animals and their physical environment – defines the beauty and richness of the natural world. Maintaining this natural diversity is key to preventing species extinctions and is a critical aspect of maintaining natural resilience into the future. The CVRD contains a range of rare, sensitive and keystone ecosystems that have very high ecological and social values. This section focuses on those ecosystems that are relatively rare (compared to the whole landbase) and have particularly high ecological values. Three particular systems (or groups of systems) are included:

Garry oak woodlands and other "sensitive" ecosystems. Garry oak woodlands are one of the most endangered ecosystems in Canada. Garry oak extends south to California, and south-western BC represents the northern edge of its range and the only place in Canada where these ecosystems are found. Garry oak and associated ecosystems provide a home for a wide diversity of species – including seven species of reptiles, seven species of amphibians, 33 species of mammals, 104 species of birds, 694 species of plants and 800+ species of insects and spiders.[38] Of these, more than 100 are identified as "at risk" – including more than 75 plants, two reptiles, 14 birds, three mammals, 13 butterflies and 10 other insect species. Some species that were formerly linked to this habitat type are no longer found here – including the western bluebird, Lewis's woodpecker, acorn woodpecker and streaked horned lark.

Other "sensitive" ecosystems that have high ecological values include wetlands and riparian areas, older forest (see section 2.1), terrestrial herbaceous areas (rocky outcrops and grassy knolls), coastal bluffs and coastal dunes and spits. These small systems have been identified as "sensitive" by the federal and provincial governments, and some are also identified as rare or threatened in the BC Conservation Data Centre's ranking. Garry oak woodlands and the other "sensitive" ecosystems are mapped together as part of a Sensitive Ecosystem Inventory (SEI).

38 Garry Oak Ecosystems Recovery Team: www.goert.ca

Shoreline ecosystems. The shoreline is the interface between terrestrial and marine environments and ecologically it is important to both. It allows access to the historical abundance of the ocean for land species, and provides critical habitats for many marine and intertidal species. Shorelines in general are important for some key species – including forage fish, which provide a prey base for many marine species.

Estuaries. Estuaries are special areas of shoreline that have particularly high ecological values resulting from the mix of habitat types present. The CVRD is home to one of BC's highest value estuaries – the Cowichan Estuary – and other smaller estuaries that are locally very high value.

Key Pressures

Many of the ecosystems of concern here are small, or have only small remaining areas compared to their historic distribution. As a result they tend to be inherently sensitive. Key pressures differ for individual areas, but in general include:

- **Ecosystem loss** from conversion to agricultural or residential lands, which typically results in complete loss of the original ecosystem
- **Ecosystem degradation** through harvesting, which alters species composition and the age of trees, and alters natural disturbance processes
- **Ecosystem degradation/modification** as a result of lower impact development or invasive species, which can radically alter the dynamics of the system
- **Loss of natural processes** – Many of the drier terrestrial ecosystems were historically maintained by frequent low severity fires which maintained open meadow and woodland ecosystems. Fire suppression has resulted in changes to ecosystem dynamics for these systems, and loss of open meadow ecosystems

Measuring Sensitive Ecosystems

Fine-scale mapping – such as Terrestrial Ecosystem Mapping (TEM) – can be used to assess the current distribution of Garry oak and other sensitive ecosystems. TEM mapping is available for some areas of the CVRD, but public availability is typically limited to Crown land (see Section 2.1). A Sensitive Ecosystem Inventory[39] for the eastern portion of the region has been completed and assessed for changes over time based on an approximate 10-year review.

39 See BC Ministry of Environment Sensitive Ecosystems Inventories website: www.env.gov.bc.ca/sei/

Shoreline and potential forage fish habitat mapping has been undertaken by a large number of stewardship groups, under various projects.

This report uses the following indicators:

> Sensitive Ecosystem Inventory – analysis of a decade (1992-2002)
> Garry oak ecosystems – historic change analysis (1800-2003)
> Shoreline condition and forage fish
> Estuary condition

Note that, although an ecosystem may be "mapped as existing", the actual functioning condition can be difficult to assess. For example, small, isolated patches of ecosystems may not maintain a full complement of species or be able to act as useful habitats due to isolation. Invasive species, disturbance from humans, or pollution can also affect habitat functionality.

It can also be difficult to assess the current condition of sensitive ecosystems because there is often a lack of historic information to provide an appropriate benchmark. For this section's indicators, some information on trends through time is available.

Sensitive Ecosystem Inventory

Indicators and Measures

A Sensitive Ecosystem Inventory (SEI) was initiated on the east side of Vancouver Island and southern Gulf Islands in 1993, primarily focused on the Coastal Douglas-fir (CDF) biogeoclimatic zone.[40] Seven relatively unmodified, rare and fragile terrestrial ecosystem types, plus two important but modified ecosystems that provide high wildlife habitat, are identified within that inventory. The inventory has been further updated to 2002. It is therefore possible to analyze how much of these important ecosystems have been lost over this period. The specific indicators used here are:

> Area of sensitive ecosystems present in 1990-1992, on the east of the Island and in the CVRD
> Updated area of sensitive ecosystems present in the CVRD in 2002

These indicators do not provide a comparison with a "natural" historic benchmark for all important ecosystems within the whole area, since the historic distribution and condition for smaller ecosystems is unquantified.

40 http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=2124

Findings

Nine specific sensitive ecosystems are identified: seven "natural" systems and two modified systems that have high value for biodiversity.[41] These are:

> Coastal bluffs

> Sparsely vegetated areas (sand dunes/gravel spits)

> Terrestrial herbaceous areas – natural grasslands and grass- or moss-covered rock outcrops

> Wetlands

> Riparian habitat

> Woodland – dominated by Garry oak, mixed Douglas-fir/arbutus/Garry oak assemblages or trembling aspen

> Older forest – more than 100 years in age

> Older second growth forests (modified system 60–100 years in age)

> Seasonally flooded agricultural fields (modified system)

An overall assessment of the whole east coast of the Island (a study area which included part of the Cowichan Region) shows that about 8% of the study area had one of the seven unmodified ecosystems present, and an additional 11.6% of the study area had one of the two modified types, with much of this being the older second growth forests. The portion of the Cowichan Region that was included in this study was found to have a lower percent of sensitive ecosystems remaining than the full study area – with 5.4% of the landbase having an unmodified sensitive ecosystem present and 5.0% of the Cowichan study area having one of the two modified ecosystems in 1994.[42] This study was based on sampling photos taken between 1990 and 1992.

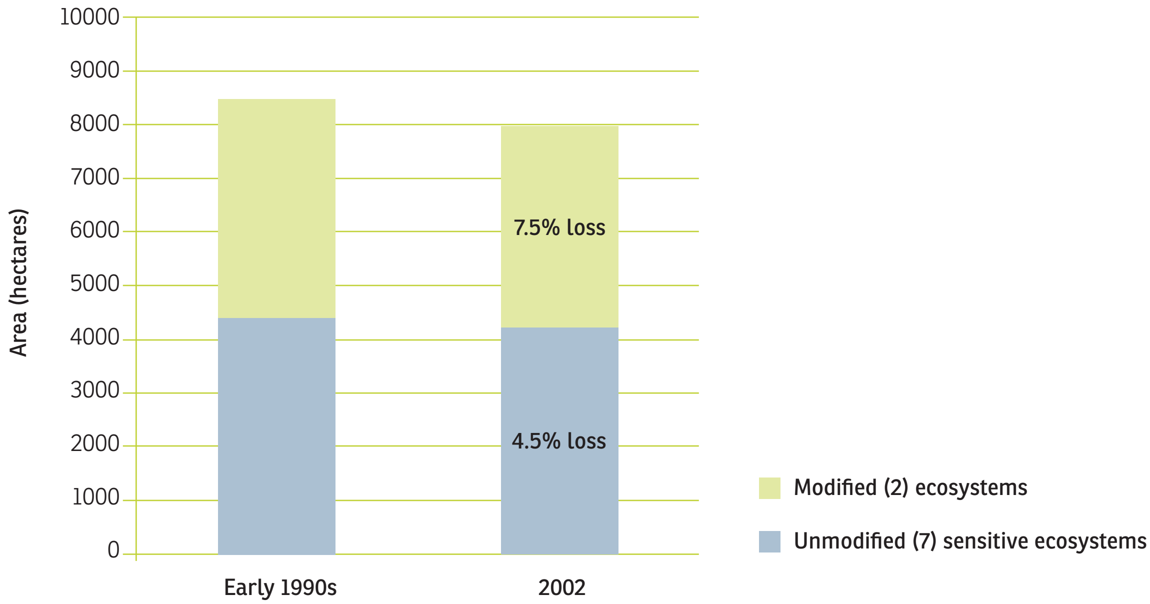
An update of the area of sensitive ecosystems was undertaken based on air photos taken in 2002. Over this approximately 10-year period between samplings, over 8,800 ha or 11% of the nine ecosystems identified in 1992 had been lost over the whole study area (east side of Vancouver Island). This included 1,460 ha of the seven unmodified sensitive ecosystems – with losses primarily in old forest (8.6%), riparian habitat (4.6%), woodland (2.6%) and wetland (2.0%).

41 See www.env.gov.bc.ca/sei/ for information and photographs about each type

42 Note that the mapping does not include all of the CVRD region, but only a limited portion primarily within the Cowichan watershed.

In the Cowichan Region, 4,417 ha of sensitive ecosystems were originally identified in the early 1990s, with a loss over 10 years of 205 ha (4.7%) for the seven unmodified systems, and a 7.5% loss for the two important but modified systems (Figure 2.4). Note that this does not provide an assessment of this historic loss of these ecosystems, compared with a natural benchmark over a longer time period.

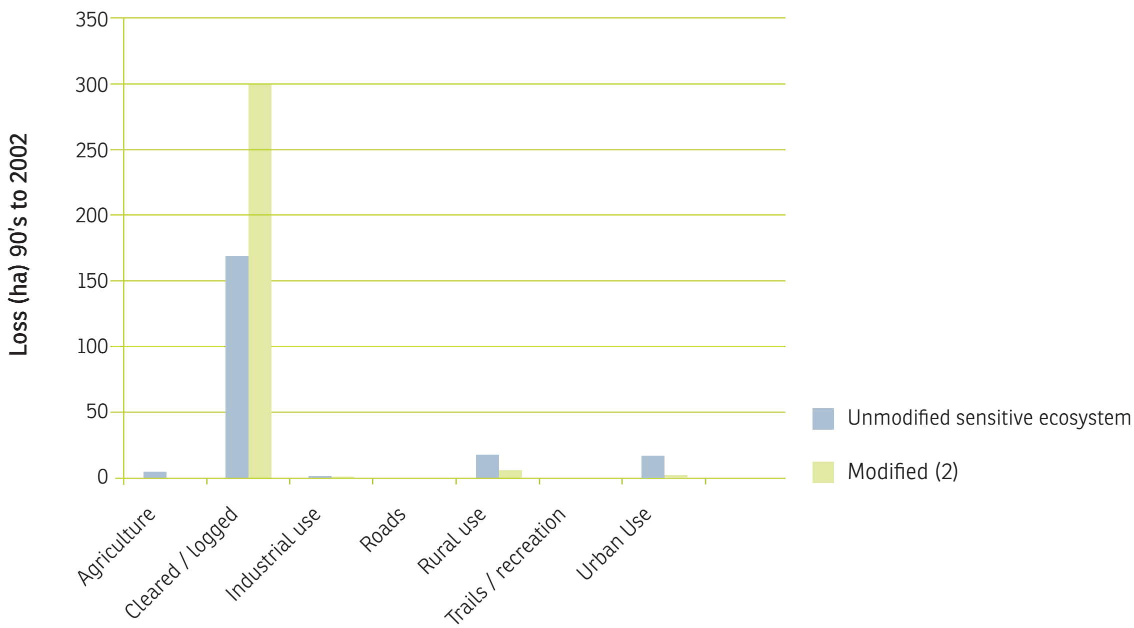
FIGURE 2.4: Loss of sensitive ecosystems over a 10-year period from areas of the Cowichan watershed



Source: Data from AXYS Environmental Consulting Ltd., 2005.

The analysis over the 10-year period also identified the pressures that appeared to have caused the changes in ecosystem condition within the Cowichan Study area (Figure 2.5). The primary cause of change is the clearing or logging of land, with smaller impacts due to rural/urban development. The sub-regional areas where losses have occurred within the CVRD are shown in Table 2.5.

FIGURE 2.5: Cause of ecosystem loss by broad disturbance categories



Source: Data from AXYS Environmental Consulting Ltd., 2005.

TABLE 2.5: Locations within the Cowichan study area (which does not include Gulf Islands) where losses primarily occurred (1992 – 2002)

	1992 Area of SEI (ha)	Loss in 2002 (area in ha)	Loss %
Duncan	0.2	0	0%
Ladysmith	57.6	1.1	2%
Lake Cowichan	15.6	0	0%
North Cowichan	3027.7	135.1	4.5%
Unincorporated	5382.3	375.8	7%
Total	8483.5	512	6%

Source: Data from AXYS Environmental Consulting Ltd., 2005.

Of the total area of sensitive ecosystems remaining in the landscape today, very few are thought to be pristine or existing with a full complement of native species. For most areas mapped as "existing in 2002", many are expected to have: significant losses of functionality due to fragmentation, which prevents effective movement of species between patches; small patch size, which results in a lower number of species present in any one patch; disturbances (e.g., dogs or soil disturbance from human activities); and invasive species – all of which are not factored into this analysis. In addition, development has continued in the remaining SEI areas since 2002, so the extent of losses to these areas since that time is unknown.

> *"The Coastal Douglas-fir zone is the rarest biogeoclimatic zone in BC and is of great conservation concern."* BioDiversity BC[43]

Garry Oak Ecosystems

Garry oak ecosystems are included in the analysis of sensitive ecosystems above. However, they also represent a particular area of concern and have been the focus of detailed work, so are reported on separately here.

Indicator and Measure

A mapping exercise has been undertaken for Garry oak ecosystems in part of the Cowichan Region and on Saltspring Island, showing trends through time from the year 1800 to 2003.[44]

Findings

Less than 10% of the original Garry oak ecosystems remain on south-eastern Vancouver Island.[45] Within the Cowichan Region (and including Saltspring Island), there has been a similar loss of 78% of the Garry oak ecosystems (Figure 2.6). Matching the broader geographic pattern, loss of deep soil ecosystems has been higher, since these sites are more productive and better for development and agriculture. Many of the remaining shallow soil ecosystem sites are still at risk of development today. Much of the remaining area is dominated by invasive plant species, and less than 5% of the total remaining Garry oak ecosystems are in natural condition. In addition, it is important to remember that development activities and invasive species both continually change the distribution and condition of these mapped ecosystems.

43 Austin et al., 2008.

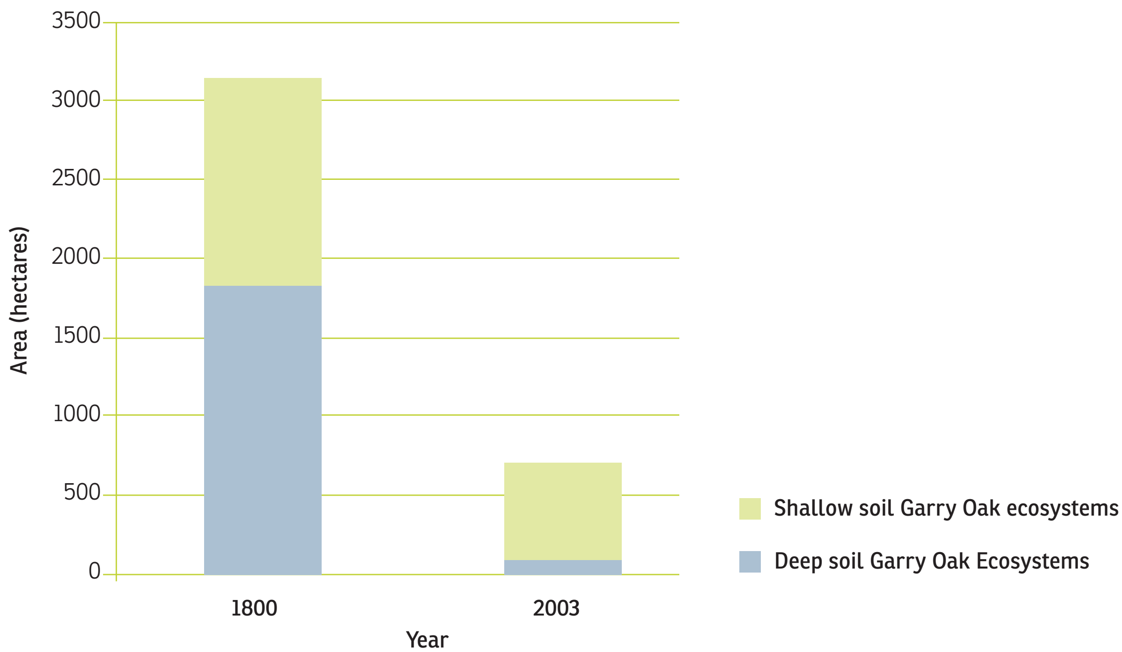
44 Miller and Lea, 2004.

45 Lea, undated.

One of the best examples of remaining Garry oak ecosystem can be found at the Cowichan Garry Oak Preserve (near Maple Bay) (Figure 2.7).

The geographic location for Garry oak ecosystems is shown for the mid- 1800s (Figure 2.8) and in 2003 (Figure 2.9).

FIGURE 2.6: Estimated area of deep and shallow soil Garry oak ecosystems in year 1800 and in 2003

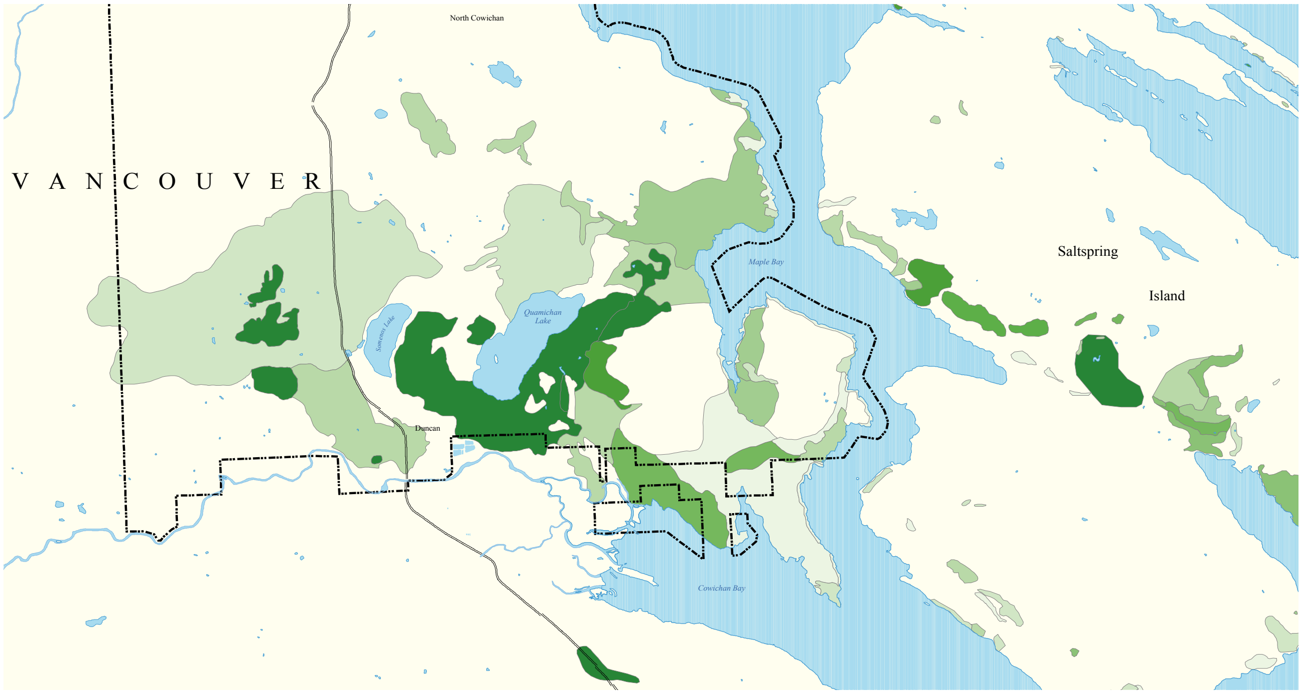


Source: Miller and Lea, 2004.

<< *FIGURE 2.7: Cowichan Garry Oak Reserve, showing camas meadow*

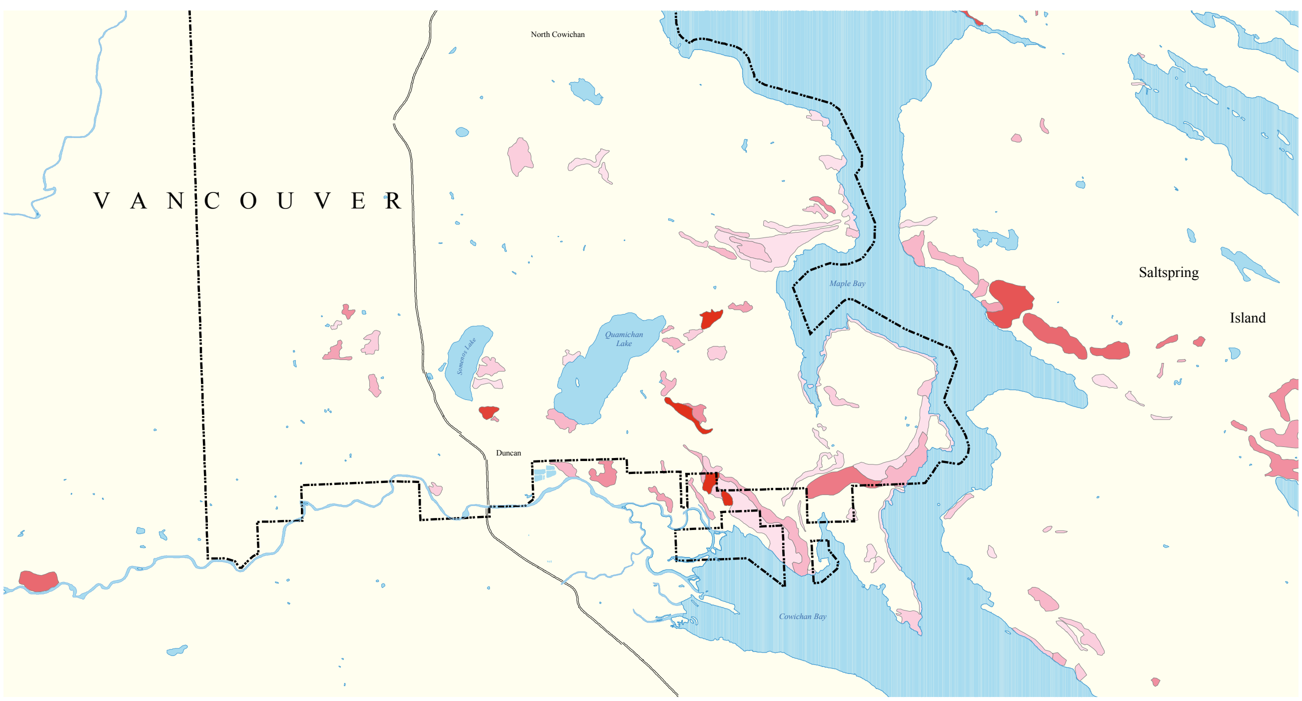
Source: Chris Junck, Garry Oak Ecosystem Recovery Team.

FIGURE 2.8: Distribution of ecosystems dominated by Garry Oak in combination with Douglas-fir and/or arbutus. Darker green shading indicates higher percent composition of Garry oak ecosystems. Compiled from mapping from the 1850s and 1860s



Source: Miller and Lea, 2004.

FIGURE 2.9: Current distribution of Garry oak ecosystems within the same area. Darker red shading indicates higher percent composition of Garry oak ecosystems



Source: Miller and Lea, 2004.

Shoreline Condition and Forage Fish

Shorelines provide the interface between the marine and terrestrial environments – they are high value for humans and for biodiversity, and for all the processes that sustain both. Shorelines are being increasingly "modified" by human activities, as they are converted to industrial, residential and recreational uses. "Hardening" (moving in rocks to reduce natural erosion) or altering vegetation along the shoreline can impact many important ecological functions (Figure 2.10).

FIGURE 2.10: Example of a hardened shoreline

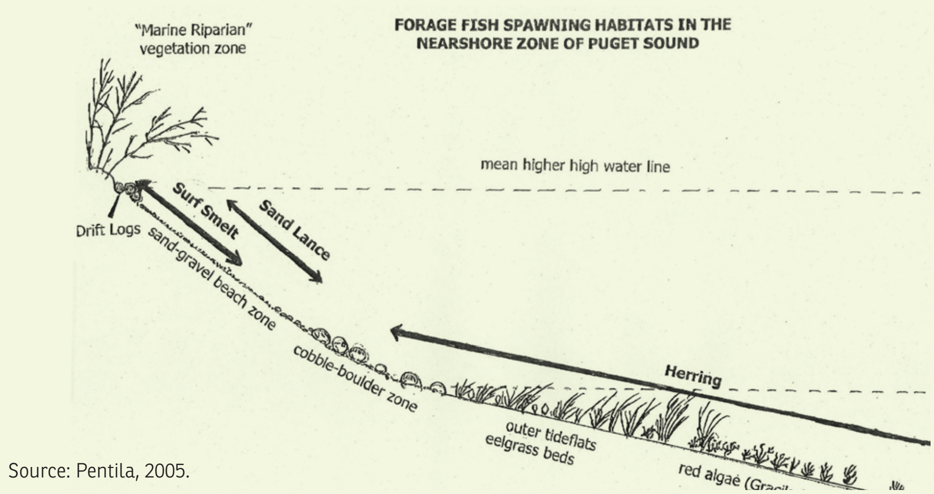
Source: R. de Graaf

> *"Across the Georgia Basin, only 5.3% of the shoreline was "modified" as of 2003, but these tend to represent some of the most important functional areas on the coast – estuaries, sheltered bays and sloping shorelines."*
>
> SeaChange Marine Conservation Society, 2009a.

Shorelines are important for many different values. Many marine species inhabit the intertidal zone for some or all of their life history – including crabs and shellfish. Many terrestrial species also use the shoreline as an important food source. Linkage or interface areas are often of high biodiversity value, since they provide habitat for a wide range of species.

One particularly important role of the nearshore is to provide spawning habitat for "forage fish" (e.g., Pacific herring, surf smelt and Pacific sand lance) which school in large numbers to spawn in intertidal or shallow water, and therefore are particularly vulnerable to disturbance (Figures 2.11 and 2.12). These species are in the middle of the marine food web and are important prey species for a large number of other species, ranging from salmon to a diversity of bird species to marine mammals. The native eelgrass (Zostera marina)[46] is an important component of this habitat, providing an environment for herring (and many other species) within the tidal flats.

FIGURE 2.11: Distribution of forage fish habitat in the nearshore



Source: Pentila, 2005.

FIGURE 2.12: Surf smelt eggs

Source: R. de Graaf

46 An introduced eelgrass, Zostera japonica also inhabits these coastal shorelines. It is unknown to what extent the two species are functionally similar, and they inhabit slightly different depths of water, with the native species tending to be at greater depths.

The specific spawning habitat requirements for forage fish vary by species: herring favour the subtidal and spawn on vegetation such as eelgrass habitats and algae, while surf smelt use the upper intertidal zone and require small gravel and coarse sand. Sand lance use the intertidal zone and dig small pits in the sand in which to spawn. In addition to specific substrate features, the vegetation along the shoreline can affect the quality of habitat by moderating temperature and wave disturbance conditions – though relatively little is known about the specific factors that impact spawning success. The physical process of sediments moving from terrestrial surfaces and along beaches through wave action is also key to maintaining beaches in a functioning condition. Many shoreline modifications disrupt these processes.

In addition to direct spawning habitat, conditions that allow successful foraging and reduced predation are also key. Eelgrass and kelps are important elements of the nearshore. For example, eelgrass roots in the substrate and provides structural diversity within the water column, as well as providing food and shelter to many species. Eelgrass also plays an important functional role in the ecosystem by "fixing" carbon and thereby making it biologically available.

It is hard to predict whether a particular shoreline provides good forage fish habitat. Although potential habitat can be identified using a combination of slope, gravel and sand composition, only about 10% of "apparently suitable" shoreline is actually used at any time.[47]

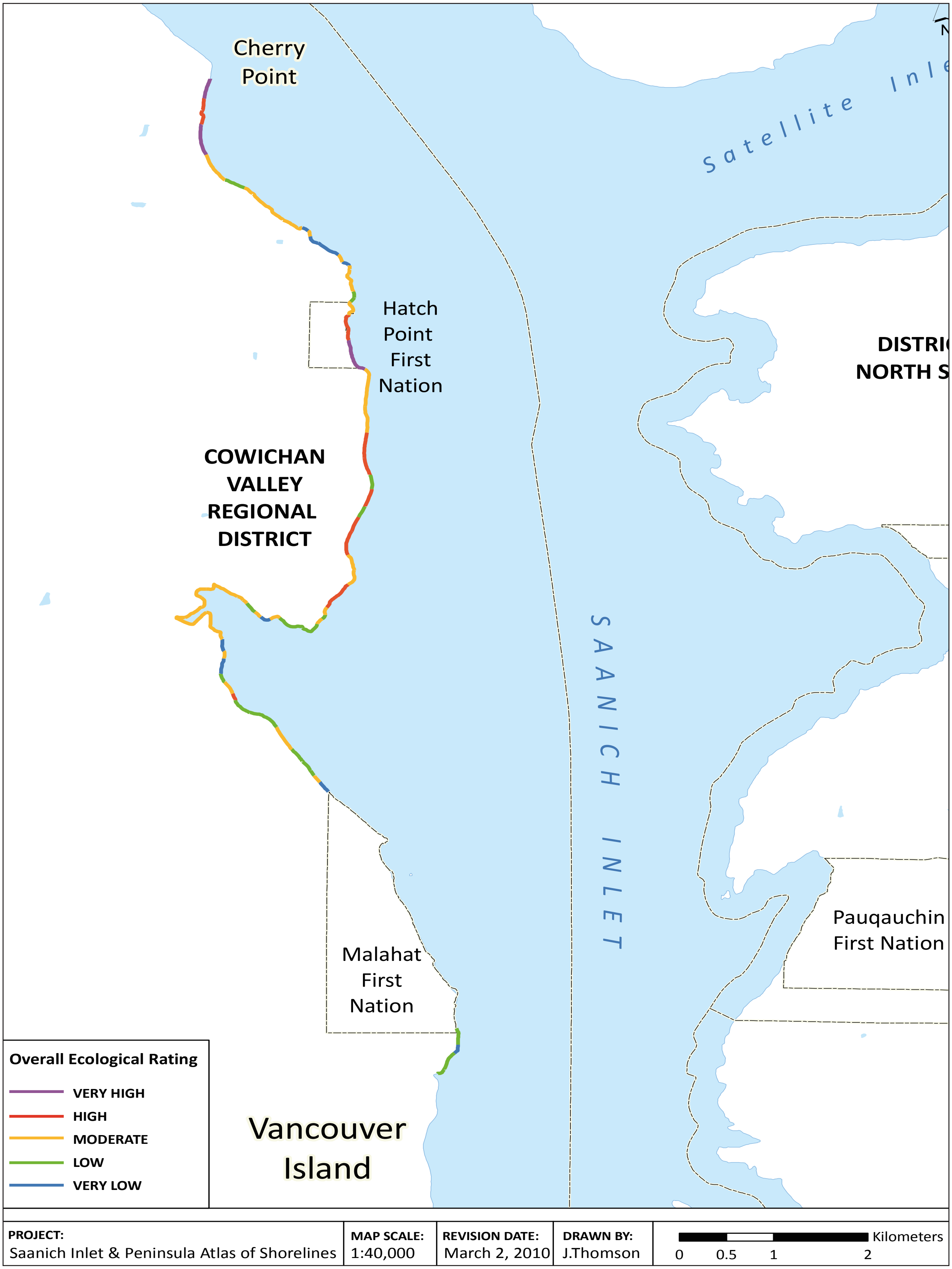
Impacts to all these habitats can be caused by a wide variety of activities, from "hardening" the shoreline, building docks that reduce light and disturb the breakwaters, and dredging the shoreline, to disturbance from propellers, pollution from boats, oil and other forms of industrial disturbance and pollution. The cumulative impacts of multiple small modifications can result in considerable change through time, resulting in the loss or significant degradation of these habitat values.

Indicators and Measures

SeaChange[48] conducted shoreline modification surveys over a period of three years for the shorelines around the Saanich inlet and peninsula (Table 2.6), using the shore zone mapping data collected by Parks Canada. Only a portion of the CVRD shoreline has been mapped (Bamberton to Cherry Point), of which the vast majority is in the yet-to-be-developed areas. The following field data were included in the final rating system: specific intertidal features (e.g., eelgrass), habitat cover, wildlife features, proximity to sensitive ecosystems, and presence of key lifecycle species. In addition, focused sampling for forage fish habitat has been done along a longer length of shoreline by a range of stewardship groups.[49] These two sets of data were combined and used to create an ecological ranking system for the entire shoreline (very high to very low ecological rating).

47 R. de Graaf, personal communication, 2010.

48 SeaChange Marine Conservation Society, 2009b.



Cherry Point
Satellite Inle
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DISTRI
NORTH S
COWICHAN VALLEY REGIONAL DISTRICT
SAANICH INLET
Malahat First Nation
Pauqauchin First Nation
Vancouver Island
Overall Ecological Rating
VERY HIGH
HIGH
MODERATE
LOW
VERY LOW
PROJECT: Saanich Inlet & Peninsula Atlas of Shorelines
MAP SCALE: 1:40,000
REVISION DATE: March 2, 2010
DRAWN BY: J.Thomson
0 0.5 1 2 Kilometers

The level of modification within each section was then quantified from field data and summarized for each section of shoreline. The specific indicators used here are:

> Length of shoreline in each category (very high to very low ecological rating), and percent modification of each.

Findings

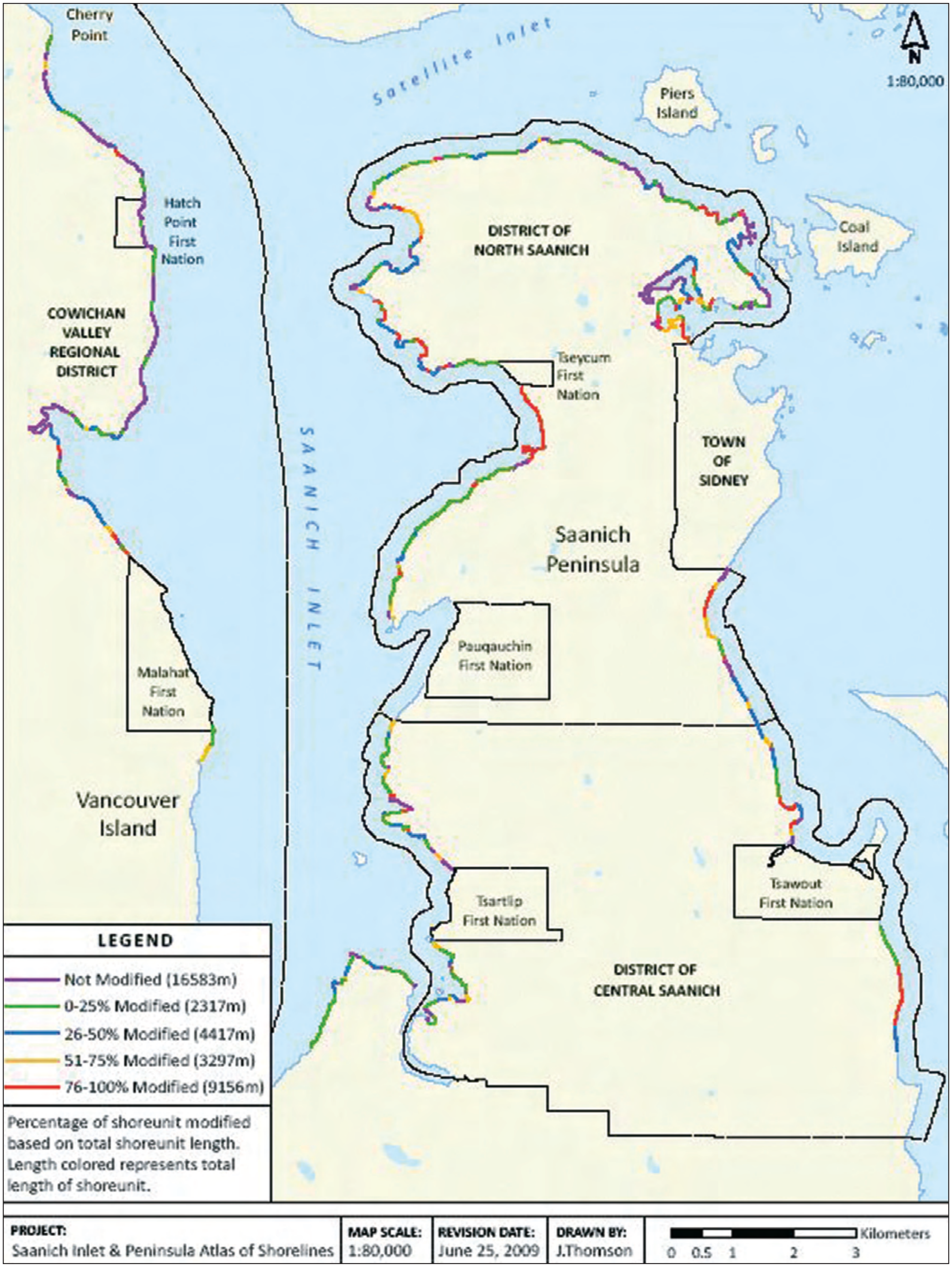
Within the CVRD, only 13.8km of shoreline was categorized in terms of its ecological rating. Of this length, a relatively small proportion of the CVRD shoreline has been classified as having a "very high" (5%), or "high" ecological rating (15%), with 44% of the shoreline identified as "moderate" and another 36% identified as "low" or "very low" (see Figure 2.13 and Table 2.6).

Of these areas, a total of 16% (representing 2.2 km in length) is identified as "modified." This is lower than the average over the whole Saanich inlet and peninsula, which has an average of 30% modified (Figure 2.14).

<< *FIGURE 2.13: Ecological ratings of the CVRD shoreline*

Source: SeaChange Marine, 2009.

49 Data collected by the following groups: Cowichan Valley Youth Streamkeepers; Cowichan Valley Naturalists; Friends of Forage Fish Maple Bay; Ramona C. de Graaf, BSc, MSc. (BC Shore Spawners Alliance) and Dan Penttila, MSc, Washington Department of Fish and Wildlife


Cherry Point
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Hatch Point First Nation
DISTRICT OF NORTH SAANICH
Coal Island
COWICHAN VALLEY REGIONAL DISTRICT
Tseycum First Nation
TOWN OF SIDNEY
SAANICH INLET
Saanich Peninsula
Pauquachin First Nation
Malahat First Nation
Vancouver Island
Tsawout First Nation
Tsartlip First Nation
DISTRICT OF CENTRAL SAANICH
LEGEND
Not Modified (16583m)
0-25% Modified (2317m)
26-50% Modified (4417m)
51-75% Modified (3297m)
76-100% Modified (9156m)
Percentage of shoreunit modified based on total shoreunit length. Length colored represents total length of shoreunit.
PROJECT: Saanich Inlet & Peninsula Atlas of Shorelines
MAP SCALE: 1:80,000
REVISION DATE: June 25, 2009
DRAWN BY: J.Thomson
Kilometers
0 0.5 1 2 3

TABLE 2.6: Ecological ratings for 13.8km of the CVRD shoreline, with total length and percent modified

Overall Ecological Rating	% of total CVRD area	Shore unit Count	Total Length (m)	Total number of seawalls present	Total length modified (m)	% modified based on total length
VH – Very High	5%	4	1,050	1	20	0%
H – High	15%	12	2,332	6	269	2%
M – Moderate	44%	35	6,245	21	603	4$
L – Low	23%	18	3,005	19	798	6%
VL – Very Low	13%	10	1,248	12	513	4%
Totals	100%	79	13,880	59	2,203	16%

Source: SeaChange Marine Conservation Society, 2009.

For the CVRD shoreline that has been studied, a relatively low percent has been modified. However, it is important to note that relatively small sections of the 13.8km of shoreline that have been categorised have high ecological ratings (only 5% is rated very high); therefore relatively small amounts of modification may have significant impacts overall. A key example would be shoreline hardening that results in loss of forage fish habitat, which has significant impacts throughout the food web (within both the marine and the terrestrial environment).

In comparison with the broader study area (Table 2.6), which includes the entire Saanich inlet and peninsula, the CVRD area has had relatively little modification of its shoreline to date. However, trends point to increasing modifications through time.

<< FIGURE 2.14: Shoreline modification for the entire Saanich inlet and peninsula area

Source: SeaChange Marine Conservation Society, 2009b.

More subtle changes may also occur. Loss of the marine riparian zone can impact shade levels – often critical to smelt egg survival – and can affect the amount and species of insect prey available for migrating smolts and resident animals in estuaries and marine shorelines. Disruption of sediment drift along shorelines can also affect nutrients available on beaches, altering erosion processes and habitat quality. In addition, the cumulative effects of increasing areas of impervious surface (Section 3.1) affect the rate of run-off and the amount of pollutants that enter the water courses. This, combined with loss of riparian and shoreline vegetation, negatively affects the overall functioning of the shoreline.

Often, lack of understanding of the importance of shoreline habitats results in unintentional impacts. This, combined with a lack of detailed knowledge about critical habitat areas (such as forage fish habitat), may be having a significant yet largely unquantified series of effects on a wide variety of ecological values.

Cowichan Estuary Condition

Estuaries are extremely high-value ecosystems. Their location at the intersection of the terrestrial, aquatic and marine environments results in very high productivity and high biodiversity values. They also provide key habitat for species and key ecosystem services.[50]

The Cowichan Estuary (Figure 2.15) is located where the Cowichan and Koksilah rivers join Cowichan Bay. One of the larger estuaries in the province, it is identified as one of the top 10 important estuaries in BC.[51] This complex of tidal flats, shallow marshes, and marine zone provides habitat for at least 229 bird species. It is a critical stopover along the Pacific Flyway. Eelgrass habitats and other areas provide rearing habitat for salmonids and other marine species, and the intertidal area is used for at least 31 species of fish, including juvenile herring and salmonids.

Threats to this system include a wide diversity of potential impacts caused by the interplay of the three realms: terrestrial, freshwater aquatic and marine. Key pressures include terrestrial land development causing direct habitat loss, dyking around rivers that causes changes to nutrients available in intertidal communities, the pollution of freshwater or marine environments from septic systems or industrial use, and marine pressures such as fishing and oil spills.

50 Ministry of Environment, 2006.

51 Viz-a-viz Management Resources Inc., 2005.

FIGURE 2.15: Cowichan Estuary

Source: Google Earth, 2009.

The Cowichan Estuary Management Plan (1987) zoned the estuary and reduced the amount of area open for log storage. In addition, it initiated an environment review process, and identified areas for habitat enhancement and restoration. This plan was revised again in 1995 and reviewed for relevancy in 2006.

Indicators and Measures

Two specific indicators of estuary condition used here are:

> Habitat loss over time, due to different factors within the estuary

> Water quality within the estuary

Findings

Habitat Loss

Historically, habitat has been lost from the Cowichan Estuary through settlement that resulted in dyking to provide flood protection and create agricultural lands. Around 32% of marsh habitat was lost from eastern Vancouver Island estuaries at the turn of the century, with an estimate of 50% loss from the Cowichan Estuary.[52, 53] These losses of habitat have been caused by a wide range of impacts, including the 1920s railway loading platform built across the tidal flats and into the estuary, and log booming, handling and storage that have occurred until recently over significant areas of the estuary/bay. All of these activities have impacted intertidal habitats compared to the historic condition of the estuary. Loss of eelgrass habitat remains of particular concern and is implicated in the declines observed for local fish populations (Section 2.5).

Habitat loss in upland areas adjacent to the estuary has been caused by sawmill construction, dumping of waste material, and marina expansion adjacent to Cowichan Bay. Run-off of pollutants from the mill, from agricultural activities and from communities surrounding Cowichan Bay all combine to impact habitat quality and functioning.

In addition, ongoing habitat degradation is occurring due to increasing numbers of invasive plant and animal species. Key species that appear to be increasing include Japanese knotweed, yellow flag iris, bullfrogs and white clematis.

52 Campbell and Boyd, 1988.

53 Ministry of Environment, 2006.

The Cowichan Estuary Management Plan has contributed substantially to reductions in habitat loss and degradation in the estuary complex[54, 55] by:

> Reducing the area impacted by log storage and handling (from more than 50% to around 19% of the estuary area)

> Promoting the acquisition of marsh and farm land for conservation and restoration by stewardship groups (approximately 300 ha is protected within the estuary area)

> Promoting joint stewardship restoration of key habitats

> Reducing the impacts of wood waste in the estuary from sawmills.

Water Quality

Water quality for the estuary and bay is potentially affected by a variety of sources, including inputs from the two main rivers systems (Cowichan and Koksilah, see Section 2.6), from adjacent agricultural land (grazing animals and manure spreading), from adjacent industrial uses (sawmill waste and industrial railway), from adjacent communities (sewage inputs), and from boats and marinas.

In the 1980s, three primary major sources of water quality concern were identified: wood treatment stains (antisapstains); dioxins and furans (typically from wood waste), which were found in crabs and resulted in a closure for crab fishing between 1989 and 1996; and fecal coliform bacteria, which was well known and the cause of the closure for shellfish harvesting that has been in place in the estuary since 1973.

More recently, the water quality of the estuary appears to have improved to some degree.[56] Many water quality indicators (nutrient levels, total and dissolved metal levels and toxic substances) were found to be below threshold levels and, in addition, there appeared to have been a reduction in both the stain pollution and dioxins and furans. These gains appear to have resulted from specific measures identified within the management plan that were intended to reduce the release of these pollutants into the estuary.

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54 Williams and Langer, 2002.

55 Vis-à-vis Management Resources Inc., 2005.

56 Rideout et al., 2000.

However, levels of fecal coliform bacteria were still consistently over guideline levels in both the Cowichan and Koksilah rivers, and in the Cowichan Estuary and Bay. The source of this pollution is hard to determine, but appears to be a combination of non-point sources in the river systems and (until 2006) the sewage treatment plant for Cowichan Bay, particularly during winter months. More recently, the original Cowichan Bay sewage treatment facility has been closed, and sewage is now pumped to a site further up the Cowichan River, which has a larger capacity. However, fecal coliform levels in the bay remain in excess of provincial standards, particularly at specific times of year. Pollution levels tend to be lowest during the summer dry period when freshwater inflow is lowest and sewage "leakage" is lowest. During wetter periods bacteria levels increase as septic systems overflow and storm drains become active, which results in higher levels of contamination in the estuary.

Additional potential sources such as cattle grazing adjacent to the estuary have generally been moved away from the site. However, manure is spread in the area and may also be a source of ongoing fecal coliform contamination (in addition to the continuing inputs from river systems, as discussed above).

Fecal coliform contamination indicates potential impacts to human health due to the presence of pathogenic bacteria found in mammalian feces. As a result of this contamination the shellfish fishery in the estuary has been closed since 1973.

In addition to human health concerns, contamination with significant amounts of fecal waste also has ecological impacts. For example, the additional nutrients can over-stimulate algal growth, which has the effect of reducing the levels of dissolved oxygen in water. This affects the natural benthic community[57] present in the ecosystem, and can result in impacts on or death of aquatic life due to lack of oxygen. Typically, this is noticed when it gets to the "fish kill" stage. Algal blooms have been noted in the lower reaches of the Cowichan and Koksilah rivers.

Fecal coliform bacteria are an indication that a water supply is being contaminated by feces from a warm blooded animal (e.g., cows, humans, birds). The fecal coliform bacteria themselves are typically harmless, but they indicate the potential for other deleterious bacteria. Ease of monitoring is the reason this indicator is commonly used to test water quality.

57 A benthic community is made up of a group of organisms that inhabit the bottom of a body of water, such as a lake or ocean. Benthic organisms do not have a backbone, and can be seen with the naked eye.

In summary, the Cowichan Estuary has undergone significant impacts over time, due to a wide variety of development. The management plan appears to be reducing further impacts in some areas, and restoration activities are improving habitat conditions on conservation lands around the estuary. However, there are ongoing concerns about the health of the estuary system, including:

> Ongoing water pollution from non-point sources from the two rivers supplying the estuary

> Fecal coliform pollution of the estuary/bay, and the shellfish closure that has been in effect since 1973.

Summary

The CVRD has within its boundaries some of the most unique ecosystems in BC, which confers a high responsibility for their maintenance. Within the Coastal Douglas-fir zone there is a high diversity of smaller ecosystems – forests, meadows, riparian areas, and wetlands – many of which are "sensitive," and tend to be inherently fragile or located in areas where development pressure is greatest.

An assessment of one of these – Garry oak ecosystems – for part of the Cowichan Region shows the extent of the impact over time. Less than 20% of the historic ecosystem remains, and less than 5% remains in its "natural" condition. The pressure on these ecosystems comes from a wide diversity of sources and so is hard to quantify, keep updated and manage.

Shorelines have high ecological values, and are also under high development pressures. A range of best management practices can reduce impacts to these values, but are often not implemented. We lack knowledge of the importance of different shorelines (for example, forage fish habitat is not well understood). Ongoing development along shorelines is resulting in continued loss of and degradation of these habitat types.

Estuaries are scarce features along shorelines, and have typically seen high development pressure. Habitat loss within the Cowichan Estuary has been high, but its condition is improving over time. However, water quality issues remain, particularly in wetter seasons and from non-point sources.

Missing Information

A full analysis of trends for all potentially "sensitive" ecosystems compared with their historic condition is not possible with available data. The trends presented here therefore do not give the full picture of trends across a longer timescale.

The ecosystem services provided by many of these habitat types is largely unquantified. For example, the effect of the loss of mature riparian forest on flooding probability is recognized, but not specifically quantified. Similarly, the effects of shoreline ecosystem degradation on forage fish spawning success and cascading impacts through marine ecosystems are unknown.

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2.3 Species at Risk

Introduction

The number of species at risk is a key indicator for the current health of an ecosystem, because species in trouble today are likely responding to changes that happened in the past. Tomorrow's species at risk will be those that are responding to today's impacts. Loss of species from an area is important because it lowers the resilience of the ecosystem to future change and can have unforeseen cascading consequences into the future.

Many different species have very specific life history requirements and can be affected by many subtle specific changes; however, loss of key habitat types is often the main cause of species decline. Habitats in the Cowichan Valley Regional District (CVRD) that have been particularly impacted include old forests, wetlands, Garry oak ecosystems and the associated meadows and grasslands, marsh and estuarine habitat, rocky bluffs, and shorelines. Many of the species at risk in this region inhabit these ecosystems.

Species at Risk in the Cowichan Valley Regional District

The diversity of ecosystems that occurs in the CVRD, ranging from some of the wettest to some of the driest in BC, provides habitat for a great diversity of species. Many species are largely unknown, and new species have been recently discovered here. For example, the number of known arthropods[58] found in the canopy of ancient trees on the West coast increases every time someone studies them. Some species are naturally rare – found only in certain habitat types, or at low levels across the landscape – and these species may or may not be at risk. Some species, however, are known to be "at risk" due to small population sizes or the specific impacts of human activities on their habitat.

58 Arthropod are invertebrates of the phylum Arthropoda (the largest phylum in the animal kingdom). Arthropods have jointed limbs, a segmented body, and an exoskeleton made of chitin. The group includes the crustaceans, insects, arachnids, and centipedes.

Measuring Species at Risk

The BC Conservation Data Centre systematically assigns "risk" ratings to different species and populations that may be of concern. A number of different systems are used, including global ratings and provincial conservation status rankings. This section reports on the "red" list – extirpated, endangered or threatened in BC – and the "blue" list – those of special concern in BC. Ideally, trends through time for species of concern could be tracked, in order to understand whether conditions are improving or worsening for individual species. However, in the absence of good trend population data for most species, this section's indicators focus on:

> Number of animals at risk, with a focus on Vancouver Island marmot and Roosevelt elk

> Number of plants at risk

> Number of ecological communities at risk

Animals at Risk

Indicator and Measure

The BC Conservation Data Centre compiles information and trends on species that may be at risk in BC, and classifies them based on global and provincial ranking systems.[59] The information provided is based on these rankings for species found or thought to be found within the Cowichan Valley Regional District.

Findings

The Conservation Data Centre identifies a total of 71 animal species that are known to be at risk in this region and are thought to be found within the CVRD (Table 2.7). In addition, there are other species highlighted as yellow-listed, which are under status review.

59 BC Conservation Data Centre: www.env.gov.bc.ca/cdc/

This section provides detailed findings about the Vancouver Island marmot and the Roosevelt elk.

TABLE 2.7: Number of red- and blue-listed animal species within the CVRD

Type	#Red	#Blue	Total
Amphibians		1	1
Birds	4	16	20
Gastropods	5	7	12
Insects	5	10	15
Lampreys	1		1
Mammals	4	4	8
Reptiles	2		2
Ray-finned fishes		2	2

Source: BC Conservation Data Centre.

Many of the individual species at risk are associated with estuarine or riverine habitats, and many are associated with the ecosystems of concern highlighted in Section 2.2. Of these, some are also of high global concern – including the Cowichan Lake Lamprey (G1 global ranking[60]) and Vancouver Island Marmot (G1 global ranking).

Of these animals, eight are found only on Vancouver Island and nowhere else in the world (endemics) – the northern pygmy owl, the white-tailed ptarmigan, an ermine, the Cowichan lake lamprey, the Vancouver Island marmot, the American water shrew, the "greenish blue" butterfly and the (now-thought-to-be-extinct) Vancouver Island wolverine.

60 Conservation status ranks are based on a one to five scale, ranging from critically imperiled (G1) to demonstrably secure (G5). Status is assessed and documented at three distinct geographic scales: global (G), national (N), and state/province (S).

Some are well-known species, such as Stellar sealions and the old-growth-forest-nesting marbled murrelet. Others are lesser known or understood, such as the broadwhorl tightcoil, the western thorn snail, and the warty jumping slug.

A full list of species at risk is available in Appendix A.

Jumping Slugs. Five different species of jumping slugs exist and are endemic to western North America. The warty jumping slug is known to exist in Canada only on 14 different sites on Vancouver Island, south of Nanaimo. It lives in moist riparian low-lying areas and requires decaying logs and litter as shelter. All five species display a "jumping" or twisting behaviour that is thought to be a defence against predators. Habitat loss and fragmentation are thought to be the greatest threats to the population. Only three or four of the known locations are within protected areas – the others are subject to development or private forest land management.[61]

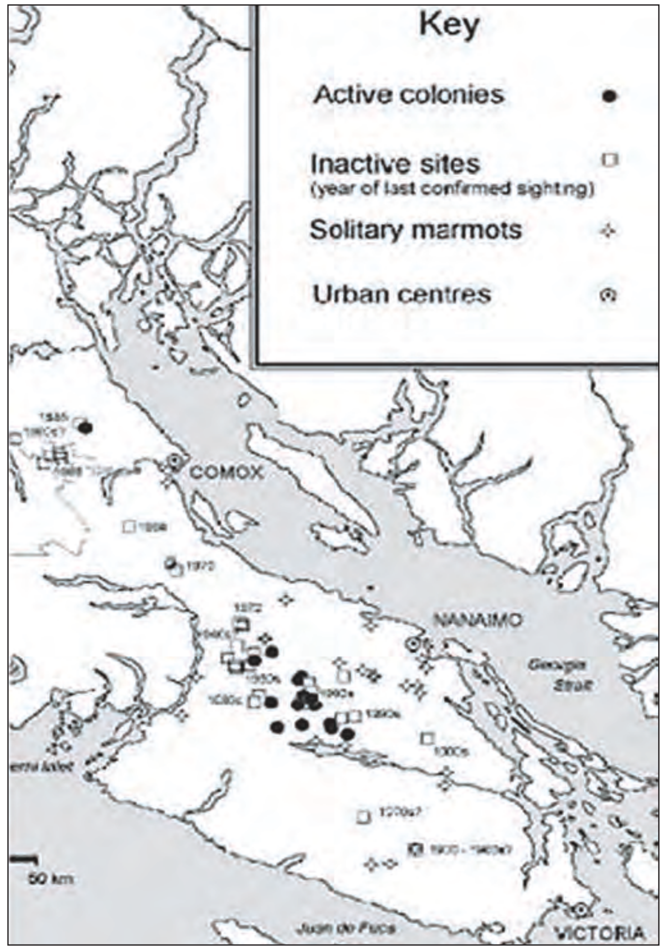
Vancouver Island Marmot

The Cowichan Valley Regional District is home to a significant proportion of the remaining wild population of the Vancouver Island marmot, a globally rare subspecies (Figure 2.16). It is red-listed in BC, and endemic to Vancouver Island. Unusually, compared to many of the other species of concern within the regional district, the marmot is a high-elevation species, historically living in the alpine and treeline areas, and – more recently – primarily inhabiting recently logged habitats where they are thought to be more vulnerable to predation. With the exception of Mount Washington, all known active colonies are located within five adjacent watersheds – the Nanaimo, Cowichan, Chemainus, Nitinat and Cameron River drainages – with 90% of the estimated population in the year 2000 found within this 150 km2. The CVRD obviously plays a key role in the recovery of this species (Figure 2.17).

FIGURE 2.16: The at-risk marmot is one of Canada's most significant species

61 COSEWIC, 2003.

FIGURE 2.17: Marmot population centres



Note: Most southern locations are located within the CVRD.

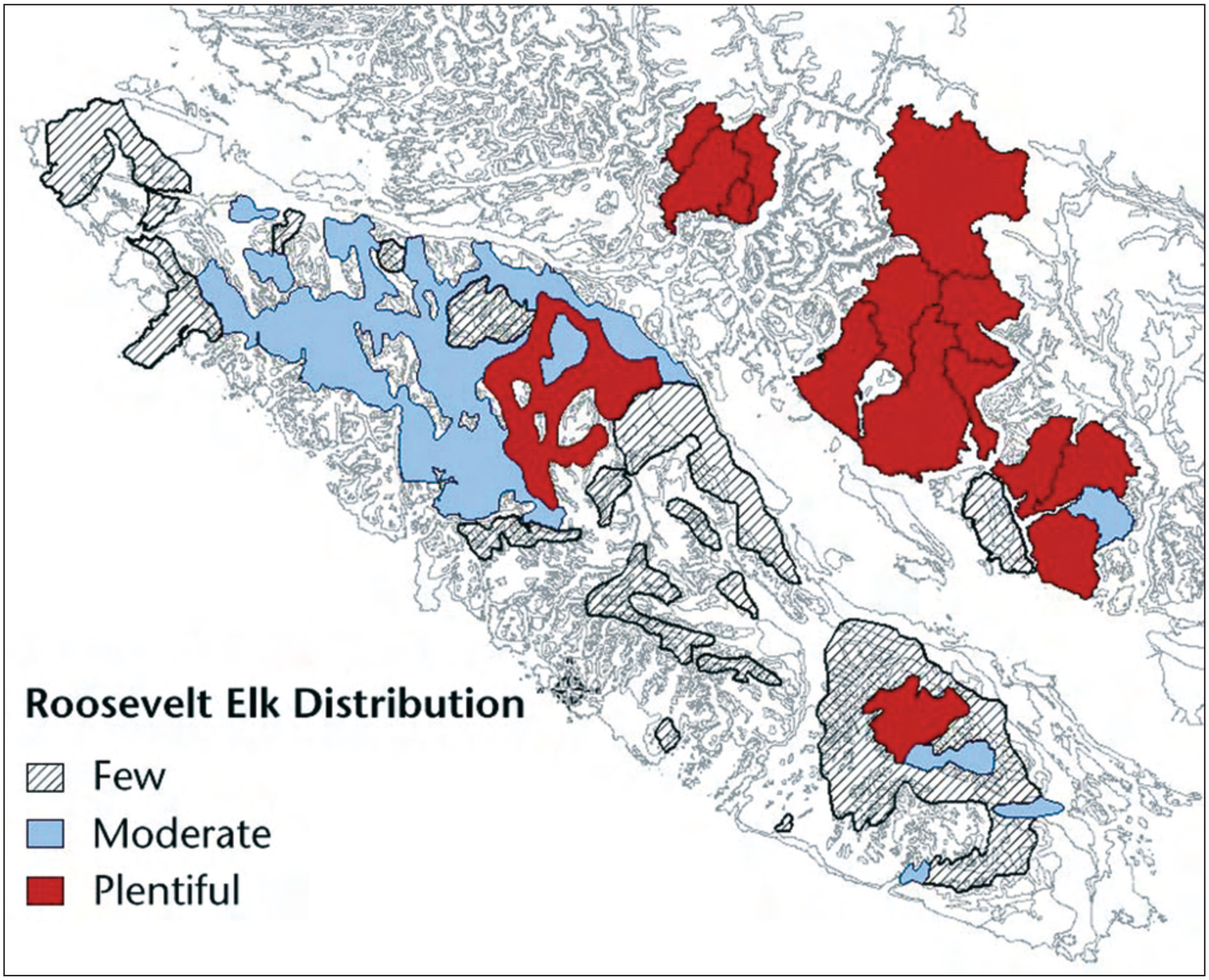
Source: Vancouver Island Marmot Recovery Team, 2000.

Roosevelt Elk

Roosevelt elk are a blue-listed species with high cultural and social values within the Cowichan Valley Regional District. There are around 5,000 Roosevelt elk in BC, of which about 4,000 are on Vancouver Island. Most are found in the northern regions of the Island, but there are relatively isolated sub-populations in the south, and in the CVRD (Figure 2.18). There are areas of local decline, but the populations are increasing overall.

Loss of habitat from human development and over-hunting has extirpated local populations in some areas of southern Vancouver Island. Sub-populations of elk on Vancouver Island have been categorized as to whether they are increasing, stable, or declining. Within the south Island meta-population, most of which are part of, or border, the CVRD, there is a tendency for sub-populations to be small (80% of the local populations have less than 25 animals). Of this total of 560 animals, around 30% are thought to be in stable-to-declining sub-populations, 30% are stable, 30% are increasing and 10% have unknown population trends. On the rest of the Island, populations tend to be bigger and more stable (data from 2000). Historically, elk lived in old forests, which provided food and cover – particularly in riparian areas. Fragmentation of this habitat by forestry and urban expansion, combined with predation pressures, mortality on highways, and hunting and poaching has resulted in declines in populations from historic levels.

FIGURE 2.18: Roosevelt elk distribution on Vancouver Island



Source: Henigman et al., 2003.

For the CVRD, recent population estimates (June 2009) for the sub-units identified in Table 2.8 are shown in Figure 2.19. The largest sub-unit within the regional district is area 4-10 (the Shaw sub-unit) which contains an estimated population of 175 animals. Many of the other sub-units have small estimated numbers of elk.

TABLE 2.8: Number of elk estimated for each sub-unit

Area	Sub Population	Name	Area (km2)	Estimated #elk	Percent local population	Percent total population
4	1	Koksilah	317	10	2	0.6
4	2	South Cowichan	118	15	3	0.9
4	3	North Cowichan	198	50	12	2.9
4	4	Robertson	158	10	2	0.6
4	5	Sutton	110	5	1	0.3
4	6	Meade	88	20	5	1.2
4	7	Cottonwood	50	40	9	2.3
4	8	McKay	44	60	14	3.5
4	9	Nixon	76	5	1	0.3
4	10	Shaw	92	175	41	10.2
4	11	Nitinat	326	30	7	1.7
4	12	Little Nitinat	139	10	2	0.6
4		TOTAL	1716	430	100	25.1

Note: The size of the sub-units varies significantly. The location of each sub-unit is identified by the numbers on Figure 2.19.

FIGURE 2.19: Location of population sub-units for Roosevelt elk, relevant to the CVRD

Source: Kim Brunt, Ministry of Environment.

Plants and Ecological Communities at Risk

Indicators and Measures

The BC Conservation Data Centre compiles information and trends on species that may be at risk in BC, and classifies them based on global and provincial ranking systems.[62] The information provided is based on these rankings for plants and ecological communities at risk that are found or thought to be found within the Cowichan Valley Regional District.

Findings

The Conservation Data Centre lists a total of 63 plant species that are either red- or blue-listed, and are found or are likely to be found within the CVRD (Table 2.9). Of these, one – Macoun's meadowfoam – is endemic to Vancouver Island (Figure 2.20).

62 BC Conservation Data Centre: www.env.gov.bc.ca/cdc/

FIGURE 2.20: Macoun's meadowfoam

Source: www.ubcbotanicalgarden.org

TABLE 2.9: Number of plant species at risk in the CVRD

Name	Class	Blue	Red	Total
Non-vascular plants		14	3	17
Vascular plants	Conifers	1		1
	Dicotyledons	25	25	50
	Ferns	1		1
	Monocotyledons	5	5	10
	Quillworts	1		1
Totals		47	33	80

Source: BC Conservation Data Centre.

Many of the plants of concern are associated with the "at risk" or sensitive ecosystems (Section 2.2) such as Garry oak communities and shoreline systems.

Ecological Communities

In addition to the individual plants and animals at risk, 84 ecological communities are also identified as at risk: 35 are blue-listed, and 49 are red-listed. Many of these are associated with the Coastal Douglas- fir (CDF) ecosystem (see Section 2.2). For example, 36 of the 84 are primarily associated with dry CDF ecosystems, with eight blue-listed and 28 red-listed ecological communities, including the Garry oak- and arbutus-dominated systems. The conversion of native ecosystems to urban or rural developments and agricultural land (again, as outlined in Section 2.2), combined with the high level of private land in the CDF ecosystem, result in this high density of at-risk communities found in the CVRD.

Communities at risk within the CVRD also include a variety of riparian ecosystems. For example, the Sitka spruce/false lily-of-the-valley ecosystem on the outer west coast occurs on infrequently flooded riparian benches which are highly productive and grow some of the tallest spruce trees in the world. This impressive ecosystem is now red-listed across its range as a result of harvesting.

Summary

The CVRD has a high density of animals, plants and ecological communities at risk, compared to many other areas of the province. This results from the natural diversity of the region – some of the wettest and some of the driest ecosystems in the province occur in the CVRD – combined with its long history of development.

The identification of a plant, animal or ecological community as "at risk" in BC does not necessarily confer any special protection for that species. In order for federal "endangered species" legislation to apply, a long and specific process has to be undertaken. Many local, provincial and even globally rare species and ecosystems are not captured under this federal legislation. No provincial "endangered species" legislation exists in BC, though some species are protected to some degree under other more general legislation. Ecological communities, such as the massive riparian Sitka-spruce forests, are not protected from harvesting provincially, even if they are identified as red- or blue-listed, unless the decision is made to do so voluntarily.

Missing Information

For many species within the CVRD, the specific locations and habitat requirements of endangered species are unknown. This makes protection difficult, even when there is the will to do so. For other species, the lack of regulations makes identification and maintenance of habitat difficult as development or harvesting continues.

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2.4 Invasive Species

Introduction

Invasive species – both plants and animals – are identified as one of the primary threats to maintaining native biodiversity world-wide. Invasive species move into areas where they have not evolved as part of the ecosystem, and are often aggressive species capable of taking over natural ecosystems, frequently with high rates of spread or of reproduction and a lack of natural predators. Defining what constitutes "invasive" species can be difficult, since species move naturally around the globe – from some perspectives, European settlers into the CVRD were the quintessential "invasive" species that facilitated many of the other cascading impacts on biodiversity in the region (dealt with in other sections of this report). This chapter focuses more specifically on those animal and plant species that were not historically present in this region.

Invasive Species in the Cowichan Valley Regional District

Invasive species tend to follow humans into new environments. European settlement brought a large number of invasive species to Vancouver Island – deliberately, through horticultural interest, and by the accidental movement of species. Since that time, invasive species have continued to arrive through various means – on ships with lumber, as garden exotics gone wild, and under their own steam. When we think of invasive species, we tend to think of the most obvious species (e.g., plants such as scotch broom or animals such as bullfrogs), but invasive species also include insects and diseases. Species that are "native" to a region can also be classified as problematic "invasive" species if, for environmental reasons (e.g., droughts or land disturbance), they become overly prevalent within a region (such as the mountain pine beetle which has killed more than 16 million hectares of forest in interior BC in the last decade).

Invasive species have significant ecological impacts. The combination of rapid colonization and lack of native predators tends to result in the rapid spread of these species, which can radically alter the ecology of an area. Ecological changes affect food supplies for other species, including the timing and availability of resources; they can also alter chemical processes within ecosystems, resulting in the loss of nutrients for other species and alterations to the entire successional pathway for communities. Many native species can be lost as a result.

Human disturbances such as changing original ecosystems, creating linear corridors (roads/powerlines) and compacting soil, all lead to increased opportunity for many invasive species. The impact of climate change on invasive species is also expected to be significant; drier conditions are expected to significantly increase the ease of colonization by novel species from other places, further increasing the pressures on today's ecosystems.

Invasive species are found in most of the different ecosystems present in or adjacent to the CVRD, including terrestrial systems, freshwater aquatic systems, the marine foreshore, and marine aquatic systems.

Measuring Invasive Species

Keeping tabs on the diverse array of potential invasive species is extremely difficult. Mapping of key species – usually obvious plants and some animals – occurs in some areas of high interest, such as some sensitive Garry oak ecosystems. The Coastal Invasive Plant Committee[63] tries to monitor and maintain complete information for plant species, including identifying focal species that should be a priority for action, but the task is very large. Once a species becomes ubiquitous it often stops being a focus of sampling. Comprehensive mapping for all species does not exist, though great efforts are being made in this direction, particularly for plant species. Some aquatic invaders (such as some fish species) are actively encouraged as sport fish, and are purposely moved between lakes. There is a lack of systematic review of aquatic invasive species (though efforts are currently underway). Marine exotics are also less of a focus, though a few key species are notable. Included in this report are the following indicators:

> Number of invasive plant species and area affected

> Some invasive animal species of interest

Invasive Plants

Indicator and Measures

This report looks at the number and area of invasive plant species within the Cowichan Valley Regional District.

Findings

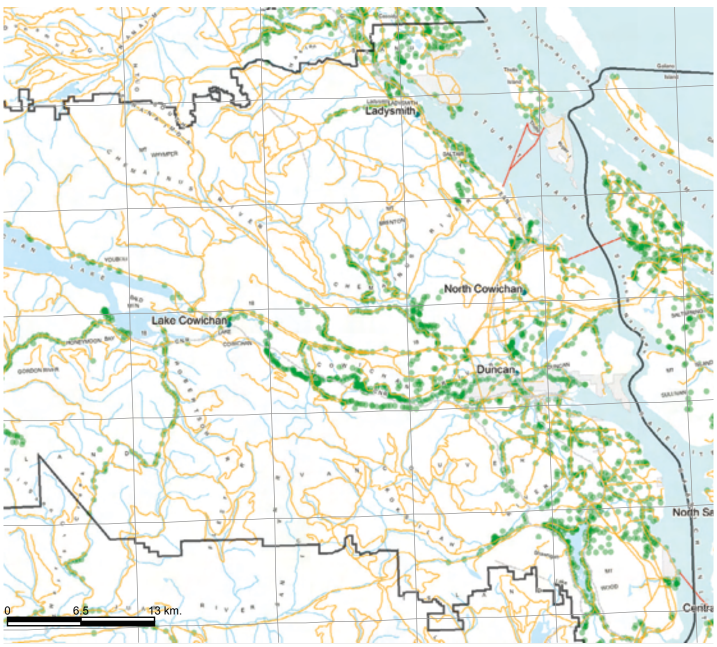
At least 30 invasive plant species are found within the CVRD region (Figures 2.21 and 2.22). According to the Invasive Alien Plant Program data (IAPP)[64], a total of appropriately 909 ha within the CVRD are affected by invasive species, located on approximately 2,000 individual sites. These figures are known to under-estimate the total area affected by invasive species. The most significant species by area included in the database are Scotch broom, followed by oxeye daisy, St John's wort, Himalayan blackberry, bull thistle and Canada thistle. A large number of other species are noted in that database, and though they affect relatively small areas, they can have significant ecological consequences.

63 coastalinvasiveplants.com/invasive_plants.php

64 Invasive Alien Plant Program: www.for.gov.bc.ca/HRA/Plants/index.htm

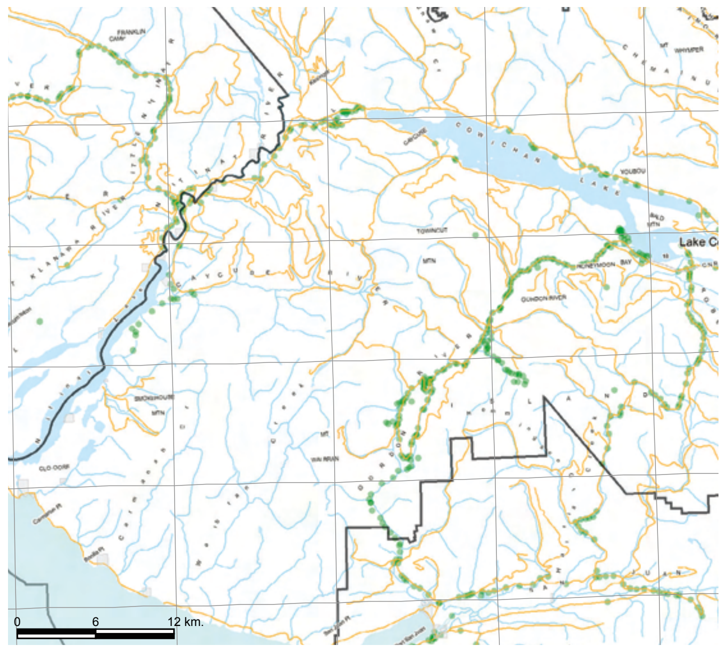
The general distribution of invasive plant species is shown on Figures 2.21 and 2.22 by green dots representing specific areas where one or more invasive plant species have been mapped. The higher density on the east coast, compared with the west coast, is clear, as is the tendency to have highest densities along road and river systems. This is reflected in the dataset, with almost half of the mapped sites occurring in the Coastal Douglas-fir (CDF) zone, and the majority of the rest occurring in the dry portion of the Coastal Western Hemlock (CWH) zone (Figure 2.21).

FIGURE 2.21: Distribution of mapped invasive plant species – east side of the CVRD



Source: Invasive Alien Plant Program, accessed 2010.

FIGURE 2.22: Distribution of mapped invasive plant species – west side of the CVRD



Source: Invasive Alien Plant Program, accessed 2010.

TABLE 2.10: Number of mapped sites of invasive species, by biogeoclimatic zone

Biogeoclimatic zone	Number of sites
CDF mm	919
CWH mm 1	67
CWH mm2	13
CWH vm1	99
CWH xm 1	612
CWH xm 2	219
Grand Total	1929

Source: Invasive Alien Plant Program, accessed 2010.

Some of these invasive species are relatively benign garden species, but others are having (or have the potential to have) very significant ecological, economic and health impacts. The most obvious impacts are the loss of "space" and increased competition for native biodiversity, resulting in increased impacts to sensitive ecosystems such as Garry oak meadows, as well as a wide diversity of impacts throughout the food chain (from insect predators and pollinators to the provision of edible forage for ungulates). Other species, such as knotweeds, can result in higher levels of soil erosion, since they alter streamside stability compared with native riparian species.

The economic impacts of invasive species are significant – invasive plants are estimated to result in losses of $50 million annually due to effects on agricultural crops in BC.[65] Knapweed alone is estimated to result in losses of $400,000 a year due to impacts on hay production in BC. Species that colonize roadsides (such as broom) also affect critical infrastructure and maintenance costs. The true cost of economic impacts, however, is unknown – particularly the impacts on ecosystem services such as the provision of clean water, flood control in natural riparian ecosystems, or loss of species and ecosystem diversity where impacts are difficult to quantify.

65 Invasive plant council of BC: www.invasiveplantcouncilbc.ca/invasive-plants-bc/invasive-plants-in-bc

A few invasive species are relatively isolated within the region at the present time, in terms of area or number of sites affected, but have the potential for significant ecological impacts. Specific isolated invasive species are: common gorse (drier sites), giant hogweed (which is major public health hazard[66]), three species of knotweed[67](which affect many different habitats) and policeman's helmet (also known as Himalayan balsam, which affects riparian and moist areas).

FIGURE 2.23: Common gorse, giant hogweed, knotweed

Surveys by the Coastal Invasive Plant Committee show that giant hogweed has been found on seven sites, and gorse on 10 sites primarily within the Coastal Douglas-fir (CDF) zone, although distribution is understood to be much greater than existing surveys suggest. Giant knotweed has been found in small clumps, but also as continuous cover in a larger number of sites in the CDF and in the drier zones of the Coastal Western Hemlock (CWH) zone, primarily around Duncan, the Cowichan River and Maple Bay.

Bohemian knotweed is more common (with around 50 sites) primarily around the Cowichan River, while Japanese knotweed is most widespread (found on more than 100 sites from Shawnigan Lake to Cowichan River, Mill Bay and Cobble Hill). Policeman's helmet is a less well-known species of importance newly discovered on Vancouver Island, with four known locations within the CVRD. This species colonizes riparian areas; growing up to 3 m tall, it is an extremely invasive species with high seed production and rapid dispersal through hydrologic systems. As a result, it is often listed in the top-20 of invasive species.

66 Hogweed produces a noxious sap that can result in severe and painful burning and blistering when it comes into contact with skin. Hikers must take precautions not to brush against this dangerous plant that often grows alongside trails.

67 Lynne Atwood, Coastal Invasive Plant Committee, personal communication, 2009.

All of these species can quickly crowd out native vegetation, affecting native species and changing how important areas like riparian habitat function. In addition, smaller, apparently benign species such as the yellow iris can alter the availability and flow of water. Their very dense rhizomes raise the level of the land, turning riverine and marsh ecosystems into more terrestrial systems that favour different overstorey species.

Invasive Animals

Indicator and Measure

No systematic assessment of invasive animals is available. Some forest-specific information is available for species of interest to commercial forestry operations.

Findings

Many of the most ecologically significant invasive animal species are often not even considered as such. For example, house cats are one of the most prevalent and impactful invasive species, estimated to kill more than a billion small mammals and hundreds of millions of songbirds in North America annually. Cats – feral and house – are designated as one of the top-100 worst invasive species on the globe.[68] Similarly, domesticated dogs also have significant impacts – from the spreading of disease to the general disturbance of native species resulting in reduced populations. Other species such as the European starling, the European house sparrow, rats and grey squirrels have also become so ubiquitous in the ecosystem that they are not included on invasive species lists. In some areas however, these species can have significant impacts on native species. For example, starlings can have significant impacts on breeding sites for cavity nesting birds in natural habitat adjacent to more urban settings.

Other species, such as the bullfrog and green frog, are both invaders of ponds within the CVRD. The bullfrog – a native of eastern North America – was introduced for “farming” in the early 1900s. This large species is a significant predator for many native pond-dwelling species, including fish, native amphibians, snakes, and even ducklings.

68 IUCN, accessed 2010.

There are a variety of "introduced" fish species in various lake systems that have a variety of impacts on the native biodiversity. Species such as smallmouth bass can negatively affect native fish species and amphibians. One species of particular concern is the pumpkin seed sunfish (Figure 2.24), which is found in many bodies of water within the region. This species is a particular problem because it impacts native amphibians, and is thoughtlessly relocated by the public because it is an attractive species.

FIGURE 2.24: Pumpkin seed sunfish – attractive, but ecologically disastrous

Some species, such as slider turtles, have been released by the public (who bought them as pets), and appear to have become established in some areas. They have an omnivorous diet and their effects on native biodiversity are largely unknown. The extent of their range is also unknown.

Not all invasive species are obviously ecologically problematic. Some, such as the non-native eelgrass Zostera japonica, appear to function relatively similarly to the native species. However, long-term studies are lacking. The New Zealand mudsnail is a dramatic invader – radically changing aquatic environments in brackish habitats, sometimes occurring in densities of half a million individuals in a square metre. Currently, it is not found within the CVRD, but the potential for spread on recreational craft or fishing gear is ever-present. A recent new discovery of a population of mudsnails in Port Alberni, which spread northwards up the coast, shows the potential for the sudden spread of this and other invasive marine species.[69]

69 Davidson et al., 2008.

Many areas of the province are seeing significant impacts on forests as a result of invasive species. A few species of concern are currently active within the CVRD – including the fir engraver beetle, which impacts grand fir within drier biogeoclimatic (BEC) zones (CDF and CWHxm1) and which appears to have been increasing in the last 5 years. Drier conditions, predicted with climate change, exacerbate the effect of this beetle on grand fir, making these trees more susceptible to attack. Also, the spruce weevil is currently active within the CVRD; it affects regenerating Sitka spruce.

As for pathogens, there are currently few exotic pathogens in BC's forests, though one – Cryptococcus gattii (a microscopic pathogen which is normally found in tropical or subtropical locales in Australia, Africa, India or South America) – was identified on Vancouver Island in 2001 and is known to be present in the Cowichan Region[70]. With the potential to cause a human health risk, this species has unknown consequences for the broader ecosystem. With climate change, more invasions of this type are predicted in the future.

Summary

The most significant impacts to ecological systems worldwide are the combined effects of habitat loss due to human activities and invasive species.[71] Human activities often promote other invasive species, and so the intertwining and cumulative effects often increase the overall impacts on biodiversity values.

The CVRD is home to a wide variety of invasive plant and animal species, and this list continues to grow through time. Ecological impacts are varied, but invasive species primarily exacerbate loss of habitat caused by development in the drier east-side areas of the region. Many of the sensitive ecosystems identified in Section 2.2 are particularly hard-hit by invasive species, including Garry oak ecosystems, riparian areas and wetlands.

The full scale of impact, however, is unknown. Knotweed, for example, likely affects how riverine systems function in response to moderate floods, but effects such as these remain largely unquantified. Climate change is expected to significantly increase the ease of colonization by novel species from other places[72] – further increasing the pressures on today's ecosystems.

70 Robert F. Service, New Concerns About Deadly Fungus Found in Oregon, Science Magazine, April 2010. http://news.sciencemag.org/sciencenow/2010/04/new-concerns-about-deadly-fungus.html

71 Millennium Ecosystem Assessment, 2000.

72 Harvell et al., 2002.

Missing Information

Various agencies maintain databases on invasive species, particularly plants, due to their known economic impacts to agriculture and forestry. However, these databases are often out of date, and focus only on specific species. Great efforts are made to prioritize invasive species actions, however the full task of trying to deal effectively with the wide range and abundance of invasive species typically swamps the capacity of agencies. In the CVRD, this situation is exacerbated by the large area of private forest land, for which data are largely unavailable.

Most databases currently focus on plant species, however work is ongoing on Vancouver Island to compile a database of invasive aquatic species.

In largely rural settings such as much of the CVRD, the effects of accepted invasive species such as cats and dogs are significant but unquantified or managed.

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2.5 Fish

Fish are an important part of the Cowichan Valley Regional District (CVRD). They are ecologically critical to both the terrestrial and aquatic ecosystems as food for other organisms, as users of the habitat and food resources, and as nutrient inputs into these ecosystems. They are also important to people and communities for food, economic wealth, and their spiritual and cultural value. Salmon species in particular are a cultural icon of this region and a key indicator of ecosystem health because they reflect the cumulative impacts occurring in marine, freshwater and terrestrial environments of the CVRD and larger area.

Introduction

The CVRD covers a wide range of different watersheds, each of which has its own specific fish values, and each of which is vital to maintaining the biodiversity of fish, and especially salmon, in the area. Watersheds such as the Nitinat, Caycuse, Cheewhat, Carmanah, and Walbran flow west into the Pacific. Others, such as the Koksilah, Chemainus, and Cowichan rivers flow east into the Strait of Georgia. In addition, there are numerous small streams and lakes, many of which are affected by specific local land and water uses.

While there is a considerable diversity and abundance of fish present, declines are occurring – particularly for some species in some systems, and likely due to human activities. There are many species and stocks of fish which use the Cowichan Region in different ways and at different times. Some are year-round residents, some are ocean migrants that can return in a single year or multiple years. Some fish have several genetic and physical variations within the same watershed in response to different habitat conditions around the watershed. Different characteristics of each individual watershed, such as water quality and temperature, the annual flow regime, and spawning habitat availability are just a few of the variables that affect fish populations.

This report focuses on one of the most important watersheds for salmon: the Cowichan Basin drainage area. It is one of the largest tributaries flowing into the Strait of Georgia and has significant salmon populations. The Cowichan Basin is also relatively data-rich and is culturally significant for this region.

The Cowichan Basin watershed is influenced by many natural factors, including a mountainous terrain and coastal climate. Historically, mild-wet winters and cool-dry summers were the norm. Climate trends now suggest increasing annual stream temperatures. Rain-dominated watersheds such as the Cowichan will be more easily affected by changes in winter flood events (increasing in frequency) and low-flow periods. Unlike most of other river systems in the district, the Cowichan River flow is buffered (or moderated) by the presence of a large lake (Cowichan Lake), and further by the presence of a water-control structure (weir) at the outlet of this lake.

Human impacts on the watersheds have been extensive: early forest harvesting proceeded through extensive clearcutting, resulting in significant changes to the quality and quantity of water entering the system. The rivers themselves were impacted by the running of logs through the system. Fish harvesting has been extensive, both in the rivers and the ocean. Ocean conditions themselves have changed. All these impacts have occurred and interacted over significant periods of time during the last century, and many are ongoing today.

Fish in the Cowichan Basin Watershed

The Cowichan River is designated as a Canadian Heritage River System. One major reason for this designation is the significant abundance and importance of the fishery resource. The Cowichan River is historically known for its substantial runs of chinook, coho, chum, and steelhead salmon. As a result, it is an index river for the US/Canada Pacific Salmon Treaty, and is used as an indicator of abundance, survival, and exploitation of chinook in the broader region of the Georgia Basin.

Chinook salmon have a special status in BC. The Cowichan has, in the past, supported some of the largest spawning runs of chinook in the entire Georgia Basin.

Other native species include rainbow trout, resident cutthroat, and Dolly Varden char, and – within Cowichan Lake – resident Kokanee salmon. The Cowichan is known as one of the finest trout rivers on Vancouver Island and possibly in the whole of BC. In addition to these well-known fish species there are many smaller fish, such as minnows, chub, sculpins, and lamprey which are important parts of the ecosystem. The Vancouver lamprey, resident in Cowichan Lake, is listed as a "threatened" species under the Canadian Species at Risk Act.

Several species of fish have been introduced into the Cowichan watershed, mostly in the early 1900s, including brown trout, Kamloops trout, speckled char, lake trout, catfish, and Atlantic salmon.[73] Only brown trout appear to have established themselves to significance in the system. There are other, more recent, observations of invasive fish species which are not documented in this report but are a concern to the native biodiversity in the region.

73 Neave, 1941.

Measuring the State of Salmon in the Cowichan Basin Watershed

Indicator and Measures

For the purpose of this report salmon abundance is a main indicator of watershed health, both at present and as a trend through time. Ideally, historical data on the salmon runs (i.e., prior to extensive harvesting that was initiated more than 100 years ago), would provide the most appropriate benchmark for understanding recent trends. While this data cannot be readily accessed in this timeframe, data does exist on relatively long-term escapement (number of adults that escaped being caught and returned to the river to spawn) for key species within the Cowichan. These data sets are presented for each major species/stock.

It is important to note that other, more detailed, watershed trend indicators might provide additional insight into fish abundance trends, and a more precise indication of the factors affecting specific components of the salmon life history, from egg in the river to returning adult. These additional indicators might include habitat area and quality changes over time, water quality, food productivity for species such as aquatic invertebrates, egg-to-fry survival rates, fry density and distribution, predator pressures (such as presence of predator birds and fish), etc. These indicators would provide more baseline data to help us understand the trends in adult fish abundance. Some of this information will be available in an assessment of the habitat in the Cowichan watershed which was undertaken in conjunction with this report.[74]

However, the number of adults spawning remains an overall indicator which is relatively easy to measure. Like a canary in a mineshaft, salmon are an indicator of the overall health of the watershed, because they integrate so many of the factors mentioned above.

When interpreting trends in numbers of fish, it is important to understand that fish abundance is determined by a combination of the following three general types of factors (a few of these factors are explored in detail towards the end of this section):

1. The ocean ecosystem (factors such as ocean conditions affecting food sources, near-shore habitat complexity, productivity of the estuary, competition with other species, natural predation, etc.)
2. The freshwater ecosystem (factors such as spawning and rearing habitat, habitat quality, water quality, adjacent land use, predation pressures, water temperatures, competition and predation from other species, etc.)
3. Direct human interventions such as fishing or hatchery production.

74 DFO, 2010.

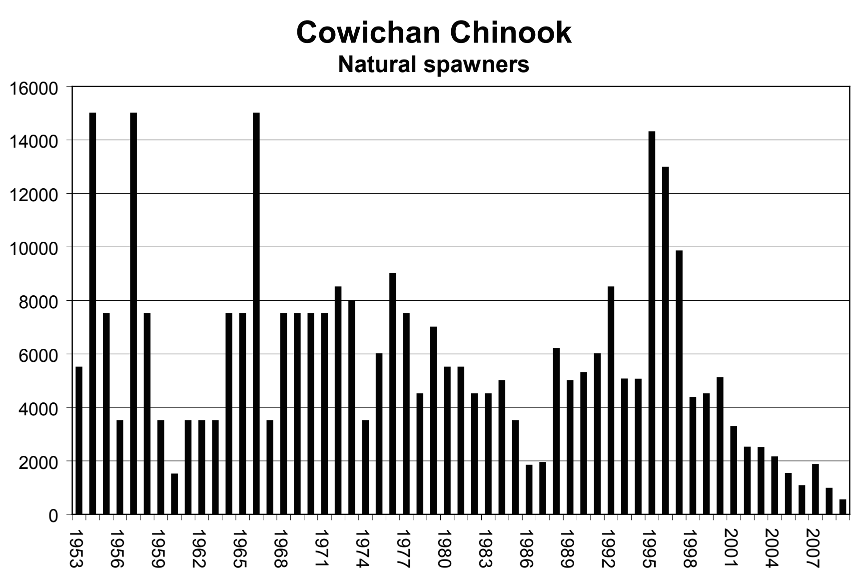
Determining which of these many factors has the most influence on fish population trends is a complex issue. Multiple species can be affected differently by different factors and can in turn affect one another. In addition, trends can alter within individual systems – making it difficult to summarize information. One thing is certain; the freshwater ecosystem is an important determining factor in the abundance of fish in the Cowichan Basin watershed.

Findings

Chinook

Historically, the major chinook run in the Cowichan returns in the fall, and over the last 56 years has had an average "escapement" (i.e., returning spawning adults) of 6,000 fish (Figure 2.25), with high variability across the years. For example, a strong El Niño in 1983 resulted in poor spawning numbers three to four years later, and improved ocean conditions in the late 1980s led to some large return numbers. Since the mid-1990s, however, natural spawning numbers have declined significantly to very low numbers, with the lowest ever recorded in 2009. Other contributors to this declining trend include: ocean conditions combined with continued high fishing pressure (catch rate), both from commercial and sport fisheries, fluctuating hatchery production, and impacts to freshwater areas (fish rear their young in the lower river and estuary prior to heading to the ocean, and survival in these zones has decreased through time). It is important to note that Cowichan chinook abundance has declined more than other chinook populations in the lower Strait of Georgia (such as Nanaimo or Squamish), suggesting that local impacts are significant for the Cowichan fish.

FIGURE 2.25: Annual estimates of chinook salmon "fall" spawners in the Cowichan River, 1953 – 2009



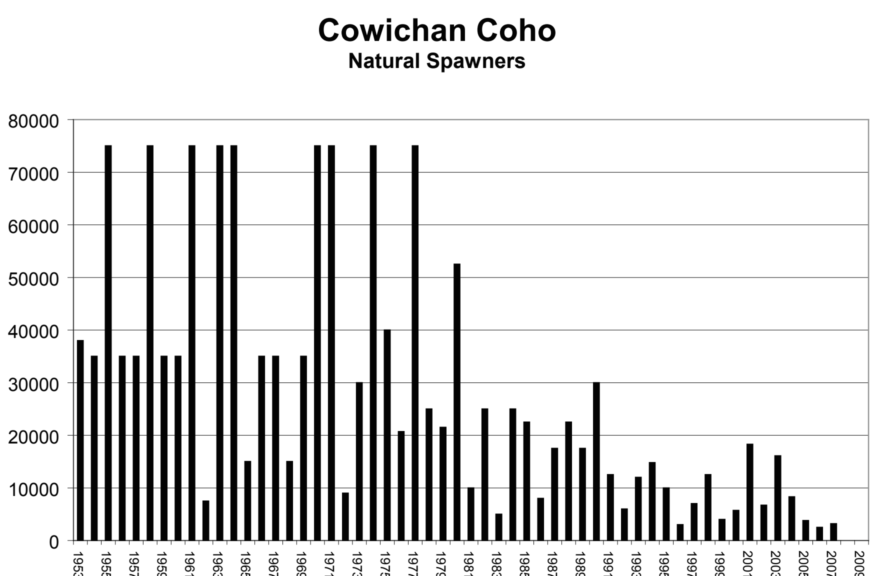
Source: Data from 1953 to 1987 are based on DFO Fisheries Officers' estimates. Data from 1988 to present are based on DFO fixed point enumeration (counting fence) and carcass mark/recapture estimates where necessary. DFO Salmon Escapement Database (NuSEDs), 2010.

The spring-run population of chinook salmon is currently at an extreme low, practically at zero. Little is known about the historic size of this population, though anecdotal information suggests that this run was once of similar size to the fall run.[75] Good information on the factors affecting this population is unavailable.

Coho

Coho populations are currently at low levels throughout the Georgia Basin. The coho return to the Cowichan in the fall, taking advantage of habitat and migration options as water levels rise significantly from October through December. As with chinook, the escapement numbers for coho spawning in the Cowichan system have also dramatically declined recently – with 2007 numbers lower than any seen previously (less than 1,000 individuals compared with in excess of 70,000 in periods up to the 1970s) (Figure 2.26). One important difference from chinook is that the commercial and sport fishery catch rate for coho is low. Therefore, the continued low abundance of coho is most likely due to a combination of factors affecting survival in both the ocean ecosystem and the freshwater ecosystem. Coho spend a full year in freshwater prior to entering the ocean, making the freshwater ecosystem especially important. Suitable freshwater rearing habitat and/or near-shore marine habitat has likely become a major limitation for coho abundance (see Section 2.2 for information on the condition of the Cowichan estuary).

FIGURE 2.26: Annual estimates of coho salmon spawners in the Cowichan River, 1953 – 2009. No estimates were made for 2008 and 2009



Source: Data from 1953 to 1992 are based on DFO Fishery Offices' estimates. Data from 1993 to 2007 are based on expansion of selected tributary estimates. DFO Salmon Escapement Database (NuSEDs), 2010.

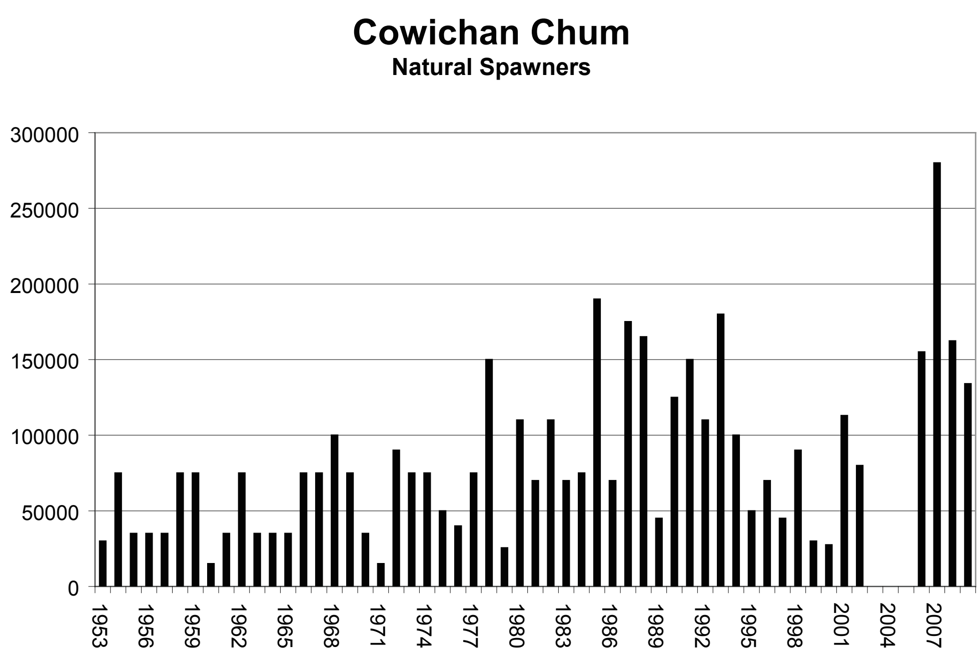
75 Burns, 2002, referenced in Burt and Robert, 2002.

Chum

Chum salmon stocks are considered as part of a single management unit called the Inner South Coast (ISC) chum stock. The average return for ISC wild chum salmon was 1.3 million from 1968-1982, which reduced to 1.1 million for 1983-1996[76].

Although numbers fluctuate widely (Figure 2.27), the estimates for chum spawning returns do not show the obvious negative trends seen for the other species. Chum salmon have the most limited interaction with the watershed of all the salmon species. They spawn in the lower reaches of the river and migrate to the ocean shortly after emergence from the gravel. The factors generally considered to have the greatest influence on chum abundance are those which affect eggs in the gravel (flooding, stream bed movement, predation, etc.), as well as ocean conditions.

FIGURE 2.27: Annual estimates of chum salmon spawners in the Cowichan River, 1953 – 2009. No estimates were made for 2003 through 2005



Source: Data from 1953 to 2003 are based on DFO Fishery Officer and Fishery Managers' estimates. Data from 2006 to present are based on enumeration of migrants using a Dual Identification Sonar unit (DIDSON). DFO Salmon Escapement Database (NuSEDs), 2010.

76 DFO, 1999, quoted in LGL, undated.

Steelhead and Trout

Steelhead on the Cowichan have both winter runs and spring runs. Many steelhead stocks on Vancouver Island have declined significantly in the last 30 years. The distribution of steelhead within the Cowichan system has also declined; steelhead are now absent from many tributaries of Cowichan Lake. Similarly, the steelhead in the Koksilah River are classified as of conservation concern.[77] Data for steelhead are more difficult to obtain, but Cowichan River abundance is thought to be 500 – 800 winter-run escapement, which is considered to be at 10 – 30% of habitat capacity,[78] though it is not known if this represents the historic abundance of fish in this system. A number of stewardship-based restoration projects, such as the remediation of Stoltz Bluff, are hoped to benefit this species.

Resident rainbow trout are very limited within the Cowichan system today, though they were historically abundant. They are suspected to have been impacted by historic heavy fishing pressure.

Resident cutthroat trout appear to be scarce, while sea-run cutthroat trout appear more numerous. However, detailed population trends are unavailable.

Factors Affecting Salmon Abundance in the Cowichan Basin

Fish (particularly salmon) abundance and distribution is affected by a wide range of factors in both the freshwater and marine environments. Some of these factors, such as those related to environmental change or marine harvest regimes, are determined on a broader scale than the Cowichan Region. Others, such as instream water levels and riparian conditions, are directly related to impacts in the local area. The table at the end of this section (Table 2.11) summarizes the range of factors affecting Cowichan salmon abundance and distribution, and their relative impacts on these species.

There is general agreement within the local Cowichan Stewardship Roundtable (which deals with local fisheries issues) that the highest risks in the freshwater ecosystem stem from low water flow, high water temperature, and sediment loads from bank erosion. Additionally, the loss of rearing area in the lower river is significant. As the fish migrate to the ocean, the ability to feed and grow in the lower floodplain, in the estuary (where much habitat has been lost as a result of a wide variety of development – see Section 2.2), and in the nearshore environments of the southern shores of Vancouver Island and the Gulf Islands, is critical

77 Lill, 2002.
78 Lill, 2002.

to determining overall abundance. Other important factors affecting salmon returns include harvest by commercial and sport ocean fisheries (particularly for chinook), the production from the Cowichan hatchery, and broader ecosystem considerations such as seal and killer whale predation, land use impacts and changes in ocean currents.

A few of these factors are explored below.

Water Quality and Quantity

In the Cowichan, water flow and quality (e.g., temperature) are thought to be key issues affecting fish populations, at least in some years[79]. The Cowichan is a rain-dominated system, so water levels are maintained by groundwater aquifers adjacent to the river and reduced precipitation levels can significantly alter low-flow levels during critical periods of the year. Natural hydrology in the Cowichan is altered by a low-head weir located at the outlet of Cowichan Lake, and intakes for the Crofton Mill and City of Duncan water supplies, both located about 10 km above the mouth of the river. The weir is theoretically to be used to maintain fish habitat in time of low flow, and is typically successful in maintaining water levels. However, lake levels have at times been insufficient to maintain adequate water flow, leading to conflicts between ecosystem, fish and human water requirements.

There have been recent years when summer (low-flow) water levels in the Cowichan Basin system have been critically low – which results in significant impacts to habitat availability for spawning, migration and rearing, reducing overall fish productivity. At critically low levels, fish are dissuaded from even entering the watershed system and cannot bypass physical barriers in the system. The stranding of fish in side channels at times of low flow can be a significant issue and, although stewardship efforts are made to recover these losses, both coho and chinook salmon incur significant mortality through stranding.

Water quality also interplays with habitat quality. For example, above Skutz Falls the spawning habitat is of high quality, with much lower quality below the falls due to the high proportion of cobbles and boulders, combined with high fine sediment inputs. In addition, higher air temperatures combined with low water flow results in increasing water temperature, which, in turn, can have significant impacts on these primarily cold-water species (e.g., reducing growth rates, survival of fry and resistance to parasites and diseases). Increased temperatures are thought to be of particular concern within the Koksilah River system, as the temperature within this system is not buffered by a major lake (as is the case with the Cowichan River).

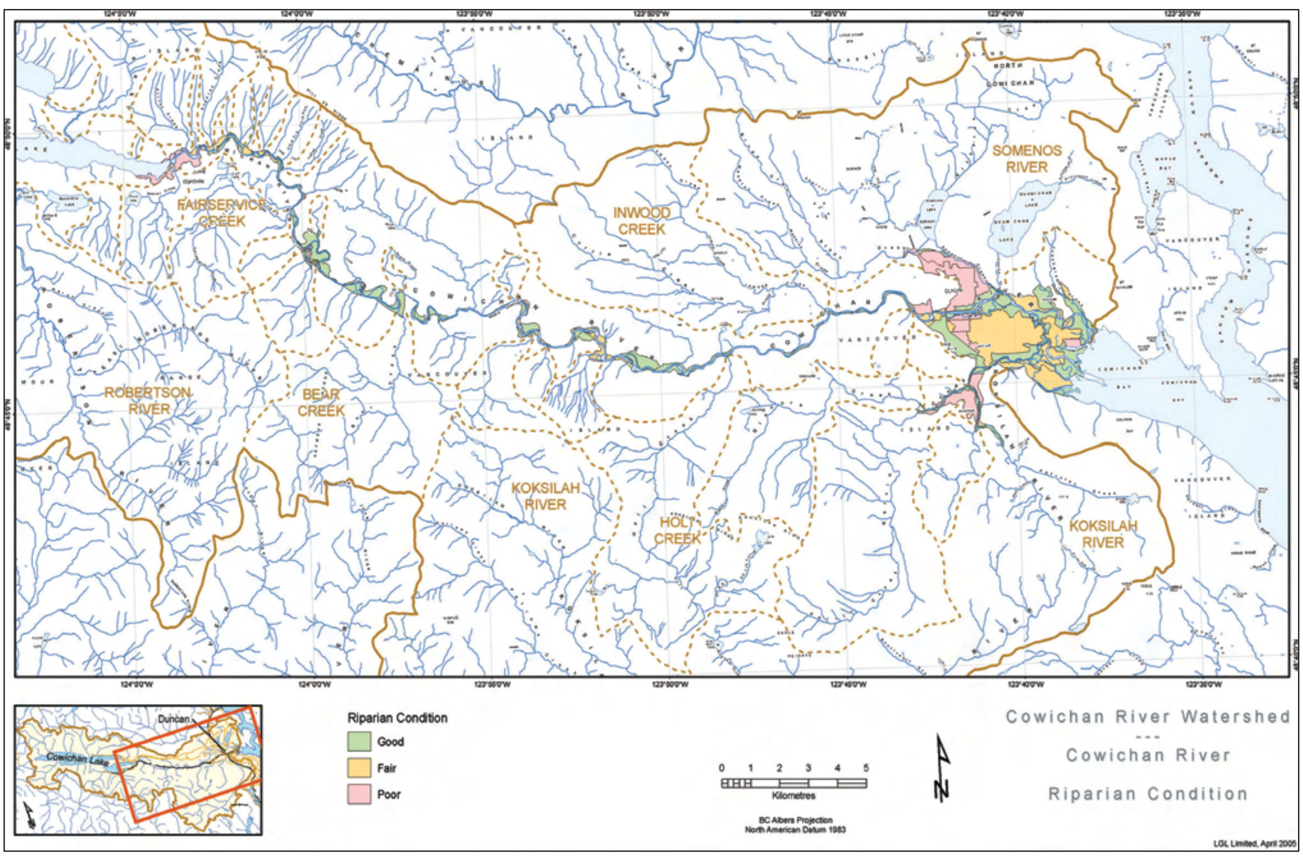
79 W. Luedke, Department of Fisheries and Oceans, personal communication, 2009.

Habitat Quality

In general, spawning and rearing habitats have been degraded over time compared to their historic condition. No "natural" habitat baseline is available because the most significant effects occurred over the last hundred years or more, with progressive clearcutting of most of the Cowichan watershed and harvesting of second-growth underway. Over this period, significant changes have occurred within stream channels and riparian habitat, reducing the natural complexity of the system, altering the input of natural coarse woody debris to the system (which creates spawning habitat under natural conditions), and affecting water quality and temperature. Development and dyking on the floodplain has changed the natural dynamics of the floodplain and affects habitat availability, particularly for rearing fish.

At the lower end of the system (from Cowichan Lake to Cowichan Bay), significant areas of riparian habitat are also considered to be in poor condition (Figure 2.28). The effects of pollution and habitat degradation on fish populations in the Cowichan Estuary (Section 2.2) are largely unquantified, but this area is important as a juvenile rearing habitat. Stewardship efforts have worked to improve the condition of habitat, but significant limitations remain.

FIGURE 2.28: Riparian condition for the lower Cowichan system



Note: This map used with permission of Cowichan Tribes.

Marine Harvesting

Marine harvesting can be a significant factor affecting the abundance of salmon in a watershed. Marine harvesting occurs through commercial fisheries using seine, gillnet, or troll gear, and through recreational fisheries and First Nations fisheries.

For Cowichan chum, coho, and steelhead, the ocean harvest is relatively low and not likely a limiting factor for abundance. For chum salmon spawning in the Cowichan, the marine harvest is held at a conservative level of less than 20%, mostly from commercial fisheries in Johnstone Strait and more locally in Satellite Channel, but also including a small portion of recreational catch. Cowichan Tribes also harvest fish in the vicinity of the Cowichan River.

For coho salmon, the marine exploitation is even lower, mostly likely in the range of 5-10%. However, this level of fishery impact is relatively recent (since 1997). Prior to 1997, coho catches were significant, up to 80% of the total production of many stocks. For wild steelhead, harvest is currently at low levels. For chum, coho, and steelhead, river abundance is not determined by harvest, but more likely by natural limiting factors in both the freshwater and marine ecosystems.

Cowichan chinook are harvested at a much higher rate in ocean fisheries. In recent years, an average of about 60% of the Cowichan chinook were harvested by marine fisheries, plus another 10-15% by Cowichan Tribes for constitutionally protected food, social, and ceremonial use. The marine harvest of these chinook included about 15% by Washington State fisheries, about 15% by the commercial troll fishery, and about 30% by recreational fisheries in southern BC.

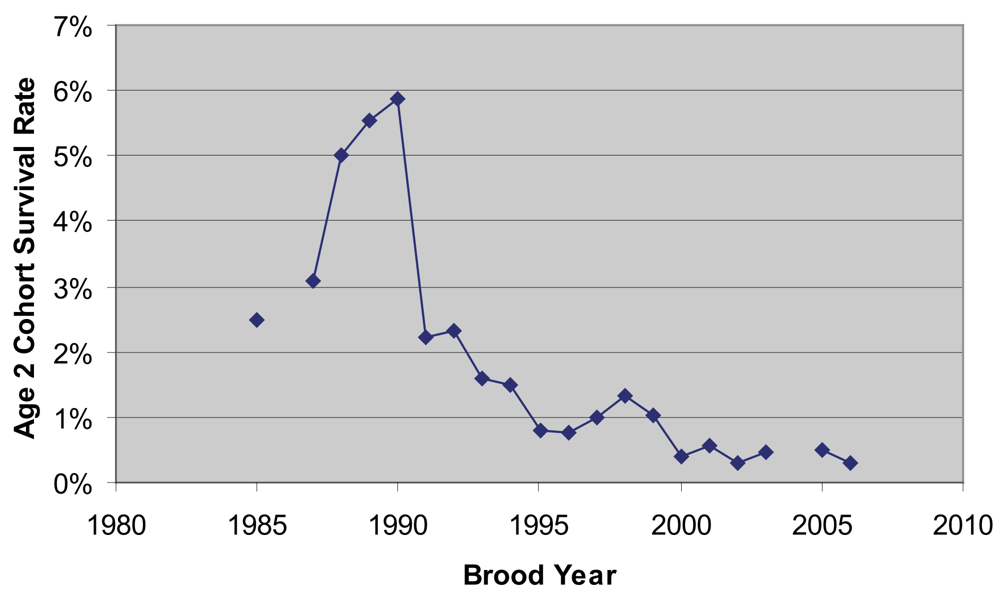
Ocean harvest of Cowichan chinook has been a significant factor in the low number of these fish returning to the river. In order to reduce overall harvest, several actions have been taken in recent years. These have included an approximately 50% reduction in allowable catch by the commercial troll fishery, significant closures of the recreational fishery in the Gulf Islands during the fall migration, and the extensive implementation of more selective fisheries in Washington State. Whether these management actions are sufficient to effect a reversal in recent precipitous declines in Cowichan chinook returns will become clear in upcoming years.

Marine Survival

The trends in marine survival of chinook and coho entering the Strait of Georgia suggest that changes in marine conditions have had a negative consequence on salmon abundance. There is substantial evidence that salmon mortality in the ocean occurs mainly in the first few months after leaving the river and estuary, as they mature in the nearshore areas of the region's coastline, Gulf Islands and Georgia Strait. The specific causal factor is not known and is widely debated, but lack of food, lack of habitat, and increased predation are all likely contributing factors. Changes in the Strait of Georgia, such as increased water temperature, may in part be due to climate change; other changes such as water quality may have a range of causes, including storm water and upland development. Additional changes include more variable primary plankton production, loss of kelp forests in many parts of the Strait, and major shifts in the ecosystem structure.

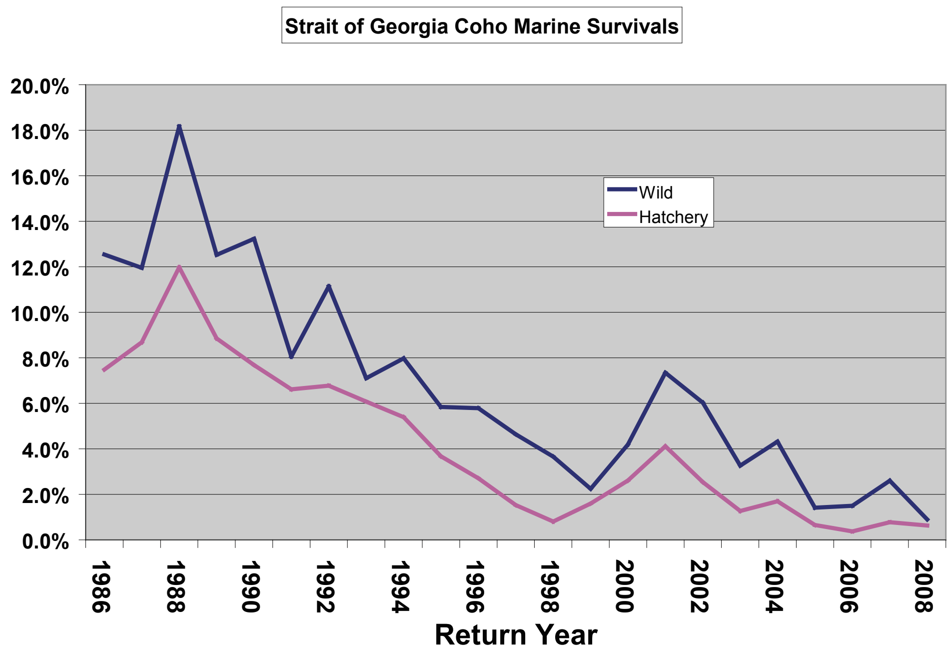
Figure 2.29 below shows a significant decline in marine survival of chinook from smolts released from the hatchery to age two since the early 1990s. Note that using age two precludes most of the fishery impacts, and so is a good indicator of natural impacts. The recent survival rate of Cowichan Hatchery chinook is only 0.3% on average (e.g., three out of 1,000 chinook survive to age two). This level is comparable to other hatcheries in the lower Strait of Georgia. Similarly, marine survival for Strait of Georgia coho has been poor for both hatchery and wild stocks, with the decline starting about 1990 (Figure 2.30).

FIGURE 2.29: Cowichan Hatchery chinook survival rate trend to age 2, based on coded wire tag recoveries



Source: DFO, 2010.

FIGURE 2.30: Marine survival data for Coho in the Strait of Georgia showing declining trend



Source: DFO, 2010.

Summary

Fish – particularly chinook and coho salmon – historically have been foundation species in the Cowichan Region, as these abundant species provided massive inputs of nutrients to both aquatic and terrestrial ecosystems. Their populations have been central for maintaining human populations, and remain a critical component of both the First Nations' cultures and community vitality. In addition, fish populations have an important impact on the functioning of the broader ecosystem, providing food and nutrients to ocean, aquatic and terrestrial ecosystems. Because of all these factors, dominant fish species are good indicators of broader ecosystem health since they are affected by a wide range of factors and reflect these factors in data on their survival to reproduction.

In the last five years, the number of returning spawners for two of the Cowichan River's primary salmon runs – fall coho and chinook – have been reduced by approximately 90% from levels documented in the last 80 years, while others, such as chum are at relatively high levels. Often, the diversity of trends, and of factors affecting these fish (see Joint Technical Working Group evaluation in Table 2.11) is used as a reason for inaction, since

it is always easy to point the blame at some factor that is out of local control. Yet many land-use factors within the terrestrial and freshwater ecosystems of the CVRD are highlighted in this evaluation as having a high impact on these fish populations.

The long-term implications of the fish population crashes will be realized over the coming generations for both ecosystems and humans. These implications can be expected to cascade through ecosystems and human communities, and result in both obvious and less obvious changes into the future. Significant effort and action is required at all levels and jurisdictions to return these stocks to their former abundance and to reverse the current trends of increasingly poor ecosystem health.

The Joint Technical Working Group (organised by DFO[80]) has provided an initial evaluation of the significance of the issues or limiting factors affecting salmon life history (Table 2.11). The impact level suggests how important various factors are in the decline of the Cowichan fishery. The certainty column defines how certain it is that the impact rating is correct.

80 W. Luedke, DFO, personal communication, 2009.

TABLE 2.11: Qualitative assessment of the importance of different factors affecting the Cowichan fishery. Note that as described above, the specifics likely change by species; however, broad patterns are visible from this table

Issue or limiting factor in salmon life history	Comment	Risk Impact	Risk Certainty
HARVEST IMPACTS			
a. Impact by **commercial** marine fisheries	> Primarily associated with chinook, where catch rates have remained high. New rules have recently reduced catch by 50%. > Other species affected very little by commercial catch.	Moderate	High
b. Impact in marine **recreational** fisheries	> Increased incidence of Cowichan chinook in the west coast Vancouver Island fishery, but lots of variation from year to year, so hard to deliver specific actions. > Recreational priority over commercial access to chinook.	High	High
c. Catch in First Nations fisheries	> Food fisheries have constitutional priority and are important to Cowichan Tribes. Part of this issue is that this fishery is at the end of the gauntlet of fisheries.	Moderate	Moderate
d. In-river poaching	> Thought to be minor issue in Cowichan.	Low-Moderate	Low
e. Bycatch in non-salmon fisheries	> Bycatch in ground fish trawl fisheries is generally low but in some years is significant.	Low	Moderate
HATCHERY ISSUES			
f. Lack of long term plan for the hatchery.	> Changes in the ecosystem, the need for succession planning at the hatchery, infrastructure issues, changing role of the hatchery all need to be addressed.	High	High
g. Hatchery infrastructure	> Water is a limiting factor in the Cowichan hatchery. There may be other potential issues which have not been clearly established at this time.	Moderate	Moderate
HABITAT ISSUES IN FRESHWATER			
h. Water quality	> Many factors affect water quality, including sewage, septic fields, sediment load due to natural erosion, increasing water temperatures, etc.	High	High
i. Water flow	> Many factors affect water flow, including high localised water use and lack of metering and monitoring. Expected to be exacerbated by climate change.	High	High
j. Smothering of eggs by sedimentation	> Typically natural erosion that is exacerbated by human impacts, particularly land use /logging /clearing and exacerbated by invasive species (e.g., knotweed).	High	High
k. Scouring substrate/ redds[81] by floods	> Land use (logging and clearing) results in greater flow variation	High	High

81 A salmon redd is a depression created by the upstroke of the female salmon's body and tail, sucking up the river bottom gravel and using the river current to drift it downstream. The female salmon digs a number of redds, depositing a few hundred eggs in each during the one or two days she is spawning.

TABLE 2.11: Qualitative assessment of the importance of different factors affecting the Cowichan fishery. Note that as described above, the specifics likely change by species; however, broad patterns are visible from this table

Issue or limiting factor in salmon life history	Comment	Risk Impact	Risk Certainty
l. Lack of rearing habitat in mainstem[82]	> Loss of habitat is caused by loss of riparian cover, reduced large natural woody debris in streams, land use issues (forest-increased runoff and flood control; agriculture-dyking, development-impervious surface, etc.)	High	High
m. Lack of rearing in lower river and estuary	> Land use reduces habitat availability, quality, and complexity (e.g., loss of large woody debris and eel grass habitat). Also impacted by log booming in the estuary and channelization of natural streams.	High	High
n. Fry stranding in side channels	> Caused by lack of water in the creek at the right time – factors include changes to groundwater hydrology, side channel morphology due to development, operation of weir, etc.	Medium	Medium
o. Stress during spawner migration and spawning	> Stress increased by many factors, particularly low water flow caused by weir operation, water extraction, groundwater hydrology changes and climate change. > High water temperature also increases stress for these “cold water” species. Impervious surface runoff, fishway blockages and human disturbance all contribute.	High	High
p. Lack of spawning gravel	> Natural dynamics of creeks are impacted by “bank stabilization” work, so new gravel does not become available. Fish can’t get access to existing gravel due to sedimentation cementing the existing gravel, and the impacts of invasive species such as knotweed.	Medium	Medium
ECOSYSTEM CONSIDERATIONS			
q. Predation on eggs or fry	> Existing fish such as trout or sculpin, birds, and other species.	Medium	Medium
r. Seal predation on smolts	> Unknown extent of this issue. Known to be high in some east coast Vancouver Island rivers. Likely have habituated seals in area.	Unknown	Unknown
s. Poor survival of smolts	> Likely a combination of low food and habitat availability. Begins with rearing success in lower river and estuary, need for complexity in foreshore areas, and changing conditions in Georgia Strait. Land use in lower watershed and effects of climate change may be primary issues. In Georgia Strait there is poor understanding of the causal factors for early marine mortality.	High	High
t. Seal predation on mature adults	> Unknown extent of this issue, but seals observed in Bay and lower river up to fishway. Evidence of predation.	Unknown	Unknown
u. Predation by southern resident orcas.	> Chinook known to be preferred food source and Cowichan chinook historically resided in lower Georgia Strait in August-Sept.	Unknown	Unknown

82 A mainstem is the main channel of the river in a river basin (as opposed to the streams and smaller rivers that feed into it).

Data Gaps

Key data gaps relate to the identification and understanding of issues and factors limiting ecosystem productivity and fish abundance, and their relation to human activities in the region. The identification of key indicators related to ecosystem health and the collection of data for these indicators will be important in linking the ecosystem health to species such as salmon. Some potential indicators to be explored were discussed above, and include such things as habitat area and quality, habitat utilization, water quality, productivity (such as benthic invertebrate densities), egg to fry survival rates, fry density and distribution, and predator interactions (e.g., birds and fish).

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2.6 Water

All life depends on an adequate supply of clean water. Water provides one of the most obvious links between ecosystem services and human and societal health. Aquatic and terrestrial ecosystems are both intimately linked to the availability of unpolluted water, with specific requirements dependent on the particular ecosystem or species. Water moves between different systems in complex and often unpredictable ways. Changes in water abundance or quality can therefore have unexpected consequences elsewhere.

Introduction

Water in its natural state is highly variable, with differences in the levels of natural nutrients, algae levels, natural turbidity (from landslides or natural breakdown of the earth's surface), water hardness, trace elements from surrounding bedrock, and dissolved oxygen levels to name just a few factors. Temperature and flow rates interact with these natural factors and affect basic water quality both seasonally and annually. Both the availability (quantity and timing) and the quality (e.g., levels of nutrients, algae, temperature) of water are key to maintaining many natural processes. Species and their ecosystems are adapted to complex natural patterns of water flow. However, since natural complexity defines water resources, it also makes it inherently difficult to monitor and understand.

In natural systems, water falls as rain or snow into watersheds. Water storage occurs as ice and snow, in lakes, rivers and streams (surface water), in the ecosystems themselves (forests/wetlands) and in aquifers (underground water bodies). The rate and timing of melt and run-off, as well as a variety of other factors, affect how
and when these reservoirs of water are maintained. Although we tend to manage individual components of this water cycle separately, they are intimately linked with each other and affect how much and when water is available for ecological systems and for human uses.

All aquatic and riparian life requires certain water levels. Some systems, such as floodplain systems, are maintained by flooding. Many species require the permanent or ephemeral habitats created by the movement of water at certain times of year. Aquatic invertebrates, which are the foundation of many food webs, require sufficient water at certain time periods to maintain their populations. Most of these values are not monitored at all. This section focuses on water as an integral part of the region's natural ecosystems, and looks at the vulnerability of particular systems in relation to the production of specific services such as fish spawning habitat.

Threats/Pressures

Many activities can affect the water cycle in subtle (or not so subtle) ways. Climate itself is a key driver, affecting how much rain falls, when, where, and at what speed snow melts, how much evaporates back into the atmosphere, and how much ends up stored in the natural reservoirs of ground and surface water systems. Changes in climate will affect this basic system.

Land management is also key. Functional forest systems store water in the biomass of vegetation, soil, trees and moss layers, and regulate the rate of flow. When mature forests are cleared, patterns and rates of flow change. Less water is intercepted by forest canopies, and less water is used in biologic processes by plants, leading to an increase in water received at the ground surface and often an increase in run-off, erosion, and sediment delivery to surface water bodies. In addition, water can be re-routed by roads associated with forest harvest or other clearing activities. Vegetation regrowth affects how long these new patterns last. Where natural ecosystems are converted to residential or urban uses, patterns of water flow can be altered more drastically and permanently.

Water quality is often also changed as land-use patterns change. Natural ecosystems, which typically function to clean water, can be changed to systems where non-natural levels of sediment or pollutants are added. Overlaid on the basic patterns of water flow, water use by humans also impacts the system. The withdrawal of water for household use, agriculture or industry from any of the natural storage systems affects water availability for natural processes. Key sources of pollutants include inefficient sewage systems (both single-house systems and treatment plants), discharge from industrial sources, pesticides or fertilizers from agricultural and forestry activities, domestic gardens, and stormwater discharge. Section 3.3 looks at the consumption of drinking water in the region.

The Cowichan Valley Regional District (CVRD) has three major watersheds on the drier east coast – the Cowichan, the Koksilah and the Chemainus. On the west coast, part of the Nitinat, and the Carmanah/Walbran watersheds are included in the CVRD. The Cowichan Region includes some of the wettest ecosystems in BC on the west coast – which remain primarily functionally intact and forested – and some of the driest systems in coastal BC on the east coast, which have seen considerable changes in natural patterns of storage, flow and water requirements. The east coast has the least water, but also the highest demand and highest potential for changes to natural hydrology due to land use changes. As a result, this section focuses on the east coast systems of the CVRD.

Measuring Water

Global forces drive water patterns: drivers such as the Pacific Decadal Oscillation[83] or El Niño result in cycles of dry or wet periods and changes in temperature, which in turn cause variations in the natural flow of water. As a result, very long term datasets are often needed to understand the state and trends of water supplies. Even without this high level of natural variability, indicators that reflect the real health of water for ecological systems are hard to find and are even harder to collect data for. As a result, data collection and indicators tend to focus on water values primarily in relation to human health. Ideal indicators for measuring the health of water sources for ecosystems might include:

- Degree of divergence from natural flow regimes
- Water integrity index for key watersheds/systems
- Degree of divergence from natural water quality
- Benthic community health for watersheds

However, data for these indicators are largely unavailable, at least for the whole region. Instead this report examines the following indicators:

- Groundwater aquifers – quantity and quality of water
- Surface water – quantity and quality

Groundwater Aquifers

Indicator and Measures

Groundwater aquifers are effectively lakes that exist largely underground, trapped within layers of rock or substrate that hold water to some extent. They are maintained by rainfall and inflow from lakes and streams above ground, combined with natural and human-caused outflow. Aquifers differ in the extent to which they naturally hold water. The vulnerability of an aquifer to contamination from surface sources depends on the thickness and extent of the geologic materials overlying the aquifer, depth to water or depth to the top of any confined aquifers, and the type and permeability of aquifer material (e.g., sand and gravel, fractured bedrock). Aquifers are categorized as high (A), moderate (B), or low (C) with respect to vulnerability.

83 A long-lived, El Niño-like pattern of Pacific climate variability.

In addition, aquifers are also affected by their level of development. This level is determined through an assessment of demand on the aquifer relative to the productivity of the aquifer. Aquifers are categorized as high (I), moderate (II), or low (III) with respect to level of development. Combining Vulnerability and Development yields nine classes of aquifers, from IA (heavily developed with a high vulnerability to contamination) to IIIC (low development and low vulnerability).[84]

Findings

Groundwater is used by various groups and individuals in the CVRD for a variety of purposes. These include:

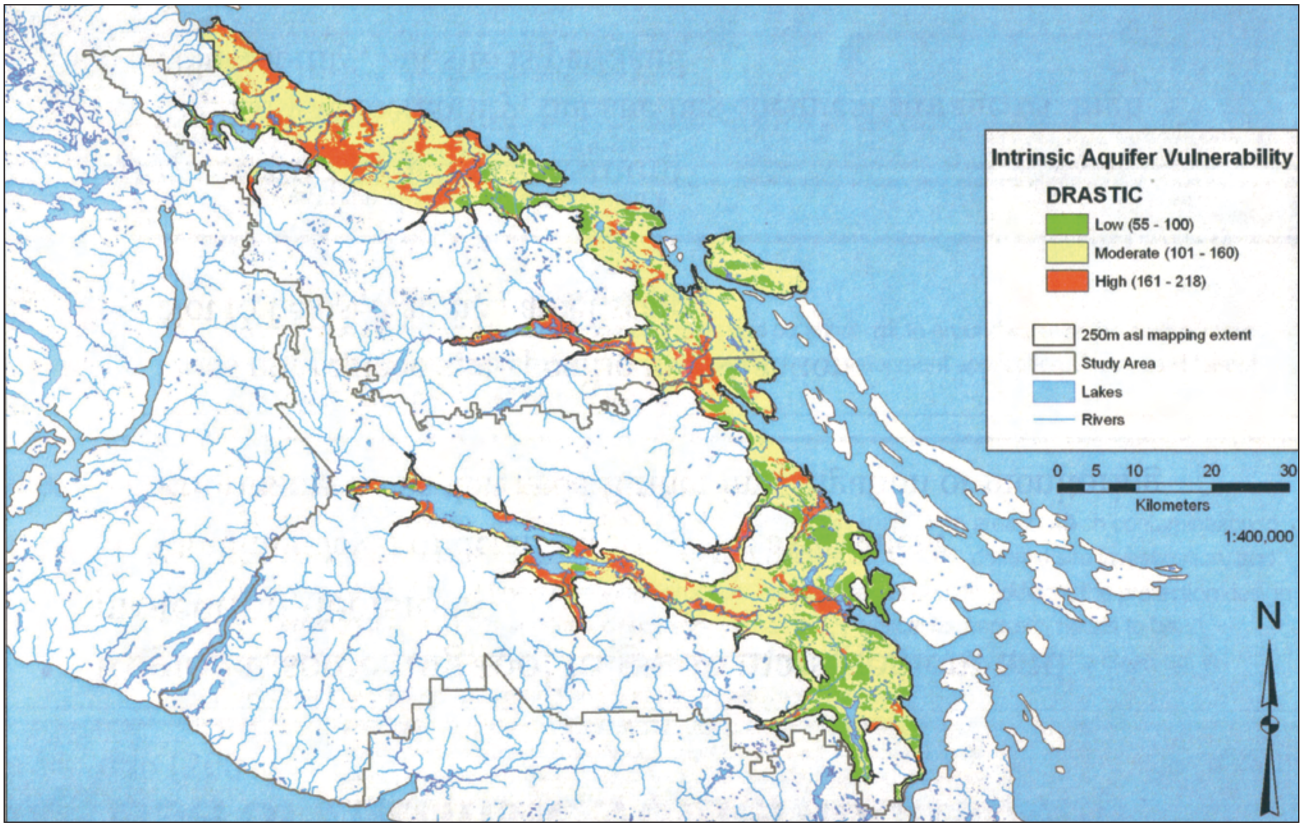
1. The provision of potable (drinkable) water by local governments (e.g., District of North Cowichan, City of Duncan, CVRD) to homes and businesses in the region
2. The provision of potable water by private individuals (e.g., bulk water sales), organizations (e.g., Braithwaite Estates Improvement District), or utilities (e.g., Arbutus Ridge)
3. Agriculture (especially for irrigation)
4. Industry
5. Golf courses
6. Private water withdrawal from wells for homes and other uses
7. Other specific uses – such as fish hatcheries

While some users monitor the total volume of groundwater they extract from the aquifers, many do not. There are 45 classified aquifers in the CVRD, including the Municipality of North Cowichan, City of Duncan, Town of Ladysmith and Thetis Island. Some of these aquifers are entirely within the boundaries of the CVRD, while others are partly in the region and partly in neighbouring regional districts (Regional District of Nanaimo to the north and Capital Regional District to the south). About half of these aquifers (23) can be characterized as sand and gravel (confined or unconfined) aquifers and the other half (22) are bedrock aquifers. The aquifers range in size from 0.6 km^2 to 76 km^2. Several of these aquifers have been studied in greater detail in the past few years. These include the Cherry Point aquifer, the Chemainus-Crofton aquifer, Thetis Island aquifers and the Cowichan River aquifer A.

The intrinsic vulnerability of these aquifers is shown in Figure 2.31.

84 Berardinucci and Ronneseth, 2002.

FIGURE 2.31: Intrinsic vulnerability of the aquifers in the CVRD



Source: Jessica Liggett, Natural Resources Canada, PowerPoint presentation, 2009.

Of these 45 aquifers, 17 are classified as inherently highly vulnerable. Four of these (Crofton- Chemainus, Duncan and two on Thetis Island) are also highly developed. In addition, six of the highly vulnerable aquifers are currently moderately developed: Upper Cassidy, Ladysmith, Honeymoon Bay, Lake Cowichan, Shawnigan Lake/Cobble Hill and Mill Bay (Table 2.12).

TABLE 2.12: Development and vulnerability rankings for the 45 aquifers relevant to the CVRD

Development	Vulnerability	Code	Number of aquifers
High	High	I A	4
High	Moderate	I B	1
High	Low	I C	1
Moderate	High	II A	6
Moderate	Moderate	II B	7
Moderate	Low	II C	8
Low	High	III A	7
Low	Moderate	III B	2
Low	Low	III C	9
Grand Total			45

Source: Pat Lapcevic, Ministry of Environment, 2010.

Examples of highly vulnerable bedrock groundwater systems include Shawnigan Lake aquifer and the Malahat aquifer. Bedrock fracture aquifers are particularly vulnerable to surface contamination because of the rapid flow of groundwater, and they require the preservation of soil cover and vegetation to maintain their water storage capacity. In addition, wells close to marine shorelines are susceptible to saltwater intrusions; this form of vulnerability is relatively unpredictable.

85 Warnock et al., 2010.

Thetis Island Aquifer

There are four aquifers and 295 wells recorded on Thetis Island. A survey of the ambient groundwater quality of Thetis Island aquifers was undertaken in 2008 by obtaining groundwater samples from 48 private wells on the Island and analyzing the water for a comprehensive suite of chemical and biological constituents.[85] Overall, the study found that the quality of the groundwater met the standards established by the Guidelines for Canadian Drinking Water Quality (GCDWQ) in over 90% of the health-based parameters. Fluoride was the only parameter detected above the guidelines in four samples. In one sample, arsenic was measured at 9.3 µg/L (standard is < 10 µg/L).

Lower Cowichan River Aquifer A

This aquifer is an unconfined, shallow but very productive aquifer which is generally overlain by the City of Duncan, Cowichan Tribes IR 1, portions of CVRD areas E and D, and North Cowichan. Between 2002 and 2007, the Ministry of Environment carried out a study of the ambient quality of the groundwater in this aquifer.[86] Overall, the groundwater quality met the water quality guidelines for most parameters and sampling dates. At one site, iron and manganese were measured on one occasion (December 17, 2002) at levels above the GCDWQ, but at much lower concentrations on subsequent sampling dates. Nitrate in the groundwater at one site increased from 0.94 mg/L to 2.1 mg/L over the course of the study. This increase is not statistically significant, but may be a reflection of chronic pollution in this system. The source of this additional nutrient and the ecological significance is unknown.

In addition, the Ministry of Environment maintains 10 observation wells in the CVRD and uses these to continuously monitor groundwater conditions. These wells monitor groundwater levels in seven different aquifers (six sand and gravel, and one bedrock). [87] Two examples of these 10 observation wells are highlighted below:

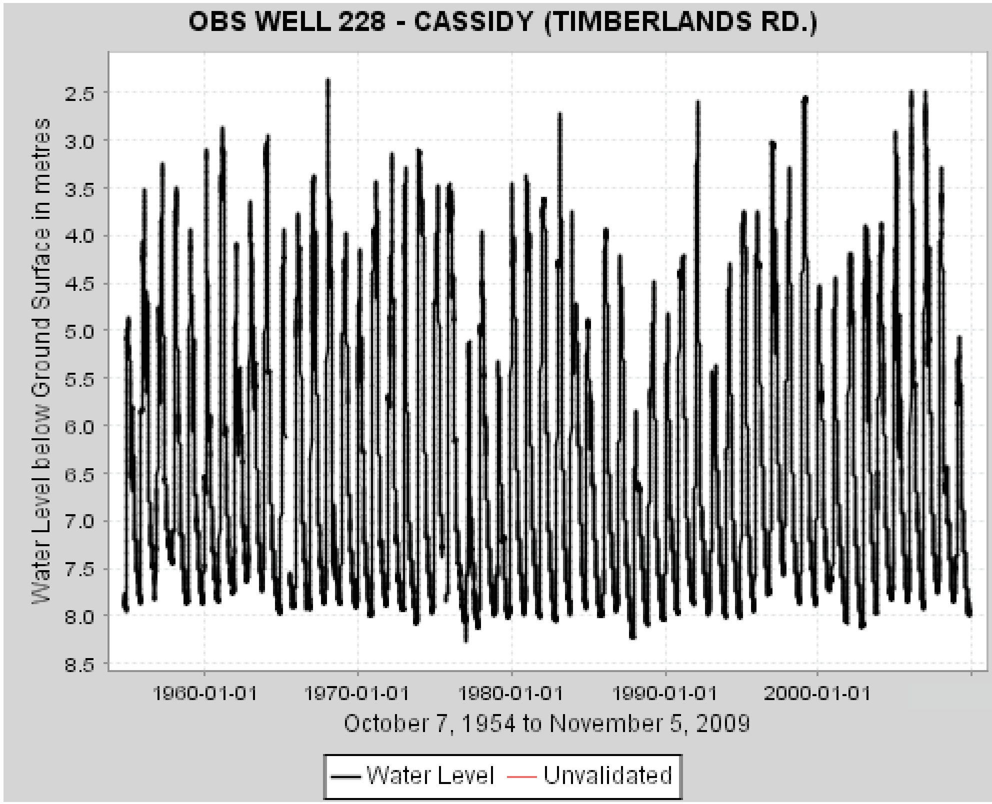
Cassidy (Well 228)

This well has been monitored for about 55 years, which represents the longest record in this area. Figure 2.32 shows the annual variation in water level, ranging from 2.5–5.5 m (most years the range is between 4 and 5 m). The annual minimum levels are consistently about 8 m below ground surface while the highs range from 2.5 m below ground surface to about 5.75 m below ground surface. This aquifer is not showing any signs of stress or unsustainable pumping, with the variations likely due to precipitation inputs in the "wet season" and discharge to the Haslam Creek in the summer.

86 Henderson and Lapcevic, 2010.

87 The data is publicly available at a100.gov.bc.ca/pub/gwl/disclaimerInit.do

FIGURE 2.32: Hydrograph (water levels) for the Cassidy Observation Well

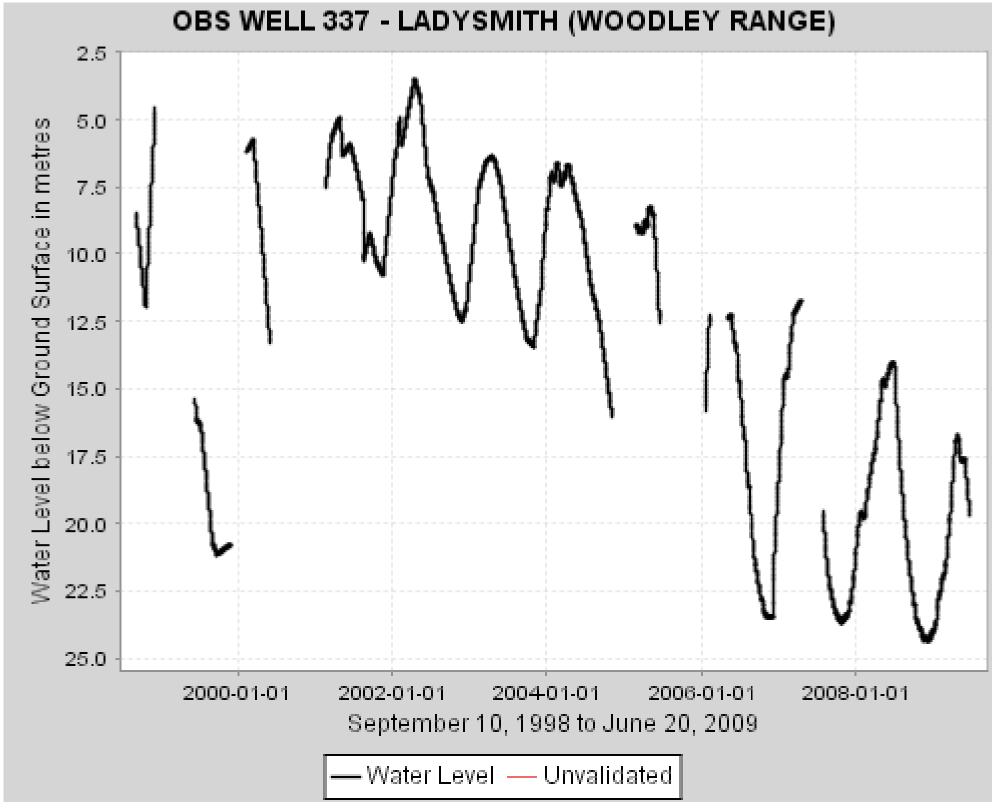


Source: Ministry of Environment, 2010.

Ladysmith (Well 337)

Figure 2.33 shows the water levels over a 10-year period for this well, with annual variability in water levels clearly visible. However, there is also a trend in reduced water levels for both maximum and minimum levels through time, with water levels in 2009 the lowest seen over this 10-year period. It is difficult to pinpoint whether these trends are a result of increased demand over time, or whether they reflect the low precipitation levels over the last period of years, or some combination of the two factors. Drying trends from climate change may influence this hydrologic system into the future. A continuation of this declining trend will result in continued impacts to the availability of water from this aquifer.

FIGURE 2.33: Hydrograph for the Ladysmith Observation Well



Source: Ministry of Environment, 2010.

It bears repeating that over 30% (17 out of 45) aquifers in this region are inherently vulnerable. Of these, 10 are highly or moderately developed today. Water quality in the areas sufficiently studied to comment on is generally good, although a few instances of contamination above drinking water standards are noted.

None of the studies comment on how aquifers interplay with other water resources, so effects on biological components of the system are unknown.

Surface Water Quantity

Indicators and Measures

> Water quantity indicators in this section focus on:

> Water quantity in the Cowichan River

> Water quantity in Shawnigan Creek

Findings

In general, many of the ecosystems within the CVRD maintain largely healthy functional aquatic ecosystems, with sufficient water levels. However, on some of the major river systems, the combined effects of human barriers (such as weirs or small dams) affecting patterns of flow throughout the year, water withdrawals for residential and industrial use, and natural or climate change-driven trends in water availability are raising concern.

Cowichan River / Watershed

The Cowichan River is critically important for fisheries values, and so a great deal of effort has been expended to gather extensive information on its water levels and whether they are sufficient to maintain fish populations. The Cowichan system is a rain-dominated system, so low-flow levels in the river naturally vary with levels of precipitation (in contrast to snow-dominated systems, which are buffered more by levels of snowpack).

In 2004, there were 667 water licenses in the Cowichan and Koksilah watersheds[88]. Catalyst Paper was the largest licensee with 83% of volume licensed. Demand for water from these licenses peaks during the months of lowest flow (typically the late summer/fall) in the system, which coincides with the critical flow periods required to maintain fisheries values and recreation opportunities. In a number of recent years, conflict between maintaining water supplies for industrial use and maintaining minimum levels to allow for the rearing and migration of salmon has become critical.[89] In many years salmon are stranded in side channels in the lower reaches of the system as these side channels dry up (see also Section 2.5). The cascading effects on other freshwater aquatic values are unquantified but are likely to be significant, particularly in these critical periods.

South Cowichan / Shawnigan Watershed

In the South Cowichan/Shawnigan area, there is significant water demand for agricultural uses – around 15 million cubic metres (m^3) annually, compared with 7 million m^3 for residential use, and 3 million m^3 for other urban uses. The relative proportion of ground versus surface water use is unknown here, since groundwater use is largely unmonitored. In general, there currently appears to be sufficient water to maintain these use rates. However, as with the Cowichan River, summer low-flow levels in Shawnigan Creek are sufficiently low that they are considered detrimental to aquatic system health[90] because, in some years, insufficient water can be stored to maintain both the highest use time and maintain downstream values. This negative effect on ecological systems is expected to increase as human demand increases through time.

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88 LGL, 2005.

89 W. Luedke, Department of Fisheries and Oceans, personal communication, 2010.

90 WorleyParsons, 2009.

In addition to actual water flow, historic and ongoing changes to riparian ecosystems alter the natural ability of the land to moderate or buffer the flow of water from upland areas into streams, rivers and groundwater storage aquifers. In addition, the hydrology of the land has been altered significantly by tree harvesting and road building to date. The third-pass harvesting that is starting in many areas will again alter the interception of rainfall, affecting water flow rates, and factors such as sedimentation that can have significant impacts on aquatic ecosystems.

Climate change is predicted to alter historic patterns of precipitation, with a good probability that at least summers will be drier than historically (some climate models also suggest that winter precipitation patterns are expected to increase). As this combines with an ever-growing demand by the human population, the pressures on natural aquatic systems will increase, resulting in increased potential conflict between maintaining aquatic functioning and human water requirements.

Surface Water Quality

Indicators and Measures

Measuring water quality is complex. Pure H_20 is rarely – if ever – found in nature. The concept of "quality" (defined by the amount of additional nutrients, metals, and/or sediments) varies both naturally and as a result of pollution by humans. Some natural water can kill those who drink it. However, in nature, species have adapted themselves to this natural variability and some have even evolved to live in water that is toxic to most other living things.

With respect to ecological values, measuring water quality is best reflected by directly measuring the levels and toxicity of pollution – this can include industrial waste, fecal matter, and even apparently harmless "sediment" that can result in decreased habitat quality in the water column for many species. However, measuring pollutants themselves is an almost impossible task, and typically more indirect indicators are used for water quality.

Measuring the health of the aquatic invertebrates that live in water is an effective example of an indirect indicator of water quality. These tiny animals – aquatic worms, the larvae of many aquatic insects, and many molluscs – live on aquatic plants and debris, in sediment, and in rock cavities at some point in their lifecycle. They are an essential part of the food chain (providing food for fish), and they feed directly on algae at the bottom end of the food chain. They can therefore be influenced by changes above and below them in the food chain. They are a good indicator of water quality because they are relatively sedentary and cannot move away from sources of pollution or sediment, and are relatively long-lived – allowing the effects of contamination to be observed over time. Ideally, monitoring the benthic invertebrates provides a robust understanding of water quality; typically, however, these data are often not readily available.

Where data exist, Aquatic Life Criteria can be used to set standards for a wide range of ecological parameters intended to maintain aquatic functioning. In addition, there are many indicators for which standard water quality guidelines or river/lake system-specific guidelines are mandated.[91]

More typically, water quality is measured in relation to human drinking water needs. The Ministry of Environment uses water quality guidelines that apply to all bodies of water, unless site-specific parameters have been set. In some cases, standards for drinking water – such as fecal coliform levels – may also reflect ecological concerns. For example, the additional nutrients present in low levels of sewage waste can over-stimulate algal growth, which has the effect of reducing the levels of dissolved oxygen in water. This affects the natural benthic community present in the ecosystem, and can result in impacts on or death of aquatic life due to lack of oxygen. Typically, this is noticed when it gets to the "fish kill" stage. Using drinking water standards to understand the ecological significance of pollution is therefore a weak indicator.

In this section, a variety of indicators are presented by watershed or components of a watershed. These indicators provide water quality results from both Aquatic Life Criteria standards and drinking water standards.

Findings

Cowichan and Koksilah Watersheds

Cowichan Lake is a naturally resilient water storage system. Its depth and relatively large size result in a fairly stable system able to regulate water temperature and assimilate localized nutrient inputs from local septic systems and new development. Using short-term trends for available standard indicators, water quality in the lake remains generally good.[92]

The Cowichan River water quality is also generally considered good. Many indicators are measured, and only a few of these do not meet thresholds, at some limited time periods. The dissolved oxygen objective was not regularly attained in the lower reaches of both the Cowichan and Koksilah Rivers, and chlorophyll-a (a measure of algal growth) has exceeded its objective in the lower portion of the Cowichan River. One consistent water quality issue is that both the Cowichan and Koksilah Rivers exceed fecal coliform bacteria levels frequently, making the river water undrinkable (Figure 2.34).[93]

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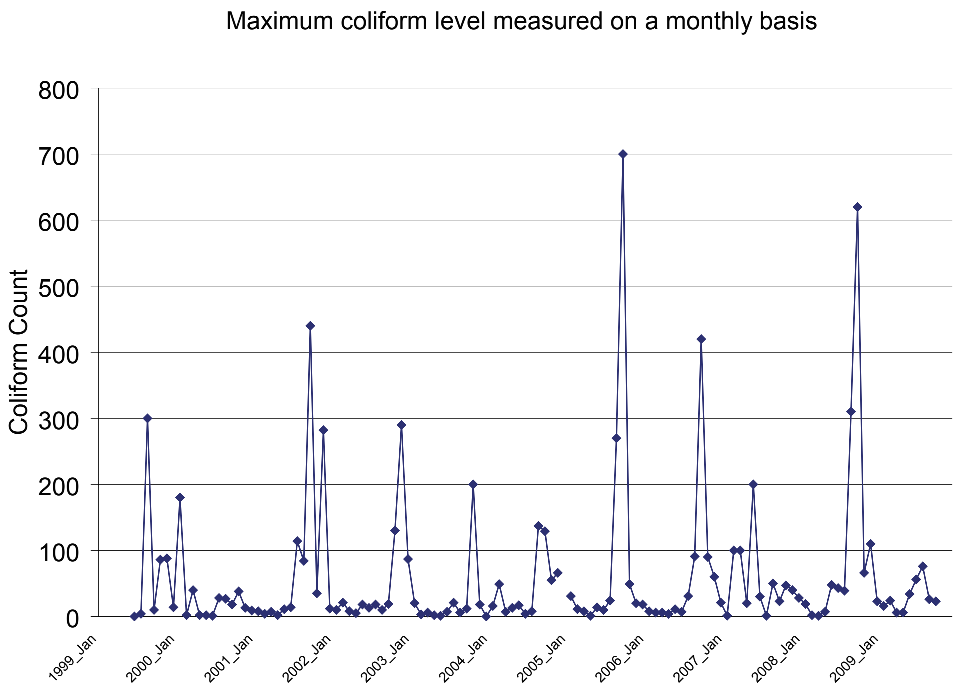
91 www.env.gov.bc.ca/wat/wq/BCguidelines/approv_wq_guide/approved.html

92 www.bclss.org/library/cat_view/60-bclsmp-lake-reports/82-level-1.html and Deb Epps, Ministry of Environment.

93 Rideout et al., 2000.

FIGURE 2.34: Maximum coliform levels measured by month for the Cowichan River, over 10 years



Note: Shows the variability in the data, with averages being very low (typically lower than the standard), with fairly frequent spikes.

Source: Analysis of data from Water Survey of Canada hydrometric station BC08HA0018 on the Cowichan River.

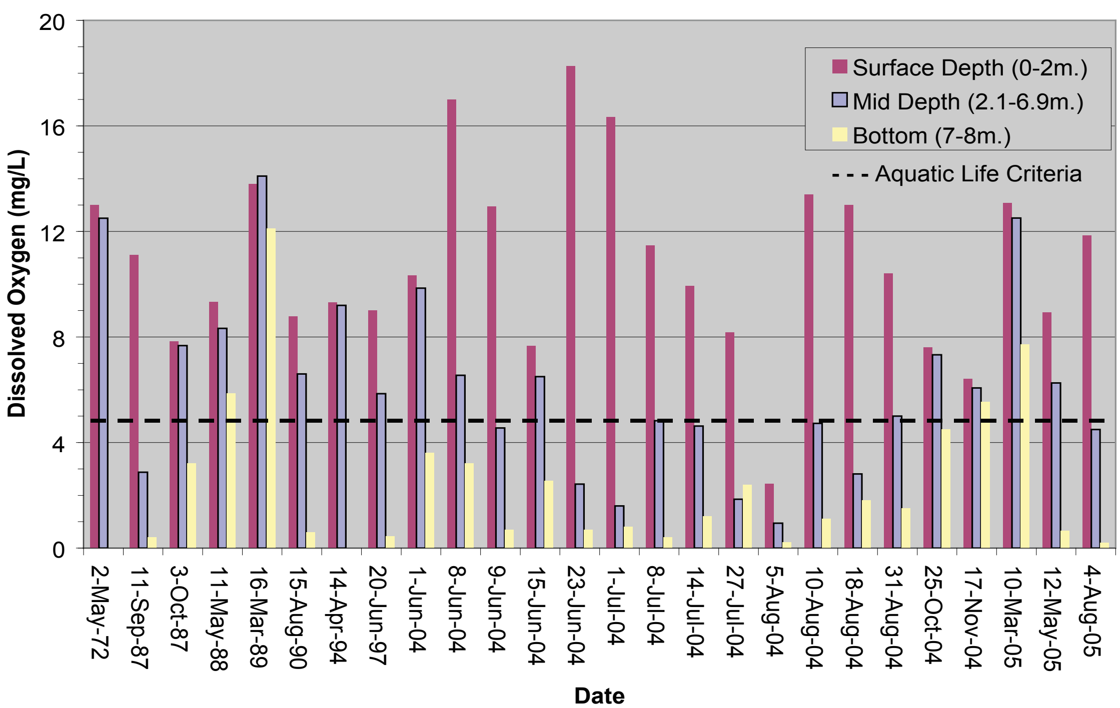
The Cowichan and Koksilah Rivers frequently exceeded human drinking water standards for fecal coliform bacteria. Currently the two sewage facilities that discharge into the Cowichan do not appear to be significant contributors to this situation. Instead, other “non-point” sources appear to be largely responsible, including inputs from leaky septic systems and stormwater run-off. These water quality issues appear to have downstream impacts in the high-value Cowichan estuary/bay area (see Cowichan Estuary discussion in Section 2.2). In addition, the impacts of higher nutrient loads in the Koksilah River are exacerbated by the lack of significant lakes flowing into it and the slow-moving warm water in this system. It is largely unknown what long-term impacts this will have on aquatic life.

The levels of metals and other toxic substances such as oil, grease and hydrocarbons in the Cowichan and Koksilah Rivers are generally low, though on occasion there were comparatively high concentrations of these contaminants measured in a number of stormwater conduits in urban and industrial areas of the watersheds.

Quamichan Lake

Quamichan Lake is located in a sub-basin of the Cowichan watershed. Its natural properties tend to result in high nutrient levels within the lake system, with external sources also affecting nutrient levels. An analysis of water quality in relation to both drinking water standards and aquatic life standards has been completed for this lake.[94] As with the Cowichan and Koksilah watersheds, certain Aquatic Life Criteria[95] were not met for various measures in some years in Quamichan Lake: dissolved oxygen levels (see Figure 2.35), temperature for trout rearing, phosphorus levels, total copper levels and total iron levels. These measures can have significant impacts on the functioning of the aquatic system – for example, dissolved oxygen levels affect the fish population, with "fish kills" periodically occurring at Quamichan Lake. Such events can occur naturally in shallow, nutrient-rich lakes such as Quamichan, as algal blooms reduce oxygen levels to below those needed for other biodiversity, and can be exacerbated by external factors such as temperature, and by the input of additional nutrients from sources such as septic fields.

FIGURE 2.35: Dissolved oxygen averaged with depth at the Quamichan Lake deep station site (1972 – 2005)



Note: The Aquatic Life Criteria are shown as a dotted line.

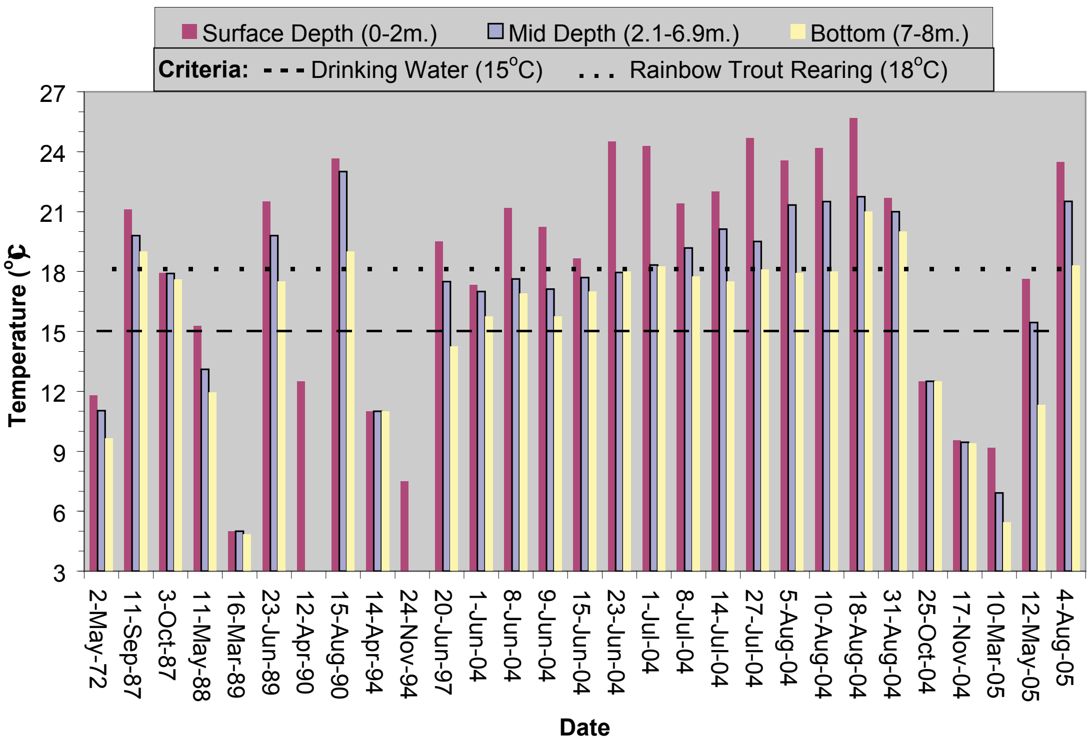
Source: McPherson and Epps, 2006.

94 Deb Epps, Ministry of Environment, personal communication, 2010.

95 McPherson and Epps, 2006.

Regarding drinking water criteria, water quality in Quamichan Lake has been identified as poor – with some of the poorest readings to date being recorded in recent years (2004 and 2005). The lake did not meet standards in some years for samples associated with temperature (see Figure 2.36), and for other values such as acidity levels, turbidity levels, organic carbon levels, phosphorus levels and fecal coliform levels.

FIGURE 2.36: Temperature data for Quamichan Lake – 1972 to 2005



Note: Two different comparison standards are shown – drinking water criteria, and Aquatic Life Criteria (rainbow trout rearing).

Source: McPherson and Epps, 2006.

Overall, productivity in Quamichan Lake appears to be increasing over the last decade, compared to the 1990s. The natural shallowness of the lake, combined with an increasing nutrient supply (both natural and from pollution) and warm weather conditions, are all working together to result in negative consequences for both ecological and human systems. Long-term data is unavailable, so a comparison of natural patterns of productivity over time is not possible. However, a trend to warmer temperatures outside the natural range has been identified, and this trend exacerbates the effects of increased nutrient levels, often with dire consequences for aquatic ecology.

Shawnigan Lake

The Shawnigan watershed is primarily forested, with approximately 10% in the Agricultural Land Reserve. The majority of the lakeshore is developed with some form of housing. Much of the forest in the watershed was harvested in the early 1900s, and additional harvesting – sometimes a third rotation – is ongoing today. The number of people living in this area has increased over the last 30 years.

Historically, conditions within the lake are thought to have changed with land use. For example, it is thought that a significant change in algae patterns occurred in the lake around the 1930s, likely as a result of the intensive logging and settlement occurring at that time. It is also hypothesized that a lack of oxygen in the lake observed in the 1970s may have resulted from the decomposition of excessive wood waste that was dumped into the lake from early harvesting practices.[96]

In relation to drinking water quality, in 1984, higher levels of fecal contamination were found in samples from the near shore than in deep water sites, with inflow areas showing the highest levels of contamination.[97] In the more recent analysis of 2004[98], most lake sampling sites met drinking water guidelines (with disinfection only) during summer low flow, but all lake sites exceeded drinking water guidelines for E. Coli and fecal coliforms sampled in the fall and on all inflows sampled during the summer low-flow period. Various factors may contribute to this, including livestock and waterfowl, inefficient septic systems and storm-water runoff. However, the primary factors are thought to be failing local septic systems combined with heavy rain events.

The west arm of Shawnigan Lake is identified as being of particular concern because of its isolation from the main body of the lake and its relatively shallow nature, making it more susceptible to increasing nutrient inputs. However, in the "big picture," Ministry of Environment water monitoring shows water quality in Shawnigan Lake to be reasonably high most of the time.

Shawnigan Lake has also been the site of detailed water quality monitoring through the University of Victoria[99], and has been compared to the adjacent Sooke Lake. Analysis of sediment cores provides a timeline of 100 years for many indicators of water quality. These two lakes are adjacent to one another, and have similar natural features. However, Shawnigan Lake has seen systematic development over the last 40 years compared with the relatively protected state of Sooke Lake. Much like the Ministry of Environment data, the broad findings of the University of Victoria studies generally suggest that water quality remains overall relatively good in both lakes. However, these studies also point to a trend of increasing concentrations of many chemicals, such as pharmaceuticals and caffeine in Shawnigan Lake, as well as human feces traces in

96 Nordin and McKean, 1984.

97 Nordin and McKean, 1984.

98 Rieberger et al, 2004

99 Azit Mazumder, University of Victoria, personal communication, 2010.

the depths of the lake. Many of these chemicals are not tracked by standard sampling regimes (e.g., those employed by the Ministry of Environment), and their detection suggests that there is an ongoing negative trend towards poor water quality in Shawnigan Lake that began in the mid-1970s as development started, and that this quality is getting increasingly poorer through time.

Summary

Water is essential to all life. Yet measuring, monitoring and understanding patterns and trends for water is complex and difficult. Based on relatively localized and short-term information, there is a general sense that there is lots of water within the CVRD most of the time, and that it is of reasonably good quality most of the time. However, some of the key groundwater aquifers in the Cowichan Region are naturally vulnerable, and an increasingly large number of them are becoming heavily developed. In addition, at critical periods and particularly in dry years, the conflict for water can become acute – leading to the potential for significant conflicts between values, and resulting in the need to choose between impacting crucial aquatic resources such as fish spawning, or industrial processes such as the mill. The level of pollutants, as measured using standard monitoring, typically is low; however, major rivers are no longer considered fit to drink due to fecal coliform counts, and cumulative downstream impacts have led to the closure of shellfish fisheries since the 1970s.

Naturally vulnerable lakes such as Quamichan already show significant impacts by pollution from a variety of sources. Cowichan Lake, on the otherhand, is buffered by its large size and depth. However, cumulative effects are difficult to detect and often not observable until significant events such as "fish kills" are observed.

All these trends are cause for concern, and are highlighted when detailed long-term sampling is undertaken. The case study of Shawnigan Lake, which has seen significant development since the 1970s, illustrates the impacts of cumulative low-grade pollution over time. The collective understanding of how such changes affect the basis of ecological food chains requires more work.

Climate change is expected to exacerbate these impacts. Drying trends, especially during current low-flow periods, and increasing air and therefore water temperatures, will result in a myriad of future impacts.

Missing Information

As outlined in each section, although much data are collected, there remains a lack of comprehensive understanding of the ecological health of the aquatic systems of the Cowichan Region.

Directly measuring how much water is used by humans would help us to understand the state of aquifers today, and to identify potential critical thresholds into the future.

The long-term monitoring of aquifers, aimed at explaining limiting factors (e.g., how precipitation will affect future water sources), is also needed.

Many small and large systems within the CVRD lack data. For example, summarised data for the Nitinat River in the west part of the region and the Chemainus watershed in the east are unavailable at this time. In addition, many smaller lakes and rivers in the region have not seen any data collection focus, yet some impacts on water availability and quality are suspected. This raises a number of questions, such as:
What are the long-term trends for smaller streams such as Holland Creek that supply significant drinking water for Ladysmith? What are the implications of North Cowichan pumping water into the Fuller Lake to "flush" high nutrient levels?[100] Where do these nutrients go, and how will this continue if water supplies decrease with climate change?

100 John Deniseger, Section Head, Environment Quality Section, Ministry of Environment, personal communication, 2009.

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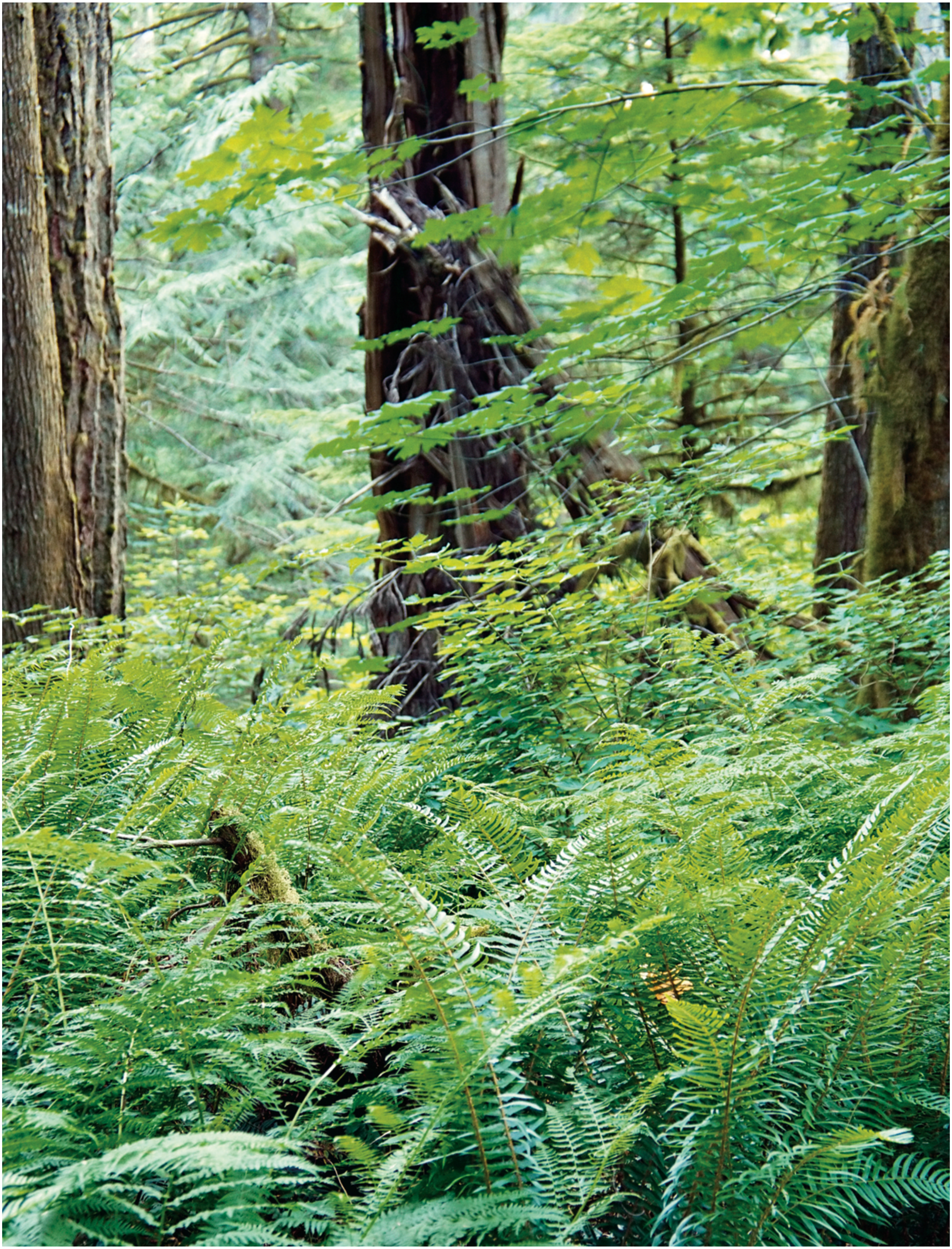


2.7 Air Quality

Introduction

Air Quality in the Cowichan Valley Regional District

Air quality is directly related to human and ecosystem health. The effects of air pollution on human health include compromised breathing, the aggravation of existing respiratory and cardiac conditions, reduced lung function, and premature death. Poor air quality harms ecosystem diversity when the deposition of pollutants inhibits the functioning of plants, animals and aquatic life.

Some of the main sources of air pollution in the Cowichan Region include: light and heavy-duty vehicle emissions, open burning of woody debris from forest harvesting operations and land clearing, woodstove and backyard burning emissions, agricultural operations, and commercial/industrial emissions.[101]

Local air quality is also compromised by what goes on outside the boundaries of the region; Cowichan's airshed is part of the much larger Georgia Basin-Puget Sound airshed (Figure 2.37). Weather patterns within this larger airshed circulate air pollution from surrounding jurisdictions into the Cowichan Region and vice versa.

FIGURE 2.37: The Georgia Basin-Puget Sound airshed

Source: Environment Canada.

101 Environment Canada.

Measuring Air Quality

Reliable ways of measuring air quality in the Cowichan Region include monitoring levels of particulate matter, ground-level ozone and other key emissions in all segments of the region, and tracking respiratory-related hospital admission rates for children.[102]

Crofton's Catalyst Paper mill operates three monitoring stations in the Crofton/Maple Bay area as part of its emission permit. The Ministry of Environment operates a fourth station, on Cairnsmore Street in Duncan (Figure 2.38). These stations record emissions such as fine particulate matter, ground-level ozone and nitrogen dioxide. Note: The Crofton South monitoring station was closed in 2008, and replaced with the Escarpment Way station.

The Vancouver Island Health Authority tracks hospital admissions for children with respiratory problems.

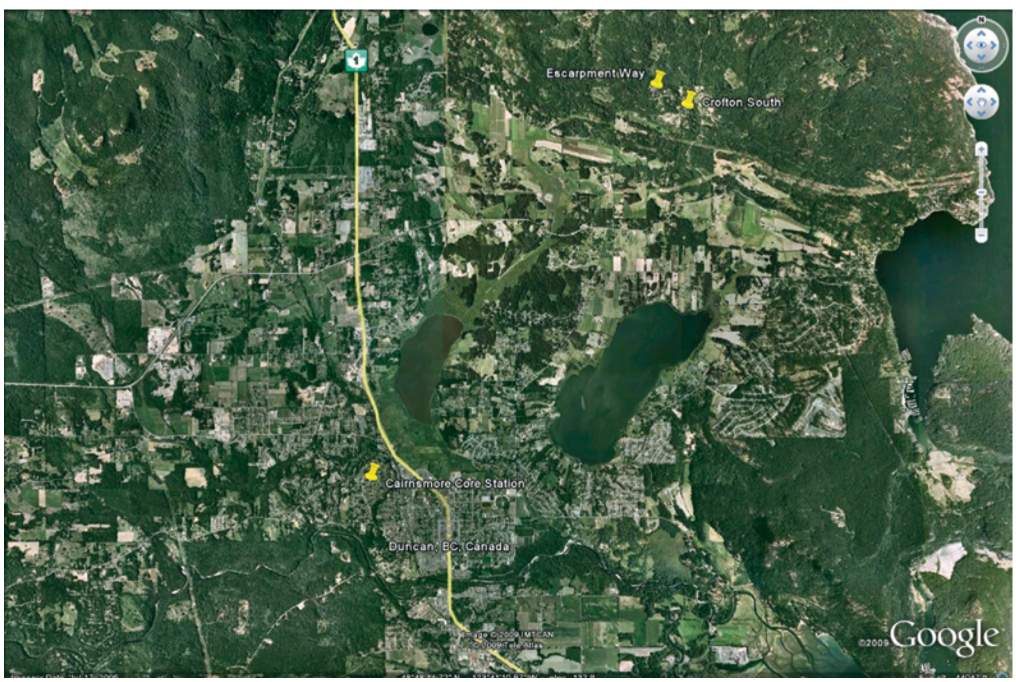
Indicators included in this report are:

> Air Quality Index (AQI)

> Fine particulate matter ($PM_{2.5}$)

> Hospital admissions (for children aged 0-14 years)

FIGURE 2.38: Air quality monitoring station locations in the Cowichan Region



Source: Ministry of Environment.

102 Ozone is considered to be a very good indicator of respiratory health (whereas fine particulate matter, or $PM_{2.5}$, is a good measure of cardiovascular health), Glen Okrainetz, Director of Air, Health Protection Branch, BC Ministry of Healthy Living and Sport, personal communication, 2010.

Air Quality Index

Indicator and Measures

The BC Ministry of Environment has been collecting Air Quality Index (AQI) data since the mid- to late-1990s at three monitoring stations: Crofton Substation, Deykin Avenue and Crofton South (replaced in late 2008 by Escarpment Way). In November 2009, the Ministry of Environment installed a new station on Cairnsmore Avenue in Duncan to collect urban air quality data using BC's new Air Quality Health Index (AQHI).

The Air Quality Index (AQI) continually measures six parameters, and reports out daily on the highest single parameter, relative to its objective or break-point (Table 2.13). By comparison, the new Air Quality Health Index (AQHI) reports out every three hours, and is an amalgamation of all measured pollutants.[103]

The AQI is interpreted using the following scale: good (0 to 25), fair (26 to 50), poor (51 to 100) and very poor (100+).

TABLE 2.13: Air Quality Index parameters and objectives

Parameter	Sulphur Dioxide		Carbon Monoxide		Nitrogen Dioxide	Ozone	Particulates <10 micrometers	Particulates <2.5 micrometers
Averaging Time	1 Hour	24 Hours	1 Hour	8 Hours	1 Hour	1 Hour	24 Hours	24 Hours
Unit of Measure	ppm	ppm	ppm	ppm	ppm	ppm	ug/m^3	ug/m^3
Break-point:								
AQI = 25	0.17	0.06	13	5.0	0.105	0.05	25	15
AQI = 50	0.34	0.11	30	11.0	0.210	0.08	50	25
AQI = 100	2.00	0.30	64	17.4	0.530	0.15	100	50

Source: BC Ministry of Environment a100.gov.bc.ca/pub/aqiis/aqi.bulletin

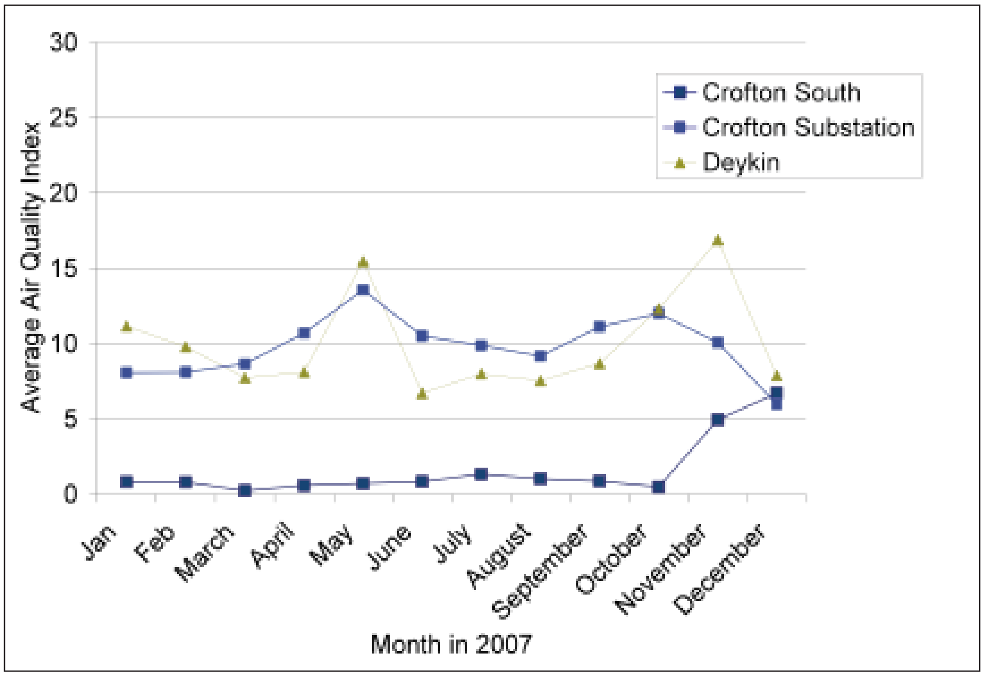
The AQI data is reliable and repeatable, and will be enhanced by AQHI data from the Duncan monitoring station.

103 BC's new Air Quality Health Index measures the combined effect of three contaminants felt to have the most direct impact on human health: nitrogen dioxide, ozone, and fine particulate matter ($PM_{2.5}$ and PM_{10}). Measurements are reported over a shorter term (the AQHI has a 3-hour running average versus the Air Quality Index's 24-hour average), and are therefore felt to provide more timely information for people with respiratory problems.

Findings

The most current and complete annual Air Quality Index (AQI) information available was for the year 2007. The data for 2007 indicate that the region's overall air quality is "good" according to the AQI scale (AQI=0 to 25). A monthly breakdown of data shows AQI readings well below the 25 mark (Figure 2.39). Hourly readings show that air quality only occasionally moves into the "fair" range (AQI=26 to 50) (Table 2.14).

FIGURE 2.39: Air Quality Index monthly readings for 2007



Source: Ministry of Environment.

TABLE 2.14: Number of "hourly maximums" in 2007 when AQI surpassed break-point of 25

Month	Crofton South	Crofton Substation	Deykin Avenue	Percentage of hourly AQI readings over break-point of 25
Jan	0	0	25	3.4%
Feb	0	0	26	3.9%
March	0	0	0	0%
April	0	33	0	4.6%
May	0	18	43	8.2%
June	1	25	0	3.6%
July	0	0	0	0%
August	0	0	0	0%
September	0	0	0	0%
October	0	0	19	2.6%
November	7	0	86	13%
December	19	0	0	2.6%
Total	27	76	199	3.4%

Note: Air Quality Index readings are taken every hour of every day, for a total of 24 readings per day and approximately 720 readings per month. This means there can be up to 24 hourly maximums that surpass an AQI of 25 in one day.
For example, all but one of the instances where the AQI surpassed the break-point of 25 at the Deykin Avenue monitoring station could have occurred in a single day.

Source: Ministry of Environment Air Quality Index readings, 2007.

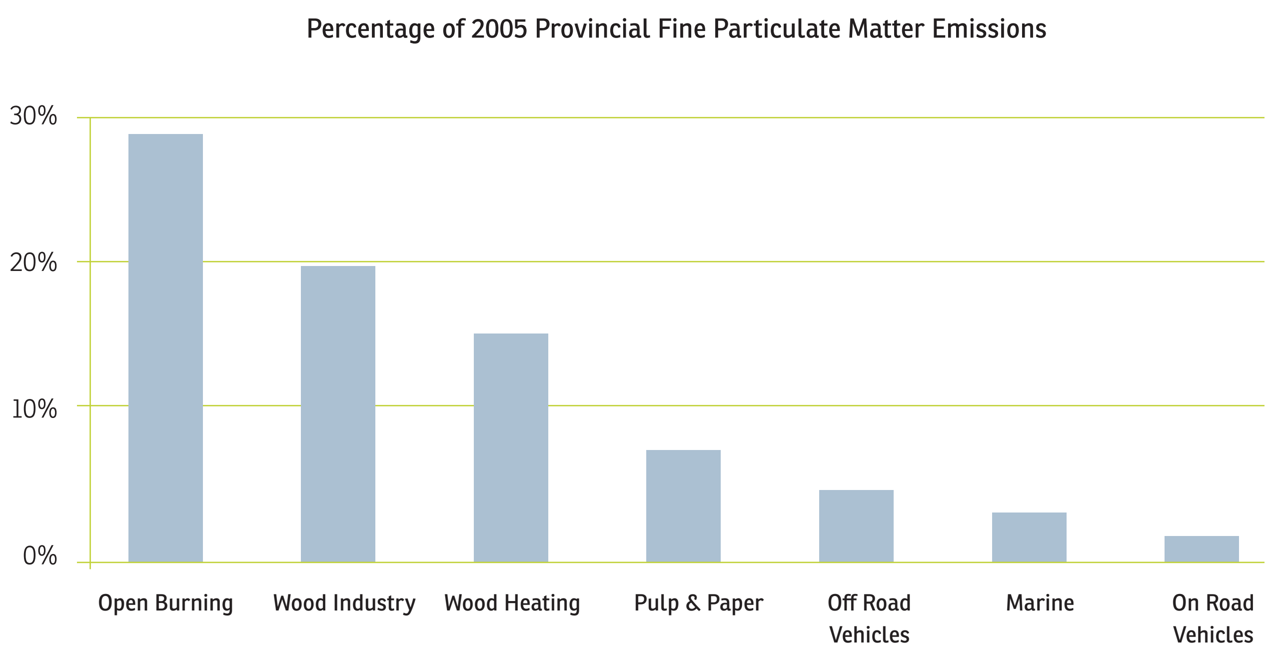
Fine Particulate Matter ($PM_{2.5}$)

Indicator and Measure

Fine particulate matter (also called $PM_{2.5}$ due to the size of the particles[104]) is one of the most important outdoor air pollutants in BC from a human health perspective, likely due to the fact that these very fine particles are easily inhaled and go deep into the lungs. $PM_{2.5}$ exposure is linked to a range of health impacts, including inflammation of the airways, more frequent use of medications, increased emergency room visits, hospitalizations and premature mortality.[105] People with heart or lung diseases, children and older adults are the most likely to be affected by particle pollution exposure.[106]

$PM_{2.5}$ comes from combustion sources, such as exhaust from vehicles (cars, trucks, buses), emissions from factories, and smoke from burning wood, land-clearing debris and garbage. Fine particulates also come from the reactions that transform some of the pollutant gases into solid or liquid particles (Figure 2.40).

FIGURE 2.40: Largest sources of $PM_{2.5}$ emissions in BC, 2005



Source: BC Lung Association State of the Air report, 2009.

$PM_{2.5}$ is measured using units of micrograms per cubic metre, and hourly readings are rolled up into a 24-hour average in order to compare to daily criteria.

104 The size of $PM_{2.5}$ particles is about 1/20th the width of a human hair.

105 BC Ministry of Healthy Living and Sport, June 2009.

106 US Environmental Protection Agency, accessed December 2009.

While no safe health thresholds for $PM_{2.5}$ have been identified[107], the provincial and federal governments have established $PM_{2.5}$ air quality objectives (Table 2.15). In addition, the Federal/Provincial Advisory Committee on Air Quality Objectives and Guidelines has developed an unofficial "Health Reference Level" for $PM_{2.5}$ that is an estimate of the lowest ambient $PM_{2.5}$ level at which statistically significant increases in health responses can be detected, based on available data and current technology.[108]

Two monitoring stations have been measuring $PM_{2.5}$ levels in the Cowichan Region since 2005: Crofton South (in operation from February 2005 to February 2008) and Escarpment Way (in operation since October 2008).

In addition, a temporary air quality monitoring site (called E-Sampler) affixed to the Cowichan Valley Regional District building in downtown Duncan collected $PM_{2.5}$ data from April 2008 to August 2009. This site has now been shut down, but its findings were useful in justifying the need for the new air quality monitoring site on Cairnsmore Street in Duncan. The Cairnsmore site is the first Air Quality Health Index monitoring site in the region, and has been gathering data, including $PM_{2.5}$ levels, since November 2009.

TABLE 2.15: $PM_{2.5}$ objectives

	Daily (24-hour period)	Annual mean	Annual voluntary planning goal
British Columbia standards	25 ug/m3	8 ug/m3	6 ug/m3
Canada-wide standards	30 ug/m3		
World Health Organization guidelines	25 ug/m3	10 ug/m3	
Health Reference Level	15 ug/m3		

Note: The Canada-wide standards are based on the 98th percentile annual ambient measurement over 3 consecutive years.

Source: BC Ministry of Environment, Environment Canada, World Health Organization.

The $PM_{2.5}$ data is accurate and reliable, and will be enhanced by new information currently being generated by the urban monitoring station on Cairnsmore Street in Duncan, and results from the CVRD's mobile aethalometer[109] testing, taking place in 2010.

107 BC Ministry of Healthy Living and Sport, June 2009.

108 National Ambient Air Quality Objectives for Particulate Matter. Part 1: Science Assessment Document. A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines.

109 An aethalometer is an instrument that provides a real-time readout of the concentration of soot particles in an air stream. These particles are emitted from all types of combustion, including diesel exhaust from vehicles and wood burning stoves.

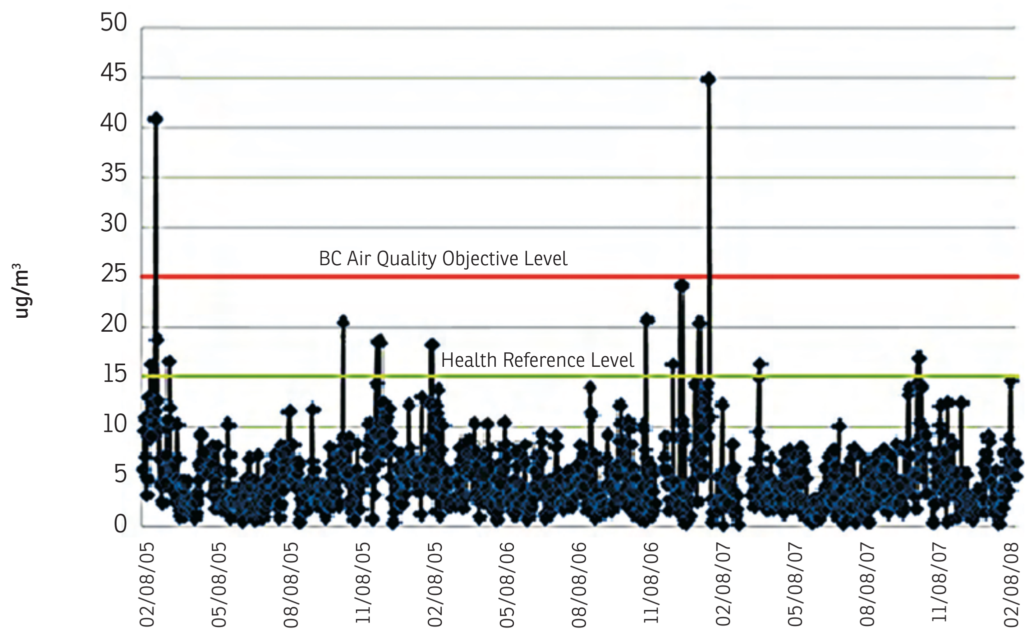
Findings

Levels of fine particulate matter ($PM_{2.5}$) are well below allowable levels, with some seasonal variation. Constant sources of $PM_{2.5}$ throughout the year include emissions from commercial/industrial processes and vehicle exhaust. In the fall and winter months, when additional sources of combustion are present (e.g., forest harvesting and land-clearing open-burning activities, woodstove use and backyard burning) and air inversions trap pollution at lower altitudes, air quality can diminish significantly. In spite of these seasonal pressures, levels of $PM_{2.5}$ remain within daily and annual objectives.

Daily levels of $PM_{2.5}$ measured at the Crofton South station have only exceeded provincial objectives two times in the last four years, and only in the winter months: in February 2005 ($PM_{2.5}$ =40.88 µg/m3) and in February 2007 ($PM_{2.5}$ =44.67 µg/m3) (Figure 2.41). Readings at the Escarpment Way monitoring station (which replaced Crofton South in 2008) have not exceeded provincial objectives, and surpassed the Health Reference Level on one occasion only (Figure 2.42).

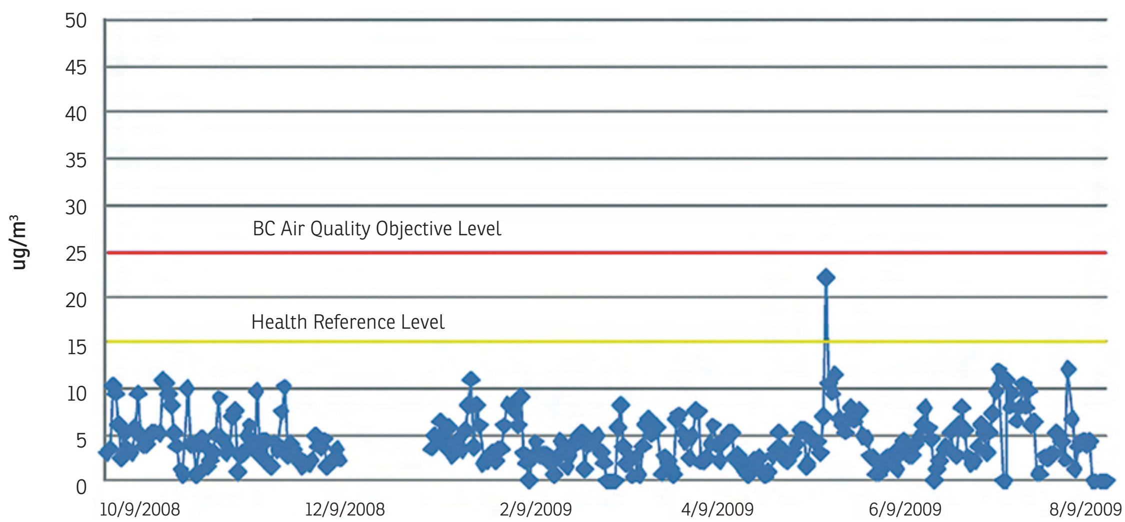
The E-Sampler station on the CVRD building recorded higher levels of $PM_{2.5}$ during the winter months, and had one reading in excess of provincial objectives in December 2008 ($PM_{2.5}$ = 36.67 µg/m3) (Figure 2.43). The Health Reference Level is frequently exceeded during the fall and winter months.

FIGURE 2.41: Crofton South daily $PM_{2.5}$ readings (February 2005 to February 2008)



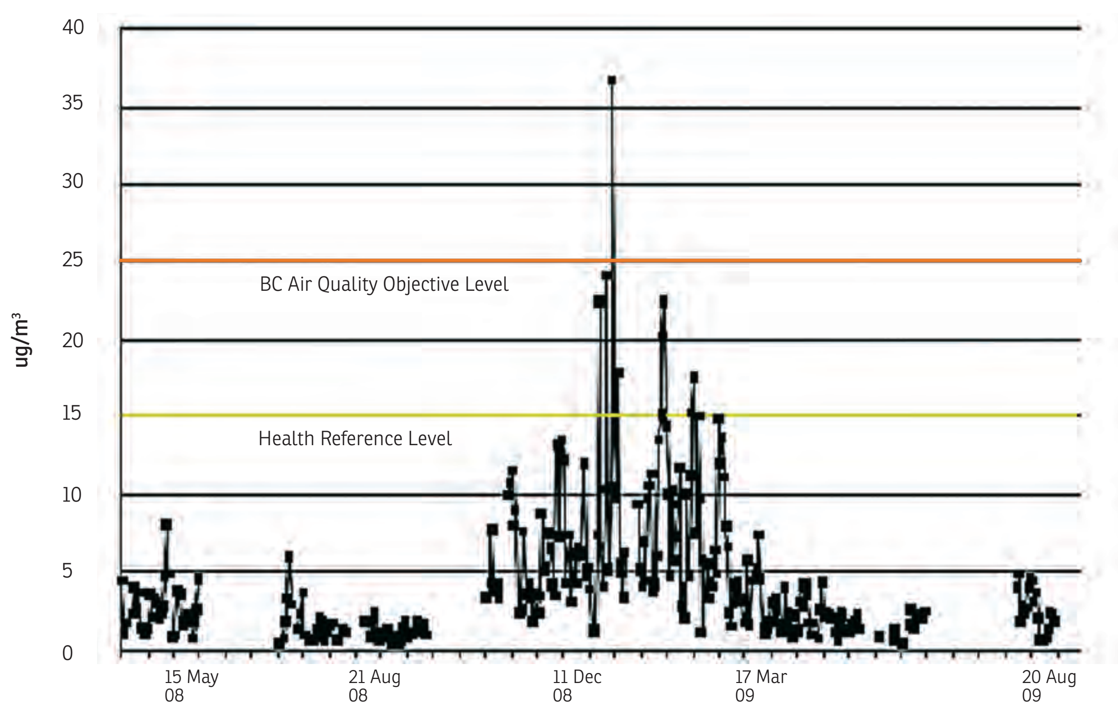
Source: Ministry of Environment.

FIGURE 2.42: Escarpment Way daily $PM_{2.5}$ readings (October 2008 to August 2009)



Source: Ministry of Environment.

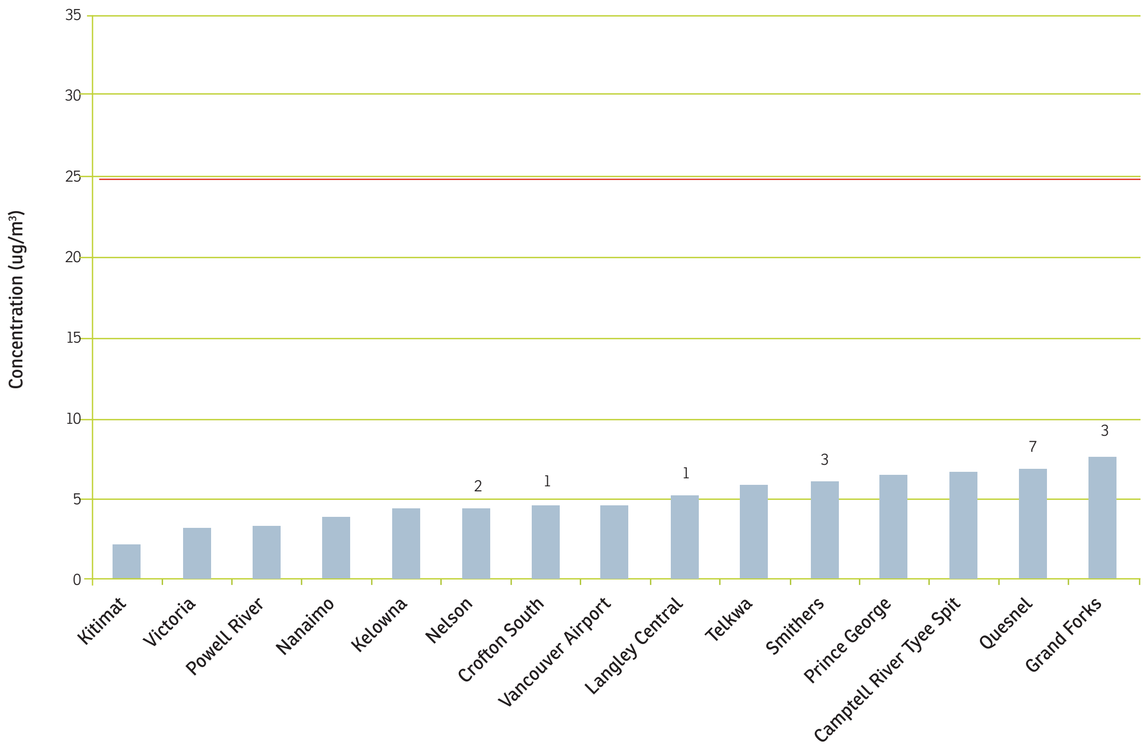
FIGURE 2.43: E-Sampler daily $PM_{2.5}$ readings (April 2008 to August 2009)



Source: Ministry of Environment.

The 2007 annual $PM_{2.5}$ level from the Crofton South station was 4.6 µg/m³, below BC's annual goal of 8 µg/m³. Using 2007 data from other BC communities, the Cowichan Region's air quality compares favourably, although it is generally higher than places such as Nanaimo and Powell River (Figure 2.44).[110]

FIGURE 2.44: Comparison of average concentrations of $PM_{2.5}$ in communities around BC, 2007



Note: The numbers at the top of the columns indicate the number of days in 2007 when $PM_{2.5}$ exceeded the provincial standard of 25 µg/m³.

Source: Ministry of Environment, Provincial $PM_{2.5}$ readings, 2007.

110 In order to determine whether or not a year of data is valid, the Ministry of Environment uses the "75% rule" that stipulates that each quarter of the year must have at least 75% data capture. Using this rule, the most current $PM_{2.5}$ data available for the Cowichan Region is for 2007.

Hospital Admissions (0-14 years)

Indicator and Measure

Air pollution causes measurable increases in the rates of hospitalization for people with respiratory and cardiovascular diseases, and for others who are considered more vulnerable to airborne pollutants, including children and seniors.[111]

Children respond to air pollution in different ways than adults, mainly because they take in more air – and thus more air pollution – per unit body weight when exercising than adults (20–50% more). In addition, children generally spend more time outside than adults. The impacts of poor air quality on children include respiratory problems such as airway irritation, coughing, and pain when taking a deep breath; wheezing and breathing difficulties during exercise or outdoor activities; aggravation of asthma[112] and increased susceptibility to respiratory illnesses like pneumonia and bronchitis; and suppressed lung growth.[113]

For these reasons, it is useful to assess air pollution levels by looking at the number of hospital admissions for children with respiratory problems.

The Vancouver Island Health Authority tracks annual hospital admissions for people between the ages of 0 and 14 years with "diseases and disorders of the respiratory system." This information is gathered at the region's three hospitals, and then broken out by patient geography and local health area.

The hospital admissions data is accurate and reliable, and could be enhanced by further disaggregation (e.g., by month, by respiratory disorder).

111 Health Canada website: www.hc-sc.gc.ca/ewh-semt/air/out-ext/effe/health_effects-effets_sante-eng.php#a6

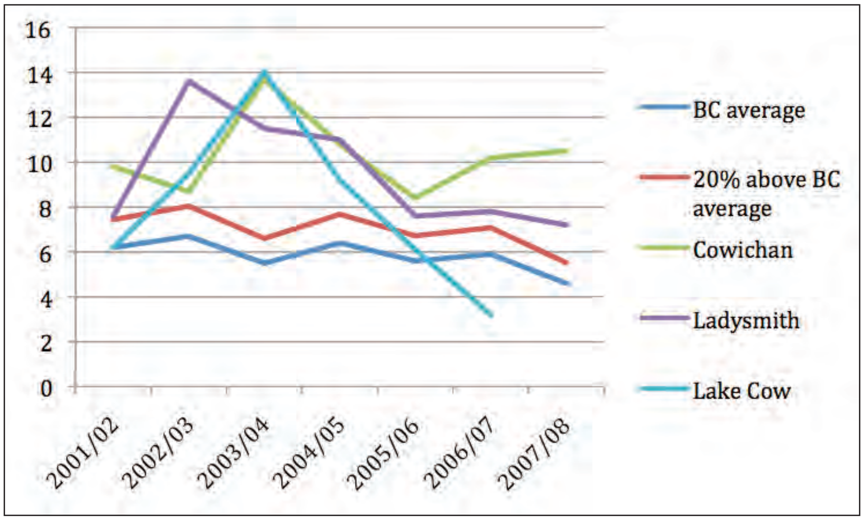
112 Children with asthma may be particularly vulnerable to air pollution at levels below current air quality standards. NIH/National Institute of Allergy and Infectious Diseases, Air Pollution Affects Respiratory Health In Children With Asthma, April 17, 2008.

113 US Environmental Protection Agency www.epa.gov/groundlevelozone/health.html. See also: Outdoor Air Quality–A Primer for Physicians (and Appendix), 2009. Prepared by the UBC School of Environmental Health and Centre for Health and Environment Research; BC Centre for Disease Control; BC Lung Association; and Ministry of Healthy Living and Sport. www.bc.lung.ca/airquality/airquality_primer.html

Findings

Hospital admission rates for children with respiratory problems in the Cowichan Region are higher than the provincial average – at times by a significant amount (Figure 2.45). The Vancouver Island Health Authority (VIHA) considers it problematic when admissions rates are at least 20% higher than the BC average.

FIGURE 2.45: Annual number of admissions per 1,000 people (case rate), by local health area, 2001 to 2008



Note: Lake Cowichan's case rate for 2007/08 was lower than the scale of this chart (meaning less than 1,000 people admitted).
Source: Vancouver Island Health Authority.

Summary

Air quality in the Cowichan Region is generally good, and pollution levels are well within provincial standards. However, there are no safe levels of air pollution, so significant human health impacts can occur even in relatively clean airsheds.[114]

Hospital admission rates for children with respiratory problems in the Cowichan Region seem to signal a problem. Admission rates are consistently more than 20% higher than the provincial average, and at times are twice this average.

114 A 2005 scientific study for the British Columbia Lung Association found that, even in areas with relatively low levels of air pollution, public health effects can be substantial and costly. This is because effects can occur at very low levels and a large number of people can potentially breathe in such pollutants. The study predicts that a 1% improvement in ambient $PM_{2.5}$ and ozone concentrations could result in $29 million in health care savings in the Lower Fraser Valley in 2010.

Seasonal variances in air quality are also of concern. Air quality diminishes significantly in the fall and winter months, due to increases in seasonal combustion (open burning and woodstove use). Sources of low-level air pollution throughout the year include vehicle exhaust and commercial/industrial emissions.[115]

Climate change has the potential to compound regional air quality. Predictions of drier, hotter summers and an increased possibility of forest fires could result in greater amounts of harmful dust and smoke particles.

Pressures on the Cowichan Region's air quality will continue to increase with a rising population and more economic activity. Mitigation of these pressures could come in the form of additional restrictions on backyard burning, "burn smart" public education campaigns, and region-wide support for smart growth principles that encourage compact, urban development and reduce reliance on vehicles.

The impacts of air pollution on Cowichan's ecosystem health appear to be negligible at present, however they are unquantified at this time.[116]

Missing information

Air quality monitoring stations are largely clustered around industrial activities in the Crofton area, and – with the exception of the new station in Duncan – do not capture information from other parts of the region. Future air quality monitoring stations and studies should be situated near major transportation corridors and areas of high woodstove use to capture other substantial sources of emissions. The CVRD's mobile aethalometer testing conducted in January 2010 will indicate whether a need exists for additional monitoring stations throughout the region.

Until recently, ground-level ozone has not been monitored in the Cowichan Region. The new Air Quality Health Index monitoring site on Cairnsmore Street in Duncan started measuring ground-level ozone in November 2009. Data generated from this site will provide vital information for subsequent State of the Environment reports. Ground-level ozone is a key determinant of human and ecosystem health, and can have devastating impacts on local economies, including significant crop damage. Ground-level ozone levels are at their worst during the summer months, when strong sunlight and hot weather trigger a chemical reaction that results in harmful concentrations.

115 This is based on modeling. Particle speciation can pinpoint actual sources of air pollution, but to date this technique has only been conducted in BC communities known to have serious air pollution problems, such as Prince George and Quesnel.

116 It is unlikely that current levels of air pollution are impacting the natural environment. Two measures of deposition-related impacts are acidification and nitrogen oxide emissions. A recent summary of data about Quamichan Lake water quality, compiled by the Ministry of Environment, suggests that acidification (measured by low pH levels) is not a concern. The BC Lung Association's 2009 Annual Report shows low levels of nitrogen dioxide in the Crofton area (less than 7µg/m3, which is well below the national objective of 60 µg/m3). These findings were validated via personal communication in 2010 with Earle Plain, Ministry of Environment Air Quality Meteorologist, who stated that regional sulphur and nitrogen oxide levels (contributors to acid rain or acidification) are extremely low and not problematic.

The usefulness of data on respiratory-related hospital admissions for children might be enhanced if records were available on a monthly basis. This might allow a more direct comparison with seasonal fluctuations in air quality (higher $PM_{2.5}$ in the fall and winter, potentially higher ground-level ozone in the summer).

VIHA is presently setting up the Cowichan Regional Health Network in order to identify health priorities. This network will bring together a wide variety of community leaders and health representatives, and will – among other things – try to identify the specific factors that are contributing to the Cowichan Region's higher-than-average respiratory admission rates.[117]

Health Canada is currently conducting a modeling study of the effects on human health of air emissions from the Canadian Pulp and Paper Industry. Crofton's Catalyst Mill is participating in the study. Findings should be available by mid- 2010, and may provide additional insight into regional health impacts of air pollution.[118]

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117 Mike Pennock, Population Health Epidemiologist and Co-Director of the Population and Public Health Observatory at the Vancouver Island Health Authority, personal communication, 2009.

118 Michelle Vessey, Manager, Environment and Technical Development, Catalyst Paper, personal communication 2009. See also: Air Quality Assessment of the Pulp and Paper Industry, PowerPoint Presentation by Gregory Crooks, M.Eng., P.Eng., July 14, 2009.