MOUNT ARROWSMITH
BIOSPHERE RESERVE

The State of Mount Arrowsmith Biosphere Reserve

Global and Climate Change in Mountain Sites (GLOCHAMOST) Report 2011

A note from the editor

This report is a work in progress. It represents a preliminary, largely volunteer effort to compile ecological, social, economic and cultural information for MABR, the first such compilation since the biosphere reserve nomination documents were prepared in the late 1990s. The document has been designed to be edited and updated as further information becomes available. Web links and text have been provided to facilitate this process.

As a *State of the Biosphere Reserve* report, it may appear to be excessive in scope. It is my hope that this document will provide a foundation for understanding the complex and often competing priorities that exist among the communities of the biosphere reserve, and facilitate efforts to effectively meet the challenges of global and climate change.

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Table of Contents

Acknowledgements

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Figures

Tables

Chapter 1

Introduction

Why monitor mountain regions to assess global change?

By Glen Jamieson

Over 160 mountainous sites are in the UNESCO World Network of Biosphere Reserves. Their high environmental sensitivity provides key conditions to study global change impact, and to facilitate this study, a set of UNESCO mountain biosphere reserves has joined international efforts in a program termed GLOCHAMORE (Global Change and Mountain Regions) to address the impact of environmental and climate change on ecosystems and people in mountain regions. Like polar regions, mountain biosphere reserves will show the greatest climate changes earliest, and so they are being used as an 'early warning' system of changes that are occurring worldwide.

Editor's note: GLOCHAMOST (Global and Climate Change in Mountain Sites) is a follow-up initiative by the UNESCO-Man and the Biosphere Programme (MAB) to the GLOCHAMORE Research Strategy (UNESCO, 2006). Its aim is to implement the strategy, by addressing five key research areas: climate, biodiversity, water (quantity), land use change and economies (UNESCO, 2011).

GLOCHAMOST mountain biosphere reserves are in both developed and developing countries, allowing comparative studies and analyses of regional differences in environmental change processes. Mountain environments and ecosystems change significantly over relatively short distances due to strong altitudinal gradients, and as a result, their biodiversity tends to be high and they have characteristic sequences of environments and ecosystems. The boundary locations between these systems are expected to shift with environmental change, which provides sensitive indicators of forcing mechanisms. Also, because the higher parts of many mountain biosphere reserves are not heavily affected by direct human activities, they provide locations where the environmental impacts of climate change alone can be studied.

Finally, the core protected mountainous areas are usually surrounded by buffer zones and transition areas that are more influenced by human activities. Changes associated with climate change are also likely to occur in these areas in socio-economic conditions, land-use and land-management, resource exploitation and the appeal of mountain regions for tourism.

MOUNT ARROWSMITH BIOSPHERE RESERVE

There are only two biosphere reserves in Canada that are contain significantly high mountains to have alpine ecosystems – Waterton in the Canadian Rockies and Mount

Arrowsmith on Vancouver Island. Mount Arrowsmith is the sole Canadian biosphere reserve in the GLOCHAMOST research initiative. Mount Arrowsmith is the largest mountain on southern Vancouver Island at 1817 m high. Its dominant rock is basalt, and it is the highest point in the MABR; as of September 18, 2009, its peak was designated part of the 1,300 hectare Mount Arrowsmith Massif Regional Park. Because of high precipitation in the Coastal Mountain Range of British Columbia, Vancouver Island has heavy snow falls and consequently the lowest treeline in British Columbia. In 2010, the cumulative snowfall over the winter was in excess of 50 m. Logging occurs on Mount Arrowsmith on all its sides, but human settlements are only on its eastern flank, where there is a combined population of about 45,000, centred mostly in the communities of Parksville and Qualicum Beach.

Purpose of this "State of the Biosphere Reserve" Report

This report begins to consolidate the results of the extensive monitoring, research and planning efforts that have been undertaken in the reserve. It provides baseline data in both the natural and social sciences to provide reference points against which future potential change may be documented. This is an on-going effort, so as new data become available, they will be added to the database, which we consider to be a "living document".

Chapter 2

Anatomy of MABR

By Holly Clermont

"Biosphere Reserves are places where nature nurtures the minds, hearts and bodies of the people, and where people strive to live gently on the land, maintaining vital processes to sustain themselves and the other species that share the biosphere." (modified from the Canadian Biosphere Reserve Association (CBRA), retrieved November 20, 2011 from http://biospherecanada.ca/en/about-2/)

Summit to Sea

Mount Arrowsmith Biosphere Reserve's snow-capped peaks draw many hikers throughout the year, in search of expansive vistas, fragile alpine meadows, and the elusive White-tailed Ptarmigan or Vancouver Island Marmot. Below, towering cedar and hemlock dominate the landscape. Beside the emerald jewel of Cameron Lake are the giants of Cathedral Grove - cedar and fir trees that are hundreds of years old. These remnants are a window into the past and a once booming forest industry.

Amid the coolness of the temperate rain forests, the Englishman and Little Qualicum Rivers make their way to the Salish Sea. One of the waterfalls along the gorges of the Englishman River has disappeared, and is now winding its way through the karst underbelly of the forest. This river is an important source of drinking water for the residents of MABR's largest community, the City of Parksville. The Little Qualicum River fills the wells of the Town of Qualicum Beach, retirement destination extraordinaire, before easing past the sandy spit that safeguards the estuary and National Wildlife Area.

Above the Sea, a mosaic of stately Garry Oak and Arbutus trees, and inviting meadows of mosses, lichens and wildflowers are a kaleidoscope of colour. The rocky areas of the coastline are interrupted by expansive estuarine mudflats and sandy beaches. The beaches of the Parksville-Qualicum Beach Wildlife Management Area draw hundreds of thousands of tourists each year. In the spring, a wildlife spectacle begins as the intertidal waters become a brilliant turquoise with an influx of herring milt. The spawning fish and their eggs attract thousands of birds, a fleet of fishermen and hundreds of marine mammals.

In the bays, the eelgrass beds are a hub of activity for an intricate web of marine life, including clams, crabs, starfish, and many others. The vast majority of participants are microscopic but vitally important. Farther from shore, along the arid, offshore islands of the Ballenas-Winchelsea archipelago, fishermen troll or drift on the swell in search of salmon and rockfish. Basking in the sunshine, they marvel at the stony profile of the sleeping maiden of Mount Arrowsmith.

SETTING

MABR is located on southeastern Vancouver Island, British Columbia (BC), nearly due west of Vancouver across the Salish Sea, and north of the City of Nanaimo (Figure 1). MABR covers 1,186 km^2 (118,592 ha) including a ~389 km^2 marine area (MABR, 1998).

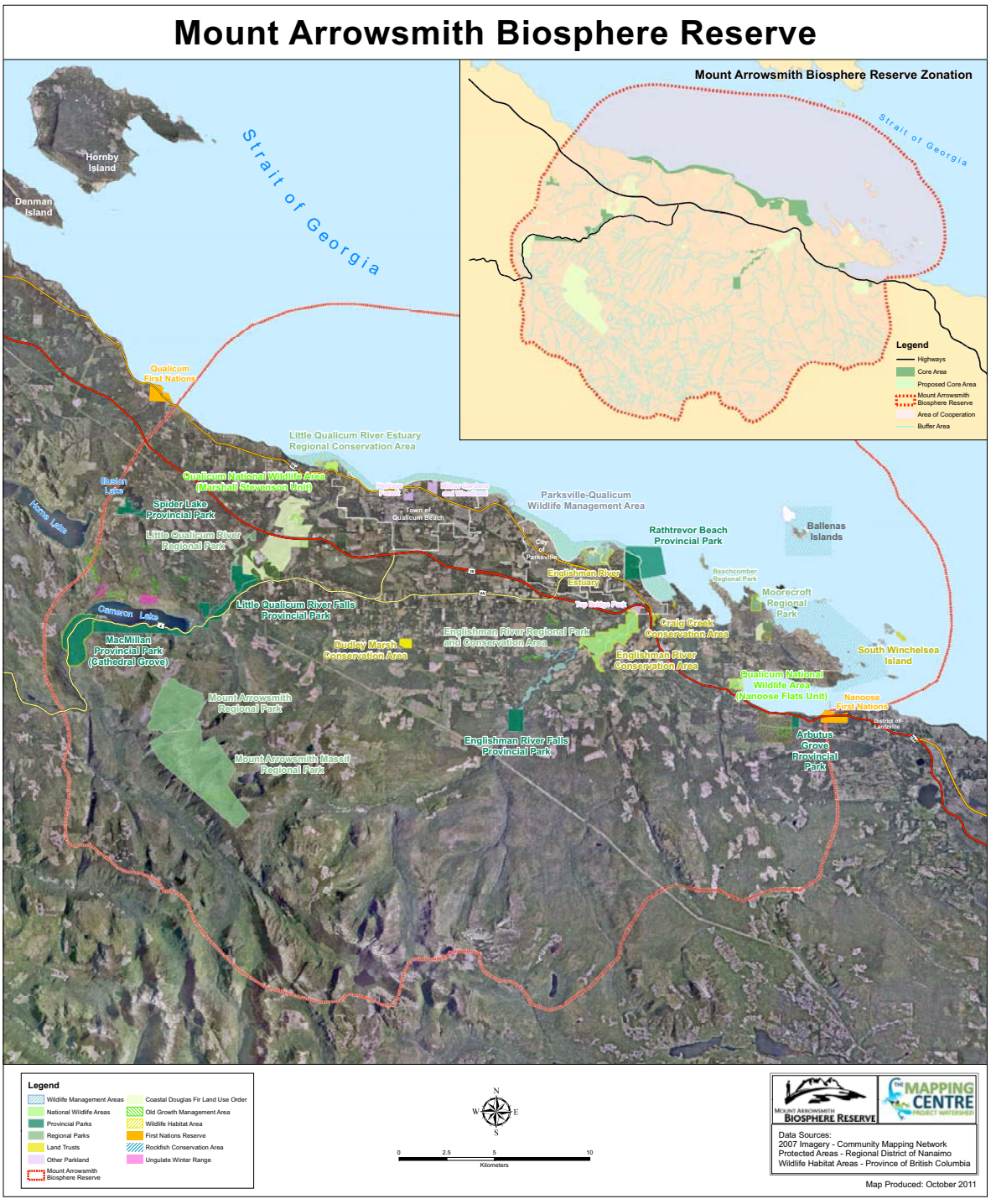
Figure 1. Location of MABR on Vancouver Island. Map courtesy of Regional District of Nanaimo (RDN).

BIOSPHERE RESERVE STRUCTURE

MABR's boundaries are based on watersheds. The biosphere reserve encompasses watersheds with headwaters on Mount Arrowsmith (1817 m), Mount Moriarty (1603 m), Mount Cokely (1619 m) and the Nanoose peninsula. The waters flow into the Salish Sea, also known as the Strait of Georgia, which separates Vancouver Island from the BC mainland. MABR includes the complete watersheds of the Englishman River, Little Qualicum River, French Creek, Craig Creek, Bonnell Creek, Nanoose Creek, Grandon Creek, Beach Creek and several others. MABR

also includes the islands of the Ballenas/Winchelsea Islands archipelago, and a marine area to approximately 300 m below sea level (Figure 2).

Figure 2. Mount Arrowsmith Biosphere Reserve



MABR's zonation structure varies from the typical biosphere reserve model of concentric circles of core, buffer and transition areas to reflect an emphasis on the protection of freshwater, estuarine, and intertidal and subtidal marine values. Many of these values have been legally protected in six provincial parks, federal National Wildlife Areas (NWAs) and the marine foreshore that is provincially managed as the Parksville-Qualicum Beach Wildlife Management Area (PQBWMA). A total of 1167 ha of terrestrial lands and 925 ha in the marine environment were protected as core areas (MABR, 1998). Since MABR was designated in 2000, there have been new areas protected, including alpine areas and arid island ecosystems that are otherwise unrepresented in Canadian biosphere reserves.

Because the health of brackish and saltwater ecosystems are directly influenced by the condition of the streams flowing into them, the regulated riparian areas were defined as biosphere reserve buffer areas. The federal *Fisheries Act* (R.S.C., 1985, c. F-14) protected attributes of the water column, the Province owned much of the stream beds, and the provincial *Fish Protection Act* (Bill 25, 1997) and *Streamside Protection Regulation* required at least a 15 m riparian buffer on all streams. Private forest landowners were also required to protect riparian areas through forestry legislation. The buffer area was approximately 500 km in length, with an estimated combined area of 1500 ha.

In 2005, the *Streamside Protection Regulation* was replaced by the *Riparian Area Regulation* (RAR). Both regulations set rules for activities in riparian areas and required setbacks for development, however there are important differences. RAR applies to freshwater fish-bearing streams as well as freshwater, fish-bearing wetlands. The minimum setback was reduced to 5 m. The cost and responsibility shifted from the provincial government to development proponents and their hired environmental consultants through local government bylaws. Qualified Environmental Professionals are required to recommend specific measures and setbacks ranging from 5 to 30 m based on a standardized methodology, and the role of provincial staff is to monitor and enforce the regulation. The RAR has had mixed results in protecting the buffer areas, but overall is successfully improving riparian integrity and the level of protection for fish habitat (Henigman, 2011). The change in the size of the buffer area is currently unknown.

The area of cooperation (also known as the transition zone) is the largest part of the biosphere reserve, an estimated 94% of the total area (Reed, Mendis-Millard & Francis, 2010).

Governance

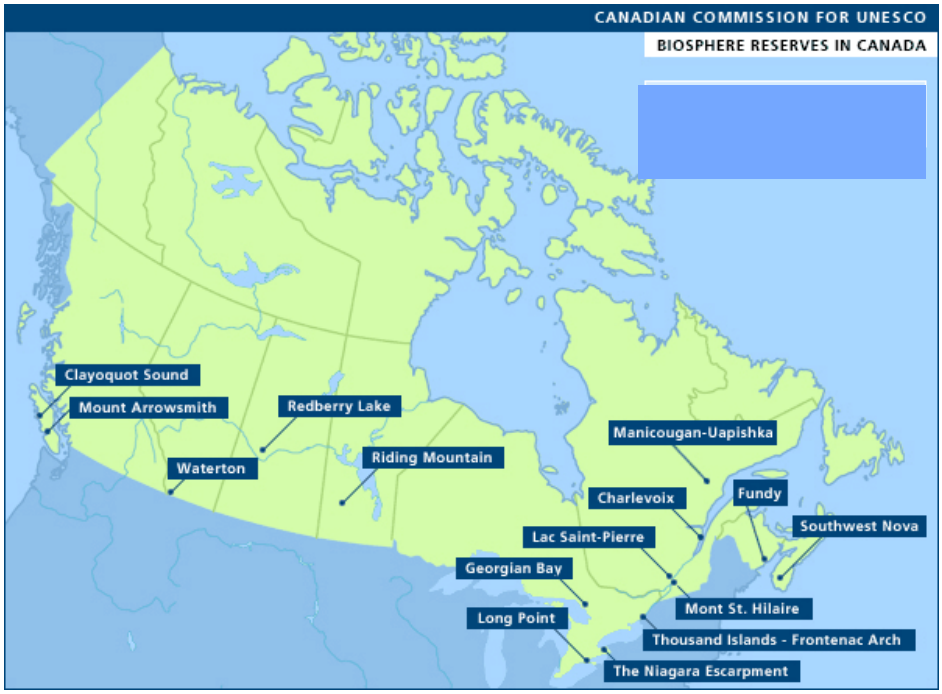
WORLD NETWORK OF BIOSPHERE RESERVES

MABR is one of 16 BRs in Canada (Figure 3), and one of 580 in the World Network of Biosphere Reserves as of November 27, 2011 (This information is periodically updated at http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/)

The biosphere reserve designation confers no legal authority, and this is believed to be one of its greatest strengths. It respects, but is not confined by the structures and roles of individual agencies and organizations operating within the reserve.

Biosphere reserves are guided by the 1996 *Seville Strategy* http://www.unesco.org/mab/doc/brs/Strategy.pdf and the 2008 *Madrid Action Plan* http://unesdoc.unesco.org/images/0016/001633/163301e.pdf, and are governed by the UNESCO's *Statutory Framework of the World Network of Biosphere Reserves* http://www.sovereignty.net/tline/statutory-framework.htm. A periodic review conducted by the Canadian Commission for UNESCO for the International Advisory Committee for the MAB Programme in 2010 concluded that MABR had failed to meet the criteria in the Statutory Framework, and reported that it might withdraw the biosphere reserve designation in the absence of an acceptable strategy and action plan by 2013.

Figure 3. Map of Canadian Biosphere Reserves. Bra D'Or Lake in Cape Breton became the 16th biosphere reserve in 2011.



Mount Arrowsmith Biosphere Foundation

Each biosphere reserve has a unifying biosphere reserve organization that works to achieve sustainability objectives in MABR, in cooperation with area stakeholders and UNESCO's MAB Programme. Mount Arrowsmith Biosphere Foundation (MABF) is a charitable non-profit society that was formed to establish the biosphere reserve. One MABF Director is designated a member

of the Canadian Biosphere Reserve Association (CBRA). Through CBRA, MABR is connected to the Canadian Commission for UNESCO and the EuroMAB Programme.

MABF's Vision

The MABR is envisioned as an area where biological diversity is sustained in functioning ecosystems and where healthy human communities enjoy an ecologically sustainable economy.

Mission

MABF's mission is to ensure that local people have ownership of, and responsibility for knowledge of the area. This includes potential changes to the area and likely consequences of those changes, based on the best available science and local knowledge. MABF strives to work with local communities and government agencies towards achieving sustainable policies and practices.

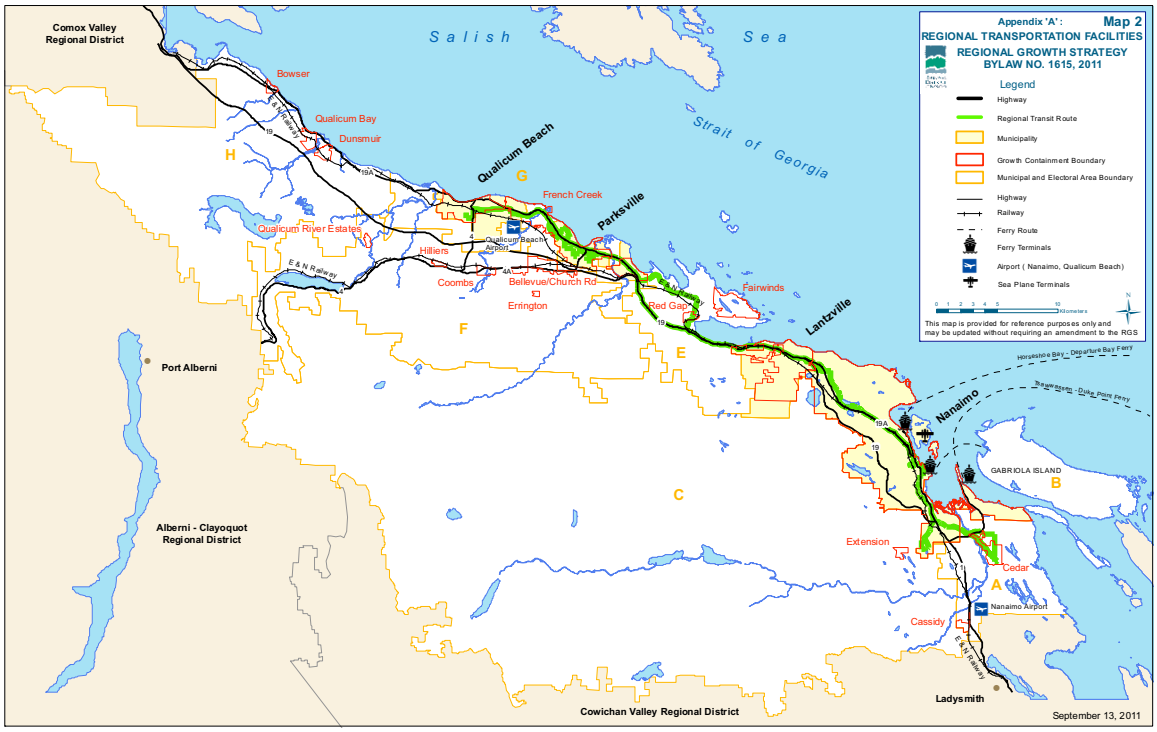
Mandate

MABF's mandate is to reconcile conservation of biodiversity and biological resources with their sustainable use by: promoting public awareness of resource management concerns facing residents of the MABR area; participating with area residents in developing projects to address local concerns; encouraging cooperative resource management practices between private landowners and governments by providing a forum for exchange of information and values; and recognizing, representing and promoting a long range, balanced view towards planning, development and management.

GOVERNMENTS

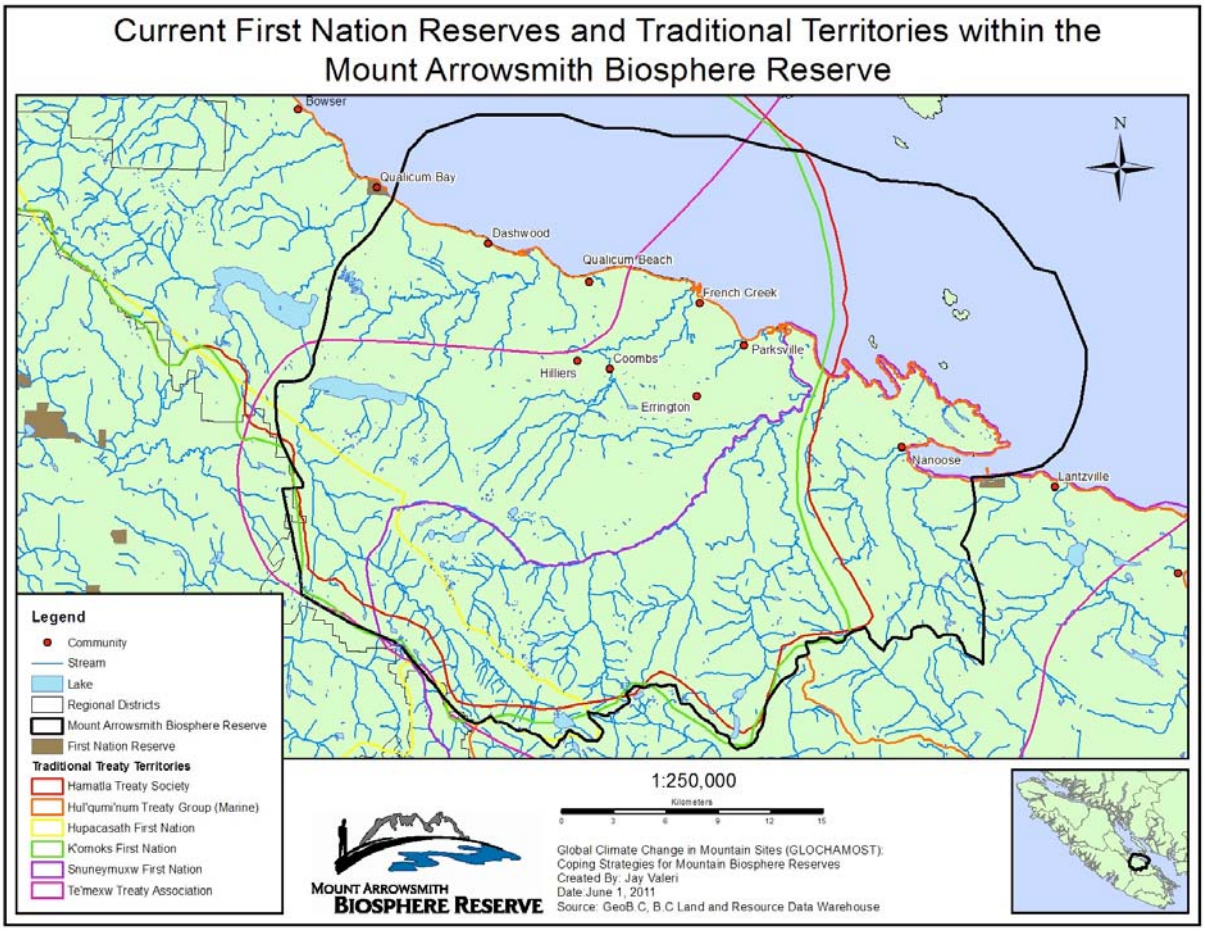
There are five levels of government in MABR: (1) federal, (2) provincial, (3) the Regional District of Nanaimo (RDN) which encompasses the rural communities of Nanoose Bay, Coombs, Hilliers, Errington, Dashwood and French Creek, (4) two municipalities (i.e., the City of Parksville and Town of Qualicum Beach) (Figure 4), and (5) First Nations. Local governments derive their authority from the Province, largely via the BC *Local Government Act* (RSBC 1996). While municipalities are often viewed as a level of government beneath the regional district, they have some powers that the regional district does not. These are outlined in the BC *Community Charter* (SBC 2003).

Figure 4. Electoral areas and municipalities within the RDN (RDN, 2011). MABR's boundaries include the municipalities of Parksville and Qualicum Beach, as well as electoral areas E, F and G. Most of areas C and H are excluded. The municipalities of Lantzville and Nanaimo are also excluded.



The two small First Nation communities of Qualicum and Nanoose have reserves just outside of the MABR boundaries, and there are several other First Nations that include parts of MABR within their traditional territories (Figure 5). Although treaties have not been settled, First Nations are considered governments, not stakeholders, and must be consulted and accommodated in accordance with federal and provincial policies and case law.

Figure 5. First Nations reserves and territories, and treaty group territories within and adjacent to MABR. Note: Qualicum First Nation traditional territory will be added in the next reiteration.



Political Boundaries

Federal and provincial electoral boundaries differ from local government and also from other federal and provincial administrative boundaries (e.g., for forestry) MABR is within the Nanaimo-Alberni federal electoral district (Figures 6). The majority of MABR is included in the Parksville-Qualicum provincial electoral district. However, three other electoral districts include parts of the biosphere reserve, i.e., Alberni-Pacific Rim, Nanaimo-North Cowichan, and Comox Valley (Figure 7).

Figure 6. Nanaimo-Alberni federal electoral district. Retrieved November 20, 2011 from http://www.elections.ca/res/cir/maps/images/atlas/59014.gif

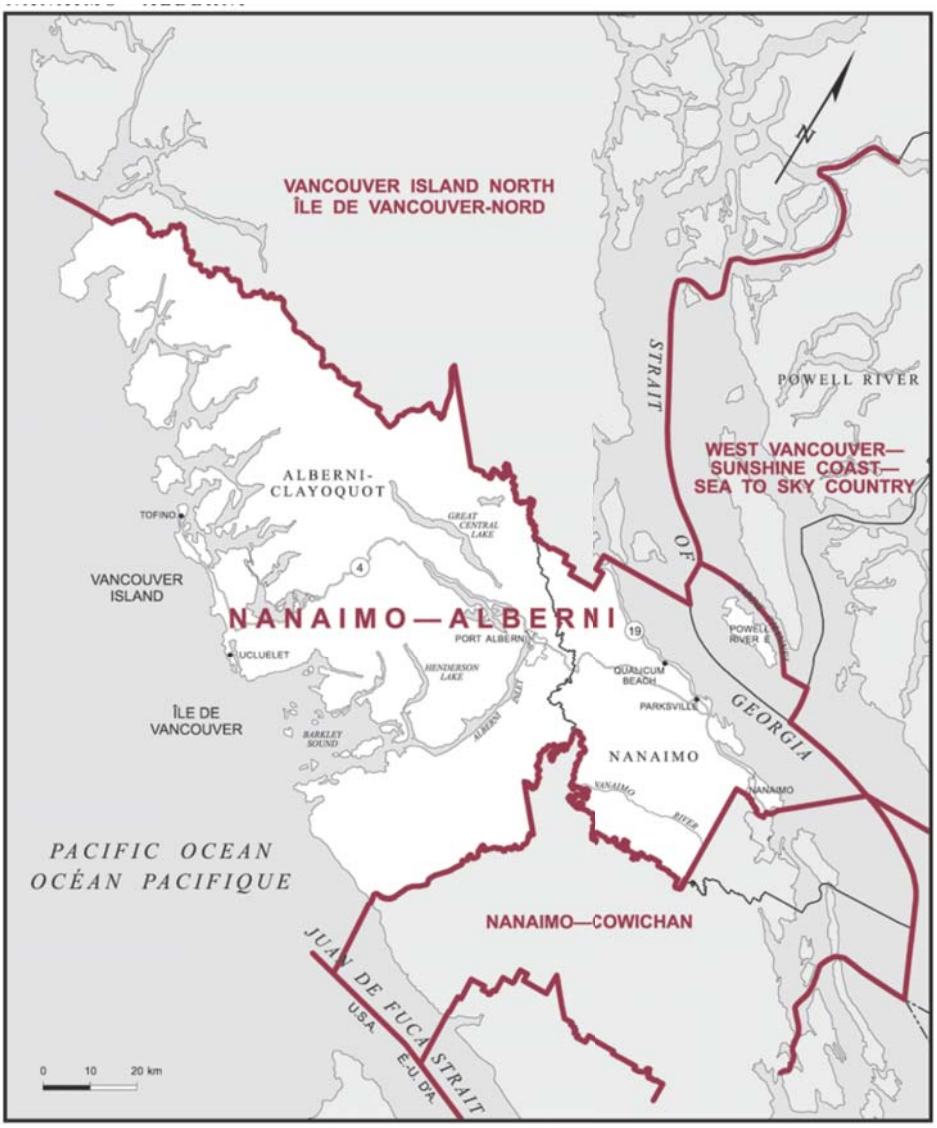
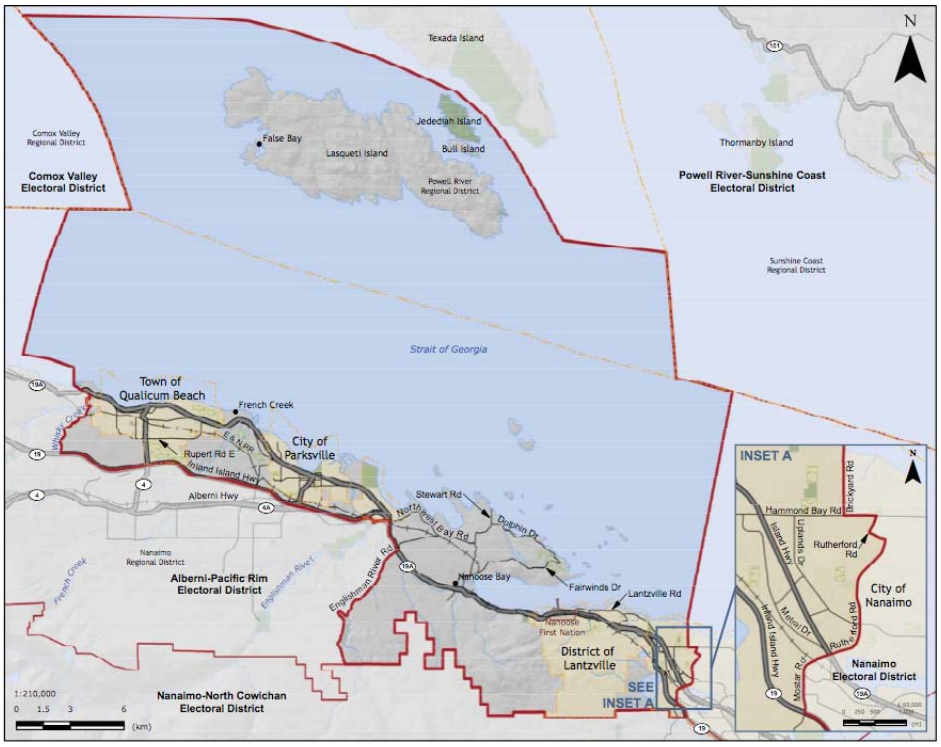


Figure 7. Provincial electoral districts. Retrieved November 20, 2011 from http://www.elections.bc.ca/docs/map/redis08/ED/PAQ_ED.pdf.



Traditional Territories

By Pam Shaw and Holly Clermont

There are several First Nations whose traditional territories lie within the MABR (Figures 8 through 14). Archaeological data and historical accounts of contact from early settlers are available, several petroglyphs are known, and Aboriginal fish fences are visible within the Little Qualicum, French Creek, and Nanoose-Bonnell estuaries. Oral histories may be shared by First Nations elders.

Moving forward, additional lands may be transferred to First Nations as part of Treaty Settlement processes. These lands may be designated as Reserve Lands, Treaty Settlement Lands, or may be fee simple land parcels.

Figure 8. The Snaw-naw-as or Nanoose First Nation is part of the Te'Mexw Treaty Association. The Treaty Association also includes Songhees (Lekwungen), Beecher Bay (Scia'new), Sooke (T'Souke) and Malahat First Nations, whose traditional lands are centred on southern Vancouver Island. For more information on the Snaw-naw-as First Nation, see http://www.nanoose.org/index.html.

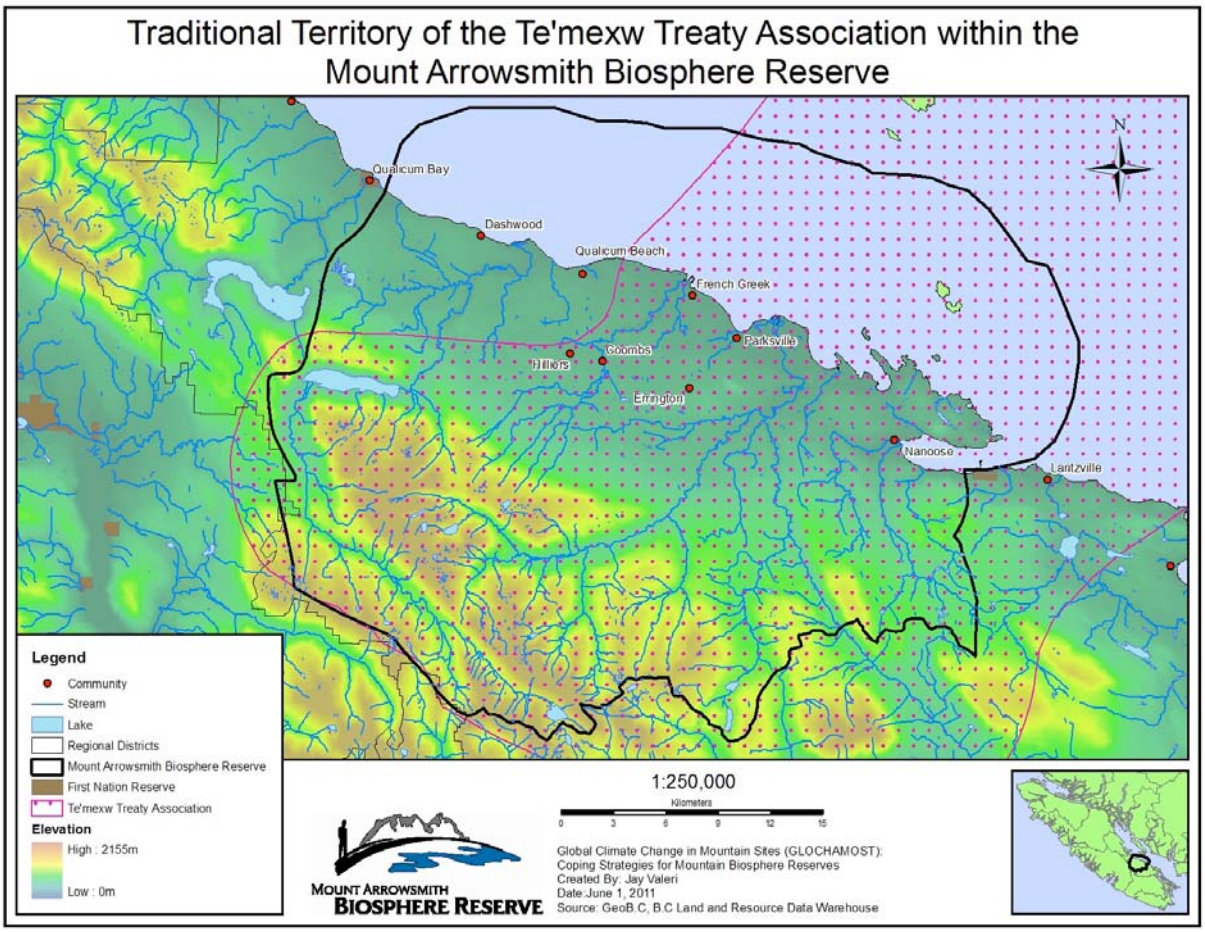


Figure 9. Qualicum First Nation traditional territory. Retrieved November 20, 2011 from http://www.for.gov.bc.ca/ftp/DSI/external/!publish/Stewardship/SIFD_Objectives_Matrix/7_Cultural_Heritage/Trad_Ter_Maps_for_SIFD_FN/Qualicum_Trad_Ter_Map_Hillshade.pdf

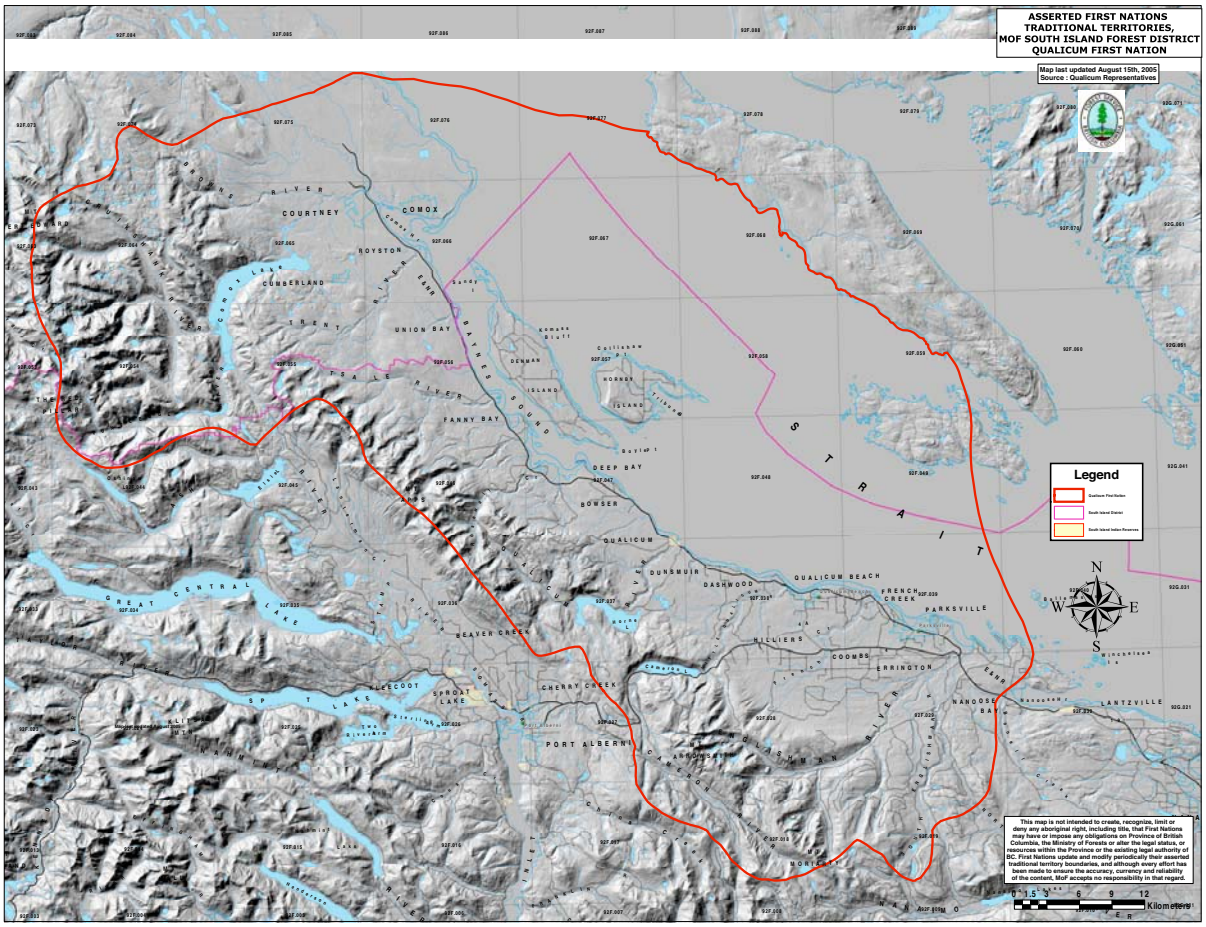


Figure 10. Traditional territory of the Hupacasath First Nation within MABR

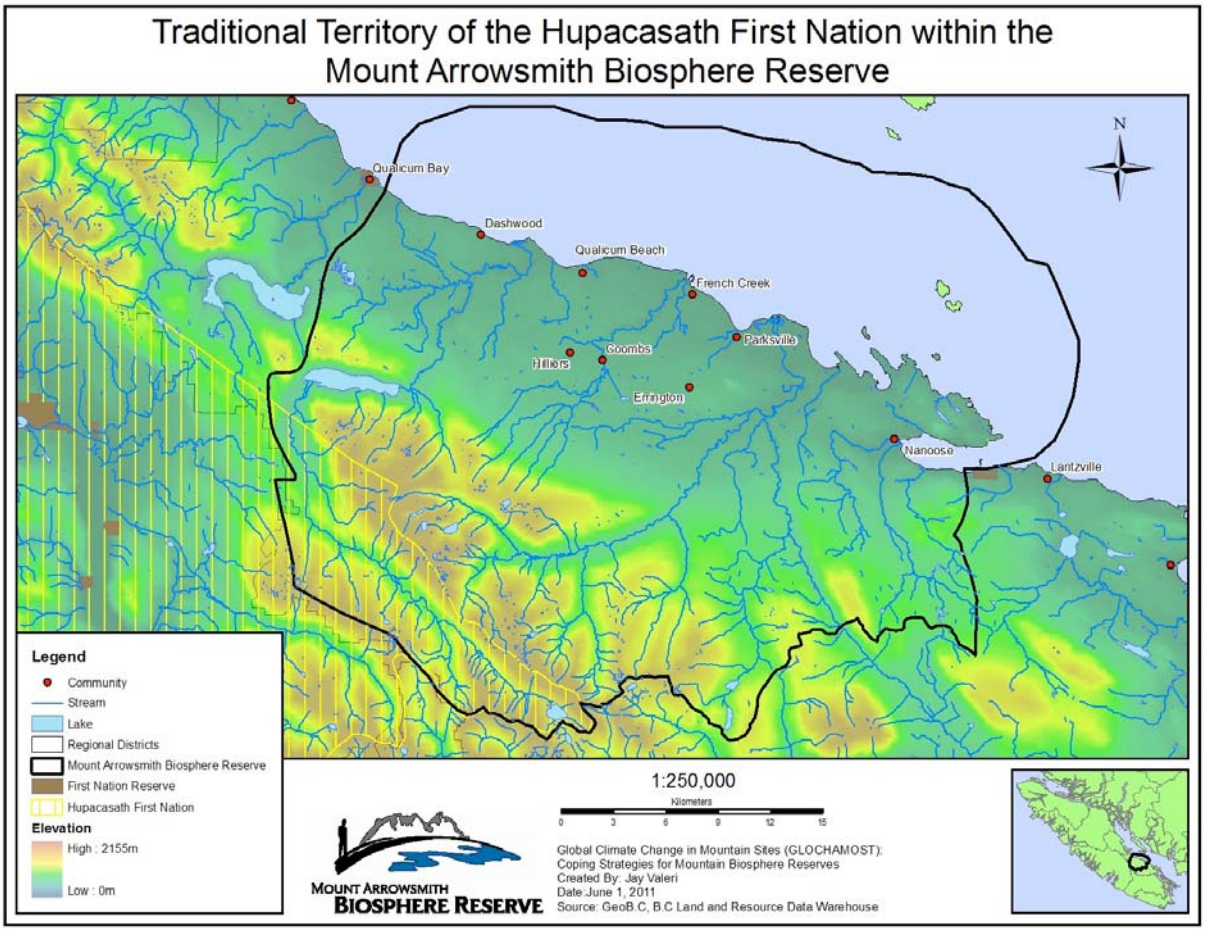


Figure 11. Traditional territory of the Snuneymuxw First Nation within MABR

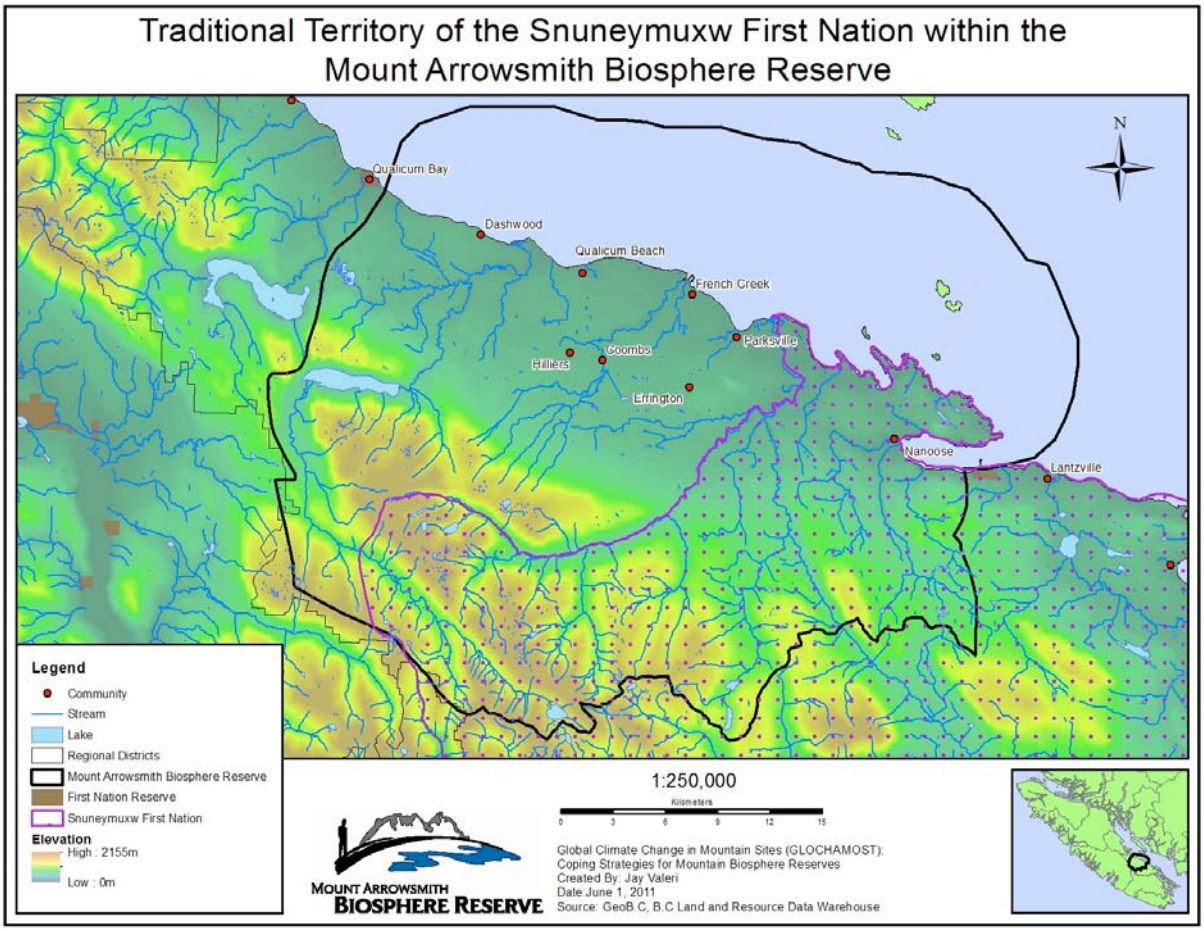


Figure 12. Traditional territory of the Laich-Kwil-Tach Treaty Society, (formerly called the Hamatla Treaty Society) within MABR. The Treaty Society includes the We Wai Kum (Campbell River), We Wai Kai (Cape Mudge) and Kwiakah First Nations.

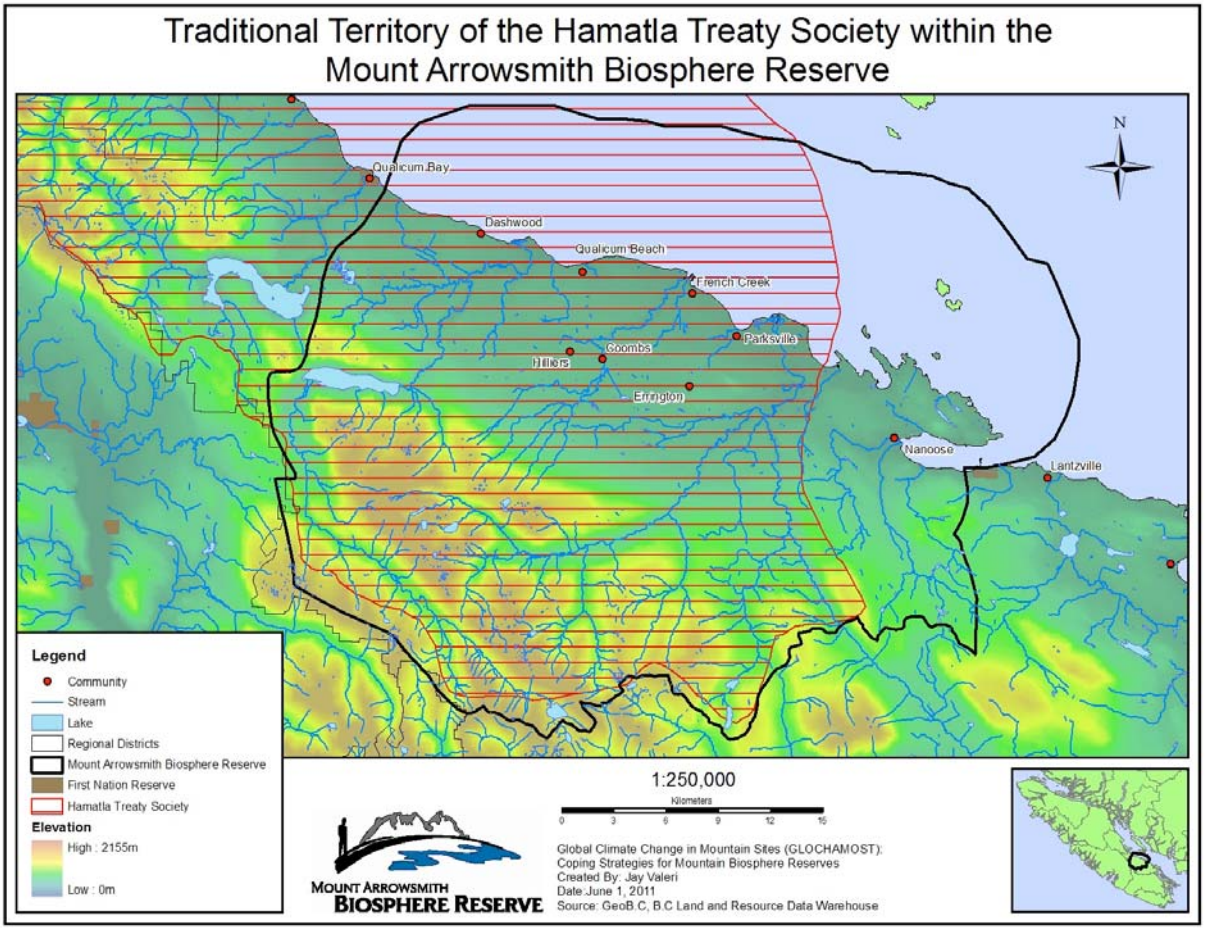


Figure 13. The traditional territory of the K'omoks First Nation within MABR

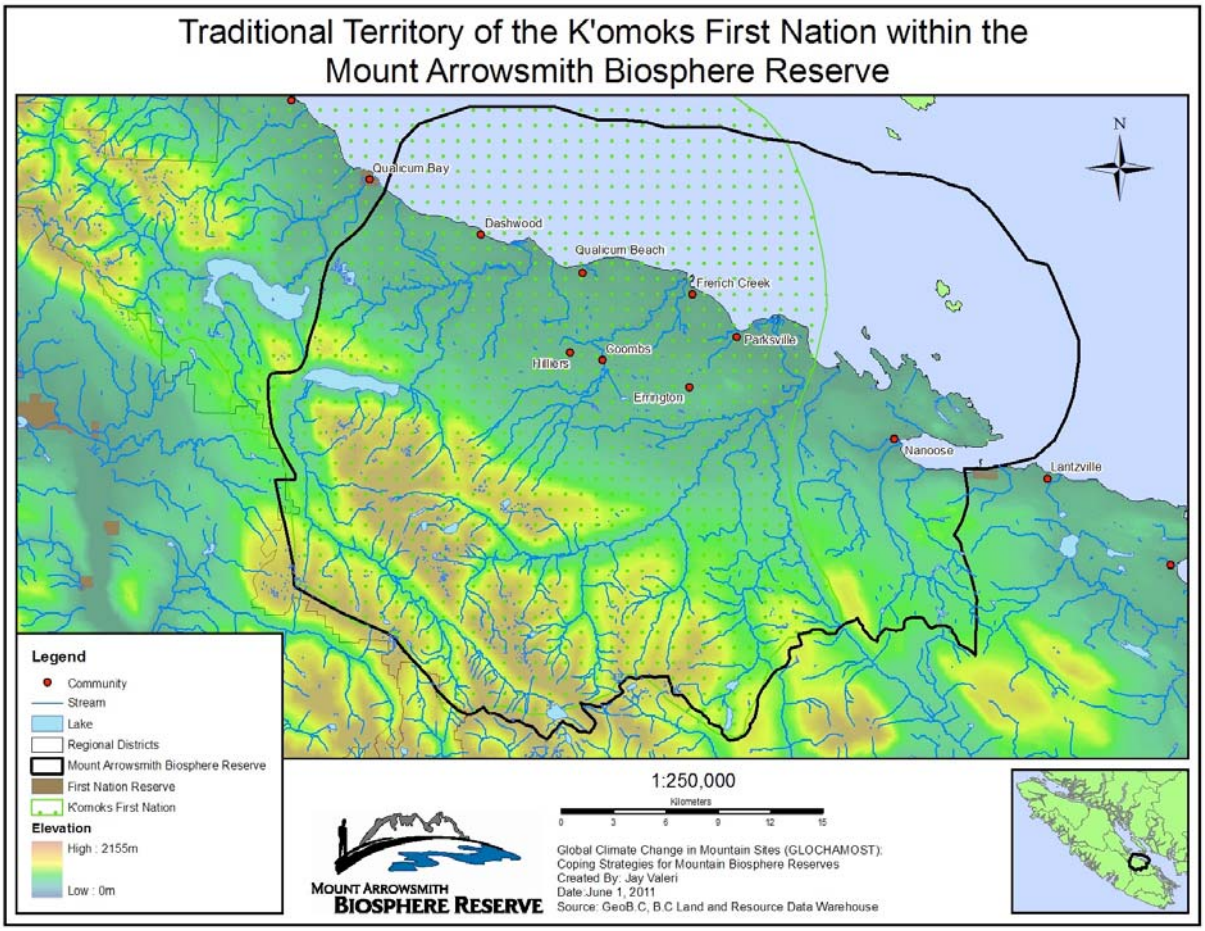
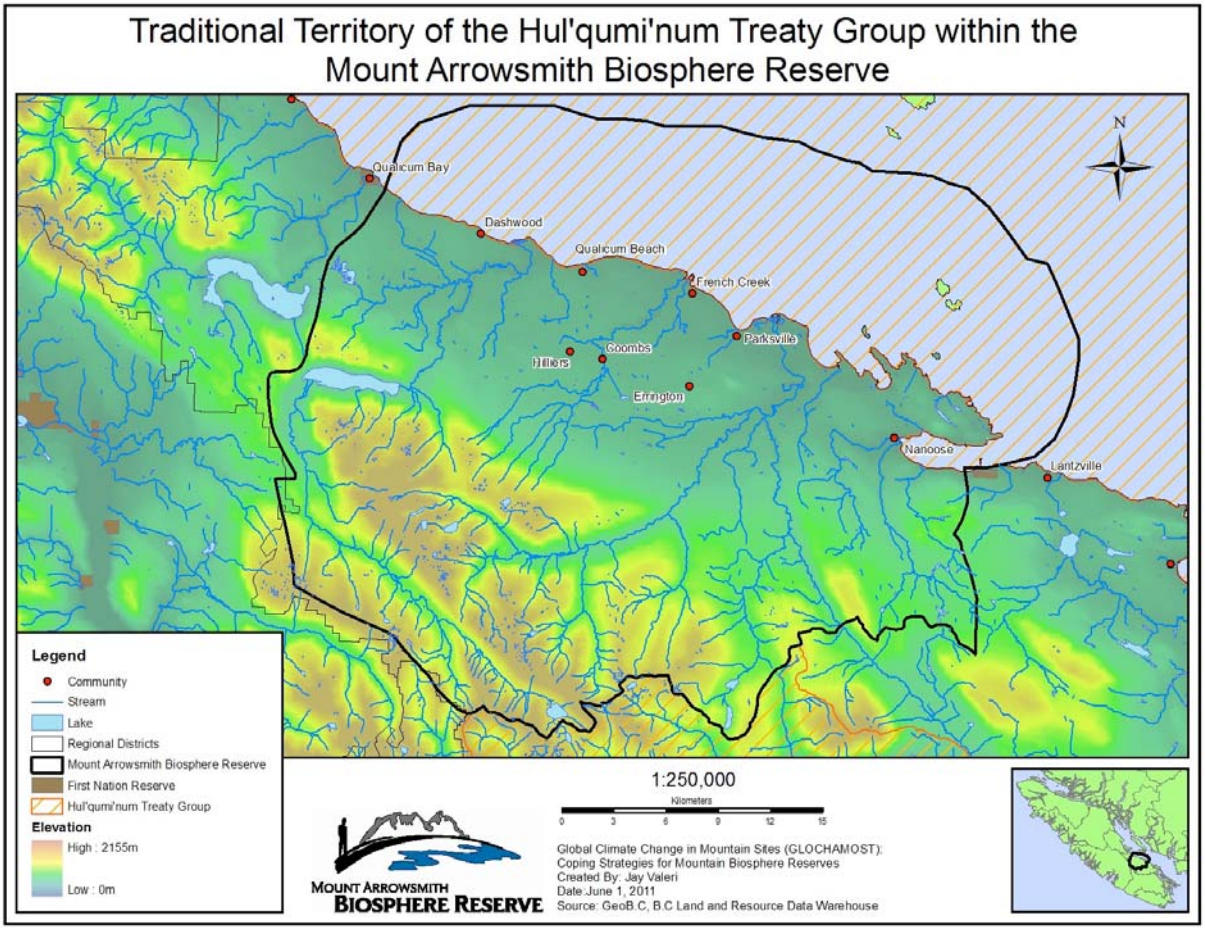


Figure 14. The traditional territory of the Hul'qumi'num Treaty Group within MABR. The Hul'qumi'num Treaty Group includes the Stz'uminus (Chemainus) First Nation, Cowichan Tribes, Halalt First Nation, Lake Cowichan First Nation, Lyackson First Nation, and Penelakut Tribe.



CO-MANAGEMENT

As park and conservation lands have become more expensive to acquire and manage, partnerships have become the norm. These partnerships are evident in **Protected Areas** below. In some cases, partner organizations are included in management planning but are not on title.

Other examples of co-management can be found in the Englishman River Watershed Recovery Plan, the Arrowsmith Water Service, the Guardians of Mid-Island Estuaries' rehabilitation projects on the Little Qualicum and Englishman River estuaries. In general, sustainability and stewardship initiatives are increasingly viewed as collaborative efforts requiring the participation of many stakeholders.

Chapter 3

The Physical Environment

Current Status and Trends

BIOGEOGRAPHICAL CLASSIFICATION

MABR is considered Subtropical and Temperate Rainforest in UNESCO's classification of the 12 major ecosystem types in the world. In the Udvardy classification of the world's biogeographical provinces, it is located at the extreme northern edge of the Oregonian Biogeographical province (MABR, 1998).

MABR is also part of Cascadia (Figure 15), a bioregion defined by the watersheds of the rivers flowing into the Pacific Ocean through North America's temperate rain forests. The "Pacific Northwest" usually refers to British Columbia, Washington and Oregon, but sometimes approximates the boundaries of Cascadia.

The Georgia Basin includes southwestern British Columbia and the Puget Sound region of the northwestern United States (Figure16). The boundaries of the Salish Sea, officially designated in 2010, closely approximates the Georgia Basin and commemorates the traditional territories of the Coast Salish people (Figure 17).

Provincially, MABR is located within the Georgian Depression Ecoprovince. The terrestrial portions of MABR are part of the Eastern Vancouver Island Ecoregion. It includes portions of the Leeward Island Mountains Ecosection and the Nanaimo Lowlands Ecosection (Demarchi, 2011). These are well described at http://www.env.gov.bc.ca/ecology/ecoregions/index.html. Biogeoclimatic ecosystem classification units are shown in **Ecosystems** below.

The Strait of Georgia Ecoregion encompasses the marine portion of MABR, and is the largest body of sheltered saltwater along the west coast of North America. Waters of this ecoregion have significant freshwater input and high turbidity. The five marine ecounits identified by the British Columbia Marine Ecosystem Classification system (Zacharias et al., 1998) are described in **Ecosystems** below.

Figure 15. Cascadia. Retrieved November 27, 2011 from http://www.sightline.org/maps/maps/cascadia_cs05m/cascadia_cs05m-med.

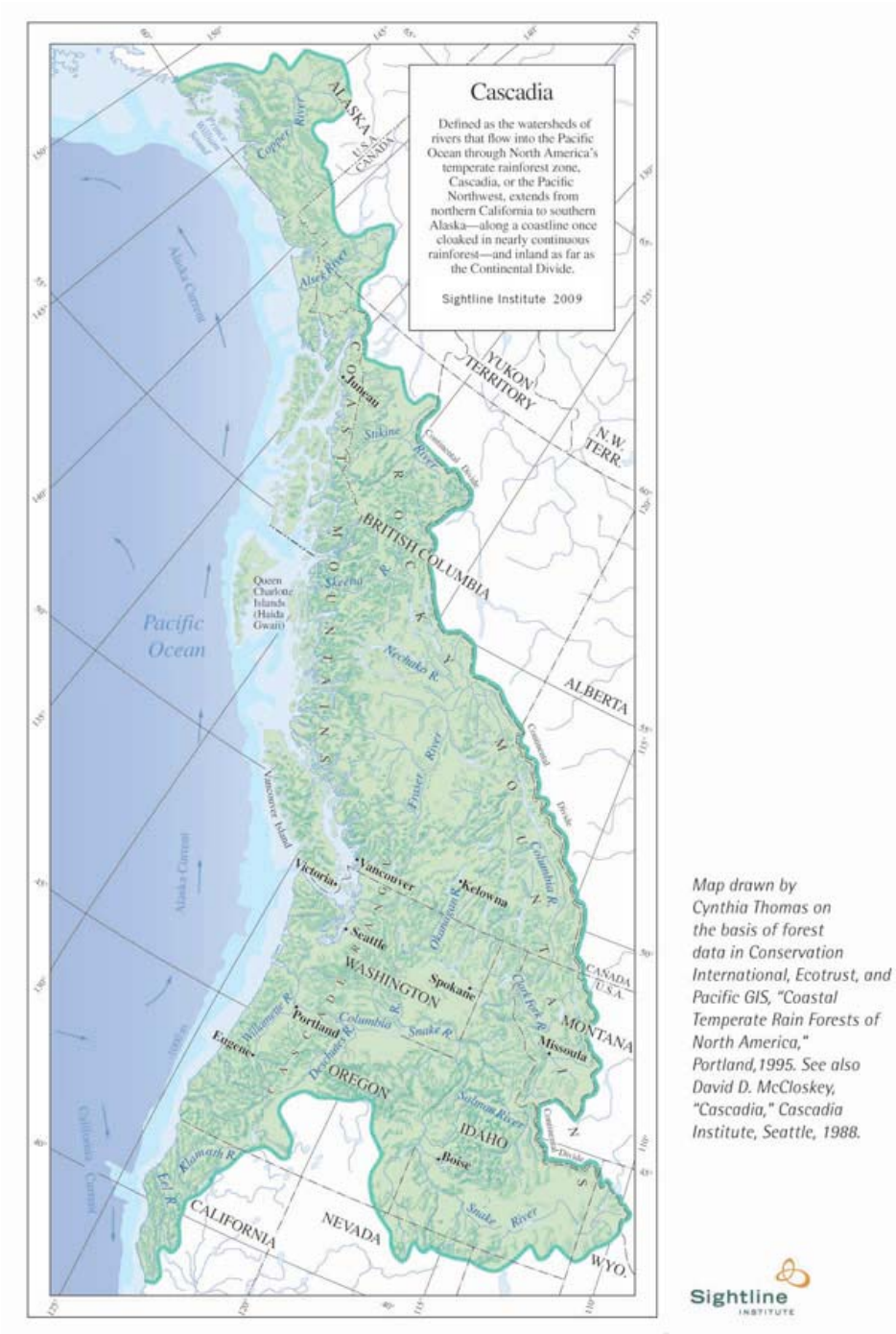


Figure 16. Georgia Basin (Environment Canada, 2008).

Figure 17. Salish Sea (Gaydos et al., 2008).

PHYSIOGRAPHIC SETTING

The craggy Beaufort Range of the Vancouver Island Mountains, which reaches a maximum elevation of almost two thousand metres, bound MABR on the west. A narrow range of rounded foothills, mostly under seven hundred and fifty metres in elevation, butt up against the eastern side of the Beaufort Range. To their east, the Nanaimo Lowlands is an undulating plain cut by river and creek valleys averaging under one hundred metres above sea level which slopes gently down to the Salish Sea. In the Nanoose area, the foothills reach the coastline and many small rocky islands are exposed in the strait. The shoreline of MABR is, for the most part, an alternation of sand and gravel-to-cobble beaches punctuated by estuaries every several kilometres, except for the rocky headlands in the Nanoose area (MABR, 1998).

Geological History

Vancouver Island is the largest part of the Wrangellian Terrane, the remains of a microcontinent that collided with the west coast of North America sometime in the late Jurassic period. This exotic terrane had its origins as an island arc far out in the ancestral Pacific Ocean and through the processes of plate tectonics was transported towards North America. On colliding with the mainland, the terrane split into three main sections: the other two being the Queen Charlotte Islands and part of the Alaska Panhandle. The collision caused the upwarping of both the Insular Vancouver Island Mountains and the mainland's Coast Mountains. Concurrently, the area between the two mountain ranges were downwarped to produce the Georgia and Hecate Basins which still separate Vancouver Island and the Queen Charlottes, respectively, from the mainland. The subsequent erosion of the two mountain ranges into the Georgia Basin during the Cretaceous period led to the deposition of thick, coal bearing Nanaimo series sedimentary formations. Subsequent Tertiary deposits have, for the most part, been obliterated, scooped out and removed by Pleistocene glaciations. The weight of the kilometre thick glaciers depressed the east coast of Vancouver Island one hundred metres below sea level and when the glaciers retreated, they left a layer of glacio-marine deposits on the rebounding lowlands (MABR, 1998).

Geology

Geology dictates the character of the landscape as well as the location of resources, water, and people (Geoscape Nanaimo, n.d.). The Nanaimo Lowlands physiographic region is comprised of unconsolidated glacial deposits underlain by late Cretaceous sedimentary rock. The mountains to the west, best exemplified by the massif of Mt. Arrowsmith, the highest peak of the Beaufort Range, are mostly late Triassic basalts of the Karmutsen formation with some Permian limestones and later Jurassic Granodiorite intrusions. The Nanoose area features Devonian to Carboniferous volcanic and sedimentary deposits of the Sicker Group formations as well as Jurassic outcrops of basalt and granodiorite of the Island Intrusions group. Surficial materials are

fluvial and glacio-fluvial in the river/creek valleys, glacio- marine in the coastal areas between river/creek valleys, moraine at middle elevations on gentle slopes, and a combination of colluvium and bedrock on steep slopes (MABR, 1998). The bedrock geology within MABR is shown in Figure 18, and more fully described in a powerpoint presentation of the *Geology of Vancouver Island*, available at Geoscape Nanaimo (http://web.viu.ca/geoscape/geology.htm) and in the BC Ministry of Environment publication *Ground Water Resources of British Columbia* at http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/gwbc/C0912_Nanaimo_Georgia.html.

Soils

By Nicole Muchowski

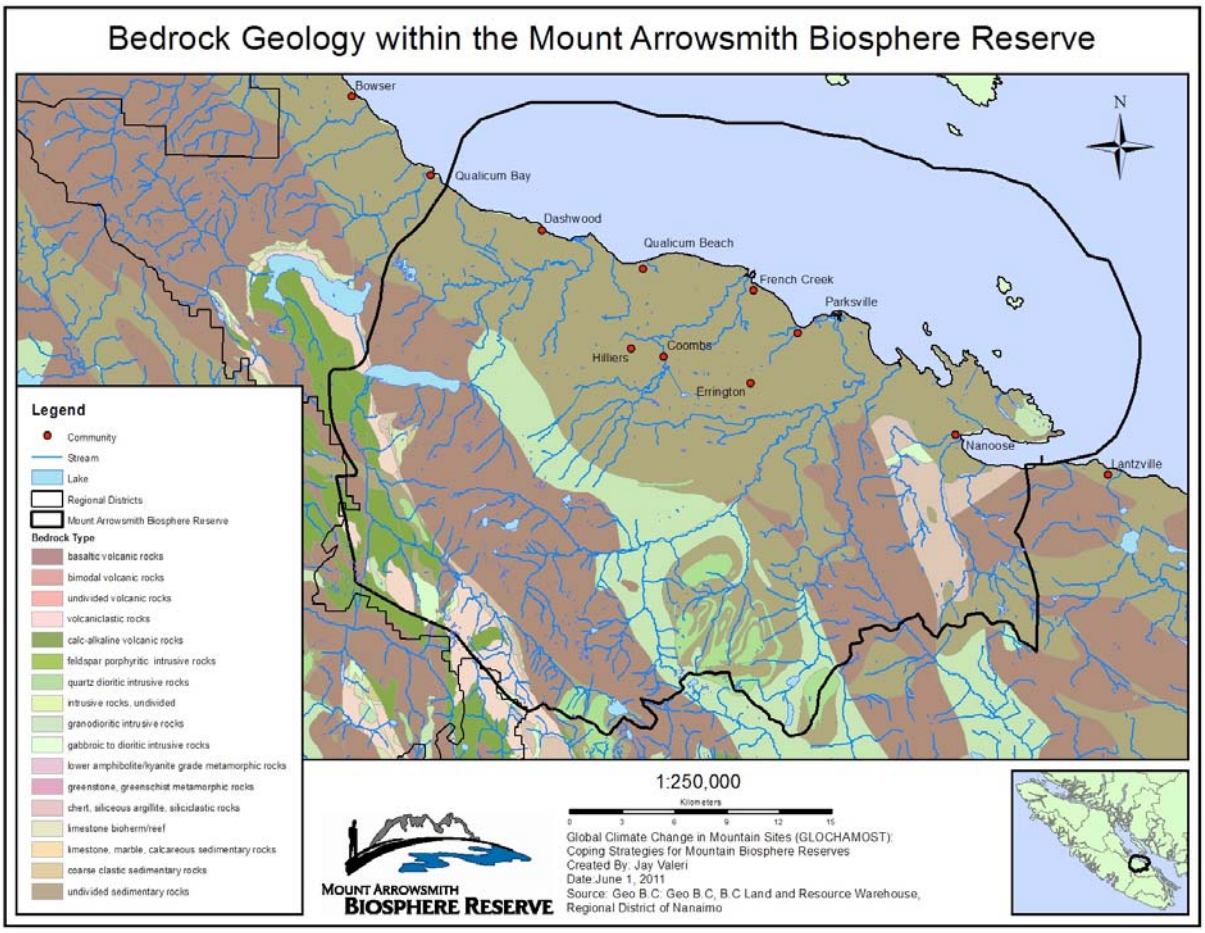
Soil parent materials are predominantly deposits resulting from glaciation and modified by the weathering and acidifing effects of the climate and vegetation. Examples of colluvial, fluvial, morainal, marine, and organic deposits exist within the MABR. Quality agricultural soils are restricted to small and scattered patches of glacio-marine and lacustrian clays and the muck soils of recently drained post-pleistocene marshes (MABR, 1998).

Podzolic soils are the most common and widespread in the region. The maritime climate, which brings high precipitation and cool to moderately cold soil temperatures, act on the soil parent material to form bright, reddish-coloured, deeply weathered soils, characteristic of podzols. The resulting soil nutrient regime is generally poor as podzols typically are strongly leached leaving behind a mineral substrate of high acidity and low buffering capacity (Jungen, 1985).

In addition to the high proportion of strongly developed podzolic B horizons, another feature of area soils is the prevalence of an impervious layer (an extremely compact, cemented layer) commonly found within the first 100 cm of the ground surface (Jungen, 1985).

Climate and vegetation also play a role in the development of organic surfaces (leaf litter, woody debris). Thicknesses of less than 4 cm have been recorded where it is generally milder and drier; organic surfaces in cool, wet regions typically measure between 30 and 50 cm in thickness (Jungen, 1985).

Figure 18. Bedrock geology within MABR



CLIMATE AND WEATHER

MABR's climate, fundamental to the ecology of the region, is characterized by mild and wet winters, and warm and dry summers. The central Vancouver Island mountains strongly affect the region's climate by producing a rain shadow to the east (Geoscape Nanaimo, n.d.). Promoted as one of the mildest in Canada, MABR's climate has a significant influence on the area's economy and social structure, attracting winter residents, summer tourists and migrants.

Despite its reputation for mild weather, MABR experiences regular windstorms and storm surges. There are two major sources of peak winds on the BC coast: Pacific Lows and Arctic Outbreaks. Pacific Lows are counterclockwise low pressure systems which move in off the Pacific. As the system moves onto the coast, winds align with the southeast-northwest orientation of the coast resulting in strong southeasterly winds. Low pressure systems moving down from the Gulf of Alaska occasionally produce strong northwest winds. Arctic Outbreaks occur when high pressure systems with cold arctic air move down over the BC interior and spill out onto the coast

through coastal inlets, sometimes traveling as far as Vancouver Island and MABR (Mitchell, 1998).

A series of severe winter storms in 2006-07 felled trees and branches onto power lines causing widespread power outages and more than $30 million in damages. BC Hydro developed a five-year, $200,00 million resiliency plan to protect the province's energy infrastructure, including vegetation management (i.e., tree-cutting) (BC Hydro, 2007).

Strong winds in summer frequently arise from subtle local effects (Environment Canada, 1990). Low pressure centres over northern Vancouver Island can also create "Qualicum" winds, when southwesterly winds are drawn through an opening in the mountain ridge, extending from Barclay Sound on the west coast of Vancouver Island to Qualicum Beach through the Cameron Valley. Qualicum winds often occur on hot summer afternoons when daytime heating and turbulent mixing bring strong westerly winds. MacMillan Provincial Park (Cathedral Grove), located at a narrow bend in the Cameron valley, and the communities of Coombs and Hilliers are most exposed to these winds (Mitchell, 1998). Tree blowdown has been responsible for at least two fatalities in the area (Hansard, 2004).

Large scale climatological phenomena such as the Pacific Decadal Oscillation (PDO) and the El Niño/Southern Oscillation (ENSO can have a significant impact on MABR's climate and weather. These are described in Tinis (2011) at http://www.pac.dfo-mpo.gc.ca/sci/juandefuca/storm_surge/Almanac_2011-12.pdf.

Monitoring

Climate data for 1971 through 2000 are available for the Little Qualicum Hatchery climate station (Environment Canada Climate Station 1024638, elevation 30 m) and the Coombs station (1021850, 98.1 m). These can be retrieved from the National Climate Data and Information Archive at http://climate.weatheroffice.gc.ca/climate_normals/index_e.html. Other stations for which historic climate normal data is available include the Qualicum Beach airport (1026562, elevation 58.2 m) Cameron Lake (1021230, 193 m), Parksville (1025970, 82.3 m), Parksville Northwest (1025975, 30.5 m), and Parksville South (1025977, no elevation provided). These are found at http://www.climate.weatheroffice.gc.ca/advanceSearch/searchHistoricData_e.html. A fully automated station at the Qualicum airport is operated by the Ministry of Forests and Range, Wildfire Management Branch. It supports fire weather forecasting and aids decision-making through the Canadian Forest Fire Danger Rating System. Additional information can be found at http://bcwildfire.ca/weather/stations.htm.

There is also a marine weather station associated with an automated lighthouse on Ballenas Island; data can be retrieved from http://www.weatheroffice.gc.ca/canada_e.html. Qualicum winds are best detected by the Sisters Island weather station outside of MABR, north of Lasqueti Island (Mitchell, 1998). Models derived from data for nearby Point Atkinson are used to predict storm surges (Tinis, 2011).

Climate Change

Numerous climate change reports released by the Province are available at http://www.env.gov.bc.ca/cas/resources/reports.html#adaptation. Figure 19 shows predicted mean annual temperatures from Climate BC, a web-based program that generates climate normal data for genecology and climate change studies, accessible at http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html. Additional resources are available from the Biogeoclimatic Ecosystem Classification (BEC) website at http://www.for.gov.bc.ca/hre/becweb/program/climate%20change/index.html.

Hebda (2004) offers insights into paleoecology, climate change and forecasting the future of species at risk. Hamaan and Wang (2006) assessed the effects of climate change on tree species and ecosystem distribution in BC. Jamieson (2005) documented potential implications of climate change on species in BC estuaries. Bodtker et al. (2009) produced a bioclimatic model to assess the impact of climate change on ecosystems at risk. The Pacific Institute for Climate Solutions (PICS) is a significant source of climate change research in BC, at http://www.pics.uvic.ca/.

TEMPERATURE

Air Temperatures

Temperature data for the Coombs, Little Qualicum Fish Hatchery, and Ballenas Island weather stations are shown in Tables 1 to 3, respectively. Figure 20 shows the annual average temperatures within MABR.

Table 1. Temperature data summary for the Coombs Climate Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Temperature (°C) Get more temperature related statistics »

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average high	5.7	7.5	10.4	13.8	17.5	20.3	23.8	24	20.7	13.7	8.2	5.3
Average low	-0.9	-1	0.3	2.2	5.3	8.2	10.1	9.7	6.7	3.6	0.8	-0.8
Average	2.4	3.3	5.4	8	11.4	14.3	17	16.9	13.7	8.7	4.5	2.2
Record daily high	15	18	20	26	29	33.5	35	33	33	24	15.5	14.5
Date	Jan 28 1984	Feb 27 1986	Mar 29 1994	Apr 27 1987	May 12 1993	Jun 29 1987	Jul 27 1998	Aug 10 1990	Sep 01 1987	Oct 01 1987	Nov 09 1987	Dec 03 1993
Record daily low	-14.5	-17.5	-9	-5	-3	2	3	2	-2	-8	-18	-18
Date	Jan 06 1993	Feb 04 1989	Mar 03 1989	Apr 09 1999	May 10 1999	Jun 04 1988	Jul 01 1985	Aug 23 1992	Sep 16 1992	Oct 31 1984	Nov 29 1985	Dec 01 1985

Figure 19. Predicted future temperatures in BC

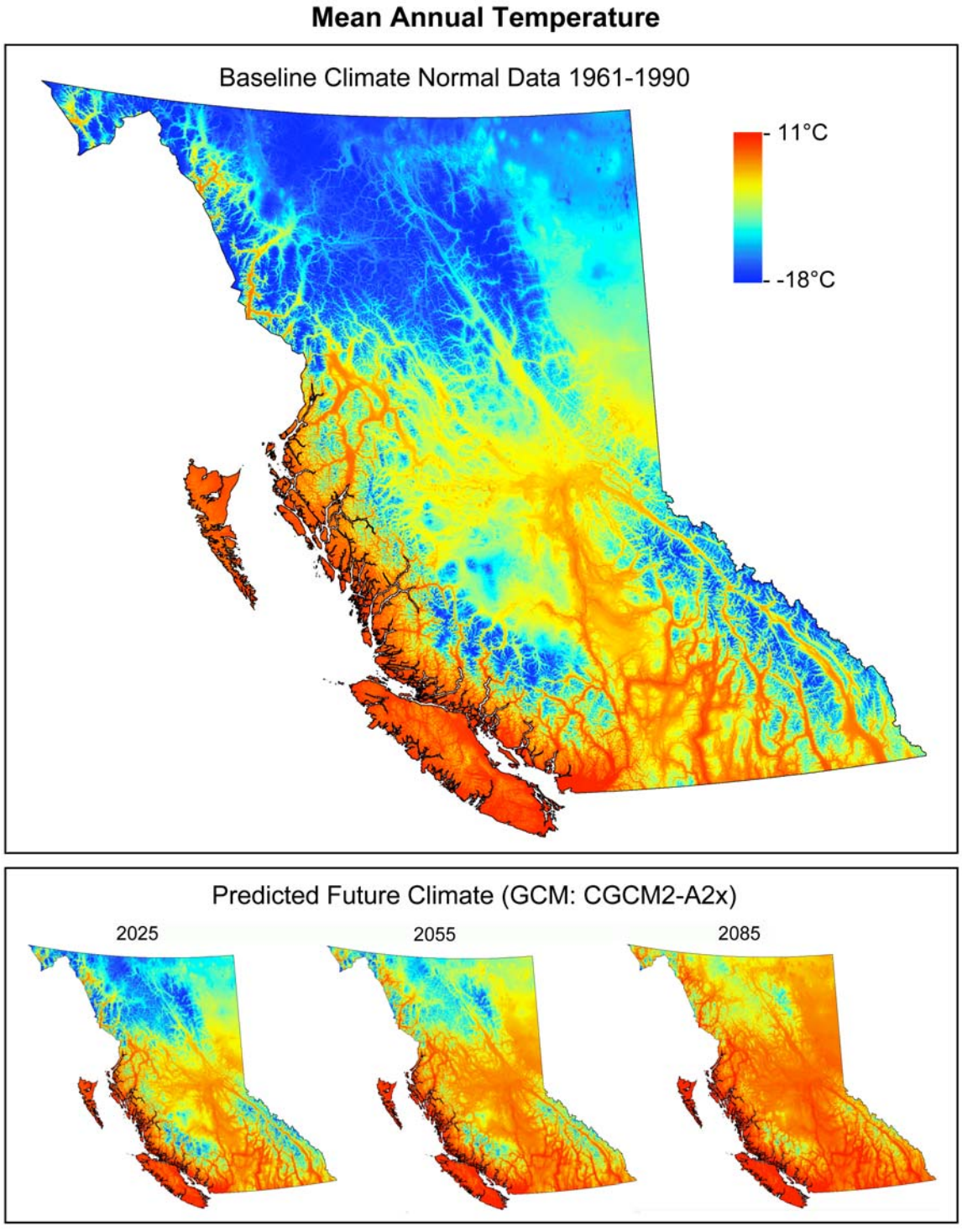


Table 2. Temperature data summary for the Little Qualicum Fish Hatchery Climate Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Temperature (°C) Get more temperature related statistics »

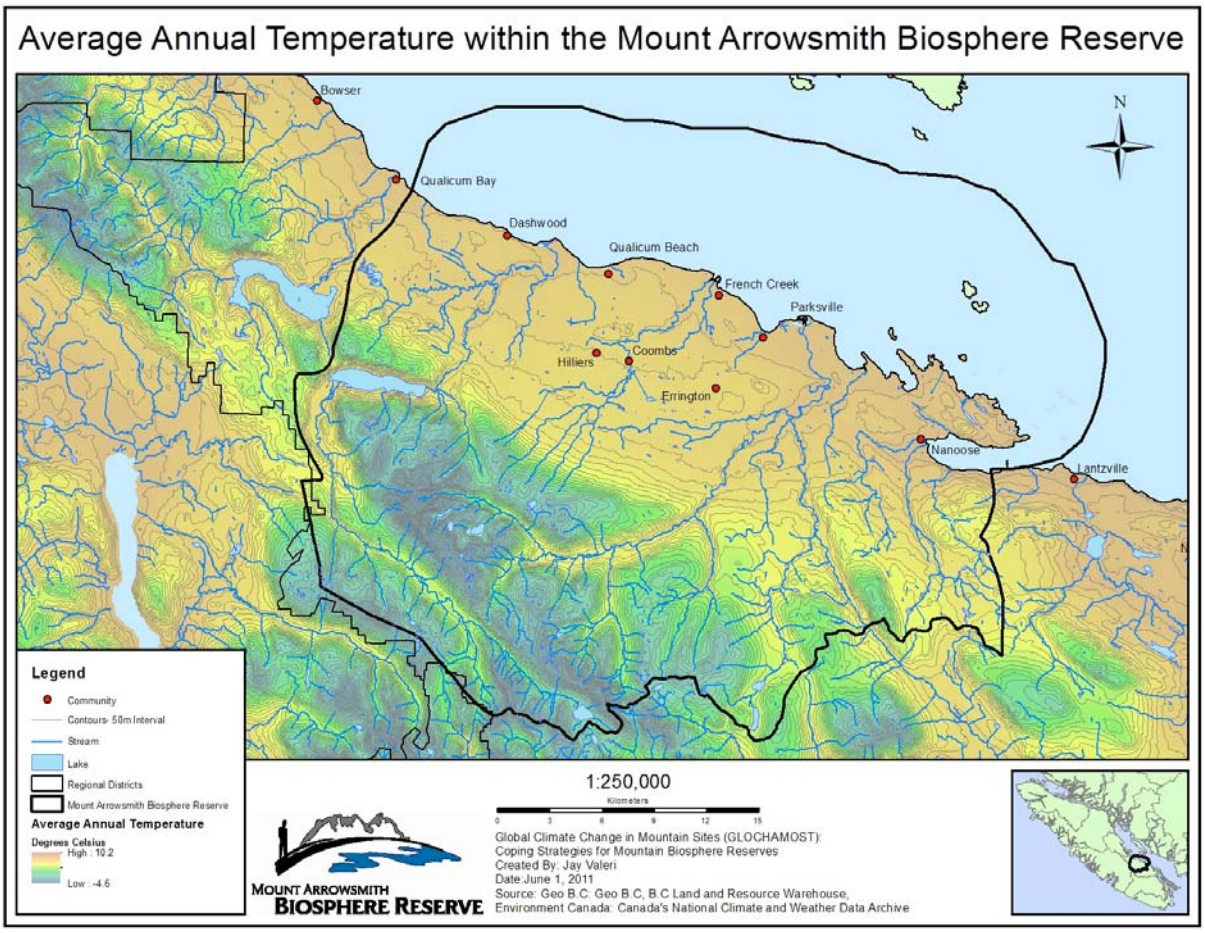
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average high	6.1	7.7	10.3	13.3	17	19.8	22.9	22.8	19.7	13.5	8.6	5.7
Average low	-0.3	-0.4	0.7	2.5	5.8	8.7	10.4	9.8	6.7	4	1.6	-0.3
Average	2.9	3.7	5.5	7.9	11.4	14.3	16.7	16.4	13.2	8.8	5.1	2.7
Record daily high	15	18.5	19.5	25.5	31.5	32	33	34	33	23.5	18.5	14.5
Date	Jan 21 1981	Feb 27 1986	Mar 29 1994	Apr 30 1998	May 29 1983	Jun 29 1995	Jul 22 1994	Aug 08 1981	Sep 01 1987	Oct 01 1992	Nov 08 1989	Dec 03 1982
Record daily low	-14	-17.5	-9	-3.5	-2	2.5	4	3	-2.5	-8	-18	-17.5
Date	Jan 06 1982	Feb 04 1989	Mar 03 1989	Apr 30 1986	May 11 1985	Jun 16 1985	Jul 08 1983	Aug 26 1985	Sep 28 1983	Oct 31 1984	Nov 29 1985	Dec 01 1985

Table 3. Temperature data summary for the Ballenas Island Weather Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Temperature (°C) Get more temperature related statistics »

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average high	7.3	8.2	10.5	13.5	17.2	19.7	22.2	20.7	19.4	13.8	10.2	6.9
Average low	2	2.3	4.3	6.9	9.4	11.7	13.5	13.9	11.1	8.2	4	1.3
Average	4.7	5.3	7.5	10.2	13.4	15.7	18	17.4	15.3	11	7.2	4.2
Record daily high	15.4	13.3	16.9	22.5	26.1	29	33.7	31.8	30.7	24	18.6	20.9
Date	Jan 30 1997	Feb 20 1995	Mar 28 1994	Apr 30 1998	May 27 1993	Jun 23 1998	Jul 27 1998	Aug 24 2000	Sep 07 2000	Oct 07 1997	Nov 18 1995	Dec 04 1996
Record daily low	-6	-4.1	-2	-2.5	1.4	6	7.9	8.9	4.5	2.2	-2.5	-11.2
Date	Jan 29 1996	Feb 11 1997	Mar 05 1997	Apr 06 1997	May 02 1993	Jun 15 1998	Jul 12 1998	Aug 08 1992	Sep 07 1992	Oct 06 1992	Nov 23 1993	Dec 04 1996

Figure 20. Annual average temperatures within MABR.



Sea-surface Temperatures

Current and tidal patterns in the Salish Sea/Strait of Georgia are well described in *Oceanography of the BC Coast* (Thomson 1981). Because of tidal resonance in the Sea, there are two tidal cycles each day and a maximum tidal range in MABR of about 4 m. This is the largest tidal range in the Sea, and sand flats in excess of a kilometre wide are exposed in shallow bays at low tide. There is a general anti-clockwise current circulation in the Salish Sea, but because of limited water exchange and freshwater-induced stratification of surface waters, there is a pronounced summer thermocline (MABR, 1998).

Surface waters can reach 20^{+o}C, while below about 10 m depth, temperatures seldom exceed 7-9ºC. In the winter, cooler air temperatures and increased winds reduce surface water temperature to about 8-9ºC. Surface waters in the summer are thermally stratified, with surface temperatures in excess of 20° C, the warmest surface marine waters in western Canada. Bottom

temperatures (below about 20 m) are about 8-9° C year-round. The timing and magnitude of the spring discharge of the Fraser River on the BC mainland influence the stratification and nutrient input of the Salish Sea, thereby affecting the productivity of the waters in MABR (MABR, 1998).

PRECIPITATION

The amount, distribution and timing of precipitation are major factors in the extent and character of vegetation cover and the nature of human use of water resources. In MABR, there is a marked mountain to sea precipitation gradient, as shown in Figure 21. MABR (1998) noted estimates of 2500 mm of precipitation on the western windward side of the mountains, 925 mm at 90 m elevation, 700 mm at sea level in Parksville and 500 mm at West Ballenas Island. Precipitation data for the Coombs, Little Qualicum Fish Hatchery, and Ballenas Island weather stations are shown in Tables 4 to 6, respectively.

Figure 21. Average annual precipitation within MABR.

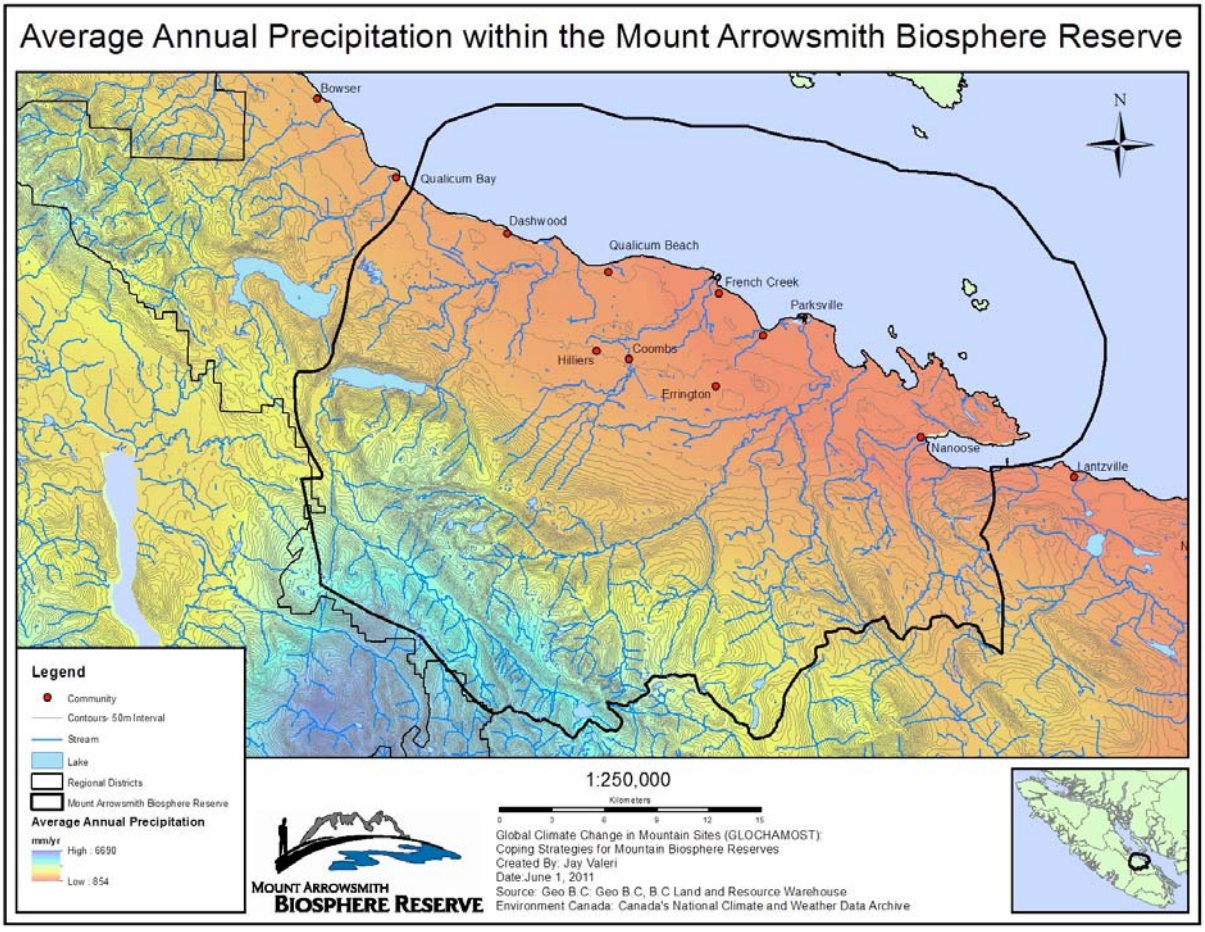


Table 4. Precipitation data summary for the Ballenas Island Weather Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Precipitation Get more precipitation related statistics »

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly rainfall (mm)	89	77	62	44	39	37	22	27	40	66	124	105
	Annual average: 733											
Monthly snowfall (cm)	11	6	1	0	0	0	0	0	0	0	3	5
	Annual average: 26											
Monthly precipitation (mm)	100	83	63	44	39	40	22	28	40	67	127	111
	Annual average: 763											
Single day record rainfall (mm)	38	33	28	29	21	25	31	37	38	34	35	41
Date	Jan 18 1968	Feb 01 1991	Mar 02 1987	Apr 16 1967	May 24 1981	Jun 24 1971	Jul 19 1968	Aug 29 1991	Sep 28 1971	Oct 23 1968	Nov 20 1974	Dec 18 1982
Single day record snowfall (cm)	32	14	8	3	0	0	0	0	0	6	18	16
Date	Jan 03 1978	Feb 11 1975	Mar 01 1991	Apr 03 1975	May 01 1967	Jun 01 1967	Jul 01 1967	Aug 01 1967	Sep 01 1967	Oct 31 1984	Nov 26 1985	Dec 30 1968
Single day record precipitation (mm)	38	33	40	29	21	25	31	37	39	39	35	41
Date	Jan 12 1968	Feb 01 1991	Mar 18 1997	Apr 16 1967	May 24 1981	Jun 24 1971	Jul 19 1968	Aug 29 1991	Sep 14 1997	Oct 17 1996	Nov 20 1974	Dec 18 1982

Table 5. Precipitation data summary for the Coombs Climate Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Precipitation

Get more precipitation related statistics »

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly rainfall (mm)	159	114	96	69	57	50	26	35	37	110	180	145
	Annual average: 1078											
Monthly snowfall (cm)	11	13	6	0	0	0	0	0	0	1	7	9
	Annual average: 47											
Monthly precipitation (mm)	170	128	101	69	57	50	26	35	37	111	187	154
	Annual average: 1126											
Single day record rainfall (mm)	80	61	83	25	27	32	33	65	26	44	56	86
Date	Jan 14 1961	Feb 01 1991	Mar 17 1997	Apr 15 1997	May 25 1984	Jun 01 1962	Jul 03 1998	Aug 29 1991	Sep 27 1961	Oct 19 2000	Nov 10 1990	Dec 12 1960
Single day record snowfall (cm)	13	35	20	0	0	0	0	0	0	8	16	42
Date	Jan 06 1991	Feb 01 1989	Mar 01 1991	Apr 01 1961	May 10 1985	Jun 01 1961	Jul 01 1961	Aug 01 1961	Sep 01 1961	Oct 31 1984	Nov 26 1985	Dec 28 1996
Single day record precipitation (mm)	80	61	83	25	27	32	33	65	26	44	56	86
Date	Jan 14 1961	Feb 01 1991	Mar 17 1997	Apr 15 1997	May 25 1984	Jun 01 1962	Jul 03 1998	Aug 29 1991	Sep 27 1961	Oct 19 2000	Nov 10 1990	Dec 12 1960

Table 6. Precipitation data summary for the Little Qualicum Hatchery Climate Station. Retrieved November 29, 2011 from http://www.theweathernetwork.com/statistics/cl1021850. The sampling period for this data covers 30 years.

Precipitation Get more precipitation related statistics »

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Monthly rainfall (mm)	151	123	92	65	50	48	25	33	40	114	182	140
	Annual average: 1063											
Monthly snowfall (cm)	9	9	4	0	0	0	0	0	0	1	5	8
	Annual average: 35											
Monthly precipitation (mm)	161	131	96	65	50	48	25	33	40	115	186	148
	Annual average: 1098											
Single day record rainfall (mm)	64	65	101	28	24	22	26	57	27	51	62	68
Date	Jan 17 1986	Feb 01 1991	Mar 17 1997	Apr 03 1991	May 25 1984	Jun 09 1998	Jul 03 1998	Aug 29 1991	Sep 30 1997	Oct 31 1981	Nov 18 1991	Dec 03 1990
Single day record snowfall (cm)	24	27	28	0	0	0	0	0	0	7	17	18
Date	Jan 07 1991	Feb 15 1990	Mar 01 1991	Apr 11 1981	May 01 1981	Jun 01 1981	Jul 01 1981	Aug 01 1981	Sep 01 1981	Oct 31 1984	Nov 26 1985	Dec 29 1984
Single day record precipitation (mm)	64	65	101	28	24	22	26	57	27	51	62	68
Date	Jan 17 1986	Feb 01 1991	Mar 17 1997	Apr 03 1991	May 25 1984	Jun 09 1998	Jul 03 1998	Aug 29 1991	Sep 30 1997	Oct 31 1981	Nov 18 1991	Dec 03 1990

MABR has a low tree line due to a heavy winter snow pack. Patches of snow remain on the barren upper slopes of the mountains year round (MABR, 1998). The rain-dominated zone on the south coast of BC corresponds to an elevation band 0-300 metres above sea level (masl), the rain-on-snow zone corresponds to the 300-800 masl band and the snow zone corresponds to the area above 800 masl (BC Ministry of Forests, 1999; Hudson, 2001; Hudson, pers. comm., 2003 in Weston, Guthrie & McTaggart-Cowan, 2003). Approximately 30% of the Englishman River watershed lies within the rainfall dominated elevation band, about 60% lies within the rain-on-snow elevation band, and roughly 10% of the watershed is within the snow fall elevation band (Weston, Guthrie & McTaggart-Cowan, 2003).

A propensity for summer droughts has long influenced natural disturbance processes in MABR. Historically, fire was a regular occurrence at lower elevations, at least on the scale of

decades or centuries, as evidenced by fire scars on the bark of old trees. Long-term fire prevention has affected forest stand-opening events and allowed a build-up of understory fuels. When fires occur today, they are considered destructive and are rarely self-limiting.

Monitoring

In 2006, a site on the Mount Arrowsmith massif became part a global network of long-term monitoring sites known as the Global Observation Research Initiative in Alpine Environments (GLORIA). Standardized protocols associated with GLORIA are used to document changes in snow cover as well as soil temperatures of microhabitats, patterns of vegetation, and species richness and composition (Swerhun, Jamieson & Smith, 2009). The site is to be resurveyed at five year intervals; a lack of funding prevented planned monitoring in 2011.

Snow was surveyed on Mount Cokely in 1954, and has been surveyed annually since 1972. Historic data for a station at 1250 m can be found at http://a100.gov.bc.ca/pub/mss/stationdata.do?station=3B02 and more recent data for the station at 1267 m is at http://a100.gov.bc.ca/pub/mss/stationdata.do?station=3B02A.

Vancouver Island Basin Automated Snow Pillow Stations are located outside of the biosphere reserve at Wolf River and Jump Creek; see http://bcrfc.env.gov.bc.ca/data/asp/realtime/basin_vanisle.htm. Archived data is available from http://bcrfc.env.gov.bc.ca/data/asp/archive.htm.

SURFACE WATER

The Englishman River and the Little Qualicum River are the largest streams in MABR. The Englishman River watershed has a drainage area of 324 km^2 (RDN, n.d.). The river is 39 km in length (Barlak, Epps & Phippen, 2010). The South Englishman River, Swane Creek, Morison Creek, Shelley Creek and Centre Creek are tributaries (RDN, n.d.). There are seven named lakes within the watershed (Table 7) (FISS (2006) in Barlak, Epps & Phippen, 2010).

Table 7. Named lakes within the Englishman River watershed (Barlak, Epps & Phippen, 2010)

Lake	Elevation (m)	Area (ha)
Fishtail Lake	1,003	15.5
Hidden Lake	1,091	15.8
Arrowsmith Lake (reservoir)	813	35.5

Rowbotham Lake	970	21.3
Marshall Lake	817	<10
Shelton Lake	548	36
Healy Lake	531	33.8

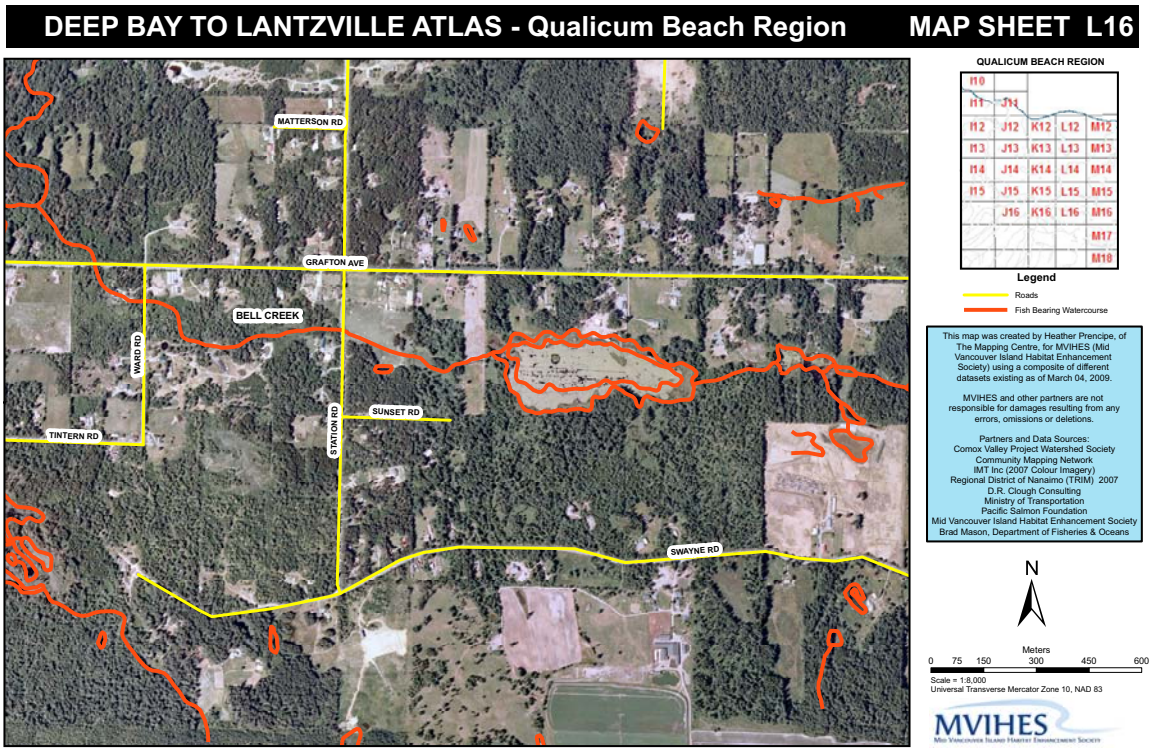
The drainage area of the Little Qualicum River is comparatively smaller. Including Whisky Creek, it is 251 km^2. Cameron Lake is located at the head of the Little Qualicum River with the Cameron River entering at the western side of the lake. The lake's outlet into the Little Qualicum River has been regulated since 1978. Whiskey Creek and Kinkade Creek are tributaries to the Little Qualicum River (Pirani & Bryden, 1996). Subterranean flow from Spider Lake and the Illusion Lakes is presumed to flow into the Kinkade Creek system (Norris, 1986 in Pirani & Bryden, 1996). During peak flows, a portion of Spider Lake may flow into Kinkade Creek. There are 3 named lakes associated with the Little Qualicum River (Table 8) ((Pirani & Bryden, 1996).

An comprehensive atlas of fish-bearing streams and ditches was produced by the Mid Vancouver Island Habitat Enhancement Society (MVIHES) and project partners in 2009 (Figure 22, for example). The intent of the atlas was to provide information to road maintenance managers, planners and other agency staff about the possibility of fish habitat in roadside ditches.

Table 8. Lakes in the Little Qualicum River area (Pirani & Bryden, 1996).

Lake	Drainage	Surface Area (ha)	Mean Depth (m)
Cameron Lake	Little Qualicum River	477.50	28
Spider Lake	Kinkade Creek/Little Qualicum River	57.51	4.48
Illusion Lake	Kinkade Creek/Little Qualicum River	6.70	2.0

Figure 22. Fish in the Ditch Atlas, Map sheet L16. Mid-Vancouver Island Habitat Enhancement Society (MVIHES).



River Discharge

The Englishman River is categorized as a pluvial or rainfall-driven hydrologic system that is influenced by heavy autumn and winter rain and rain-on-snow (Whitfield, Wang & Cannon, 2003; Weston, Guthrie & McTaggart-Cowan, 2003). Heavy rains typically begin in October and last until April. As the river system has no lakes of significant size that moderate peak flows, the river exhibits a flashy response to rainfall events. On March 3, 2003 for example, the river rose approximately 2 m in 24 hours, representing an increase in discharge from 20 to 313 cubic metres per second. Lower spring precipitation and snowmelt are followed by dry summers and low discharges from June through September (Weston, Guthrie & McTaggart-Cowan, 2003).

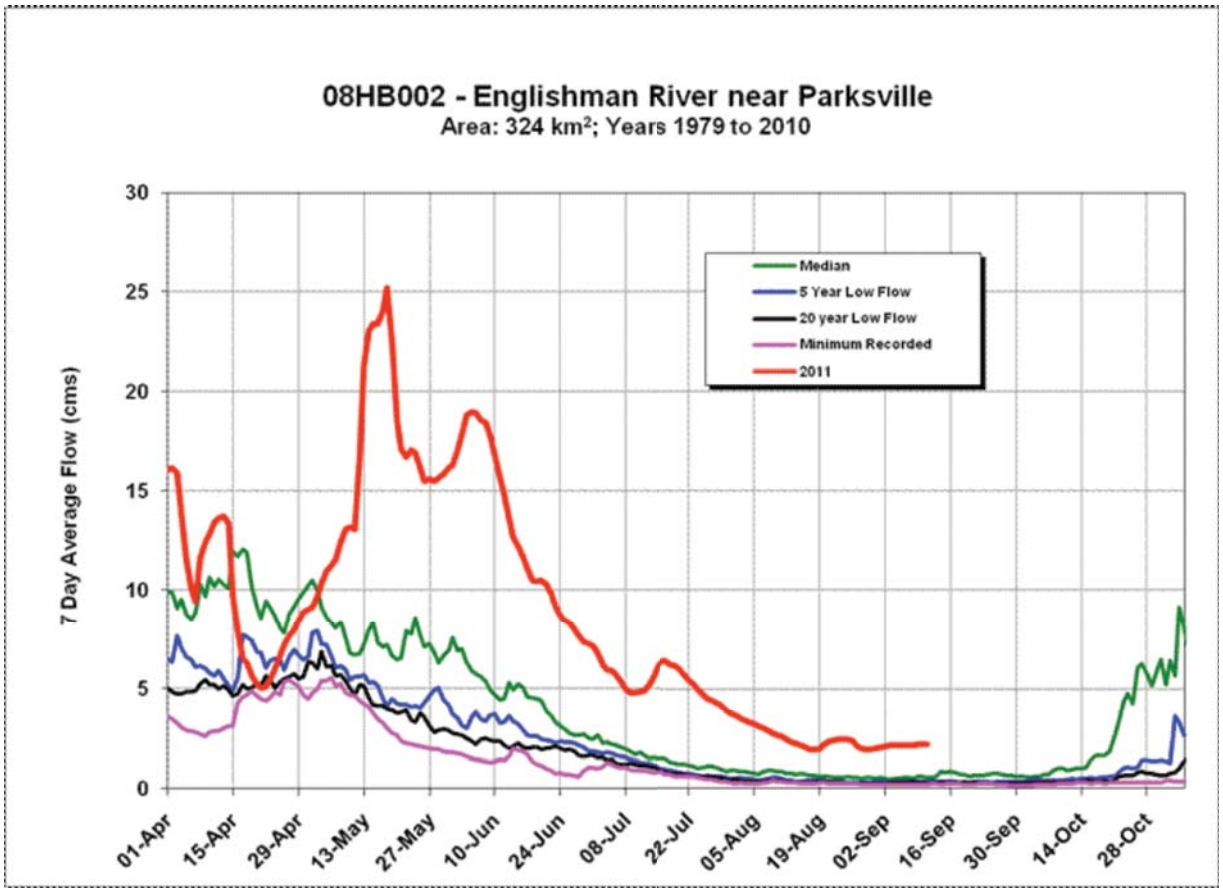
Modeled future streamflow extremes for the Englishman River indicate that the frequency and magnitude of low flow events are unlikely to change with a changing climate, but their seasonal occurrence could increase in duration, beginning earlier in summer and extending later into the autumn. Winter flood events are projected to increase (Whitfield, Wang & Cannon, 2003). Using the results of a regional climate model, Weston, Guthrie & McTaggart-Cowan (2003) predicted that peak annual flows could be 8% larger by 2020, 14% larger by 2050 and 17% larger by 2080, with significant impacts to people living on the floodplain.

Surface Water Monitoring

Real-time hydrometric data is available from http://www.wateroffice.ec.gc.ca/index_e.html. Downstream from Highway 19A and above the intake for the City of Parksville, Water Survey Canada has periodically operated a hydrometric station on the Englishman River since 1913 (Barlak, Epps & Phippen, 2010). In May 2003, the station was automated to collect water temperature, turbidity, specific conductivity and water level data every 15 minutes (Barlak, Epps & Phippen, 2010).

The Province produces a *Water Supply and Streamflow Conditions Bulletin* from July to October. This bulletin reports on the summer precipitation and streamflow conditions, and provides a commentary on water supply conditions for major watersheds in BC including the Englishman River (Figure 23).

Figure 23. Englishman River 7-day average streamflow, compared to historic median. Retrieved November 21, 2011 from http://bcrfc.env.gov.bc.ca/bulletins/watersupply/graphs/08hb002.htm



Two Water Survey of Canada hydrometric stations exist within MABR on the Little Qualicum River; there are 42 years (1913-22, 1960-93) of flow records for the Little Qualicum River at the outlet of Cameron Lake and 27 years (1960-86) of flow records for the Little Qualicum River near Qualicum Beach. There are stream flow records related to water licenses and provincial low-flow monitoring studies for the Cameron River during 1959-63 and Kinkade Creek for 1985 and 1992 (Pirani & Bryden, 1996). Additional information, including stream flow data for Whisky Creek is found at http://www.env.gov.bc.ca/wsd/water_rights/wap/vi/qualicum_river/qualicum_wap.pdf.

There is also a Water Survey of Canada station at Arrowsmith Lake, at the site of the Arrowsmith dam. See additional information in **Water Managment** below.

Five monitoring locations were established within the Englishman River watershed to accommodate a water quality study between 2002 and 2005. These were located on Morison Creek just upstream from its confluence with the Englishman River (selected to monitor potential impacts from agricultural activities and timber harvesting in the upper watershed); on the Englishman River just upstream from its confluence with Morison Creek (representing a small amount of timber harvesting, but primarily unimpacted); on the South Englishman River just upstream from its confluence with the Englishman River (representing potential impacts solely from timber harvesting); on the Englishman River just upstream from Allsbrook Canyon (a potential new location for the City of Parksville water intake); and at the site on the Englishman River below Highway 19A. A suite of water quality data were collected weekly during the summer low flow and fall high flow periods, and monthly for the rest of the year (Barlak, Epps & Phippen, 2010). Some of the results of this study are provided in **Surface Water Quality** below.

Surface Water Quality

There are no permitted waste discharges within the Englishman River watershed. However, anthropogenic impacts on water quality can occur. These may be associated with urban and rural residential development (e.g., sedimentation from land clearing, increases in impervious surfaces and runoff, contamination from aging septic fields), light industrial development, transportation infrastructure including polycyclic aromatic hydrocarbon contamination from vehicles, recreational activities, and agricultural activities including fecal contamination from livestock. Forest harvesting can affect water quality by decreasing water retention times. Road construction can change drainage patterns, destabilize slopes, lead to erosion and introduction of sediments to watercourses. (Burlak, Epps & Phippen, 2010).

There are two mineral prospects in the Englishman River watershed (MINFILE, 2005 in Burlak, Epps & Phippen, 2010)); the Okay Mountain site, consists of an ash-rich coal seam with high concentrations of sulphur, calcium, titanium, nickel and copper. The other is the Hey-Bert showing, which contains high copper concentrations. Mining activities can introduce

contaminants to waterbodies, contribute to acidification of water, and alter water flow patterns through clearing (Burlak, Epps & Phippen, 2010).

The natural erosion of an exposed clay bank approximately 300 m in length and 30 m in height, located approximately 150 meters downstream of the South Fork confluence, may also affect water quality (Burlak, Epps & Phippen, 2010). Tilling of peat bogs have resulted in major sediment loadings to nearby Morison Creek (Rosenau and Angelo, 2003 in Burlak, Epps & Phippen, 2010).

Acceptable water quality parameters and monitoring objectives to be integrated into planning initiatives are provided at http://www.env.gov.bc.ca/wat/wq/englishman/wqo-technical-englishman.pdf.

GROUNDWATER

The results of a recent study of groundwater resources in the lower Englishman River watershed were disseminated to a packed house of interested residents, resource professionals , and staff and officials from all levels of government in November 2011. Conducted by GW Solutions and supported by Mid Vancouver Island Habitat Enhancement Society (MVIHES) and project partners, the project explored the interaction of between the aquifers and the river; described the dynamics of groundwater movement in the context of bedrock, river rock, gravel and soil substrates, and other characteristics of the landscape; and mapped the topography of the water table. Water quality parameters were assessed as well.

Additional monitoring locations, a flow gauge at the Englishman River falls and a snow gauge at the Arrowsmith dam were identified as needs to better assess groundwater flow and the geometry of the aquifers. The presented also called for a watershed management team and plan. A video of the presentation is available at http://mvihes.bc.ca/.

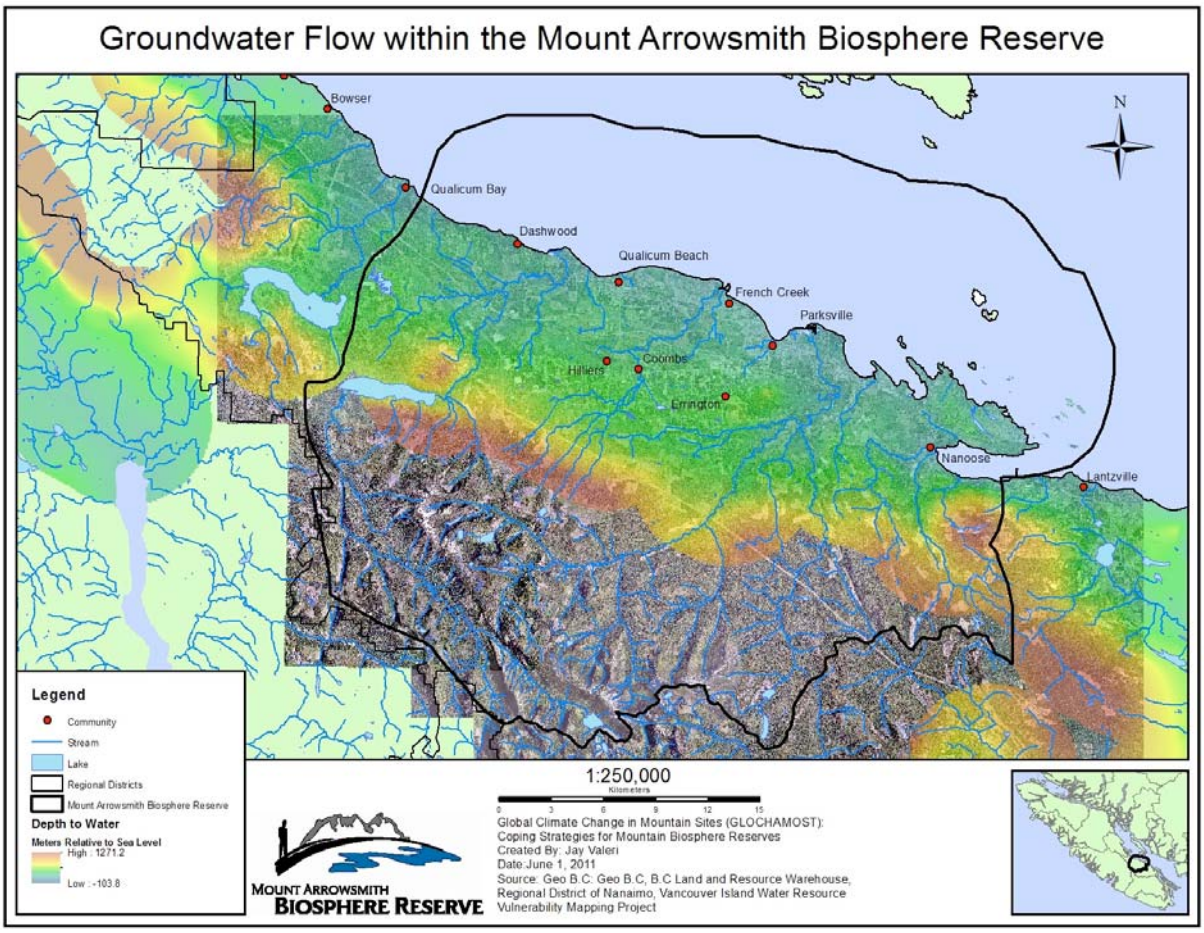
Groundwater Flow

Figure 24 provides a general overview of the depth to groundwater.

WATER USE AND MANAGEMENT

MABR residents are familiar with often heavy and prolonged winter rains, and have learned to anticipate water use restrictions in the summer months. Water withdrawals to accommodate seasonal increases in population due to tourism and to maintain gardens and lawns, together with scant summer precipitation contribute to the shortages. Ongoing population growth in the region is expected to exacerbate these shortages. Current patterns of water availability are expected to change due to the combination of drier summers and more frequent and extended drought events, wetter winters and severe storm and flood events, sea level rise and saltwater intrusion.

Figure 24. Groundwater flow within MABR.



Provincial, regional and local water managers have for many years been planning for these changes, and developing infrastructure and programs to mitigate adverse impacts.

Water Demands

At 498 litres/day, per capita water use in MABR is reminiscent of water consumption across Canada. Our country is reputed to be the highest consumer of water with the exception of the United States (Environment Canada, 2011). Use by area within MABR is shown in Table 9.

Table 9.Per capita water use within MABR (Arrowsmith Water Service, 2011).

Water Service Area	Average Day Water Demand (L/d per capita)	Maximum Day Water Demand (L/d per capita)
City of Parksville	514	1094
Town of Qualicum Beach	572	1466
RDN Nanoose	479	1374
RDN French Creek	340	1203
Weighted Average	498	1258

Water licenses and associated withdrawals are described in Barlak, Epps and Phippen (2010) at http://www.env.gov.bc.ca/wat/wq/englishman/wqo-technical-englishman.pdf

Water Supply

The Province has an observation well network with wells in Parksville and Qualicum Beach (BC Ministry of Environment (BC MoE, n.d.). Hydrographs for the wells indicate that water tables in the region's aquifers are declining (Figures 25 and 26).

Figure 25. Water level in the Parksville observation well, from 1992 to 2011, retrieved November 19, 2011 from http://www.env.gov.bc.ca/wsd/data_searches/obswell/obsw314.html

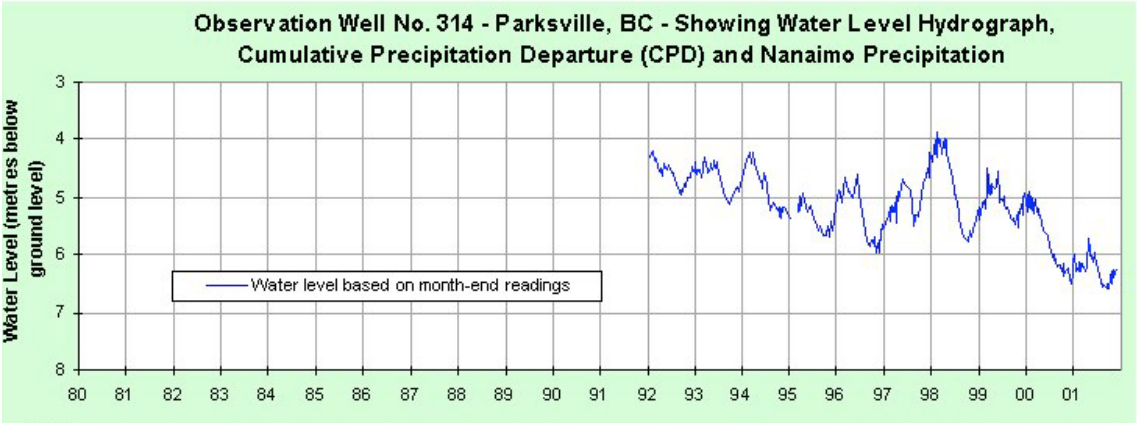
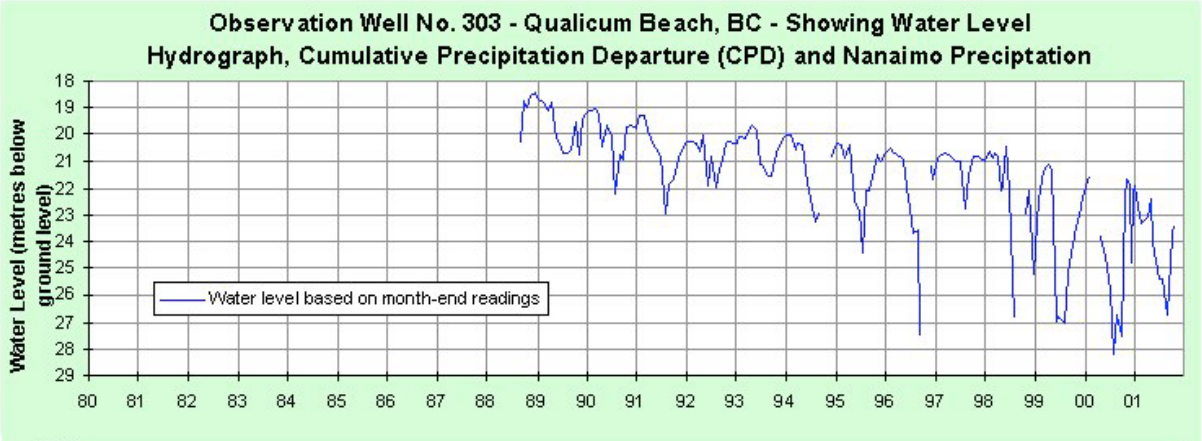


Figure 26. Water level in a Qualicum Beach observation well, from 1992 to 2011, retrieved November 19, 2011 from http://www.env.gov.bc.ca/wsd/data_searches/obswell/obsw303.html



Well Density

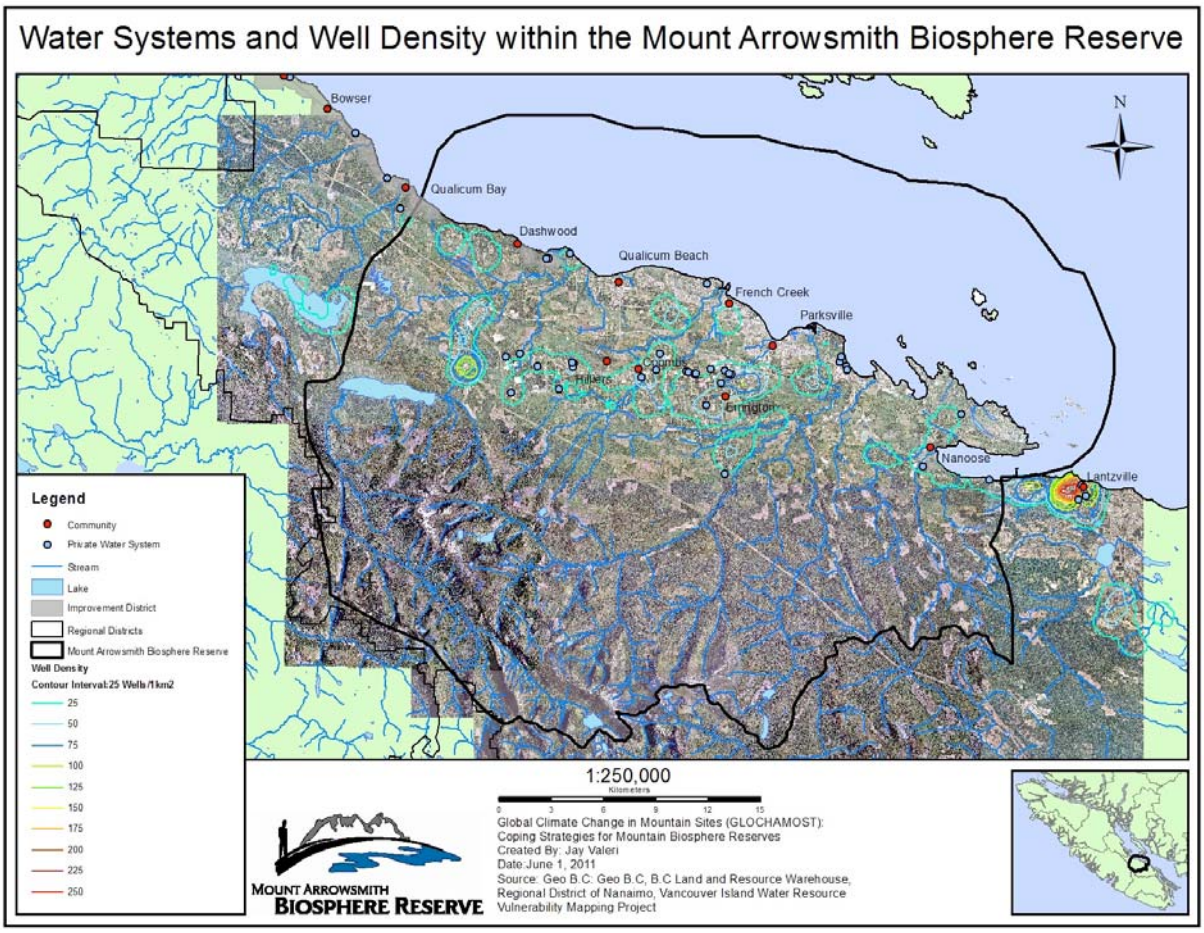
As the BC MoE database for wells is incomplete, and it is known that numerous wells are unregistered, an interpolation from unserviced address points and property parcels must be used to create a representation of likely well locations. A similar interpolation can be done for septic locations (Valeri, 2011). Figure 27 combines this information with known well data from the Vancouver Island Water Resources Vulnerability Mapping (Newton & Gilchrist, 2010) and local knowledge documented in the RDN's Watershed Snapshot Report (RDN, 2010) to identify areas and wells that are "downstream" from high septic densities and vulnerable to contamination (Valeri, 2011). See also Figure 28 in **Wastewater Management** below.

Saltwater Intrusion

Vegetative changes have been observed at the Little Qualicum River estuary indicating that the brackish upper marsh is developing the characteristics of a salt marsh (Dawe, pers. comm., 2009). Low summer flows in the river and reduced groundwater recharge appear to be contributing factors, as diminished freshwater inflows may result in higher salinities in the estuary and and saltwater intrusion into the aquifer.

Chloride, conductivity and total dissolved solid tests of adjacent wells on the Marshall-Stevenson unit of the Qualicum National Wildlife Area (NWA) show increases from 2000, and chloride spikes in autumn from about 2002. Salinity measurements however have remained constant at 0.1% and well below the threshold for suitable drinking water (RDN, June 2011).

Figure 27 . Water systems and well density within MABR.



Water Management

Water management in MABR is complex, consisting of local government entities, private water utilities, water user communities, unorganized other water systems, and an unknown number of private wells. The BC MoE is responsible for surface water allocation and licensing; , and the Ministry of Health and Vancouver Island Health Authority (VIHA) is responsible for drinking water protection. No agency has authority over watershed or aquifer protection (Lanarc, 2007).

The Englishman and Little Qualicum Rivers were designated as Community Watersheds under the *Forest Practices Code of British Columbia Act* (1996). The designation continued under the *Forest and Range Practices Act* (FRPA) in 2002 and confers a level of protection. FRPA does not apply to the parts of the community watershed that are on private land. However the *Private Managed Forest Land Act* (2003), the *Drinking Water Protection Act* (2001), and BC MoE water quality objectives are additional mechanisms to protect water quality (Barlak,Epps & Phippen, 2010).

The Arrowsmith Water Service (AWS) is a joint venture between the RDN, City of Parksville and Town of Qualicum Beach. Its principal aim is to supplement existing supply sources owned and operated by the individual jurisdictions by building up multiple supply sources in the winter when water is abundant, for use in dry summers when demands are high. Completed in 1999, the Arrowsmith Dam at the headwaters of the Englishman River was the first AWS initiative to create water storage capable of augmenting natural flows. Salmonid populations have greatly benefited from increased summer flows and the cooling effect of the reservoir water. Only 12 ha of land was flooded to create the reservoir, due to steep, rocky terrain. The AWS partners also promote water conservation through metering, pricing and public education. The Englishman River Water Service, void of representation from the Town of Qualicum Beach, is contemplating moving the intake inland to avoid tidal inundation due to sea level rise (among other reasons), establishing a new treatment facility for the river water (a provincial requirement), and developing a system of Aquifer Storage and Recovery (ASR). Additional information in a series of reports is available at http://www.arrowsmithwaterservice.ca.

The Town of Qualicum Beach benefits from the natural storage in Cameron Lake, which empties into the Little Qualicum River. Cameron Lake's outlet has been regulated by DFO since 1978 (Pirani & Bryden). In 2008, the weir at the outlet of CameronLake was improved to help stabilize Little Qualicum River flows and boost summer river flows for fish. The project was undertaken by the the non-profit society BC Conservation Foundation (BCCF) with support from DFO, BC MoE and the trust fund *Living Rivers-Goergia Basin and Vancouver Island* (Living Rivers, 2008).

Weston, Guthrie and McTaggart-Cowan (2003) predicted instantaneous peak flow discharge return intervals for the lower Englishman River. Given anticipated changes to peak flows associated with shifting weather patterns, the authors recommended actions to mitigate damage to infrastructure and advised using the return intervals contained in their thesis for planning purposes.

Watershed Management

The Englshman River, Little Qualicum River and French Creek have been designated as Sensitive Streams under the BC *Fish Protection Act* (1997) and Sensitive Streams Designation and Licensing Regulation. A stream is sensitive when the watershed contains a significant population of salmon; the stream is deemed a high priority because of the precariousness nature and value of fish stocks at risk; the stream has sensitive yearly flows and significant human populations dependent upon it; the stream flows limit fish production from achieving historic levels; water abstraction and associated waters, intakes, etc. are adversely affecting stream flows and fish migration; and the stream offers good potential for recovery of fish populations, either with or without a recovery plan.

When a stream is designated as sensitive, the sustainability of fish are to receive highest priority; recovery plans may be required if they are unable to rehabilitate naturally. Water

managers must consider the needs of fish before issuing a water license. Water license applicants may be required to provide water flow and fish habitat information, or find a reasonable alternate source of water, and water license applicants may be required to develop mitigation or compensation measures (BC MoE, n.d.a).

The Englishman River Watershed Recovery Plan (ERWRP) was created in 2001 as an initiative of the non-profit society Mid-Vancouver Island Habitat Enhancement Society (MVIHES). At that time, the Englishman River was ranked the most endangered river in the province. MVIHES coordinates projects and community discussions, guided by a multi-stakeholder steering committee. The committee has representation from Fisheries and Oceans Canada (DFO), BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO), BC Parks, RDN, BCCF, Nature Trust of British Columbia (TNT), forest companies Island Timberlands and Timberwest, and includes several environmental consultants. Coho salmon and steelhead trout populations are monitored indicators of watershed health. MVIHES has taken an holistic approach to watershed recovery, facilitating and/or undertaking a range of projects including comprehensive mapping and historical comparative analysis of the vegetation in the Englishman River estuary, *Groundwater Mapping*, and *Romney Creek Amphibian Habitat and Stream Habitat Restoration.* To enhance water quality, MVIHES encouraged automotive and marine-related businesses to eliminate pollutants and reduce runoff, and raising public awareness about the location of storm drains and the sensitivity of aquatic systems. Together with Qualicum Streamkeepers, the organization has encouraged Salmon Friendly Lawns by conserving water and reducing dependence on pesticides and fertilizers. MVIHES has also conducted some flow and water quality monitoring.

Many of MVIHES' projects have extended beyond the Englishman River watershed. *Forage Fish Mapping, Eelgrass and Kelp Mapping and Monitoring*, and a shoreline modification study of the Parksville Qualicum Beach Wildlife Management Area are some examples. A demonstration rain garden was created in Qualicum Beach. Additional information can be found at http://www.mvihes.bc.ca/.

In 2006, a closely related group known as the Qualicum Beach Streamkeepers conducted a feasibility study for a watershed recovery plan for the Little Qualicum River. This study, which focused on public and stakeholder consultation, identified issues and garnered support for a plan from agencies, organizations, and residents. Since 1995, the Qualicum Beach Streamkeepers have overseen the mapping and assessment of the watercourses of Qualicum Beach, and initiated hydrology and wetland studies and many restoration projects and public awareness campaigns. For more information, see http://www.mvihes.bc.ca/connect/qb-streamkeepers/84-qualicum-beach-streamkeepers.

In 2007, the RDN-led Drinking Water-Watershed Protection Stewardship Committee developed the *Drinking Water and Watershed Protection Action Plan* (Lanarc, 2007). The committee included several residents as well as representatives from the RDN Board and staff, Vancouver Island Health Authority (VIHA), BC MoE, Islands Trust, Coastal Water Suppliers Association,

MVIHES, Private Forest Lands Council, Arrowsmith Watershed Coalition Society, and the well drilling industry.

The ensuing Drinking Water and Watershed Protection Program had seven areas of emphasis: (1) Public Awareness & Involvement, (2) Water Resources Inventory and Monitoring, (3) Land Planning and Development, (4) Watershed Management Planning, (5) Water Use Management, (6) Water Quality Management, and (7) Climate Change (RDN, 2010). Approximately 60 actions or projects were identified in this plan. Some of these have begun, including *Team Watersmart*, a program to help residents learn more about water protection; expansion of the MoE observation well network; community watershed monitoring with participation from MVIHES, Friends of French Creek Conservation Society, Parksville-Qualicum Fish and Game Club, Qualicum Beach Streamkeepers and others; Englishman River groundwater-surface water interactions project with MVIHES and the Geological Survey of Canada/Natural Resources Canada; private well level monitoring program; RDN WaterMap, a tool to assemble geographically referenced data on water and land use; and Water Budgets, a project to better understand regional water resources by identifying where various elements of the hydrologic cycle are located, how much water they hold, how water moves between these elements, and where water is being taken or used in a way that may not be sustainable. More information on these projects are available at http://www.rdn.bc.ca/cms.asp?wpID=2245.

A related *Watershed Snapshot Report 2010* (RDN, 2010) documents the results of a watershed-by-watershed community mapping and outreach process.

Wastewater Management

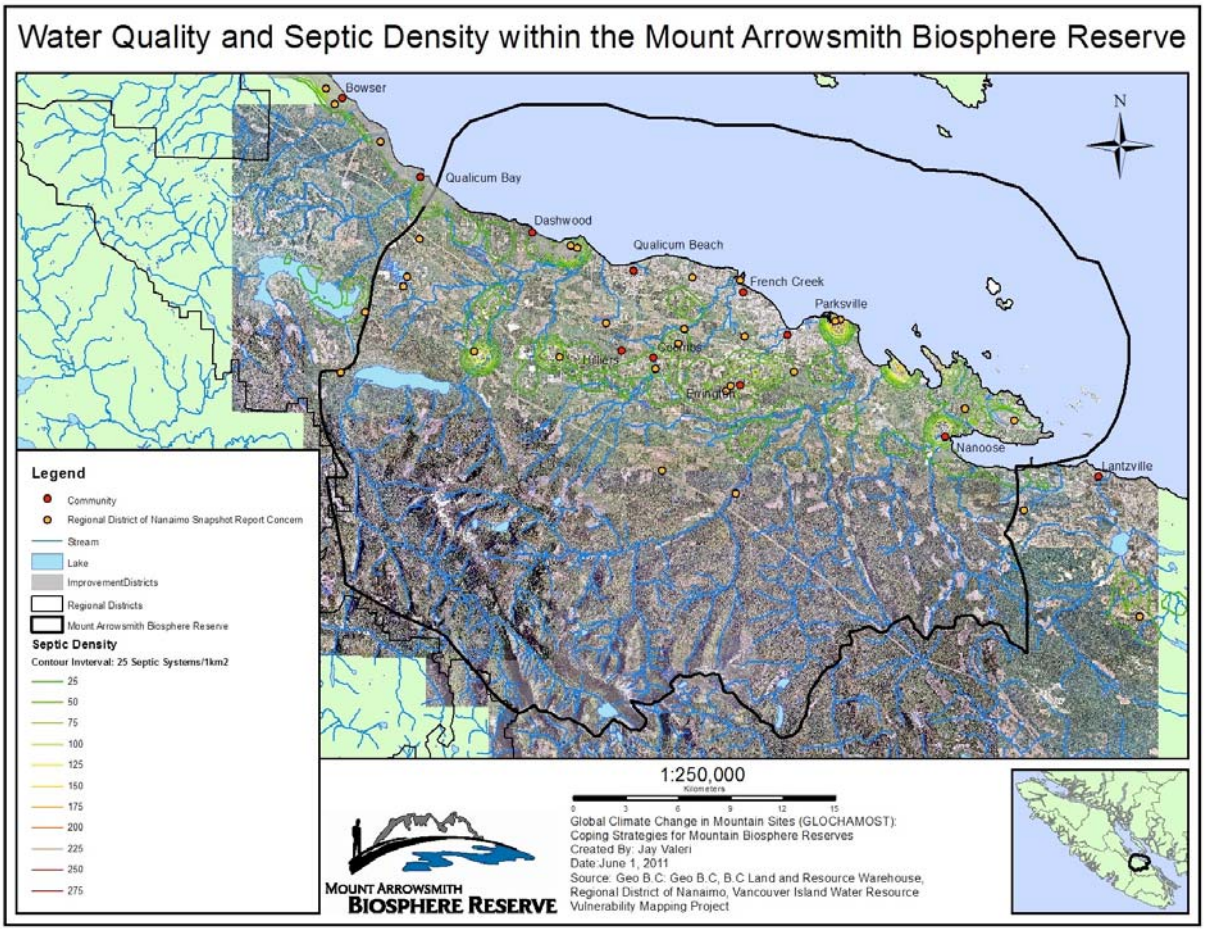
Wastewater includes contaminated storm or rainwater runoff, as well as sewage. Outside of the areas serviced by sewer systems, septic tanks hold and septic fields filter sewage. Valeri (2011) mapped septic density, shown in Figure 28. Failing septic systems along the waterfront have contributed to shellfish contamination and sanitary shellfishery closures. The closure in the Craig Creek-Madrona Point area was revoked in 2007. Wall Beach in Nanoose Bay as well as Parksville Bay from the Englishman River to French Creek remain closed. Portions of the Qualicum Beach shoreline, and the mouth of the Little Qualicum River are also closed to shellfishing (DFO, 2011). Contamination by Canada Geese and other wildlife could be contributing factors in some areas.

As noted above in **Watershed Management**, MVIHES has encouraged better management of runoff through education programs. The BC Ministry of Environment encourages the use of a series of municipal solid and liquid waste guidelines, including stormwater guidelines http://www.env.gov.bc.ca/epd/mun-waste/guidelines.htm

The French Creek Treatment Plant/Pollution Control Centre services a broad area extending from Nanoose Bay to Qualicum Beach, and discharges secondary treated effluent into the Salish Sea at a depth of 61 m, 2,440 m offshore. In 2007, the plant treated 9,544.6 cubic metres per day, on average. The plant is located near Morningstar Creek, a tributary of French Creek. Some

wastewater is piped to lagoons at Morningstar Golf Course, and used for irrigation. Some biosolids are used in a mine reclamation project. The Nanoose Wastewater Treatment Plant/ Pollution Control Centre provides primary sewage treatment for the Nanoose service area and discharges treated effluent 450 m offshore via an outfall 39 m deep. In 2007, the plant treated 218 cubic metres per day, on average (RDN Wastewater Services, 2011).

Figure 28. Water quality and septic density in MABR.



Marine Water Quality

Vancouver Island University operates the Deep Bay Centre for Shellfish Research, a field station just north of MABR. Researchers at the station, as well as nearby scallop farmers are exploring whether the ocean is acidifying and no longer absorbing CO2. To enable larvae to grow, scallop farmers must expel CO2 from the ocean water pumped into their inland tanks (Daily News, October 2011). The centre is installing monitoring units on their shallow and deep water intakes that will continuously monitor dissolved oxygen, salinity, temperature and pH. This will allow researchers to track changes in ocean acidification and compare results with data from identical units being installed at other oyster hatcheries (Kingzett, 2011)

The Coast Salish, United States Geological Survey (USGS) scientists, members of western Washington Tribes and British Columbia First Nations measured water quality in Puget Sound and the Strait of Georgia/Salish Sea during the Tribal Journey, an annual summer canoe voyage. Data is available for 2008 through 2011. In 2008, the Homalco Nation from Campbell River monitored temperature, salinity, pH, turbidity and dissolved oxygen (Akin et al., 2009). Maps and histograms are available at http://walrus.wr.usgs.gov/reports/reprints/TJWQP.pdf. Additional information regarding the project can be found at http://www.usgs.gov/features/coastsalish/.

Chapter 4

Land Use

Current Status and Trends

By Pam Shaw

Moving from the top of peaks toward the ocean, land uses within MABR include park lands and other protected areas, forestry lands, farm lands, rural residential areas, urban residential development, industrial lands, commercial areas, marine-based recreational development, and aquaculture harvesting areas.

The ecosystems of the area are threatened by the impacts of growth. Of great significance are the rare Coastal Douglas-fir ecosystems which have been heavily impacted by human activity. Population growth and associated development continue to pose a threat to remaining Coastal Douglas-fir ecosystems along with other ecosystem types. Two thirds of British Columbia's population is clustered in the Georgia Basin's urban areas of Greater Vancouver and Greater Victoria, and in smaller urban centres in the Lower Fraser Valley, on Vancouver Island, and along the Sunshine Coast north of Vancouver.

The biosphere reserve encompasses approximately 38% of the total area of the RDN. All lands within the regional district are subject to the recently adopted Regional Growth Strategy (adopted September 2011). The lands within MABR are also regulated by the official community plans for Nanoose Bay, French Creek, and Electoral Area F (each regulating a different part of MABR), the City of Parksville, and the Town of Qualicum Beach, and there are zoning bylaws that also apply to the lands. Other forms of local government regulations over land use include development permit areas and parkland regulations.

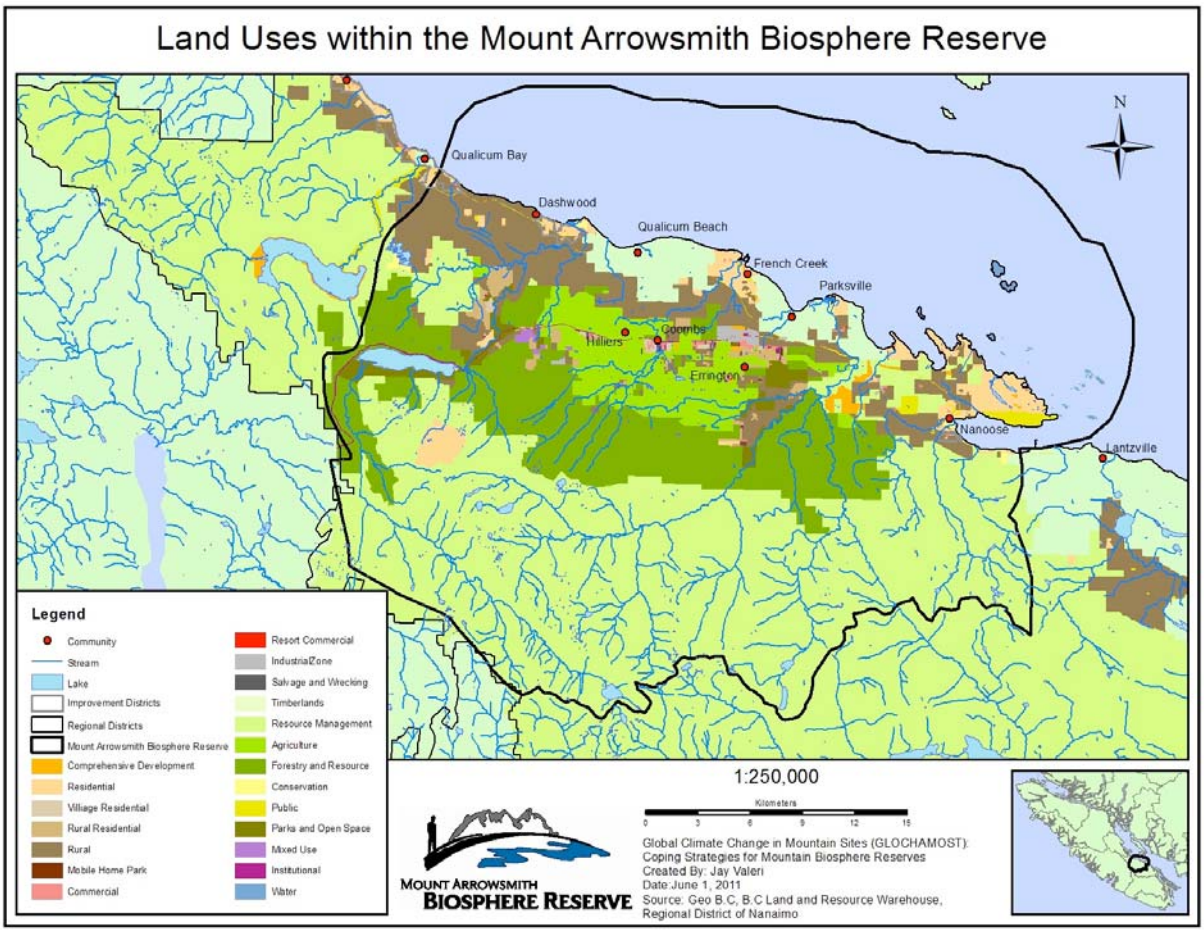
A portion of the lands within MABR are contained within the Agricultural Land Reserve (ALR), a provincial designation that protects higher quality arable lands for farming. The ALR is land designated by the Province for agricultural use. It includes lands that may be forested, farmed or vacant land that has the potential for agricultural production.

LAND USE PATTERNS

By Pam Shaw

Figure 29 shows land use by sector within MABR, while Figure 30 shows land use designations permitted by the *Regional Growth Strategy* (RDN, 2011). The RDN's *Regional Growth Strategy* is the guiding document for land uses in the MABR, and is further described in **Planning** below.

Figure 29. Land use by sector within MABR.

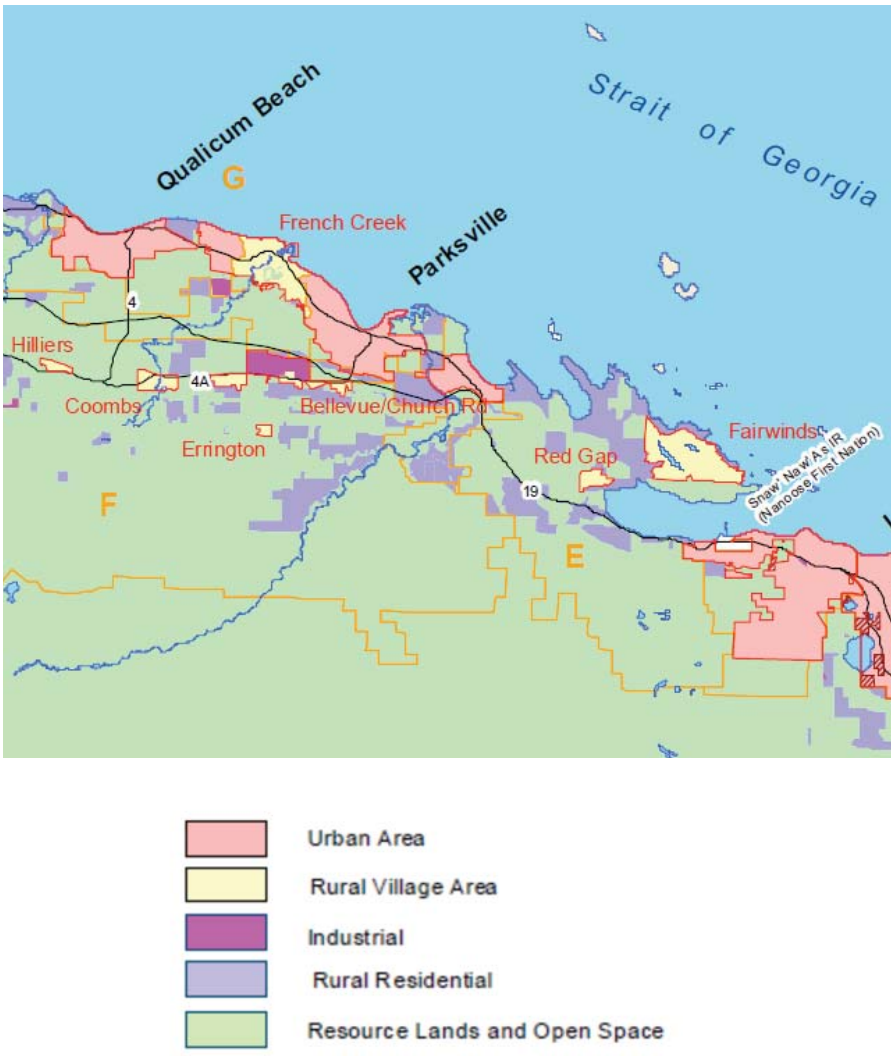


The Urban Areas are located in the coastal zones and are the areas of highest density development. These areas either contain or are intended to contain a broad mix of land uses and medium to high density development. Rural Village Areas are communities in electoral areas that are defined by Growth Containment Boundaries and intended to accommodate a limited range of land uses and development compatible with rural village character. Industrial Areas contain a range of industrial uses, from airports to warehousing to manufacturing facilities. Rural Residential Areas are characterized by large parcel sizes, on-site servicing, limited transportation infrastructure and a limited range of community services.

Most of the MABR is contained within the Resource Lands and Open Space land use designation. These lands are primarily intended to accommodate agricultural activities, forestry, aggregate mining and other primary industries, and for recreational and/or environmental protection purposes. In addition, uses that complement these activities are encouraged, such as recreation uses that enhance the economic viability of the primary uses and/or contribute to the

protection of environmentally sensitive lands. Such uses may include, but are not limited to, nature-based tourism activities and development, small-scale food processing industries and value-added wood product industries.

Figure 30. Permitted land uses within MABR, from the RDN Regional Growth Strategy (RDN, 2011).



Land Ownership

By Pam Shaw and Holly Clermont

Approximately 94% of the Biosphere Reserve lands are privately owned (Reed, Mendis-Millard & Francis, 2010). The remaining 6% are protected under a variety of designations, described in **Protected Areas** below.

Land ownership patterns within the MABR follow a general pattern of small, privately owned lands along the developed areas closer to the Salish Sea, larger parcels of privately owned lands in interior lower slope areas of the MABR, and large tracts of land owned by forestry companies in the interior upper slope areas: in total, about 70% of the MABR is owned by two forestry companies, Island Timberlands and Timber West.

The current status of land ownership is attributable to the Esquimalt and Nanaimo (E&N) Railway Land Grant, which placed all of the land on the east side of Vancouver Island within 20 miles of the then Strait of Georgia (now Salish Sea), between Comox and Victoria, into private ownership. From 1883 to 1925, the "Government of the Dominion" entered into a series of agreements with Robert Dunsmuir of the E&N Railway Company to complete the railway on Vancouver Island for a sum of money and land grants totaling nearly 2 million acres, including rights to timber, coal, and ores other than silver and gold. The first land grant, together with the *Settlement Act* of 1884, allowed homesteaders to purchase up to 160 acres for $1 per acre (Taylor, 1975). First Nations called the E&N land grant "colonial theft" and "an act of piracy". The grant represents a serious challenge to treaty negotiations, as private lands are "off the table" (Hul'qumi'num Treaty Group, n.d.).

Barlak, Epps & Phippen (2010) documented land use ownership for the Englishman River community watershed. Island Timberlands Limited Partnership owns and manages the majority (22,488 ha, approximately 69%) of the watershed (primarily in the South Englishman, Upper Englishman and upper Center Creek sub-basins). TimberWest Forest Corp. owns and manages 18% (5,656 ha) of the total watershed, primarily in the lower Center Creek and upper Morison Creek sub-basins.

There is a significant amount of rural residential development in the lower portions of Morison Creek, Shelly Creek and the lower Englishman River sub-basins, as well as along the lower 1 km of the Englishman River, at and just downstream from the water intake. The rural and urban development represents approximately 10% of the overall watershed area, with the provincial park representing 1.4% of the total area and Crown Lands and right of ways representing the final 1.6% of the overall watershed area (Barlak, Epps & Phippen, 2010).

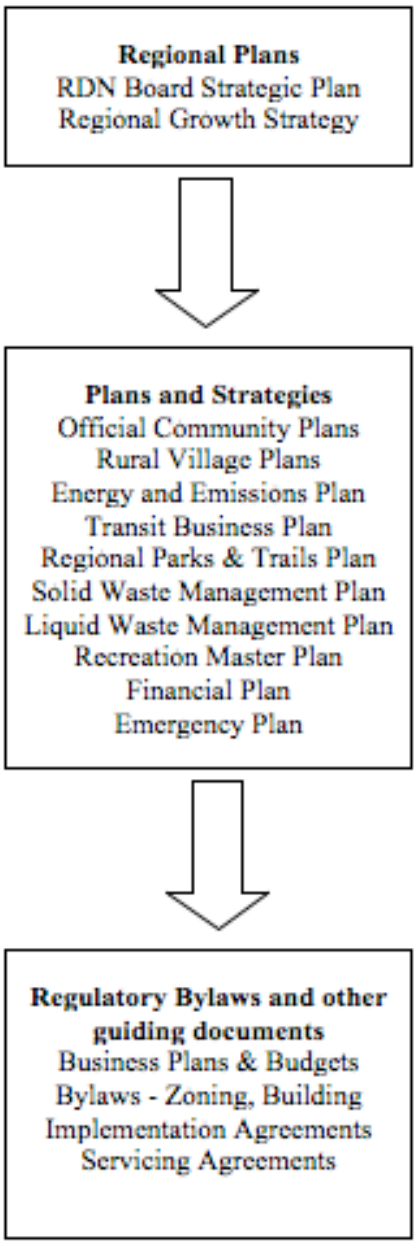
URBAN AND RURAL

Planning

By Pam Shaw and Holly Clermont

The RDN, City of Parksville and Town of Qualicum Beach regulate various aspects of land use in MABR (Figure 31).

Figure 31. Plans and bylaws applicable to the MABR.



A *Regional Growth Strategy* (RGS) is a strategic plan and bylaw mandated by the BC *Local Government Act* for the purpose of establishing a consistent and coordinated approach across a region in order to foster socially, economically and environmentally sustainable communities. The RGS must be accepted by affected municipalities, including the City of Parksville and Town of Qualicum Beach. A new RGS was completed in November 2011. It addressed provisions in Bill 27, the *Local Government (Green Statutes) Amendment Act* (2008) and its requirements for greenhouse gas reduction, other aspects of climate change, food security and affordable housing (RDN, 2011).

In 2006, the RDN produced a sustainability report, *Prospering Today, Protecting Tomorrow: The State of Sustainability of the Regional District of Nanaimo.* This report reviewed a wide range of parameters and assessed the implementation and progress of the RGS, a requirement of the BC *Local Government Act* (RDN, 2006). Indicators that were measured are provided in Table 10 below.

All subsequent Official Community Plans (OCPs) must be consistent with the RGS. OCPs are comprehensive, strategic bylaws that set both broad and specific policies on land use, community development, operations and conservation within a municipality or electoral area. OCPs often represent lengthy, lively public consultation processes. They provide valuable guidance to decision-makers when assessing the merits of development applications.

In accordance with Bill 27, the provincial *Green Communities Act*, all local governments are required to include "targets for the reduction of greenhouse gases…and policies and actions of the local government proposed with respect to achieving those targets" in OCPs by May 31, 2010. As a signatory to the Provincial Climate Action Charter, Qualicum Beach has committed to making their civic operations carbon neutral by 2012 and to create complete, compact, more energy-efficient communities. The municipality amended its OCP to include a Sustainability Plan in 2010 (Town of Qualicum Beach, 2010). In summer 2011, the City of Parksville received a Federation of Canadian Municipalities *Green Municipal Fund Grant* to include a Sustainable Community Plan in its upcoming OCP review (City of Parksville, 2011).

Real Estate

By Pam Shaw

Real Estate sales remain steady in the mid-Island area and the urban areas within MABR, largely due to the continued in-migration of retirees from Alberta, Ontario, and the United States. The sales trend is characterized as a "buyer's market" as prices and supply have remained fairly constant over the last three years. In addition, interest rates remain low and the Bank of Canada has indicated that no interest rate increases are anticipated in the near future, which further supports a stronger position for buyers over sellers. Overall, the economic recovery in Canada and British Columbia remains intact, and real estate values are forecast to increase by 2% to 4% annually over the next 36 months.

The new housing market has been impacted by a recent referendum which requires the removal of a provincial and federal sales tax (the Harmonized Sales Tax - HST). This tax applies to new housing but not pre-owned housing, and has caused some concern among home builders as buyers appear to be waiting to see what the HST will be replaced with before making a decision to buy a new home with an elevated tax rate.

The average price of a single family home sold in October 2011 in the mid-Island area through the Vancouver Island Real Estate Board (VIREB) MLS system was $325,308, up 2% from the $318,609 posted in September 2010. Figure 32 below details average sales prices for the Parksville-Qualicum Area (the developed lands within the MABR) and illustrates that the average single family sale price for this sub-area of the Mid-Island Area was even higher at $397,000 in October 2011.

Editor's note: The average value of occupied private dwellings was $151,708 in 1999.

Figure 32. Average single family dwelling sales in the Parksville-Qualicum Beach area. Retrieved October, 2011, from the Vancouver Island Real Estate Board.

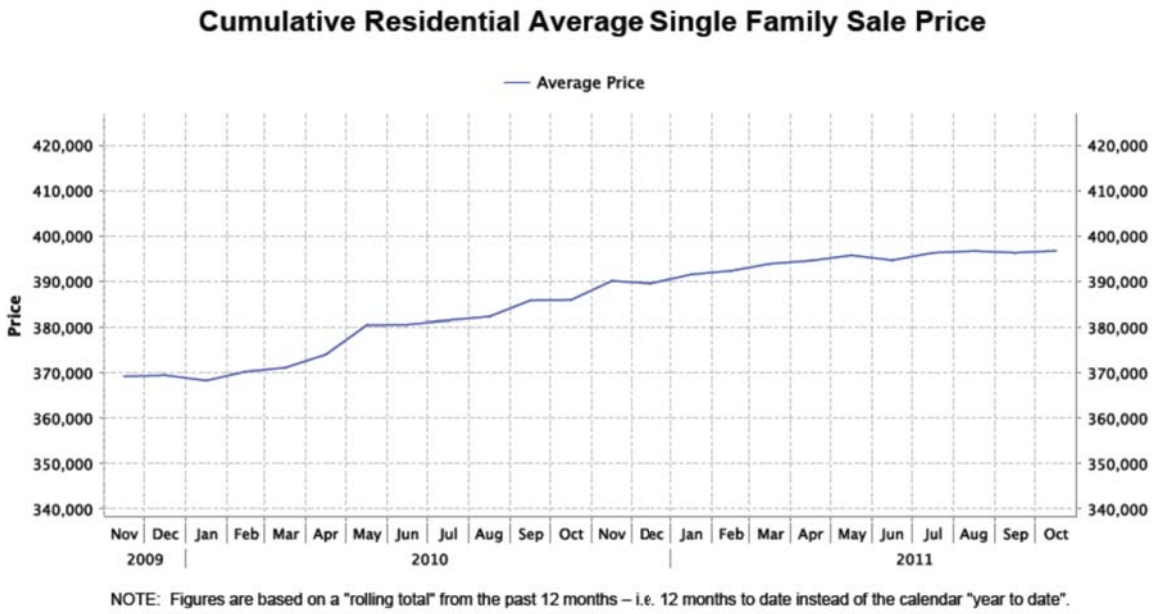


Table 10. RDN sustainability indicators

Tier 1 Indicators:
Recommended for inclusion in the sustainability report

Environment	
1-E1.	Water quality for aquatic organisms in selected lakes and rivers
1-E2.	Ground level ozone
1-E3.	$PM_{2.5}$
1-E4.	Current and projected age class distribution for Arrowsmith Timber Supply Area
1-E5.	Amount of land and watercourses protected (nature park or DPA designation) by type
Resource	
1-R1.	Domestic water consumption trends (total and per capita)
1-R2.	Area of private and Crown forestry land
1-R3.	Change in amount of ALR Land
1-R4.	Sustainable farming practices
1-R5.	Proportion of farmland in crops
1-R6.	Amount of land outside of urban boundaries or designated industrial areas that permit subdivision minima of less than 4 (or 10) ha
1-R7.	Number of farms reporting sale of organic products
1-R8.	Amount of electricity and natural gas consumed, total and per capita
1-R9.	Amount of waste to landfill per capita, amount of waste diverted from landfill in tonnes and amount recycled per resident
1-R10.	Quality of biosolids from wastewater treatment plants
Community Function	
1-CF1.	Population growth, density, and amount of land in areas designated for growth and not designated for growth
1-CF2.	Percent of residents in core housing need
1-CF3.	Mode of transportation to work (and location of work)
1-CF4.	Number of bus rides per capita per year
1-CF5.	Number of residents (households) within walking distance of services
1-CF6.	Number of residents inside urban boundaries living within 400 metres of a bus route
1-CF7.	Vehicle ownership (total and per household)
1-CF8.	Area of active and nature parkland for every 1000 residents
1-CF9.	Percentage or square footage of retail inside and outside urban cores
Social	
1-S1.	Percent healthy birth weight (percent low birth weight)
1-S2.	Life expectancy at birth
1-S3.	Motor vehicle accident rates
1-S4.	Teen pregnancy rate
1-S5.	Education attainment levels
1-S6.	Number of applicants on wait list for subsidized housing compared to number of housing units available
1-S7.	Crime rate by crime type
1-S8.	Number of, and participation in, recreational and cultural programs offered by local government and post secondary institutions
1-S9.	Participation in federal, provincial, and local elections

Building

The RDN adopted a Green Building Action Plan in 2007 and commissioned a study of the barriers to green building. Barriers stemming from RDN regulations and approvals, senior government regulations and approvals, and market barriers were identified (RDN, 2010a).

PROTECTED AREAS

By Tim Clermont and Holly Clermont

Figure 33 shows the various protected areas in MABR, and Table 11 describes ownership and management authority. Excluded are most regional and municipal community parks.

The *Canada Wildlife Act* (RSC 1985, c. W-9) authorizes the establishment of National Wildlife Areas (NWAs). NWAs typically do not facilitate public use.

Rockfish Conservation Areas (RCAs) are created by Fisheries and Oceans Canada (DFO) to ensure a portion of inshore rockfish are protected from harvesting. Rockfish grow slowly and can be extremely long-lived, reaching lengths of 90 centimetres and ages greater than 100 years. They reach sexual maturity at ~20 years of age, and good survival years for the young occur every 15 to 20 years. These life history characteristics result in low productivity, making inshore rockfish particularly vulnerable to over harvest (DFO, 2002).

Provincial parks are established under the Section 5 of the *Park Act* (RSBC 1996, c. 344). The PQBWMA, which includes 17 kms of foreshore, was established under the Section 4(2) of the *Wildlife Act* (RSBC 1996, c. 488).

Old Growth Management Areas (OGMAs) are areas of older forest that forest licensees are required to maintain when preparing Forest Stewardship Plans. OGMAs contribute to biodiversity targets in Crown forests. They are first derived from the non-contributing (to timber harvest) land base, and can overlap with lands protected by other means, including WHAs, LUOs and parks. Because they are typically on the non-contributing land base, they may be associated with unstable terrain, poor growing sites or areas already reserved as riparian habitat. As the life cycles of the trees end, they may be harvested providing the licensee offers a replacement OGMA with similar qualities (BC Ministry of Forests and Range, ILMB, 2009). It is important to note that the timber harvest and non-contributing land bases are not legal land designations and are periodically altered in favour of timber harvesting (Forest Practices Board, 2008).

Wildlife Habitat Areas (WHAs) are established by provincial Ecosystems biologists to protect species and ecosystems designated as "Identified Wildlife" under the authority of the *Government Actions Regulation.* General Wildlife Measures limit activities on the land. The Identified Wildlife Strategy (IWMS) is carried out under provisions of the *Forest and Range Practices Act* (FRPA, SBC 2002, c. 69). WHAs cannot unduly reduce the supply of timber from BC forests, and are therefore subject to a 1% impact budget to the short and long-term harvest levels per forest district, i.e., they must be less than one percent of the mature and total Timber Harvest Land

Base (THLB). Whenever possible, they must be placed in non-contributing areas, i.e., areas outside of the THLB and should overlap with areas that are already constrained such as OGMAs and Ungulate Winter Range (UWR) (Forest Practices Board, 2008).

In MABR, Ungulate Winter Ranges are areas set aside by Ecosystems biologists for the winter survival of Roosevelt Elk and Black-tailed Deer. Sections 9 and 12 of the *Government Actions Regulation* of the *Forest and Range Practices Act* outline the regulatory authority for establishing UWR. Objectives are set by Timber Supply Area or tree farm license (Forest Practices Board, 2008).

The Land Use Order (LUO) to safeguard Coastal Douglas-fir ecosystems is pursuant to Section 93.4 of the *Land Act* (RSBC 1996, c. 245), whereby the Minister may establish *Forest and Range Practices Act* objectives by order. Details can be found at http://www.ilmb.gov.bc.ca/content/news/2010/07/29/1598-hectares-coastal-douglas-fir-be-protected.

Land trusts began purchasing conservation lands in MABR in the 1970s to protect ecologically and culturally significant private lands. Through partnership programs such as the internationally recognized Pacific Estuary Conservation Program (PECP) (the first recipient of the Ramsar Wetland Conservation Award in 1999), most of the estuaries and associated coastal headlands have been protected and are part of the provincial Parksvile Qualicum Beach Wildlife Management Area or federal Qualicum National Wildlife Area. In the past decade, most conservation land acquisitions have involved regional and municipal governments, along with a variety of environmental non-government organizations (ENGOs). Future acquisition efforts will depend upon government and non-government partnerships to cost-share the purchase of important conservation lands in a region of high real estate values.

The RDN Parks' budget currently benefits from a parcel tax on residents. However it may soon be better able to participate in acquisition of lands for parks and conservation, with the implementation of development cost charges (DCCs) on new homes. If implemented, the RDN would be the first regional district in BC to use DCCs as a fundraising tool (Daily News, December 2011).

Figure 33. Protected areas in MABR.

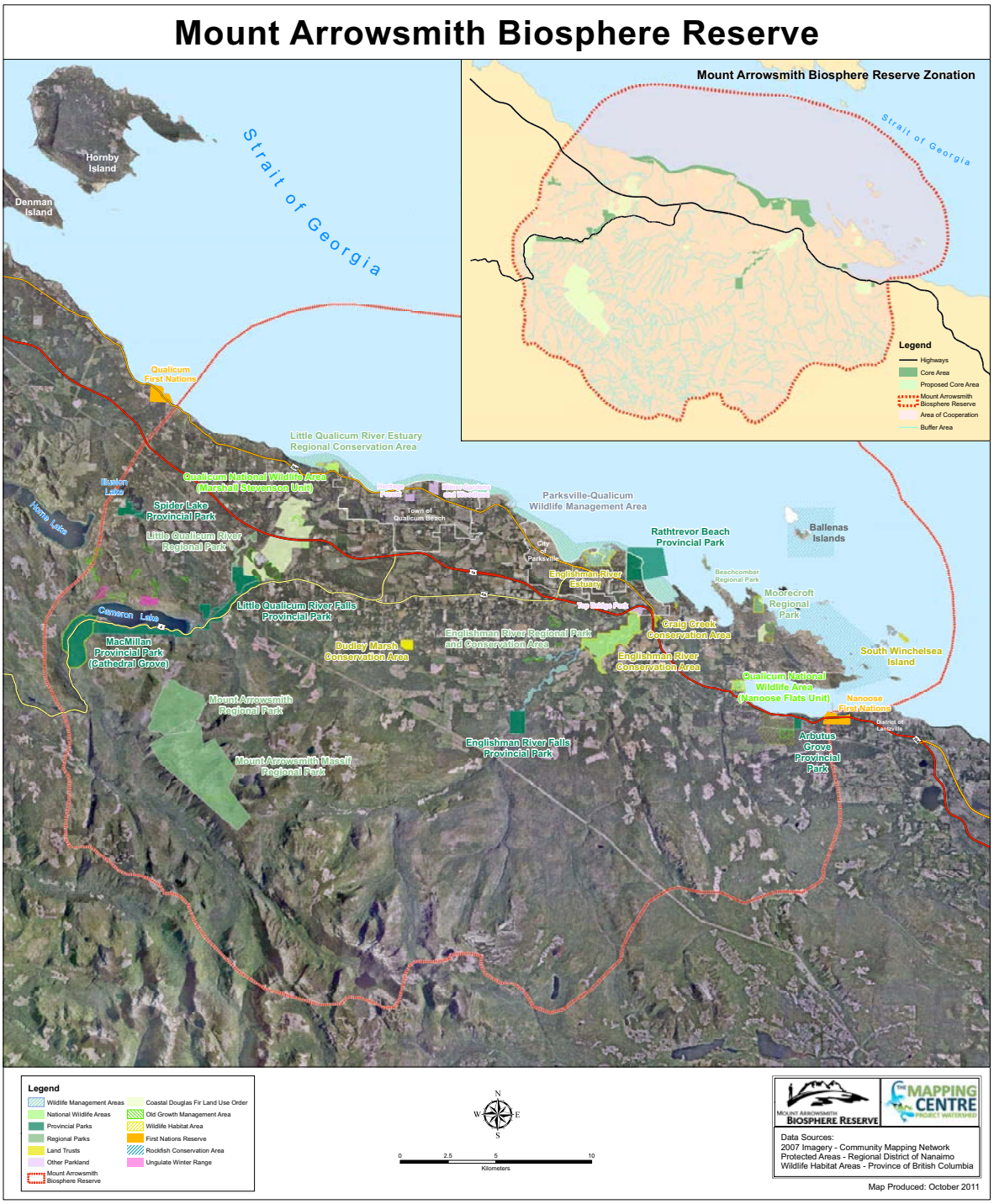


Table 11. Protected Areas in MABR. Areas marked with asterisk * were core areas at the time of designation. There are two different types of provincial park management planning documents: MP = Management Plans and PSZP = Purpose Statement and Zoning Plans.

Protected Area	Year Established	Designation	Area (ha)	Ownership; Management Authority	Latest Management Plan
Qualicum National Wildlife Area Nanoose Bay Unit*	1974-76	National Wildlife Area	34	Nature Trust of BC; Environment Canada - Canadian Wildlife Service, Agreement with Ducks Unlimited Canada to manage hayfields	1986
Qualicum National Wildlife Area Marshall Stevenson Unit*	1974	National Wildlife Area	29	Federal Crown; Environment Canada - Canadian Wildlife Service	
Ballenas Rockfish Conservation Area		Rockfish Conservation Area		Federal Crown; Fisheries and Oceans Canada	
Nanoose Rockfish Conservation Area		Rockfish Conservation Area		Federal Crown; Fisheries and Oceans Canada	
Arbutus Grove Provincial Park*	1966	Provincial Park	22	Provincial Crown; MoE - BC Parks	2003 PSZP
Arrowsmith Ski Park	1972	Regional Park	607	Alberni-Clayoquot Regional District ; RDN	
Englishman River Falls Provincial Park*	1940	Provincial Park	97	Provincial Crown; MoE - BC Parks	2003 PSZP
Little Qualicum Falls Provincial Park*	1940	Provincial Park	440	Provincial Crown; MoE - BC Parks	1986 MP
MacMillan Provincial Park* (Cathedral Grove)	1947, 2005	Provincial Park	136 + 145	1947 Provincial Crown, 2005 Nature Trust of BC; MoE - BC Parks	1992 MP
Rathtrevor Beach Provincial Park*	1967, 1969	Provincial Park	348	Provincial Crown; MoE - BC Parks	1988 MP
Spider Lake Provincial Park	1981	Provincial Park	65	Provincial Crown; MoE - BC Parks	2003 PSZP
Parksville-Qualicum Beach Wildlife Management Area	1993 and 2001	Wildlife Management Area	1029	Provincial Crown and Nature Trust of BC; MFLNRO	2003

Protected Area	Year Established	Designation	Area (ha)	Ownership; Management Authority	Latest Management Plan
Arrowsmith TSA U-1-017 Ungulate Winter Range	2003	Ungulate Winter Range		Provincial Crown; MFLNRO	
Old Growth Management Area (Arbutus)	2010	Old Growth Management Area		Provincial Crown; MFLNRO	Ministerial Order objectives
Old Growth Management Area (Cameron Lake)	2010	Old Growth Management Area		Provincial Crown; MFLNRO	Ministerial Order objectives
Old Growth Management Area (Little Qualicum)	2010	Old Growth Management Area		Provincial Crown; MFLNRO	Ministerial Order objectives
Old Growth Management Area (Nanoose)	2010	Old Growth Management Area		Provincial Crown; MFLNRO	Ministerial Order objectives
Coastal Douglas-fir Land Use Order (Nanoose)	2010	LUO parcel		Provincial Crown; MFLNRO	Ministerial Order objectives
Coastal Douglas-fir Land Use Order (Little Qualicum)	2010	LUO parcel		Provincial Crown; MFLNRO	Ministerial Order objectives
Nanoose, Shooting Star Wildlife Habitat Area, 1-041, Marbled Murrelet	2005	Wildlife Habitat Area	223	Provincial Crown; MFLNRO	General Wildlife Measures
Schooner Cove Wildlife Habitat Area, 1-037, Douglas-fir/Garry oak-oniongreass	2002	Wildlife Habitat Area	21.8	Provincial Crown; MFLNRO	General Wildlife Measures
Beachcomber Regional Park	1955	Regional Park	1.04	RDN	RDN Parks and Trails Plan 2005-2015
Englishman River Regional Park (and Conservation Area)	2004	Regional Park and Conservation Area	177	Nature Trust of BC; RDN. Registered interest Ducks Unlimited Canada and Nature Conservancy of Canada	2008
Little Qualicum River Estuary Regional Conservation Area	2003	Regional Conservation Area	4.6	RDN and Ducks Unlimited Canada; RDN	2010

Protected Area	Year Established	Designation	Area (ha)	Ownership; Management Authority	Latest Management Plan
Little Qualicum River Regional Park	1998	Regional Park	44	RDN	RDN Parks and Trails Plan 2005-2015
Moorecroft Regional Park	2011	Regional Park	34	RDN and Nature Trust of BC; RDN	ongoing
Mount Arrowsmith Massif Regional Park	2008	Regional Park	1300	RDN	2011
Craig Creek Riparian Conservation Area	2003	Conservation Area	12.2	Nature Trust of BC	
Dudley Marsh Conservation Area	1982	Conservation Area	32	Nature Trust of BC; MFLNRO and Ducks Unlimited Canada	draft 2002
Gerald Island	(2007)	proposed Provincial Marine Park	11.6	Provincial Crown; MoE - BC Parks	
Englishman River Estuary (5 parcels)	1981-1993	Wildlife Management Area (PQBWMA)	76.7	Nature Trust of BC; MFLNRO	2003
Englishman River Block 564	2003	Conservation Area	93	Nature Trust of BC	
Peace Abide Park	1975	Nature Park	3.2	Nature Trust of BC	
South Englishman Conservation Covenant	2005	Covenant	8	Timberwest; covenant held by the Nature Trust of BC	
South Winchelsea Island	1998	Conservation Area	10	The Land Conservancy of BC, covenants held by Nanaimo Area Land Trust and Islands Trust	
Top Bridge - Nature Trust lands	1978	Municipal Park	0.6	Nature Trust of BC; City of Parksville	
Top Bridge - RDN	1987	Community Park	4.6	RDN	
Top Bridge - City of Parksville				City of Parskville	

Protected Area	Year Established	Designation	Area (ha)	Ownership; Management Authority	Latest Management Plan
Heritage Forest	2001	Nature Park	20	Brown Property Preservation Society; Heritage Forest Commission, covenant held by Town of Qualicum Beach, the preservation society and The Land Conservancy of BC	
Milner Gardens and Woodlands	1996	Private Park	28	Vancouver Island University; Milner Gardens and Woodlands Society and VIU	1999

Education

Seasonal interpretive programs in the provincial parks, the Brant Wildlife Festival in March and April, Earth Day celebrations on April 22nd, and the September RDN River's Day Celebration in Englishman River Regional Park are annual opportunities for education in MABR's protected areas.

Protected Area Monitoring and Research

Ecological baseline data was collected by Nature Trust of BC (TNT) conservation crews in 2007, for TNT properties including Peace Abide Park, Dudley Marsh, Craig Creek, Englishman River Block 564, Englishman River estuary, and MacMillan Provincial Park. Species composition, percent cover, soils, coarse woody debris, tree height/diameter/age, etc. were measured in 20 x 20 m^2 and 1 x 1 m^2 plots. Wildlife trees were also located (Leslie & Warman, 2007).

A master's thesis assessed the financial management of parks and conservation areas in MABR (Clermont, 2006). Williams (2011) studied stakeholder perspectives regarding Mount Arrowsmith Massif Regional Park.

Additional monitoring and research projects are documented in **Ecosystems** and in **Invasive Species** below.

FORESTRY

The maps within BC's latest State of the Forests report demonstrate the effect of the E&N land grant on the structure of Vancouver Island forests (Figures 34 and 35). While less than 3% of BC's forests have been converted to non-forest use, the conversion rate is far higher in MABR and other areas affected by the grant (BC Forests, Mines and Lands, 2010). For example, half of Coastal Douglas-fir ecosystems have been permanently converted to other land uses (Cadrin, 2011).

Figure 34. Old growth forests in BC (BC Forests, Mines and Lands, 2010).

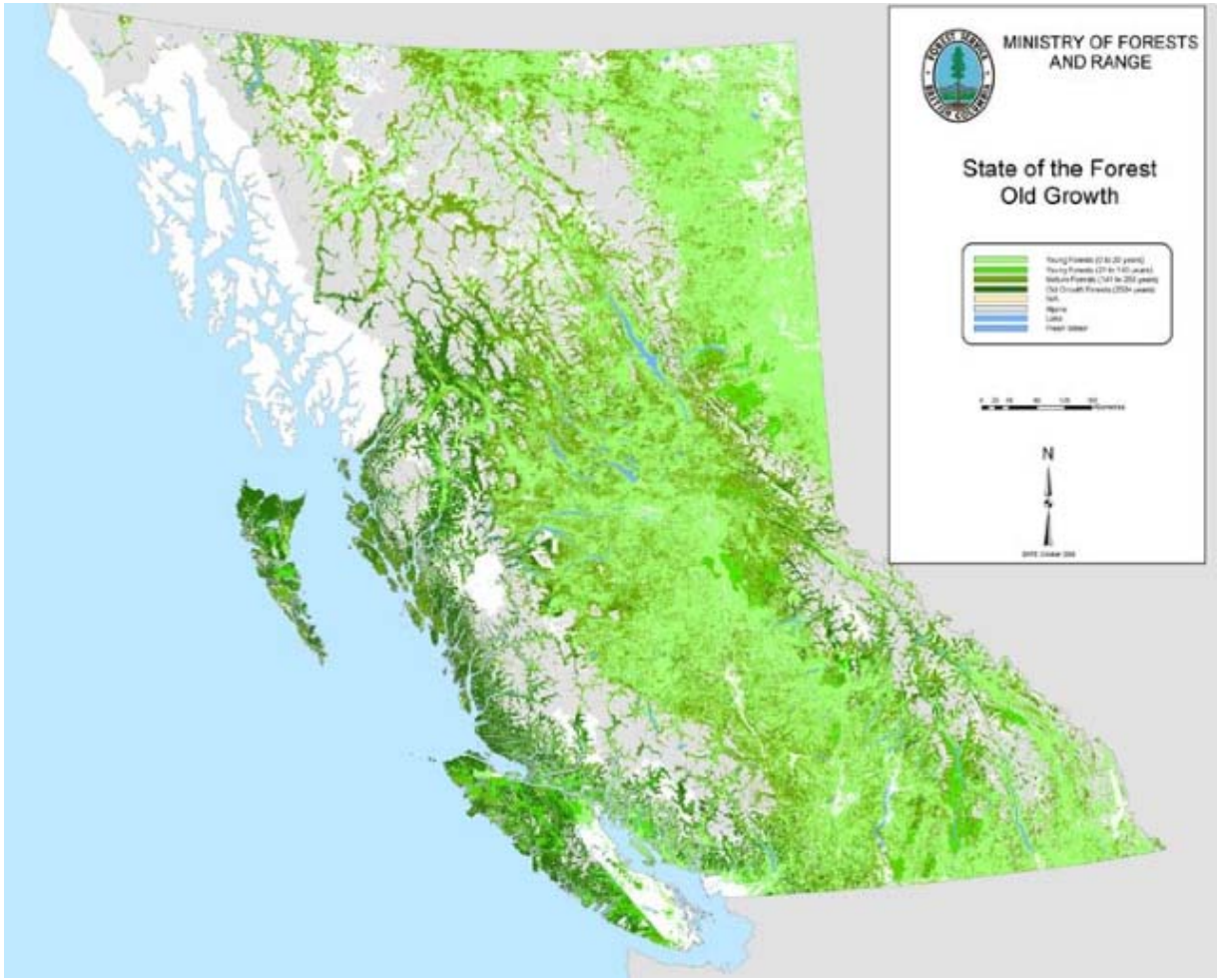
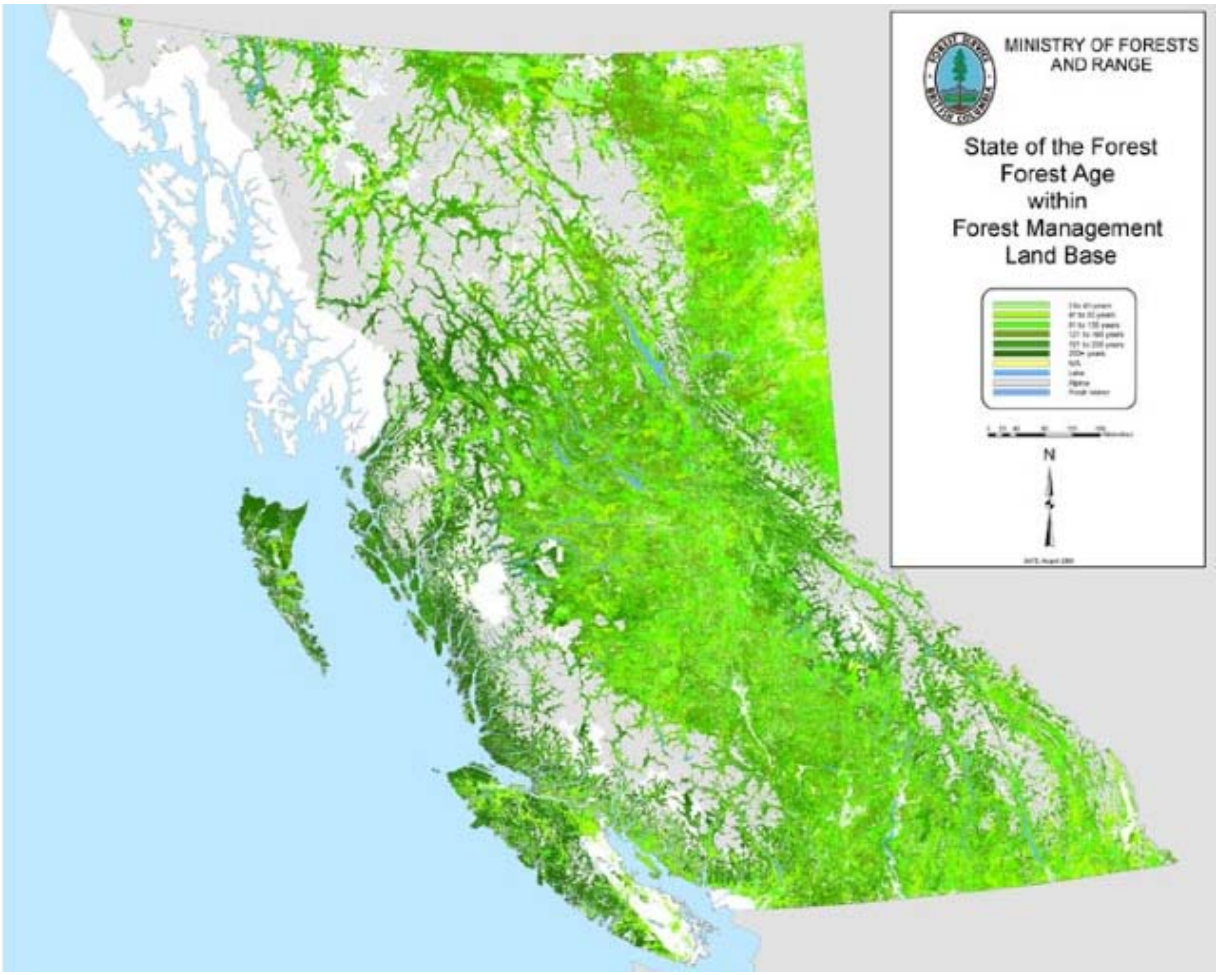


Figure 35. Forest age within the forest management land base in BC (BC Forests, Mines and Lands, 2010).



Mount Arrowsmith Biosphere Foundation partnered with Vancouver Island University to host a Healthy Forests, Healthy Communities community dialogue session on September 29, 2011. The initiative has been designed to help shape policies, regulations and legislation for sustainable forest management in BC. For additional information, see http://bcforestconversation.com/.

Private Forest Lands

Private forest land ownership is described in **Land Ownership** above. Island Timberlands and Timberwest hold Sustainable Forest Initiative certifications http://www.sfiprogram.org/sustainable_forestry_initiative_standard.php. Timberwest is also ISO14001-certified. Island

Timberlands' environmental policy can be viewed at http://www.islandtimberlands.com/sustainability/documents/Policy-Environmental%20(Apr%202010)-signed1.pdf. Timberwest's environmental policy is available at http://www.timberwest.com/sustainability/environment.aspx. It is noteworthy that Island Timberlands and Timberwest have real estate divisions, and are interested in leveraging lands with high conservation values for changes in zoning that enable development (Reed, Mendis-Millard & Francis, 2011).

An Englishman River watershed assessment was completed for areas managed by Island Timberlands in 2002 and for Timberwest-managed areas in January 2006.

In the area managed by Island Timberlands, the weighted equivalent clearcut area (ECA) as of 2002 was 10% overall, with values as high as 22% for individual sub-basins. By 2001, 81% of the first rotation had been harvested; the majority of harvesting occurred during the 1960s and 1970s (prior to Island Timberland ownership). Most roadways have a vegetated buffer between the road and the stream. However, the high density of roads in some areas suggests that runoff may impact turbidity levels within the river. Almost all alluvial reaches (representing 19% of the total stream channel length in the watershed) have experienced impacts, including channel widening, sediment aggradation, increased sediment loading and loss of functioning large woody debris. Potential impacts from these roads will decrease as roads are deactivated and reclaimed (Horel and Pollard, 2002 in Barlak, Epps & Phippen, 2010).

In the area managed by Timberwest, the weighted equivalent clearcut area (ECA) in 2006 was 4% overall. Within this area, there were 141 km of roads, resulting in a road density of 2.5 km/km2, and 48 stream crossings, resulting in 0.8 stream crossings/ km2 (Barlak, Epps & Phippen, 2010).

The assessments noted that, while the relatively low ECA in both the Island Timberlands and TimberWest management areas suggests there is a low potential for peak flow increases, it is likely the cumulative effect of the large number of small-scale disturbances associated with road construction and forest harvesting is impacting water quality to a certain degree, particularly during rain events. They believed that with improvements in harvesting practices over the past 20 years, and increased legislation and enforcement (for example, the *Water Act* and the *Private Managed Forest Land Act*), impacts to water quality will decrease as hydrologic recovery continues (Barlak, Epps & Phippen, 2010).

Crown Lands

There is very little Crown forest in MABR. Tree height and age class data for Crown forest lands are available through imap BC (e.g., Figures 36 and 37).

Figure 36. Maturity of Crown forests in the Nanoose area.

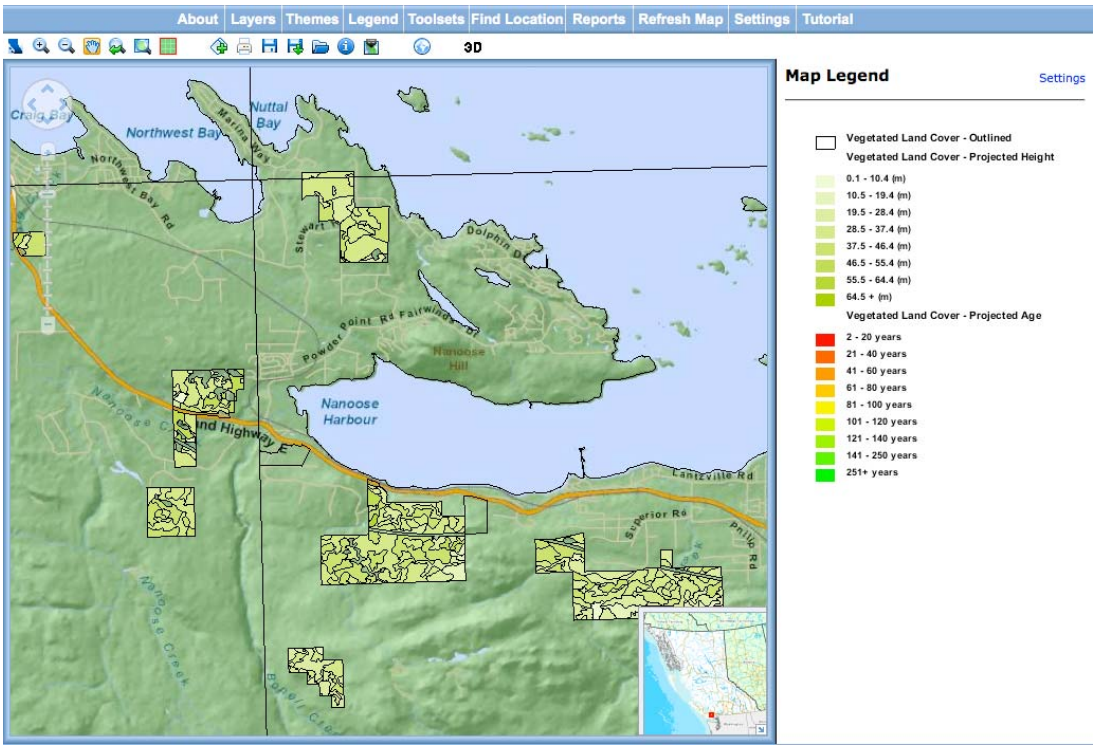
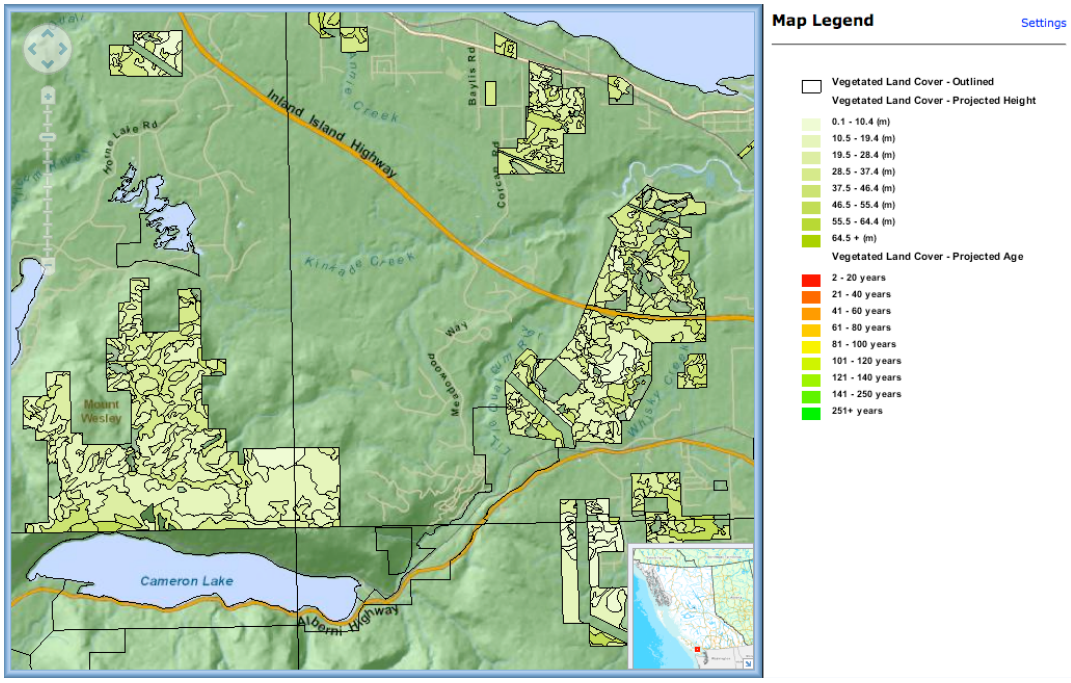


Figure 37. Maturity of Crown forests in the Cameron Lake area.



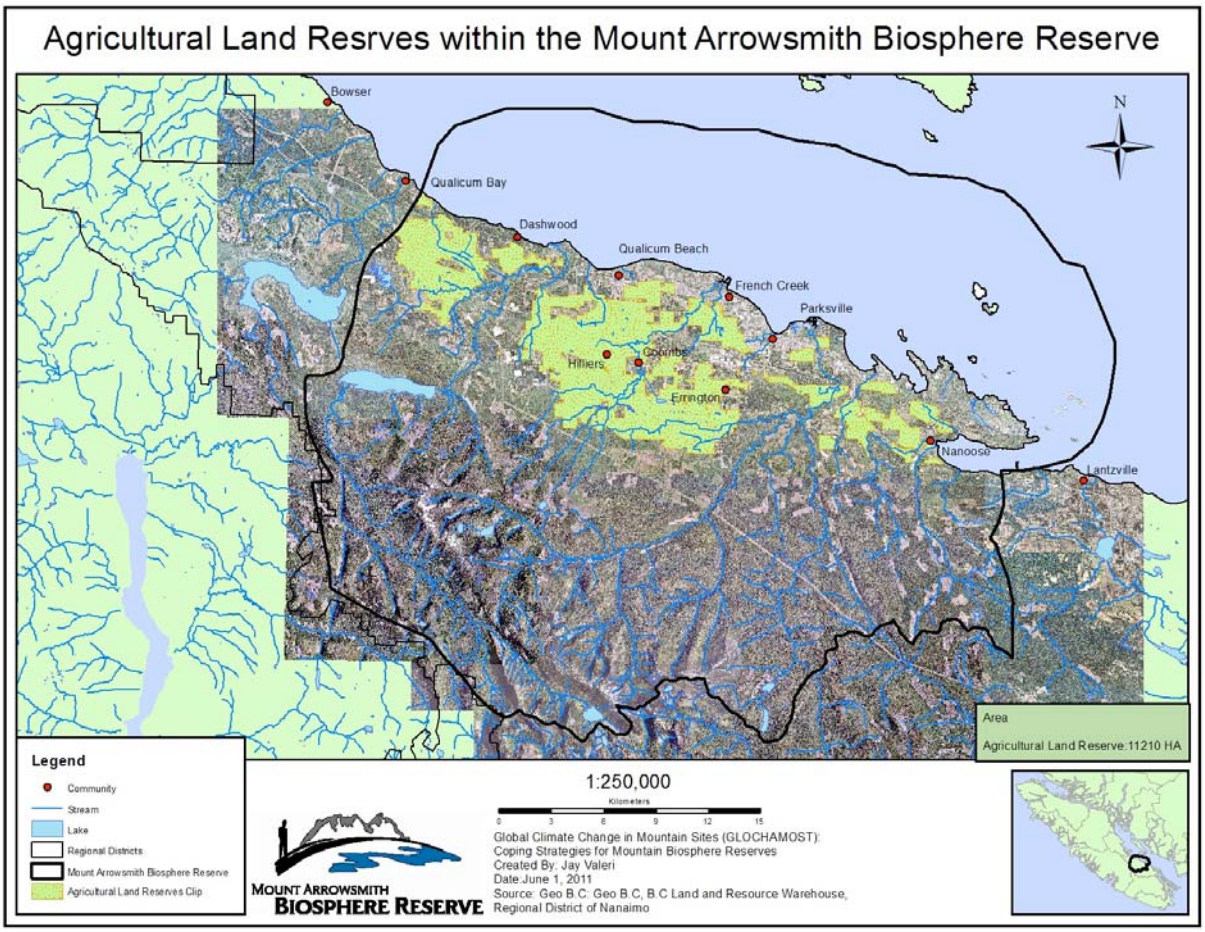
AGRICULTURE

Agricultural Land Reserve

By Nicole Muchowski

There are over 10,000 ha of land zoned as Agricultural Land Reserve (ALR) in MABR (Figure 38). The RDN recently commissioned a study for the region that includes a land use inventory and development of an Agricultural Area Plan. Results of this study are expected in June 2012. Information on the Agricultural Area Plan can be found at http://www.rdn.bc.ca/cms.asp?wpID=2520.

Figure 38. Agriculture Land Reserve (ALR) in MABR.



EDGE, RAIL, ROAD AND TRAIL NETWORKS

In-migration and development in rural and urban areas, and harvesting in forest lands inevitably expand transportation infrastructure and fragment habitats. Landscape level "edge effect" can be displayed and measured using the mapping resource *Hectares BC* at http://www.hectaresbc.org/. For example, a query can show how much land in the RDN is greater than 500 m from a road, or measure the amount of a particular ecological community 100 m or more from a road, railway or transmission line.

Rail

Rail transport on Vancouver Island is in the hands of the Island Corridor Foundation (ICF), a partnership of First Nations, five regional and 14 municipal governments http://www.islandrail.ca/. The ICF assumed ownership of the 290-kilometre rail corridor in 2006 on behalf of the communities of Vancouver Island, and hopes to preserve the E&N corridor in perpetuity for rail and compatible uses.

Transit

The RDN and BC Transit operate the Regional Transit system, which provides regular transit and HandyDART custom transit service to shopping, education and recreational facilities in Qualicum Beach, Parksville and the larger City of Nanaimo. Further information can be found at http://www.rdn.bc.ca/cms.asp?wpID=127. An independent review of local government relationships with BC Transit is pending. The review will address rising costs, funding, governance and communications (Nanaimo News Bulletin, November 2011)

Regional Trails

More than 60 km of RDN Regional Trails are managed according to the *RDN Regional Park & Trails System Plan 2005 - 2015*. Regional trails in MABR include Top Bridge Trail from Rathtrevor Beach Provincial Park, Parksville - Qualicum links, Arrowsmith Trail (Figures 39 and 40). The Top Bridge trail requires land use agreements with the City of Parksville, the Nature Trust of BC, another private landowner, and the Arrowsmith Mountain Bike Club. A pedestrian bridge across the Englishman River was built in 2007. The Arrowsmith Historic Trail is on land owned by Timberwest and Island Timberlands; five year agreements with the RDN enable public access. The risk of forest fires during dry periods is a concern. Regional trails experience ever-increasing use, requiring additional management and maintenance (pers. comm., J. Michel, December 9, 2011; RDN, 2005).

Figure 39. Regional Trails within MABR (north), retrieved November 23, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID766atID798.pdf

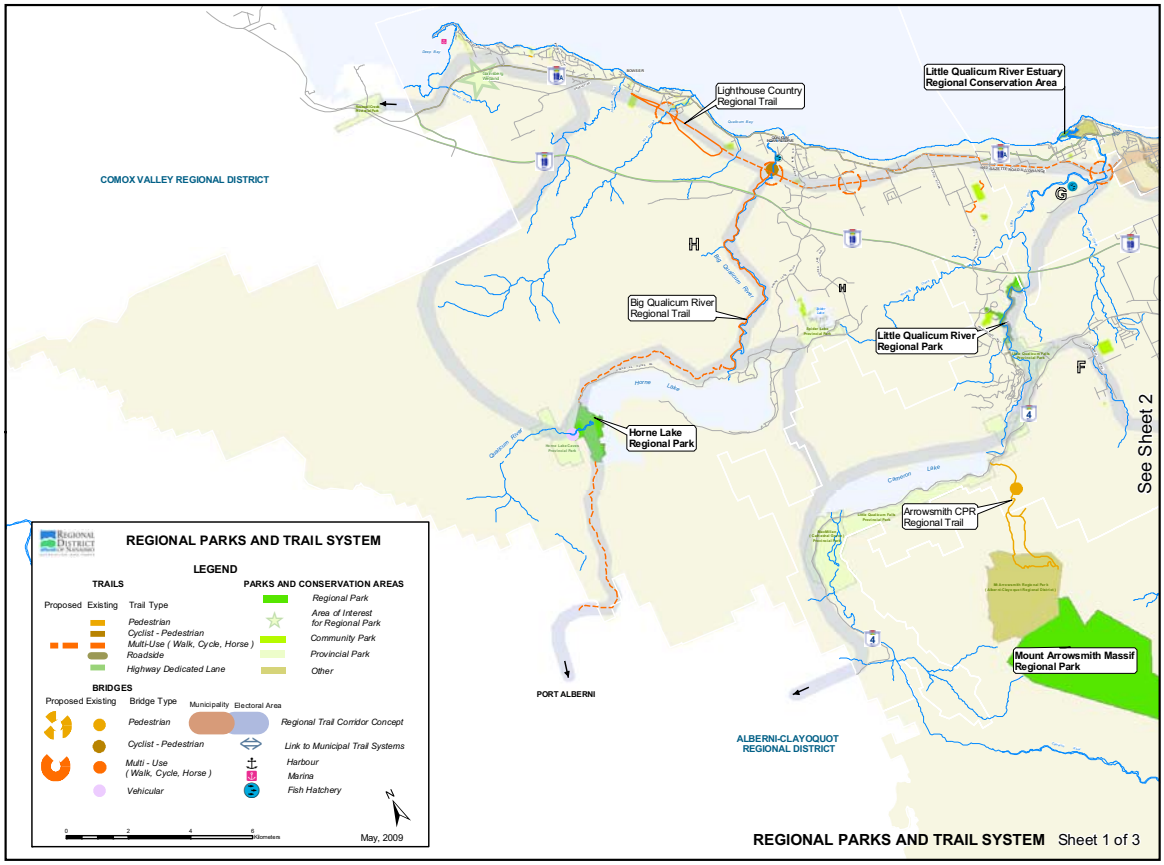
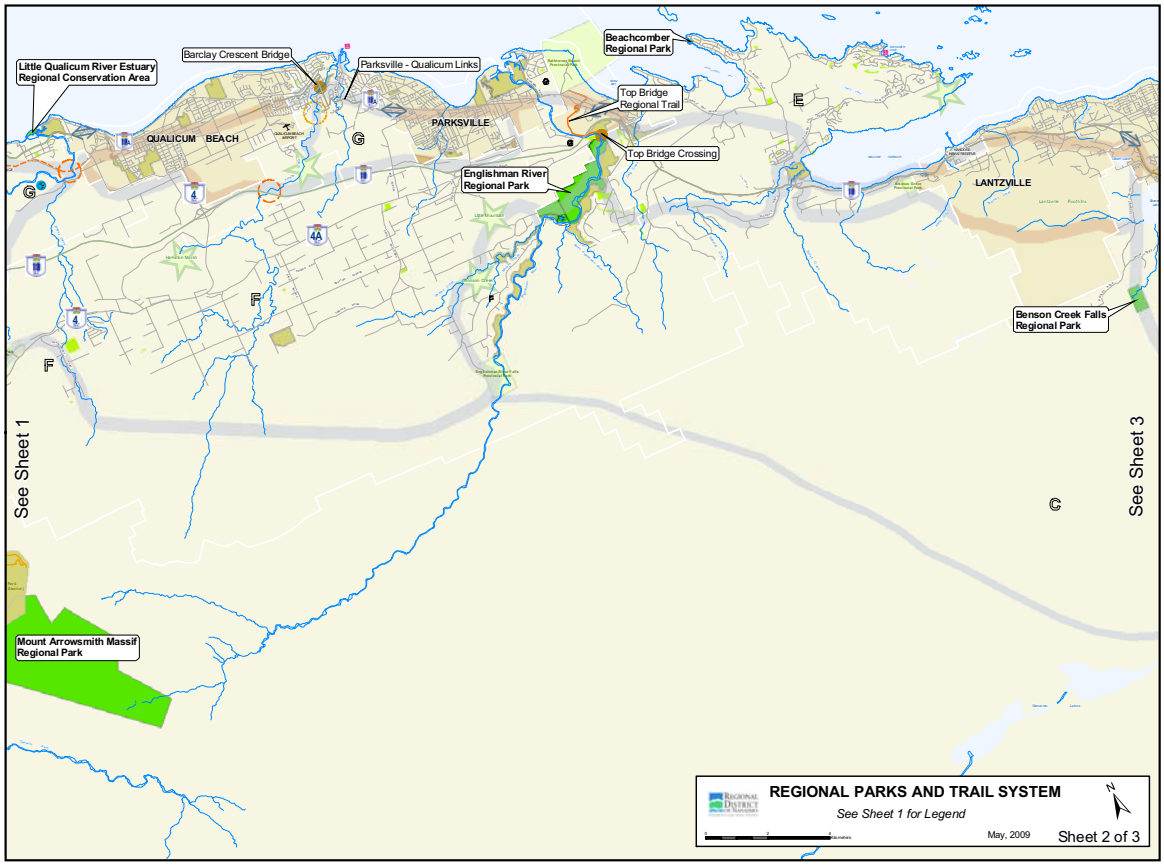


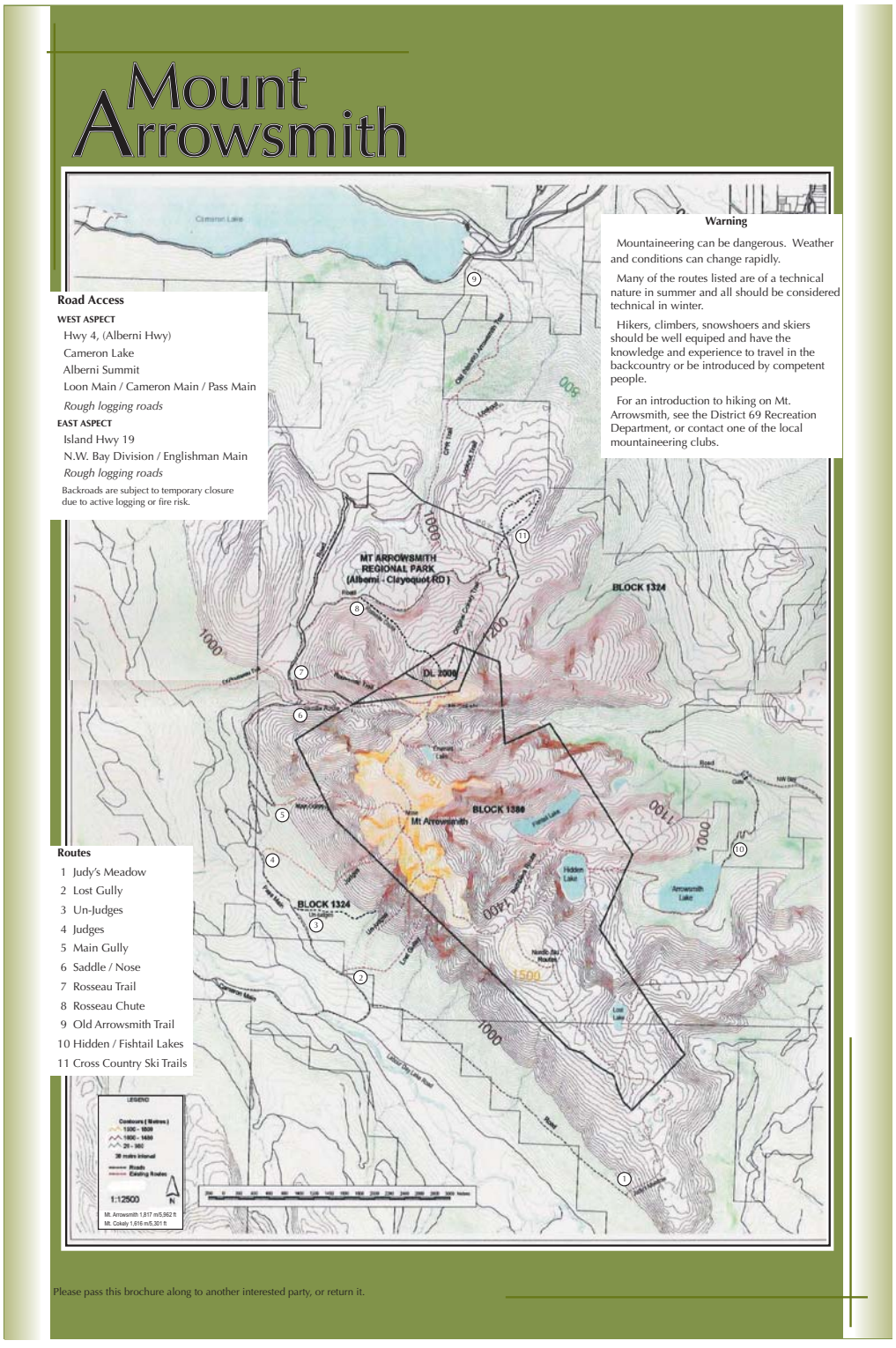
Figure 40. Regional Trails in MABR (south and central), retrieved November 23, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID766atID799.pdf



Alpine Trails

Mount Arrowsmith, Mount Cokely and Mount Moriarty are popular alpine hiking destinations. Mount Arrowsmith trails are shown in Figure 41. Maps and directions for specific Mount Arrowsmith trails as well as other MABR alpine trails are available from http://islandhikes.com/Hikes/.

Figure 41. Mount Arrowsmith Trails, retrieved November 23, 2011 from http://www3.telus.net/Mount_Arrowsmith/docs/Map.pdf



Mountain Bike Trails

The Top Bridge mountain biking trails above the Englishman River, linked to the RDN Regional Trail, are popular and include a small dual slalom course. The trails are maintained by the Arrowsmith Mountain Bike Club, which hosts "Hammerfest", a series of bike races near Englishman River Falls Provincial Park in Errington.

Street Bike Routes

The Oceanside Cycling Coalition conducted a survey among cyclists in October 2011 to identify challenges and opportunities for bicycling in the region. The results of the survey can be found at http://www.oceansidecyclingcoalition.ca/resources/Survey%20results.pdf. The 150 member Arrowsmith Mountain Bike Club, affiliated with Cycling BC, holds regular rides through area parks, and supports a series of races (Arrowsmith Mountain Bike Club, 2011).

Chapter 5

Biological Diversity

Current Status and Trends

ECOSYSTEMS

BC's Biogeoclimatic Ecosystem Classification (BEC) system, extensively described at http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/index.html, delineates ecosystem units based on mature or late seral vegetation, soils and topography. The extent of BEC subzones in MABR is strongly reflected in changes in elevation (Figure 42). For example, the Coastal Douglas-fir moist maritime subzone (CDFmm) is rarely found above 150 metres. The BEC classification is focused on forested ecosystems, however non-forested and wetland ecosystems are also derived from the BEC naming conventions (Madrone, 2008). Garry Oak ecosystems have been classified by Erickson (1995), and Erickson and Meidinger (2007), and wetlands have been classified by Mackenzie and Moran (2004). The classification of alpine zones is underway (BEC, n.d.).

Terrestrial Ecosystem Mapping (TEM) has been used in some areas to delineate ecosystems at a much finer scale, i.e., to BEC site series (see Figure 43). CDF ecosystems were identified through digitized image or aerial photograph interpretation and verified by field sampling. The air photos for the project (including areas outside of MABR) spanned a full 25 years (1980 to 2005) and were taken at scales ranging from 1:10,000 to 1:16,000. Field sampling was undertaken during the autumn and winter months, precluding consideration of certain site characteristics. Classification was further limited by access considerations on private lands, as well as disturbance of, and modifications to ecosystems (Madrone, 2008).

There are five British Columbia Marine Ecosystem Classification ecounits that occur within MABR. They include: MCHLH (Moderate wave exposure, shallow depth, high bottom relief, low current, and hard substrate); MCLLH (Moderate wave exposure, shallow depth, low bottom relief, low current, and hard substrate); MBLLS (Moderate wave exposure, photic depth, low bottom relief, low current, and sand substrate); MCLLM (Moderate wave exposure, shallow depth, low bottom relief, low current, and mud substrate); and MDLLM (Moderate wave exposure, deep depth, low bottom relief, low current,and mud substrate). The MBLLS ecounit , which represents only 4.3% of the Strait of Georgia Ecosection, encompasses the Qualicum/Parksville nearshore area and occurs at only three locations in the province. This ecounit contains low intertidal and high subtidal habitats dominated by marine grasses *(e.g., Zostera spp.)*, and sandy or muddy tidal flat habitats. The MCHLH ecounit supports rocky intertidal habitats dominated by rockweed *(Fucus spp.)* in the intertidal zone, and Bull Kelp (*Nereocystis luetkeana*) in subtidal zones] (MABR, 1998; Zacharias et al., 1998).

Figure 42. The biogeoclimatic subzones of MABR.

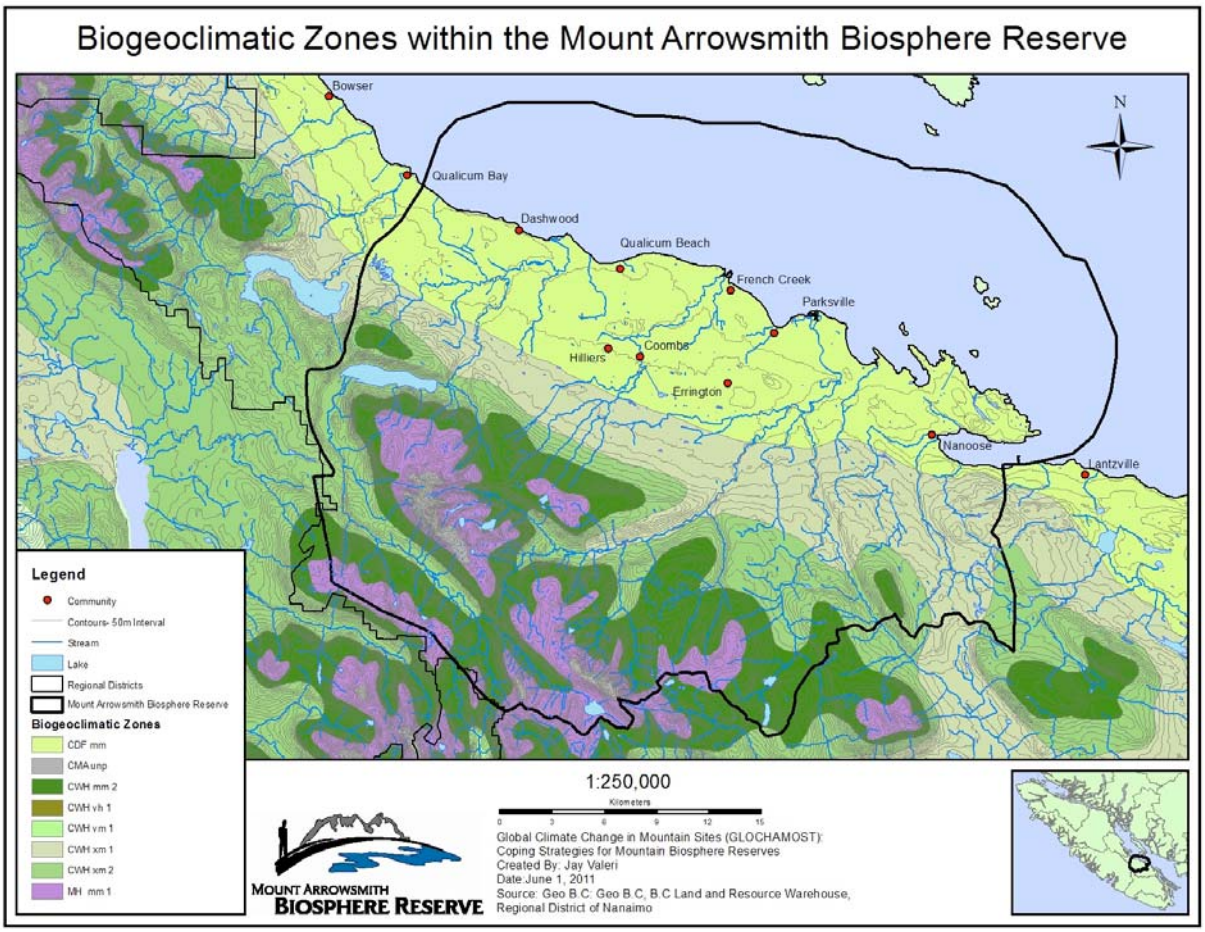
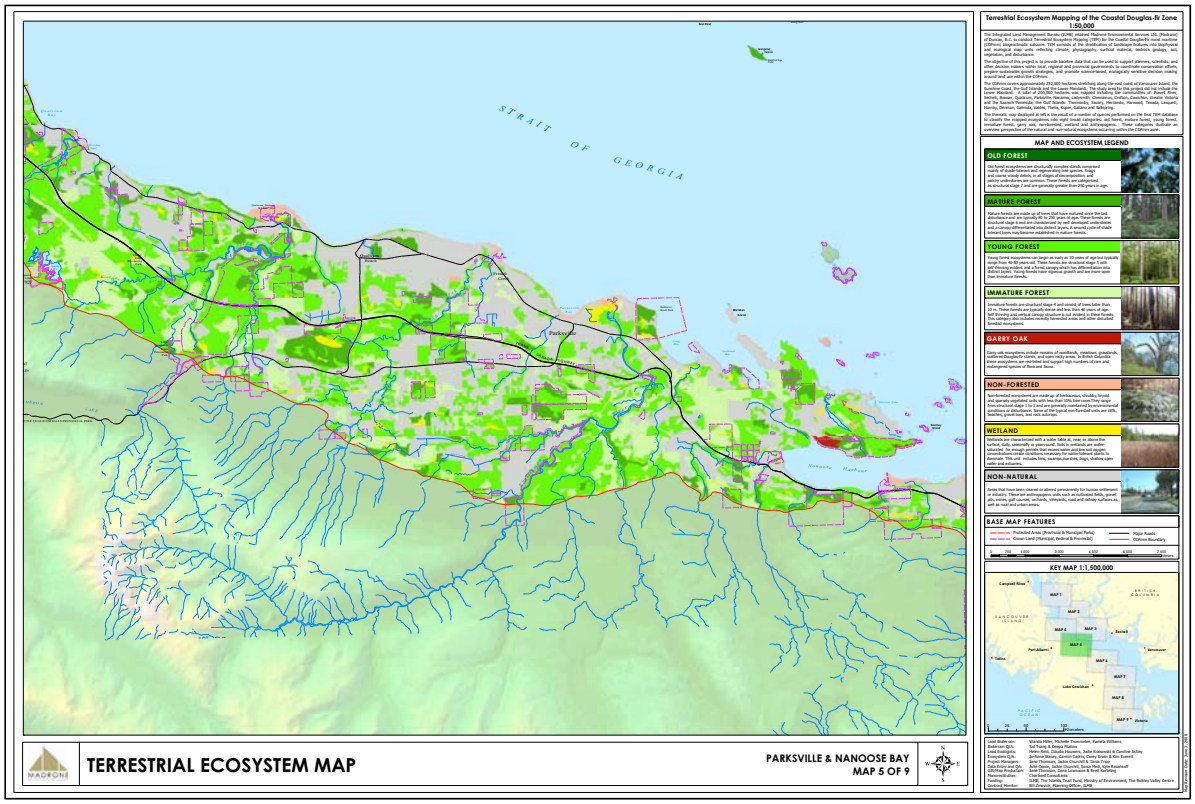


Figure 43. Thematic map of Terrestrial Ecosystem Mapping within MABR (Madrone, 2008). Spatial data for the CDF TEM project are available online through imap BC.



Ecosystems at Risk

The Sensitive Ecosystems Inventory (SEI), developed by senior governments, is frequently used by local governments in planning (Figures 44 and 45). The SEI project, which extended beyond MABR, identified and mapped rare and fragile ecosystems at a scale of 1:20,000 using air photo interpretation or TEM. Approximately 30% of sites were ground-truthed or field checked to verify interpretations and assess site condition (McPhee et al., 2000; Ward et al., 1998). The spatial information was later examined to determine the extent of disturbance, by overlaying the original polygons on 1:10,000 digital orthophotos taken in 2002; most of this imagery was black and white (Axys, 2005). The disturbance mapping showed that 11% of sensitive ecosystems had been lost, mostly from forested areas (BC MoE, 2002; McPhee et al., 2000). Some forms of disturbance, such as invasion by exotic species, were difficult or impossible to discern (Axys, 2005).

Figure 44. The extent of Sensitive Ecosystems Inventory (SEI) ecosystems within MABR.

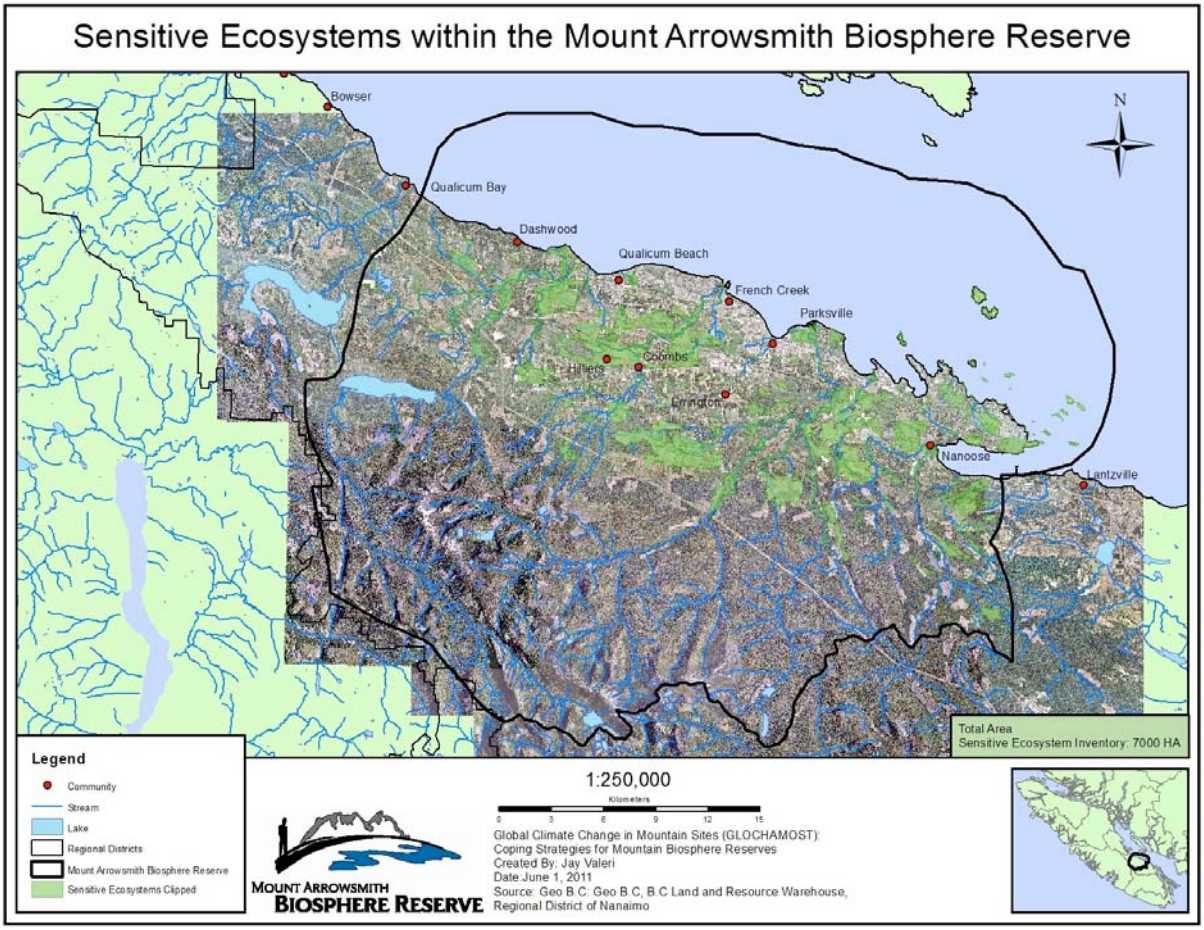
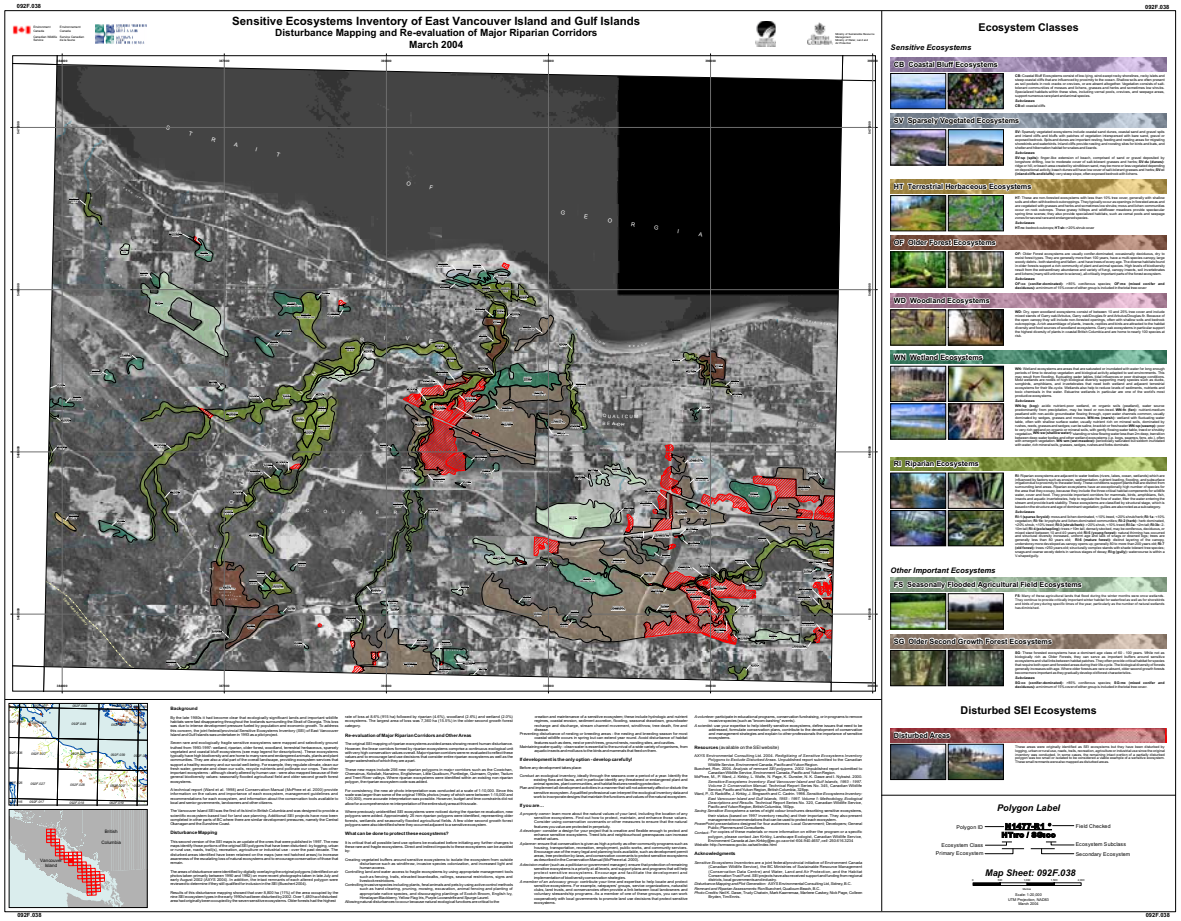


Figure 45. Some Sensitive Ecosystems Inventory (SEI) ecosystems within MABR.

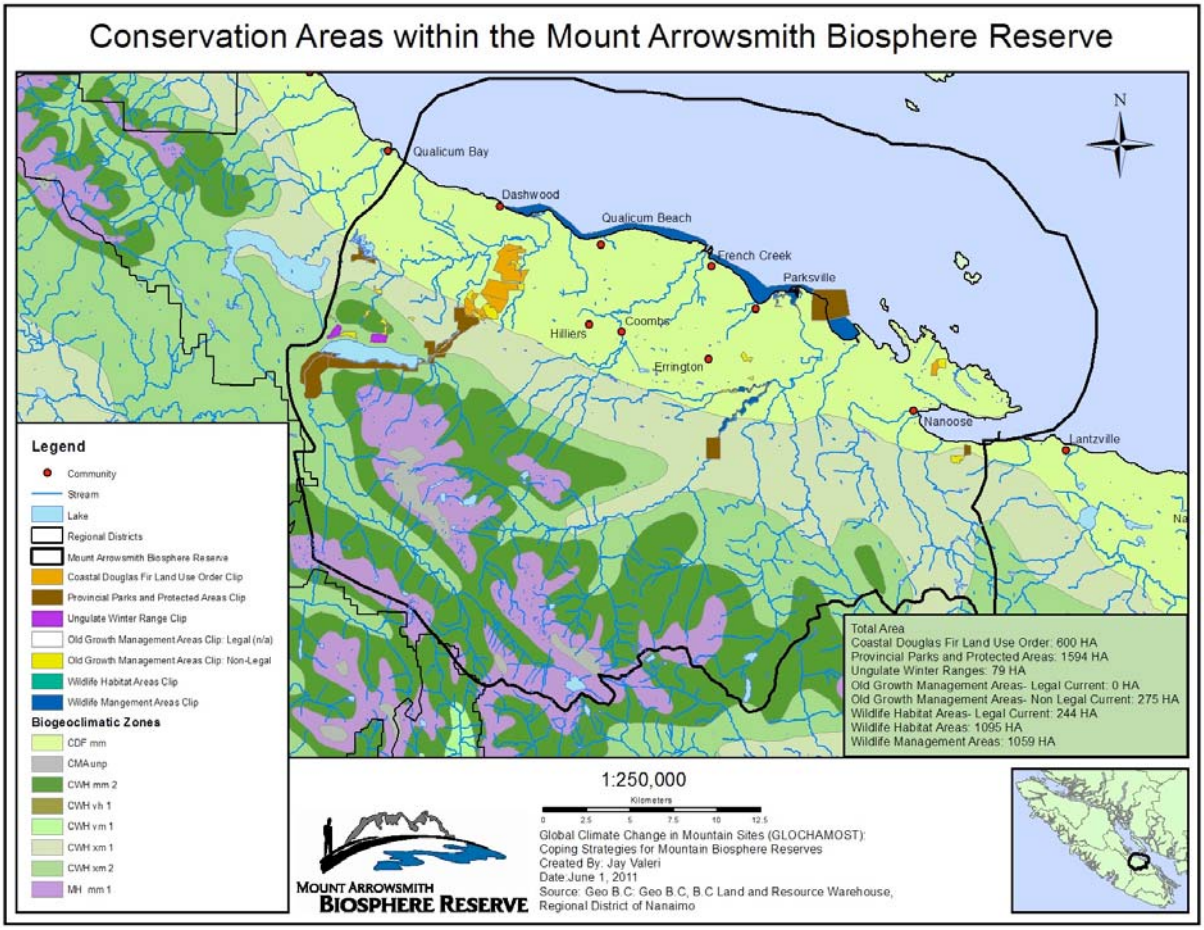


The CDF zone is the smallest of the sixteen biogeoclimatic zones in BC and has the highest density of species of global and provincial concern (Austin et al., 2008). The CDF zonal ecosystem (Douglas fir (*Pseudotsuga menziesii*)/Dull Oregon Grape (*Mahonia nervosa*), CDFmm/01), which best reflects climatic influences and represents average moisture and nutrient factors, is ranked as globally imperiled (G2), at high risk of extinction. This ecosystem is a matrix coniferous forest that once dominated the landscape, and old, structurally complex stands were common. It has been extensively harvested and the land converted to other uses. No forests of any significant size remain, and there is very little in protected areas. Most of the existing forest is in very young to young seral stages (BC CDC 2011). (See Figure 46 for a general view of overlap of CDF ecosystems with protected areas).

Some ecological communities in MABR, including communities outside of the CDF zone are ranked as provincially (S1) or globally (G1) critically imperiled, i.e., at *very* high risk of extinction

or extirpation from BC (Table 12). Less than 5% of Garry Oak and associated ecosystems remain in near-natural condition (Austin et al, 2008; Erickson & Meidinger, 2007).

Figure 46. Biogeoclimatic subzones and protected areas within MABR. Note: Protected areas on this map may be incomplete or slightly inaccurate.



Estuarine marsh ecosystems in MABR have also been significantly degraded, despite direct protection from development. The provincially blue-listed Lyngbye's sedge (*Carex lyngbyei*)/ herbaceous vegetation community in particular has been reduced to a fraction of its former extent; on the Englishman River estuary, remnants of this channel edge community are found only along the periphery of the estuary or under large woody debris. Researchers attribute the damage to heavy grazing and grubbing by locally overabundant Canada Geese (*Branta canadensis*). With the loss of above and below-ground vegetation, the rich organic substrates have progressively eroded. Upper channels have widened and become shallow with silt, while lower areas have become more saline and hardpan. The decline of primary productivity has affected critical habitat for salmonids, wintering and migratory waterbirds, and other species groups.

Table 12. Seventy-one provincially Red and Blue-listed ecological communities that are may be in present MABR. Codes are described on the BC Ecosystems and Species Explorer website at http://www.env.gov.bc.ca/atrisk/toolintro.html.

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	
Abies amabilis - Picea sitchensis / Oplopanax horridus	amabilis fir - Sitka spruce / devil's club	CWHvm1/08	S3 (2004)	Blue	GNR	2
Abies amabilis - Thuja plicata / Rubus spectabilis Moist Maritime 2	amabilis fir - western redcedar / salmonberry Moist Maritime 2	CWHmm2/08	S2S3 (2004)	Blue	G3G4	2
Abies grandis / Mahonia nervosa	grand fir / dull Oregon-grape	CDFmm/04	S1 (2005)	Red	G1	1
Abies grandis / Tiarella trifoliata	grand fir / three-leaved foamflower	CDFmm/06	S1 (2004)	Red	G1	1
Alnus rubra / Carex obnupta [Populus balsamifera ssp. *trichocarpa]*	red alder / slough sedge [black cottonwood]	CDFmm/14	S1 (2006)	Red	G1	1
Alnus rubra / Lysichiton americanus	red alder / skunk cabbage	CDFmm/ Ws52	S2 (2010)	Red	GNR	1
Anaphalis margaritacea - Aster foliaceous	pearly everlasting - leafy aster	MHmm1/00	S2 (2004)	Red	G2	2
Arbutus menziesii / Arctostaphylos columbiana	arbutus / hairy manzanita	CDFmm/00 CWHxm1/00	S2 (2004)	Red	G2	2
Artemisia campestris - Festuca rubra / Racomitrium canescens	northern wormwood - red fescue / grey rock-moss	CDFmm	S1	Red	G1	1
Carex lasiocarpa - Rhynchospora alba	slender sedge - white beak-rush	CDFmm/ Wf53 CWHmm2/ Wf53 CWHxm1/ Wf53 CWHxm2/ Wf53	S2 (2004)	Red	G2	1

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	

Carex lyngbyei Herbaceous Vegetation	Lyngbye's sedge herbaceous vegetation	CDFmm/ Em05 CWH/Em05	S3 (2004)	Blue	GNR	2
Carex macrocephala Herbaceous Vegetation	large-headed sedge Herbaceous Vegetation	CDFmm/00 CWHvh1/00	S1S2 (2008)	Red	G1G2	1
Carex sitchensis - Oenanthe sarmentosa	Sitka sedge - Pacific water-parsley	CWHxm1/ Wm50	S3 (2004)	Blue	G3	2
Carex sitchensis / Sphagnum spp.	Sitka sedge / peat-mosses	CWHvm1/ Wf51 MHmm1/ Wf51	S2 (2004)	Red	G2	1
Deschampsia cespitosa - Sidalcea hendersonii	tufted hairgrass - Henderson's checker-mallow	CWHxm1/00	S1S2 (2004)	Red	G2	1
Deschampsia cespitosa ssp. beringensis - Aster subspicatus	tufted hairgrass - Douglas' aster	CDFmm/Ed02 CWH/Ed02	S3 (2004)	Blue	G3	2
Deschampsia cespitosa ssp. *beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	CDFmm/Ed01 CWH/Ed01	S3 (2004)	Blue	G3	2
Distichlis spicata var. spicata Herbaceous Vegetation	seashore saltgrass Herbaceous Vegetation	CDFmm/ Em03	S2S3 (2008)	Red	GNR (2008)	2
Dulichium arundinaceum Herbaceous Vegetation	three-way sedge	CDFmm/ Wm51 CWHmm1/ Wm51 CWHxm2/ Wm51	S2 (2004)	Red	GNR	2
Eleocharis palustris Herbaceous Vegetation	common spike-rush Herbaceous Vegetation	CDFmm/ Wm04 CWH/Wm04	S3 (2004)	Blue	GNR	3

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	
Festuca roemeri var. *roemeri - Koeleria macrantha*	Roemer's fescue - junegrass	CDFmm/00 CWHxm1/00	S1 (2004)	Red	G1	1
Juncus arcticus - Plantago macrocarpa	arctic rush - Alaska plantain	CDFmm/ Ed03 CWH/Ed03	S1 (2007)	Red	GNR	1

Ledum groenlandicum / Kalmia microphylla / Sphagnum spp.	Labrador tea / western bog-laurel / peat-mosses	CWHvm1/ Wb50 CWHxm1/ Wb50 CWHxm2/ Wb50	S3 (2004)	Blue	G4	4
Leymus mollis ssp. *mollis - Lathyrus japonicus*	dune wildrye - beach pea	CDFmm CWHvh1 CWHvm1 CWHxm1 CWHxm2	S1S2 (2008)	Red	GNR	1
Menyanthes trifoliata - Carex lasiocarpa	buckbean - slender sedge	CDFmm/ Wf06	S3 (2004)	Blue	G3	2
Myosurus minimus - Montia spp. *- Limnanthes macounii*	tiny mousetail - montias - Macoun's meadow-foam	CDFmm/00	S1 (2004)	Red	G2	Not Assessed
Myrica gale / Carex sitchensis	sweet gale / Sitka sedge	CDFmm/ Wf52 CWHmm1/ Wf52 CWHmm2/ Wf52 CWHxm1/ Wf52 CWHxm2/ Wf52	S2 (2004)	Red	G3	3
Phlox diffusa - Selaginella wallacei	spreading phlox - Wallace's selaginella	MHmm1/00	S2 (2004)	Red	GNR	2
Picea sitchensis / Rubus spectabilis Very Dry Maritime	Sitka spruce / salmonberry Very Dry Maritime	CWHxm1/08 CWHxm2/08	S2 (2004)	Red	G3	2
Picea sitchensis / Rubus spectabilis Very Wet Maritime	Sitka spruce / salmonberry Very Wet Maritime	CWHvm1/09	S2 (2010)	Red	G3	2

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	
Pinus contorta / Sphagnum spp. CDFmm	lodgepole pine / peat-mosses CDFmm	CDFmm/10	S1 (2004)	Red	GNR	2
Pinus contorta / Sphagnum spp. *Very Dry Maritime*	lodgepole pine / peat-mosses Very Dry Maritime	CWHxm1/11 CWHxm2/11	S3 (2004)	Blue	GNR	3
Populus balsamifera ssp. *trichocarpa - Alnus rubra / Rubus spectabilis*	black cottonwood - red alder / salmonberry	CWHmm1/09 CWHvm1/10 CWHwm/06 CWHxm1/09 CWHxm2/09	S3 (2010)	Blue	GNR	2

Populus balsamifera ssp. *trichocarpa / Salix sitchensis*	black cottonwood / Sitka willow	CWHxm1/10 CWHxm2/10	S2S3 (2004)	Blue	GNR	2
Populus tremuloides / Malus fusca / Carex obnupta	trembling aspen / Pacific crab apple / slough sedge	CDFmm/00 CWHxm1	S1S2 (2004)	Red	G1G2	1
Pseudotsuga menziesii - Arbutus menziesii	Douglas-fir - arbutus	CDFmm/02	S2 (2004)	Red	GNR	1
Pseudotsuga menziesii / Mahonia nervosa	Douglas-fir / dull Oregon-grape	CDFmm/01	S2 (2010)	Red	G2	1
Pseudotsuga menziesii / Melica subulata	Douglas-fir / Alaska oniongrass	CDFmm/03	S1 (2006)	Red	G1	1
Pseudotsuga menziesii - Pinus contorta / Cladina spp.	Douglas-fir - lodgepole pine / reindeer lichens	CWHxm2/02	S2 (2004)	Red	GNR	2
Pseudotsuga menziesii - Pinus contorta / Racomitrium canescens	Douglas-fir - lodgepole pine / grey rock-moss	CWHxm1/02	S2 (2004)	Red	GNR	2

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	
Pseudotsuga menziesii / Polystichum munitum	Douglas-fir / sword fern	CWHxm1/04 CWHxm2/04	S2 (2004)	Red	G2G4	2
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Dry Maritime	Douglas-fir - western hemlock / salal Dry Maritime	CWHxm1/03 CWHxm2/03	S2S3 (2004)	Blue	G3G4	2
Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon Moist Maritime	Douglas-fir - western hemlock / salal Moist Maritime	CWHmm2/02	S2S3 (2011)	Blue	GNR	Not Assessed
Quercus garryana - Arbutus menziesii	Garry oak - arbutus	CDFmm/00	S1 (2004)	Red	G1	2
Quercus garryana / Bromus carinatus	Garry oak / California brome	CDFmm/00	S1 (2004)	Red	G1	2
Quercus garryana / Holodiscus discolor	Garry oak / oceanspray	CDFmm/00	S1 (2004)	Red	G1	2
Ruppia maritima Herbaceous Vegetation	beaked ditch-grass Herbaceous Vegetation	CDFmm/ Em01 CWH/Em01	S2 (2004)	Red	GNR	2
Salicornia virginiana - Glaux maritima	American glasswort - sea-milkwort	CDFmm/ Em02 CWH/Em02	S2 (2004)	Red	G3G4	3

Salix sitchensis / Carex sitchensis	Sitka willow / Sitka sedge	CWHvm1/ Ws06	S3 (2004)	Blue	G3	2
Salix sitchensis - Salix lucida ssp. lasiandra / Lysichiton americanus	Sitka willow - Pacific willow / skunk cabbage	CDFmm/ Ws51	S2 (2004)	Red	G2	1

Scientific Name	English Name	Biogeoclimatic Units	Status			CF Priority
			Provincial	BC List	Global	
Thuja plicata / Symphoricarpos albus	western redcedar / common snowberry	CDFmm/07	S1 (2004)	Red	GNR	1
Thuja plicata / Tiarella trifoliata Very Dry Maritime	western redcedar / three-leaved foamflower Very Dry Maritime	CWHxm1/07 CWHxm2/07	S2 (2004)	Red	G3	2
Thuja plicata - Tsuga heterophylla / Polystichum munitum	western redcedar - western hemlock / sword fern	CWHmm1/04 CWHvm1/04	S3? (2005)	Blue	GNR	1
Tsuga heterophylla - Abies amabilis / Blechnum spicant	western hemlock - amabilis fir / deer fern	CWHvm1/06	S3 (2010)	Blue	GNR	2
Tsuga heterophylla - Abies amabilis / Blechnum spicant Moist Maritime	western hemlock - amabilis fir / deer fern Moist Maritime	CWHmm2/06	S2 (2004)	Red	GNR (2010)	3
Tsuga heterophylla - Abies amabilis / Rhytidiopsis robusta	western hemlock - amabilis fir / pipecleaner moss	CWHmm1/01 CWHmm2/01	S3 (2004)	Blue	G3	2
Tsuga heterophylla - Pseudotsuga menziesii / Eurhynchium oreganum	western hemlock - Douglas-fir / Oregon beaked-moss	CWHxm1/01 CWHxm2/01	S2 (2004)	Red	G3G4	2
Tsuga heterophylla - Thuja plicata / Blechnum spicant	western hemlock - western redcedar / deer fern	CWHxm1/06 CWHxm2/06	S2 (2004)	Red	G2G3	2
Tsuga heterophylla - Thuja plicata / Gaultheria shallon Moist Maritime 2	western hemlock - western redcedar / salal Moist Maritime 2	CWHmm2/03	S3 (2004)	Blue	G3	Not Assessed
Tsuga heterophylla - Thuja plicata / Gaultheria shallon Very Wet Maritime	western hemlock - western redcedar / salal Very Wet Maritime	CWHvm1/03	S3 (2006)	Blue	G3 (2005)	2
Typha latifolia Marsh	common cattail Marsh	CDFmm/ Wm05 CWHxm1/ Wm05 CWHxm2/ Wm05	S3 (2004)	Blue	G5	1

Monitoring, Research and Management

Provincial CDF technical and strategic steering committees are beginning to address the protection of remaining CDF ecosystems. Public workshops are planned for spring 2012.

Garry Oak Ecosystems Recovery Team (GOERT) coordinates efforts to protect and restore endangered Garry oak and associated ecosystems and their species at risk (SAR). The organization maps and classifies plant communities; assesses populations of SAR and writes status reports; writes and contributes to individual and multi-species recovery and action plans for SAR; creates and disseminates a range of educational materials to guide protection, restoration and best management practices; engages local governments, First Nations, private landowners, land trusts and stewardship groups in protecting ecosystems and SAR; restores habitat through invasive species removal and propagation of native plants; and guides research to further understanding of Garry Oak and associated ecosystems and SAR. More information can be found at http://www.goert.ca.

In 1999, a Smithsonian Institute/Man and Biosphere biodiversity forest monitoring site was established in Englishman River Falls Provincial Park (Jamieson, pers. comm., 2011); however this site has not been re-surveyed.

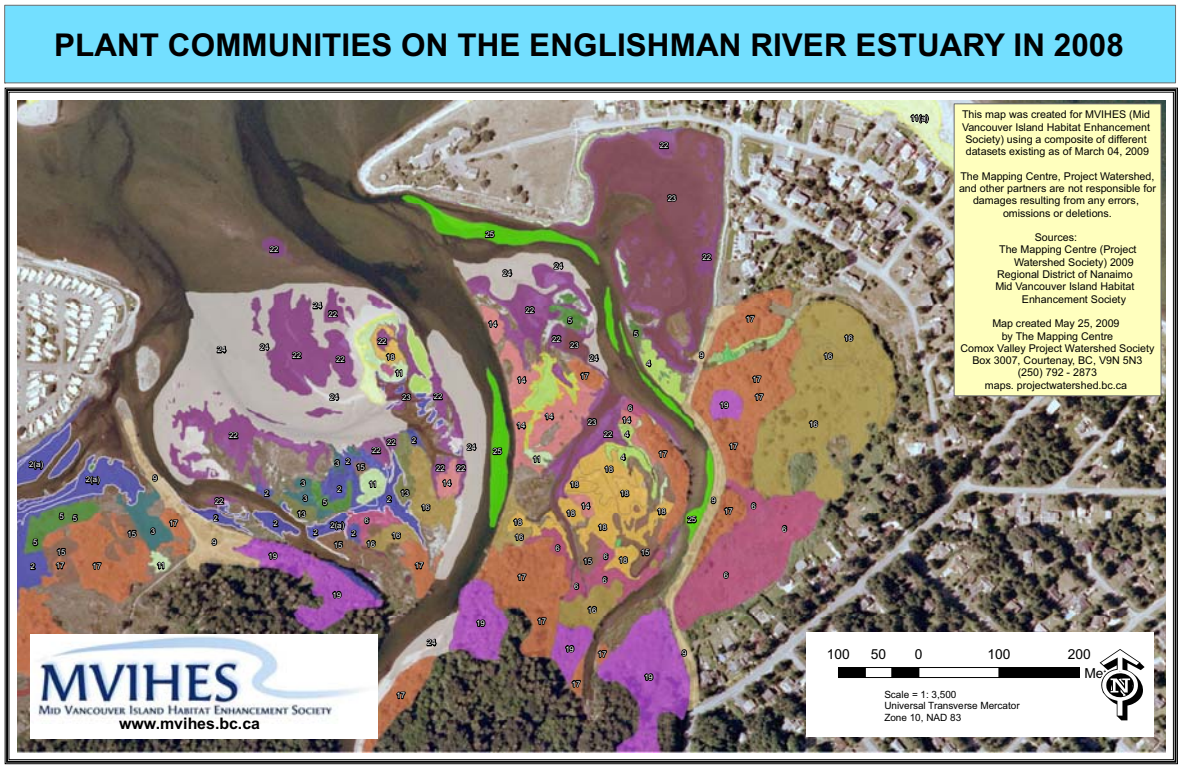
Estuarine ecosystems in MABR have been studied extensively by Canadian Wildlife Service biologists and others. Dawe (1986) documented some aspects of the vegetation ecology of the Nanoose-Bonnell estuary. Kennedy (1982) documented the plant communities and their standing crops on MABR estuaries and others. Dawe and White (1982) recorded some aspects of the vegetation ecology of the Little Qualicum River estuary. In 1983, researchers looked at estuarine restoration and salmonid utilization of a previously dyked slough in the Englishman River estuary (Tutty, Raymond & Conlin, 1983). Annand, Hillaby and Naylor published a study of the Englishman River estuary in 1993. Dawe and McIntosh (1993) studied vegetation changes on the Englishman River estuary following the breaching of a dyke.

The Mid-Vancouver Island Habitat Enhancement Society (MVIHES) conducted a bio-inventory and volunteer monitoring project on the Englishman River estuary in 2009. Plant communities were mapped (Figure 47) and compared with earlier mapping by Kennedy (1982) (Figure 48). MVIHES significantly raised community awareness of the significantly altered state of the estuary and the problem of locally overabundant Canada Geese at public seminars, presentations to local governments, and in newspaper articles.

In 2010, the Guardians of Mid-Island Estuaries Society installed eighteen 50 and 100 m^2 goose exclosures on the Englishman River and Little Qualicum River estuaries (six and twelve, respectively), with assistance from agency and NGO partners. The research project has been designed to increase the productivity of the estuarine marshes, by protecting key, high quality plant communities from grazing, and allowing eroded and denuded areas to recover. Vegetation, soil and water parameters are being monitored to assess recovery. Juvenile salmonid surveys have been conducted by the BC Conservation Foundation, and plans for installing large woody debris

on the estuaries is underway. Additional information is available on the Guardians' website at http://web.me.com/guardiansmie/Guardians_of_Mid-Island_Estuaries/The_Project.html.

Figure 47. Plant communities on the Englishman River Estuary in 2008 (MVIHES, 2009). The legend is below.



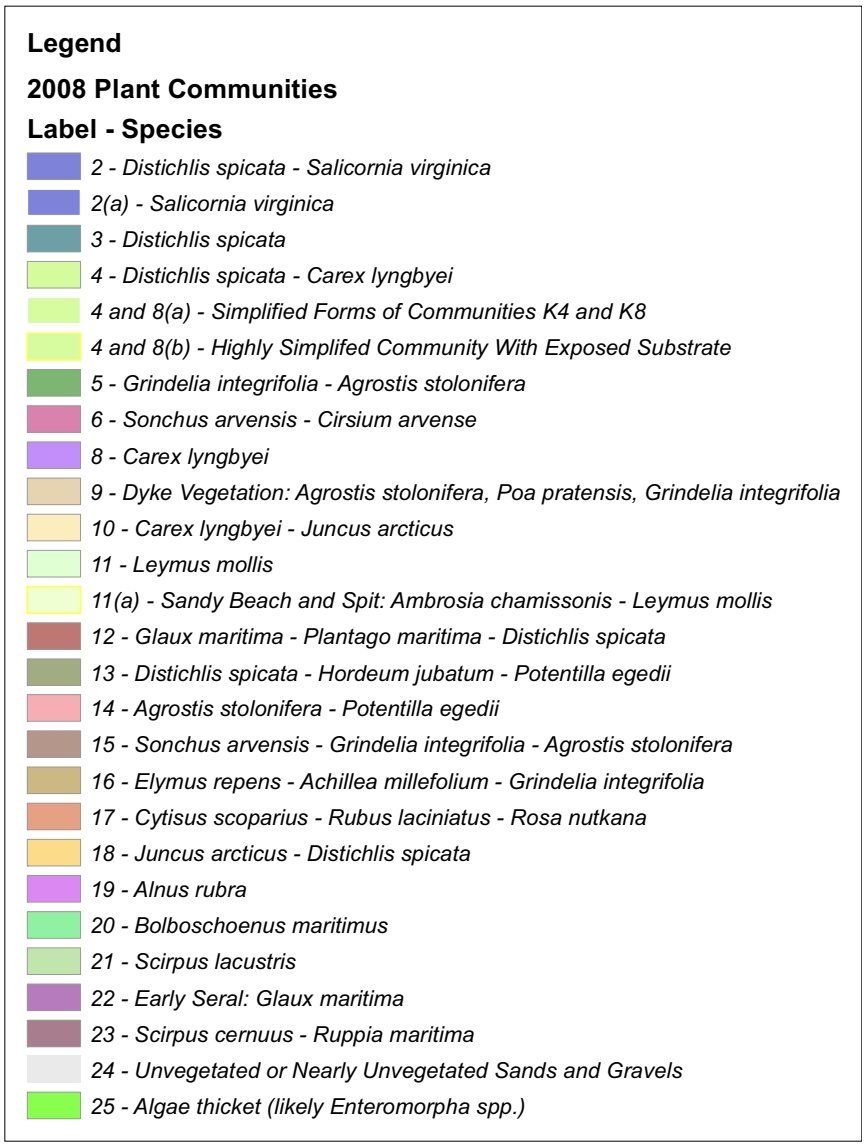
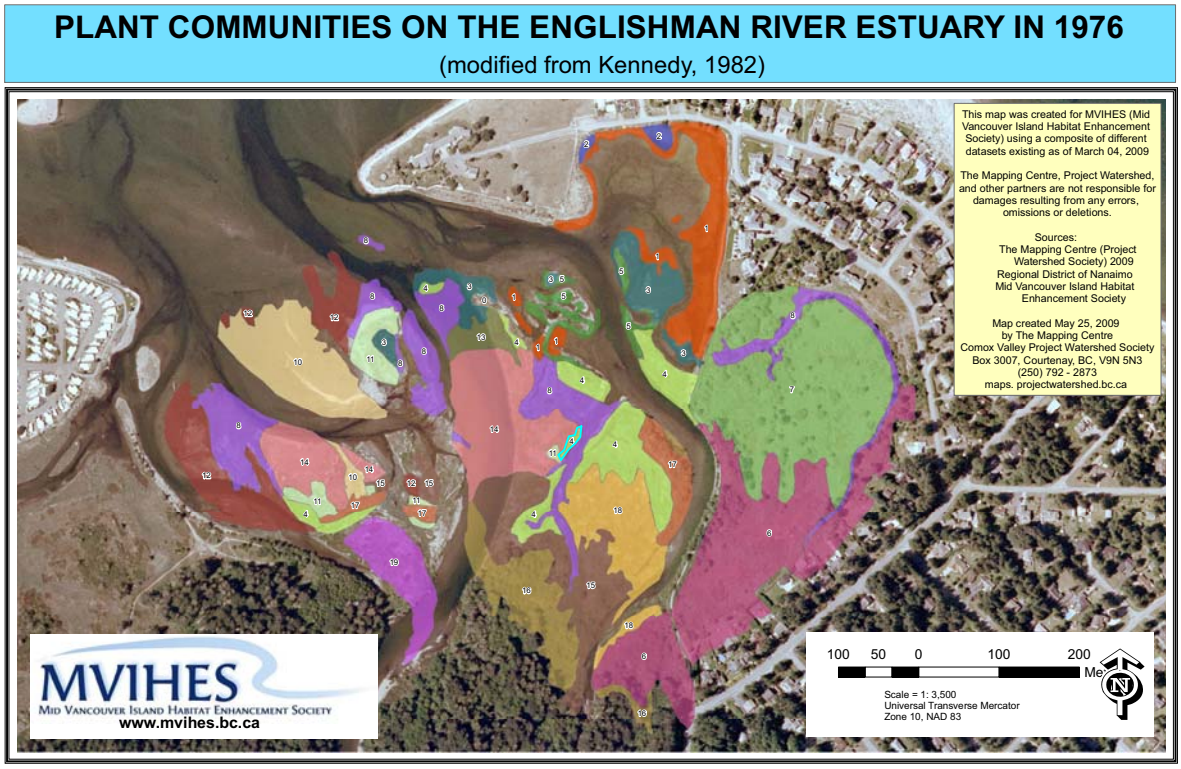

Legend
2008 Plant Communities
Label - Species
2 - Distichlis spicata - Salicornia virginica
2(a) - Salicornia virginica
3 - Distichlis spicata
4 - Distichlis spicata - Carex lyngbyei
4 and 8(a) - Simplified Forms of Communities K4 and K8
4 and 8(b) - Highly Simplifed Community With Exposed Substrate
5 - Grindelia integrifolia - Agrostis stolonifera
6 - Sonchus arvensis - Cirsium arvense
8 - Carex lyngbyei
9 - Dyke Vegetation: Agrostis stolonifera, Poa pratensis, Grindelia integrifolia
10 - Carex lyngbyei - Juncus arcticus
11 - Leymus mollis
11(a) - Sandy Beach and Spit: Ambrosia chamissonis - Leymus mollis
12 - Glaux maritima - Plantago maritima - Distichlis spicata
13 - Distichlis spicata - Hordeum jubatum - Potentilla egedii
14 - Agrostis stolonifera - Potentilla egedii
15 - Sonchus arvensis - Grindelia integrifolia - Agrostis stolonifera
16 - Elymus repens - Achillea millefolium - Grindelia integrifolia
17 - Cytisus scoparius - Rubus laciniatus - Rosa nutkana
18 - Juncus arcticus - Distichlis spicata
19 - Alnus rubra
20 - Bolboschoenus maritimus
21 - Scirpus lacustris
22 - Early Seral: Glaux maritima
23 - Scirpus cernuus - Ruppia maritima
24 - Unvegetated or Nearly Unvegetated Sands and Gravels
25 - Algae thicket (likely Enteromorpha spp.)

Figure 48. Plant communities on the Englishman River estuary in 1976 (modified from Kennedy, 1982) (MVIHES, 2009).



Legend

1976 Plant Communities

Label - Species

- *No Classification*
- *1 - Salicornia virginica - Triglochin Maritimum*
- *2 - Distichlis spicata - Salicornia virginica*
- *3 - Distichlis spicata*
- *4 - Distichlis spicata - Carex lyngbyei*
- *5 - Grindelia integrifolia - Agrostis stolonifera*
- *6 - Sonchus arvensis - Cirsium arvense*
- *7 - Holcus lanatus - Epilobium angustifolium*
- *8 - Carex lyngbyei*
- *10 - Carex lyngbyei - Juncus arcticus*
- *11 - Leymus mollis*
- *12 - Glaux maritima - Plantago maritima - Distichlis spicata*
- *13 - Distichlis spicata - Hordeum jubatum - Potentilla egedii*
- *14 - Agrostis stolonifera - Potentilla egedii*
- *15 - Sonchus arvensis - Grindelia integrifolia - Agrostis stoloniferai*
- *16 - Elymus repens - Achillea millefolium - Grindelia integrifolia*
- *17 - Cytisus scoparius - Rubus laciniatus - Rosa nutkana*
- *18 - Juncus arcticus - Distichlis spicata*
- *19 - Alnus rubra*

Morison Creek was a riparian study area as well as the site of MABR forest canopy studies (MABR, 1998). MVIHES later conducted a shoreline riparian inventory along the Parksville-Qualicum Beach Wildlife Management Area (Figure 49), and mapped areas hardened with seawalls or otherwise modified (e.g., Figure 50) (MVIHES, 2009).

Figure 49. Parksville-Qualicum Beach shoreline riparian areas (MVIHES, 2009).

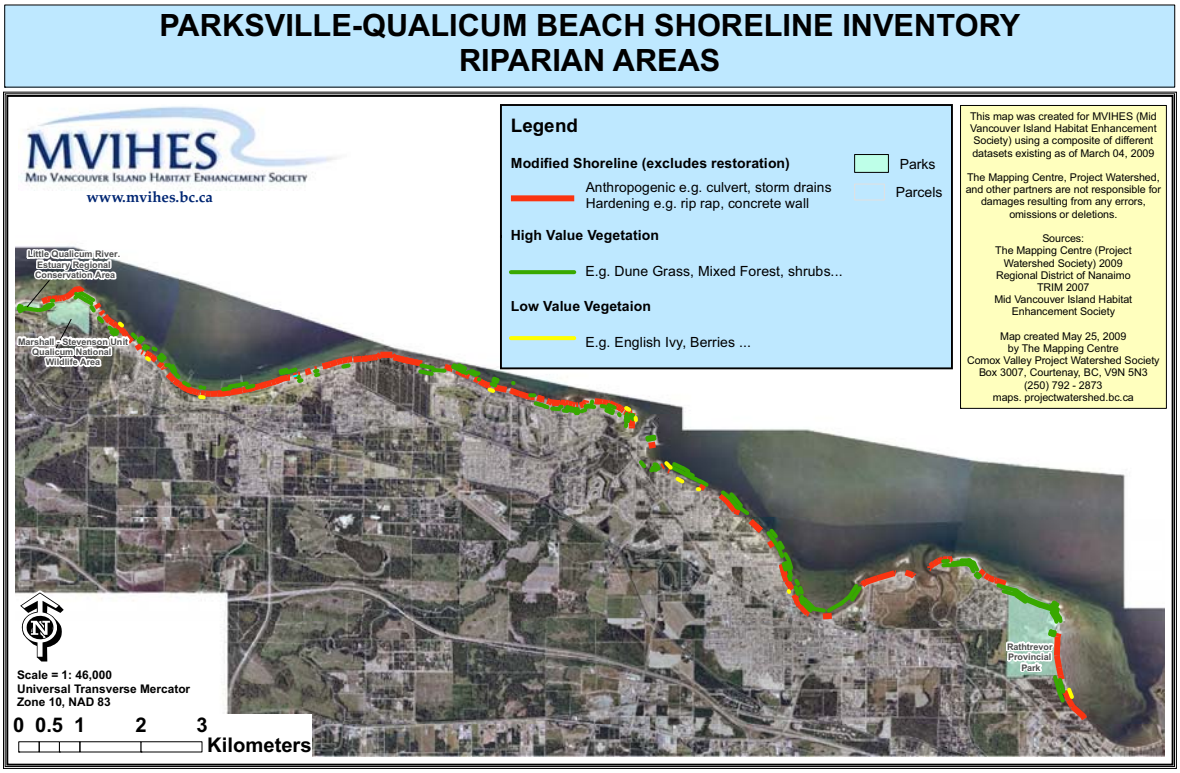
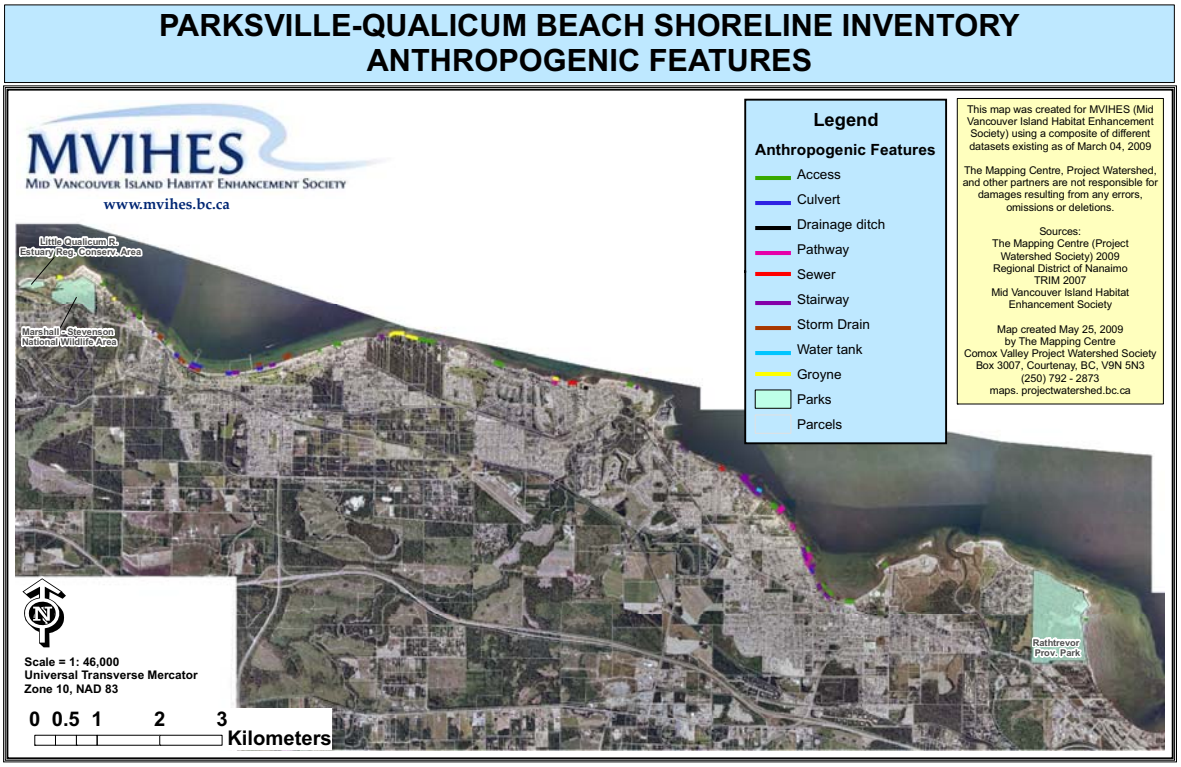


Figure 50. Parksville-Qualicum Beach shoreline inventory of anthropogenic features (MVIHES, 2009).



In 1997, ten Fisheries and Oceans Canada (DFO) Shorekeeper study sites were established in the marine intertidal zone. Monitoring data were archived at the Pacific Biological Station in nearby Nanaimo. As early as 1976, an environmental - social assessment (i.e., an environmental impact study) was conducted for the lower Englishman River (Blood and Associates, 1976).

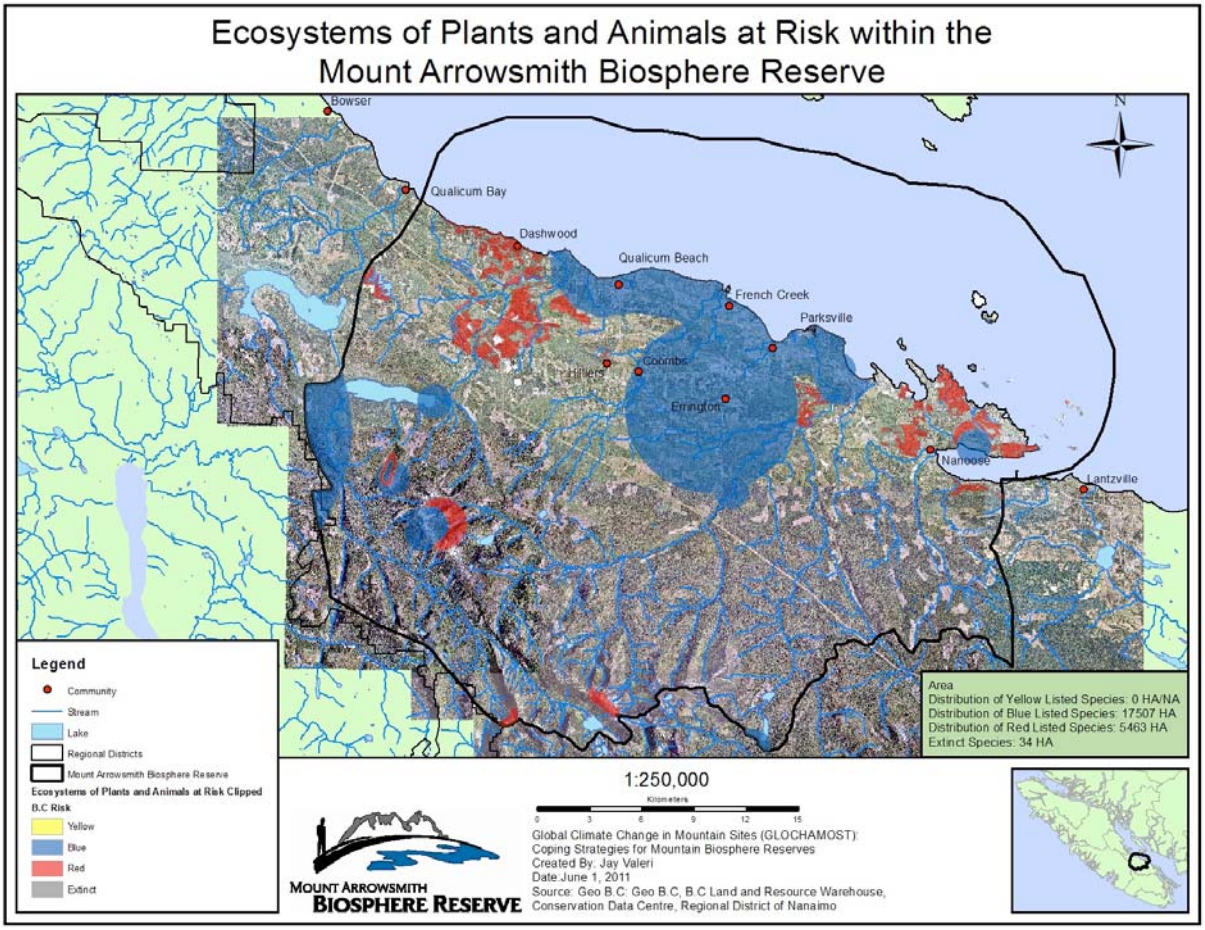
FLORA

Many reports and studies conducted in MABR include species lists; however these have not been effectively compiled. An E-Flora search for the RDN delivers 986 records. See http://www.geog.ubc.ca/biodiversity/eflora/.

Species at Risk

There are 67 provincially red and blue-listed plant species that may be present in MABR (Table 13). Figure 52 shows non-sensitive occurrences of plants (and animals) at risk within MABR.

Figure 52. Non-sensitive element occurrences of plant and animal species at risk in MABR.



In 2006, Olympic Onion *(Allium crenulatum)* and Columbia lewisia *(Lewisia columbiana var. columbiana)* were documented in a GLORIA inventory of alpine vascular plants on the Mount Arrowsmith massif; these are provincially red and blue-listed, respectively (Swerhun, Jamieson & Smith, 2009; BC CDC, 2011). Lance-fruited Draba (*Draba lonchocarpa*), Sand-dwelling Wallflower (*Erysimum arenicola var. torulosumI),* and White Wintergreen (*Pyrola elliptica*) are blue-listed species that have been found on Mount Arrowsmith (Alpine Club of Canada and Federation of Mountain Clubs of BC, n.d.).

Table 13. Provincially Red and Blue-listed plants that may be present in MABR. Codes are described on the BC Ecosystems and Species Explorer website at http://www.env.gov.bc.ca/atrisk/toolintro.html.

Plants (67 records)							
Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Abronia latifolia	yellow sand-verbena	S2S3 (2011)	Blue			G5 (1988)	1
Allium amplectens	slimleaf onion	S3 (2001)	Blue			G4 (1988)	2
Allium crenulatum	Olympic onion	S2 (2000)	Red			G4 (1988)	3
Allium geyeri var. *tenerum*	Geyer's onion	S2S3 (2005)	Blue			G4G5T3T5 (2002)	3
Anagallis minima	chaffweed	S3 (2008)	Blue			G5 (1984)	2
Bartramia stricta	apple moss	S2 (2011)	Red	E (2009)	1-E (2003)	GU (2006)	2
Bidens amplissima	Vancouver Island beggarticks	S3 (2008)	Blue	SC (2001)	1-SC (2003)	G3 (1988)	1
Botrychium simplex	least moonwort	S2S3 (2000)	Blue			G5 (1998)	3
Bryum canariense		S3? (2011)	Blue			G3G5 (1996)	3
Bulbostylis capillaris	densetuft hairsedge	S1 (2006)	Red			G5 (1984)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Carex feta	green-sheathed sedge	S2 (2002)	Red			G5 (1990)	2
Carex tumulicola	foothill sedge	S2 (2011)	Red	E (2008)	1-E (2010)	G4 (1985)	2
Ceratophyllum echinatum	spring hornwort	S3 (2002)	Blue			G4? (1995)	4
Chamaesyce serpyllifolia ssp. *serpyllifolia*	thyme-leaved spurge	S2S3 (2000)	Blue			G5T5 (2001)	2
Crumia latifolia		S2S3 (2011)	Blue			G3 (1999)	2
Cuscuta campestris	field dodder	S2S3 (2000)	Blue			G5 (2007)	2

Cyperus squarrosus	awned cyperus	S3 (2001)	Blue			G5 (1993)	2
Draba lonchocarpa var. *vestita*	lance-fruited draba	S2S3 (2000)	Blue			G5T3 (1998)	2
Dryopteris arguta	coastal wood fern	S3 (2011)	Blue	SC (2001)	1-SC (2003)	G5 (1999)	2
Entosthodon fascicularis	banded cord-moss	S2S3 (2011)	Blue	SC (2005)	1-SC (2006)	G4G5 (2001)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Epilobium densiflorum	dense spike-primrose	S1 (2010)	Red	E (2005)	1-E (2006)	G5 (1988)	1
Epilobium leptocarpum	small-fruited willowherb	S2S3 (2011)	Blue			G5 (1984)	3
Erysimum arenicola var. *torulosum*	sand-dwelling wallflower	S3 (2006)	Blue			G4G5T3T5 (2002)	3
Eucephalus paucicapitatus	Olympic mountain aster	S3 (2006)	Blue			G3? (2000)	2
Fissidens ventricosus		S2S3 (2011)	Blue			GU (2000)	2
Funaria muhlenbergii		S3? (2011)	Blue			G4 (1995)	2
Githopsis specularioides	common bluecup	S2S3 (2000)	Blue			G5 (1994)	2
Grimmia anomala		S2S3 (2011)	Blue			G5 (1998)	2
Hydrocotyle ranunculoides	floating water pennywort	SH (2007)	Red			G5 (1990)	1
Isoetes nuttallii	Nuttall's quillwort	S3 (2001)	Blue			G4? (1995)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Juncus oxymeris	pointed rush	S2S3 (2000)	Blue			G5 (1993)	3
Juniperus maritima	seaside juniper	S3 (2008)	Blue			G3G4 (2008)	3
Limnanthes macounii	Macoun's meadow-foam	S2 (2007)	Red	T (2004)	1-T (2006)	G2 (2006)	1

Lotus pinnatus	bog bird's-foot trefoil	S1 (2000)	Red	E (2004)	1-E (2005)	G4G5 (2001)	1
Malaxis brachypoda	white adder's-mouth orchid	S2S3 (2000)	Blue			G4Q (2002)	3
Meconella oregana	white meconella	S1 (2005)	Red	E (2005)	1-E (2006)	G2G3 (2004)	1
Megalodonta beckii	water marigold	S3 (2001)	Blue			G4G5 (1984)	4
Microseris bigelovii	coast microseris	S1 (2000)	Red	E (2006)	1-E (2007)	G4 (1995)	1
Montia diffusa	branching montia	S1 (2001)	Red			G4 (1994)	2
Myriophyllum quitense	waterwort water-milfoil	S2S3 (2000)	Blue			G4? (1995)	3

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Orthocarpus imbricatus	mountain owl-clover	S1 (2008)	Red			G5 (1990)	2
Orthotrichum striatum		S3 (2011)	Blue			G4G5 (1991)	3
Packera macounii	Macoun's groundsel	S3 (2001)	Blue			G5 (1993)	2
Platyhypnidium riparioides		S3? (2011)	Blue			G4 (2004)	2
Pleuricospora fimbriolata	fringed pinesap	SH (2000)	Red			G4 (1994)	2
Pohlia sphagnicola		S2S3 (1996)	Blue			G2G3 (2001)	3
Pseudocyphellaria rainierensis	oldgrowth specklebelly	S2S3 (2010)	Blue	SC (2010)	3 (2005)	G3G4 (2006)	2
Psilocarphus tenellus	slender woolly-heads	S3 (2006)	Blue	NAR (1996)		G4 (1997)	4
Ptychomitrium gardneri		S3 (2011)	Blue			G4 (1994)	2
Pyrola elliptica	white wintergreen	S2S3 (2000)	Blue			G5 (1984)	3

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Racomitrium pacificum		S2S3 (2011)	Blue			G3 (1999)	2

Ranunculus alismifolius var. *alismifolius*	water-plantain buttercup	S1 (2009)	Red	E (2009)	1-E (2003)	G5T5 (1995)	1
Rubus nivalis	snow bramble	S3? (2008)	Blue			G4? (1990)	2
Rupertia physodes	California-tea	S3 (2001)	Blue			G4 (1985)	2
Schoenoplectus americanus	Olney's bulrush	S1 (2000)	Red			G5 (1984)	1
Sericocarpus rigidus	white-top aster	S2 (2008)	Red	SC (2009)	1-SC (2003)	G3 (2007)	1
Sidalcea hendersonii	Henderson's checker-mallow	S3 (2001)	Blue			G3 (2004)	2
Syntrichia laevipila	twisted oak moss	S2S3 (2011)	Blue	SC (2004)	1-SC (2005)	GNR	2
Torreyochloa pallida	Fernald's false manna	S1 (2000)	Red			G5 (2005)	2
Toxicodendron diversilobum	poison oak	S2S3 (2000)	Blue			G5 (1999)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Trifolium dichotomum	Macrae's clover	S2S3 (2007)	Blue			G4? (2002)	2
Triglochin concinna	graceful arrow-grass	S2 (2000)	Red			G5 (1990)	3
Uropappus lindleyi	Lindley's microseris	S1 (2000)	Red	E (2008)	1-E (2010)	G5 (1990)	1
Utricularia ochroleuca	ochroleucous bladderwort	S2S3 (2007)	Blue			G4? (1989)	3
Viola howellii	Howell's violet	S2S3 (2000)	Blue			G4 (1988)	2
Viola praemorsa ssp. *praemorsa*	yellow montane violet	S2 (2005)	Red	E (2007)	1-E (2003)	G5T3T5 (2000)	1
Yabea microcarpa	California hedge-parsley	S1S2 (2008)	Red			G5? (1990)	1

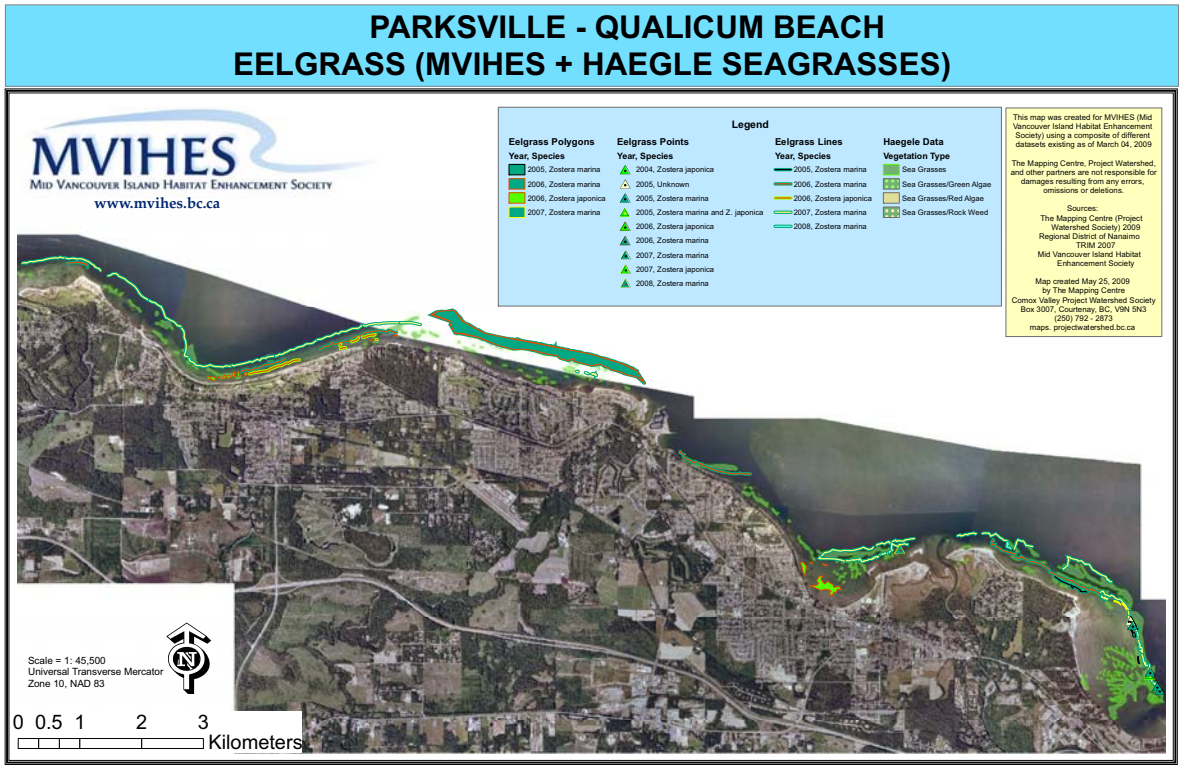
Monitoring and Research

The vascular plants within a Global Observation Research Initiative in Alpine Environments (GLORIA) site on Mount Arrowsmith were surveyed to determine species composition and percent cover in 2006, in association with monitoring for snow and temperature variables. Seventy-five species were identified within four sampling areas at 1,450 m, 1,514 m, 1,745 m and 1,800 m elevations (Swerhun, Jamieson & Smith, 2009).

Laroque and Smith (2005) used tree-ring radial growth modeling to define short-term climate change scenarios to estimate the impact upon mature trees found growing at high elevation on Vancouver Island. Mount Arrowsmith was one of forty sampling sites. Eight scenarios showed that species growing at an ecotonal boundary are typically very sensitive to a specific climatic variable, such as July temperature (Laroque & Smith, 2005).

Intertidal and subtidal eelgrass beds (*Zostera spp.*) were mapped by MVIHES from 2004 through 2008, according to methodology standardized by Environment Canada. The data was compared to the results compiled by Heagle in the 1970s and early 1980s (Figure 51). (MVIHES, 2009). Eelgrass maps can be accessed via the Community Mapping Network at http://www.cmnbc.ca/.

Figure 51. Eelgrass along the Parksville-Qualicum Beach shoreline (MVIHES, 2009).



FAUNA

Many reports and studies conducted in MABR include species lists; however these have not been effectively compiled. Dawe (1976, 1980) are foundational documents for comprehensive species lists. The Arrowsmith Naturalists have developed a bird checklist (2005). Nanoose Naturalists' checklist describes 217 birds and is available online at http://members.shaw.ca/halaue/Nanoose_Birdlist/.

There are two Important Bird Areas in MABR. Important Bird Areas (IBAs) are sites that support specific groups of birds: threatened birds, large groups of birds, and birds restricted by range or by habitat. The BC056 - Little Qualicum Estuary to Nanoose Bay area encompasses the PQBWMA and supports large numbers of waterfowl. The BC271 - Mount Arrowsmith and Area Mountains area supports significant numbers of White-tailed Ptarmigan *(Lagopus leucurus saxatilis)* (IBA, 2011).

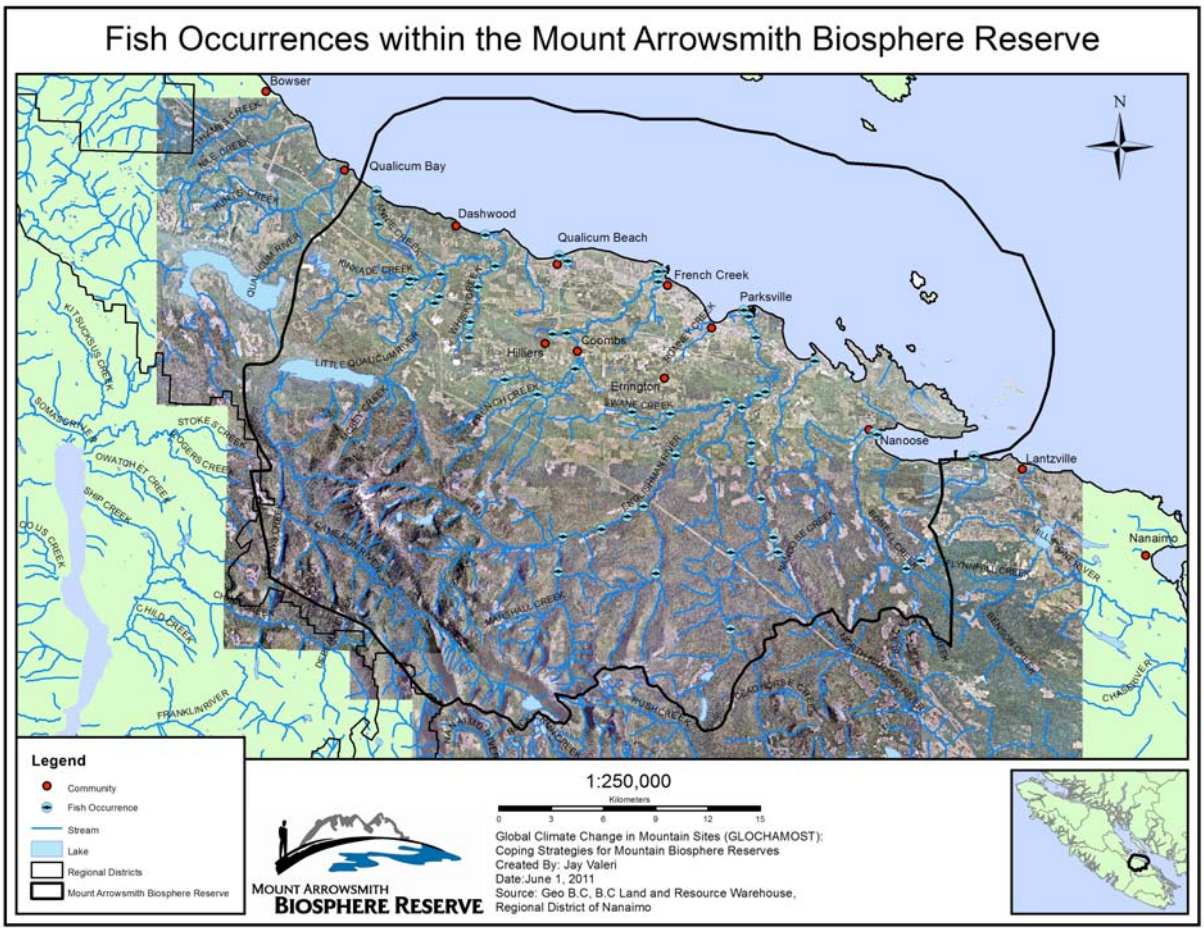
The Wildlife Tree Stewardship (WiTS) atlas documents occurrences of nest sites for Bald Eagles (*Haliaeetus leucocephalus*), Great Blue Herons (*Ardea herodias*), hawks, owls and woodpeckers. It can be accessed at http://www.wildlifetree.ca/

The Sensitive Streams of MABR (See **Watershed Management** above) are subject to extensive fishing closures. Escapement data is available for salmon runs at DFO Mapster. (Escapement refers to the number of fish that have escaped the fisheries and arrived at the natal stream to spawn.) Estimates of Steelhead Trout populations are available from the BC Conservation Foundation (BCCF). There have been numerous salmonid enhancement initiatives to bolster salmonid populations, including a hatchery program, artificial spawning channel and carcass planting program.

At a Pacific Herring seminar hosted by Mount Arrowsmith Biosphere Foundation in February 2011, DFO scientist J. Schweigert noted recent declines in Pacific Herring (*Clupea pallasii*) abundance. Recovery has not occurred with cessation of fisheries. Declines may be related to increases in Pacific Sardine (*Sardinops sagax*) populations, as sardines compete with herring for food. Schweigert acknowledged that herring are short lived and subject to dynamic fluctuations in abundance driven by changing oceanographic conditions.

Figure 53 shows fish occurrences in streams in MABR. See also the MVIHES "Fish in a Ditch" atlas; an example is provided in **Surface Water** above.

Figure 53. Fish-bearing streams within MABR.



Species at Risk

There are 62 Red and Blue-listed animals that may be present in MABR (Table 14).

Black Brant (*Branta bernicla*) are surveyed under contract by the Canadian Wildlife Service. Purple Martin (*Progne subis*) are extensively monitored by the Georgia Basin Ecological Assessment and Restoration Society http://www.georgiabasin.ca/puma.htm. A nesting habitat suitability model has been developed for Marbled Murrelet (*Brachyramphus marmoratus*) on the BC coast (Mather et al., 2010). Recovery actions for Vancouver Island Marmots are supported by the Landowners Partners Fund, which includes the Province, Island Timberlands and Timberwest. More information is available at http://www.marmots.org/index.php.

The Enos Lake stickleback (Gasterosteus spp.) are now extinct (BC CDC, 2011).

Table 14. Provincially Red and Blue-listed animals that may be in present MABR. Codes are described on the BC Ecosystems and Species Explorer website at http://www.env.gov.bc.ca/atrisk/toolintro.html.

Animals (62 records)							
Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Accipiter gentilis laingi	Northern Goshawk, *laingi* subspecies	S2B (2010)	Red	T (2000)	1-T (2003)	G5T2 (2008)	1
Anaxyrus boreas	Western Toad	S3S4 (2010)	Blue	SC (2002)	1-SC (2005)	G4 (2008)	2
Aneides vagrans	Wandering Salamander	S3S4 (2010)	Blue			G4 (2005)	2
Ardea herodias fannini	Great Blue Heron, *fannini* subspecies	S2S3B,S4N (2009)	Blue	SC (2008)	1-SC (2010)	G5T4 (1997)	1
Asio flammeus	Short-eared Owl	S3B,S2N (2009)	Blue	SC (2008)	3 (2005)	G5 (2008)	2
Botaurus lentiginosus	American Bittern	S3B (2010)	Blue			G4 (1996)	2
Brachyramphus marmoratus	Marbled Murrelet	S3B,S3N (2010)	Blue	T (2000)	1-T (2003)	G3G4 (2008)	1
Butorides virescens	Green Heron	S3S4B (2009)	Blue			G5 (1996)	4
Callophrys eryphon sheltonensis	Western Pine Elfin, *sheltonensis* subspecies	S3 (2006)	Blue			G5TNR	4
Callophrys mossii mossii	Moss' Elfin, *mossii* subspecies	S2S3 (2006)	Blue			G4T4 (2001)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Carychium occidentale	Western Thorn	S2S3 (2008)	Blue			G3G4 (2002)	2
Cercyonis pegala incana	Common Wood-nymph, *incana* subspecies	S2 (2006)	Red			G5T4T5 (2003)	2
Cervus canadensis roosevelti	Roosevelt Elk	S3S4 (2010)	Blue			G5T4 (1997)	2

Chrysemys picta pop. 1	Western Painted Turtle - Pacific Coast Population	S2 (2007)	Red	E (2006)	1-E (2007)	G5T2 (2007)	2
Coenonympha tullia insulana	Common Ringlet, *insulana* subspecies	S1 (2006)	Red			G5T3T4 (1998)	1
Contopus cooperi	Olive-sided Flycatcher	S3S4B (2009)	Blue	T (2007)	1-T (2010)	G4 (2008)	2
Corynorhinus townsendii	Townsend's Big-eared Bat	S3 (2006)	Blue			G4 (1996)	2
Dendragapus fuliginosus	Sooty Grouse	S3S4 (2009)	Blue			G5 (2007)	2
Epitheca canis	Beaverpond Baskettail	S3 (2004)	Blue			G5 (2004)	4
Eremophila alpestris strigata	Horned Lark, *strigata* subspecies	SXB (2010)	Red	E (2003)	1-E (2005)	G5T2 (2008)	1

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Erynnis propertius	Propertius Duskywing	S2S3 (2006)	Blue			G5 (2009)	2
Erythemis collocata	Western Pondhawk	S3 (2004)	Blue			G5 (2000)	2
Euchloe ausonides insulanus	Large Marble, *insulanus* subspecies	SX (2006)	Red	XT (2010)	1-X (2003)	G5T1 (2010)	2
Eumetopias jubatus	Steller Sea Lion	S2S3B,S3N (2006)	Blue	SC (2003)	1-SC (2005)	G3 (2004)	2
Euphyes vestris	Dun Skipper	S3 (2006)	Blue	T (2000)	1-T (2003)	G5 (2006)	2
Falco peregrinus anatum	Peregrine Falcon, *anatum* subspecies	S2?B (2010)	Red	SC (2007)	1-T (2003)	G4T4 (2006)	2
Falco peregrinus pealei	Peregrine Falcon, *pealei* subspecies	S3B (2010)	Blue	SC (2007)	1-SC (2003)	G4T3 (1997)	1
Fossaria vancouverensis		SH (2008)	Red			GHQ (2009)	1
Glaucidium gnoma swarthi	Northern Pygmy-Owl, *swarthi* subspecies	S3 (2009)	Blue			G4G5T3Q (1996)	1

Gulo gulo vancouverensis	Wolverine, *vancouverensis* subspecies	SH (2010)	Red	SC (1989)		G4T1Q (1997)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Haliotis kamtschatkana	Northern Abalone	S2 (2002)	Red	T (2000)	1-T (2003)	G3G4 (2010)	2
Hemphillia dromedarius	Dromedary Jumping-slug	S2 (2008)	Red	T (2003)	1-T (2005)	G3G4 (2005)	2
Hemphillia glandulosa	Warty Jumping-slug	S2S3 (2008)	Blue	SC (2003)	1-SC (2005)	G3G4 (2005)	2
Hesperia colorado oregonia	Western Branded Skipper, *oregonia* subspecies	S2S3 (2006)	Blue	C (2011)		G5T3T4 (2000)	2
Hirundo rustica	Barn Swallow	S3S4B (2009)	Blue	T (2011)		G5 (1996)	2
Lagopus leucura saxatilis	White-tailed Ptarmigan, *saxatilis* subspecies	S3 (2005)	Blue			G5T3 (1996)	2
Marmota vancouverensis	Vancouver Island Marmot	S1 (2006)	Red	E (2008)	1-E (2003)	G1 (2006)	1
Megascops kennicottii kennicottii	Western Screech-Owl, *kennicottii* subspecies	S3 (2009)	Blue	SC (2002)	1-SC (2005)	G5T4 (2003)	1
Monadenia fidelis	Pacific Sideband	S3S4 (2008)	Blue			G4G5 (2002)	2
Mustela erminea anguinae	Ermine, *anguinae* subspecies	S3 (2010)	Blue			G5T3 (1996)	2

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Myotis keenii	Keen's Myotis	S1S3 (2006)	Red	DD (2003)	3 (2005)	G2G3 (2006)	1
Nearctula sp. 1	Threaded Vertigo	S2 (2008)	Red	SC (2010)		G3G5 (2006)	2
Oncorhynchus clarkii clarkii	Cutthroat Trout, *clarkii* subspecies	S3S4 (2004)	Blue			G4T4 (1997)	2

Pachydiplax longipennis	Blue Dasher	S3S4 (2004)	Blue			G5 (2008)	4
Patagioenas fasciata	Band-tailed Pigeon	S3S4B (2009)	Blue	SC (2008)	1-SC (2011)	G4 (2000)	2
Phalacrocorax auritus	Double-crested Cormorant	S3B (2005)	Blue	NAR (1978)		G5 (1999)	2
Physa acuta	Pewter Physa	S1S3 (2008)	Red			G5Q (2008)	2
Plebejus icarioides blackmorei	Boisduval's Blue, *blackmorei* subspecies	S3 (2006)	Blue			G5T3 (2006)	3
Plebejus saepiolus insulanus	Greenish Blue, *insulanus* subspecies	SH (2006)	Red	E (2000)	1-E (2003)	G5TH (2003)	1
Pooecetes gramineus affinis	Vesper Sparrow, *affinis* subspecies	S1B (2010)	Red	E (2006)	1-E (2007)	G5T3 (1996)	1

Scientific Name	English Name	Status					CF Priority
		Provincial	BC List	COSEWIC	SARA	Global	
Pristiloma johnsoni	Broadwhorl Tightcoil	S2S3 (2008)	Blue			G2G3 (2004)	2
Progne subis	Purple Martin	S2S3B (2005)	Blue			G5 (1996)	3
Promenetus umbilicatellus	Umbilicate Sprite	S3S4 (2008)	Blue			G4 (2000)	2
Prophysaon vanattae	Scarletback Taildropper	S3S4 (2008)	Blue			G4 (2002)	4
Rana aurora	Northern Red-legged Frog	S3S4 (2010)	Blue	SC (2004)	1-SC (2005)	G4 (2008)	1
Salvelinus malma	Dolly Varden	S3S4 (2004)	Blue			G5 (2000)	2
Sorex palustris brooksi	American Water Shrew, *brooksi* subspecies	S2 (2010)	Red			G5T2 (1996)	1
Speyeria zerene bremnerii	Zerene Fritillary, *bremnerii* subspecies	S2 (2006)	Red			G5T3T4 (1998)	2
Sympetrum vicinum	Autumn Meadowhawk	S3S4 (2004)	Blue			G5 (1985)	4
Tyto alba	Barn Owl	S3 (2009)	Blue	T (2010)	1-SC (2003)	G5 (1996)	2
Uria aalge	Common Murre	S2B,S4N (2005)	Red			G5 (2003)	2

Zonitoides nitidus	Black Gloss	S3S4 (2008)	Blue			G5 (2003)	2

Management

A Brief Summary of Vancouver Island Game Species Inventory and Hunting/Trapping Regulation Review by Kim Brunt, MFLNRO Senior Wildlife Biologist

Assessments of game species abundance for review of hunting and trapping regulations on Vancouver Island typically occurs as a result of the review of information from two sources - 'dead side' and 'live side' data. There are many game species where the logistics and/or economic feasibility of conducting periodic count surveys, throughout the geographic range of the animal, are simply unrealistic. Examples of such species on Vancouver Island include all of the large predators (black bears, cougars, and wolves), and upland birds, such as grouse. For these species, review of the so-called dead side data can provide reliable information on population abundance and trends. Each year, hunters are randomly sampled and their effort and harvest, by species and area, are determined. From this 'Hunter Survey', statistics can be calculated on annual harvest and effort that can be summarized as 'catch per unit effort' (for example, hunter-days per animal harvested). While these values alone may provide minimal direct data on abundance, examination of trends over time can provide very useful information about the status of a wildlife population, and whether it is increasing, decreasing, or stable. The statistics generated from dead-side data are a key source of information that is used when regulations are being considered for adjustment that are related to season opening dates, length, bag limits, and sex-specific harvest rates.

So-called 'live side' data involves actual counts of a species – either by sign (e.g. tracks, or pellet groups) or counts and classification of individuals. Black-tailed Deer and Roosevelt Elk are examples of wildlife species for which annual inventory counts take place on Vancouver Island. In the case of deer, each spring, a deer/km index of the total population is determined for selected watersheds by conducting spotlight counts in openings along transects (logging roads). Ratio data on juveniles in the population are also collected in the spring to assess carryover, or recruitment of juveniles into the population. During the summer, fawn:doe, and buck:doe (by age class of buck) ratios are also determined. The same techniques used to collect these data have been employed on Vancouver Island since 1968, making this data set arguably the longest-running annual population assessment of deer anywhere in North America.

For Roosevelt Elk, annual counts (primarily helicopter surveys supplemented by ground counts) during the early spring provide information on total numbers (which can be estimated by factoring in sightability indices), juvenile ratios (to determine recruitment), and bull ratios. These values are determined for selected herds to help refine herd-specific population levels and adjust sex-specific annual allowable harvests as required.

Inventory information from both live- and dead-side sources are often combined in order to get a clearer picture of the status of wildlife populations and indicate regulation amendments

that may be necessary to address changes in that status. For example, hunter sightings of wolves and cougars are sampled each year and a 'Hunter Sighting Index' generated from this information. Incidental sightings of wildlife noted during field work carried out while conducting both deer and elk inventory are also used to generate a 'sightings per hour' index for several game species. Both of these sources can provide additional information on population status of these species for consideration in the hunting and trapping regulation review process.

Monitoring and Research

Dawe and Buechert (1995) recorded bird use of the Little Qualicum River estuary from 1975 through 1979. A similar study was done on the Englishman River estuary in 1979-1980 and 1988-1989 (Dawe, Martin & Trethewey, 1994). McIntosh (1986) compared bird and insect use of two old field habitats on the Qualicum NWA. Henigman (2006) studied the ecological and social constraints associated with securement of present and future Bald Eagle nest trees on the Nanoose peninsula. The disparities between the long term habitat requirements of the species, the remaining suitable recruitment trees, the stated values of the stakeholders and the existing governance frameworks were discussed. Dawe and Stewart (2010) documented trends for Canada Geese (*Branta canadensis*). Ornithologists, naturalists and others continue to collect bird information for the Coastal Waterbird Survey and during Breeding Bird Surveys and Christmas Bird Counts.

Lister, Harris and Hickey (1979) conducted a juvenile salmon downstream migration study at the Little Qualicum River. Bravender et al. (1996, 1997) reported the results of a survey of fish, juvenile salmon diets and epibenthic invertebrates in the Englishman River estuary. MVIHES surveyed the Parksville - Qualicum Beach shoreline for Sand Lance (Ammodytes hexapterus) and other forage fish eggs in 2008. Organization staff and volunteers also recorded fish species using beach seines at four sites in the Englishman River estuary in 2007-08. Each sample site was assessed for temperature, conductivity, dissolved oxygen and salinity in 2008 (MVIHES, 2009).

EXOTIC AND INVASIVE SPECIES

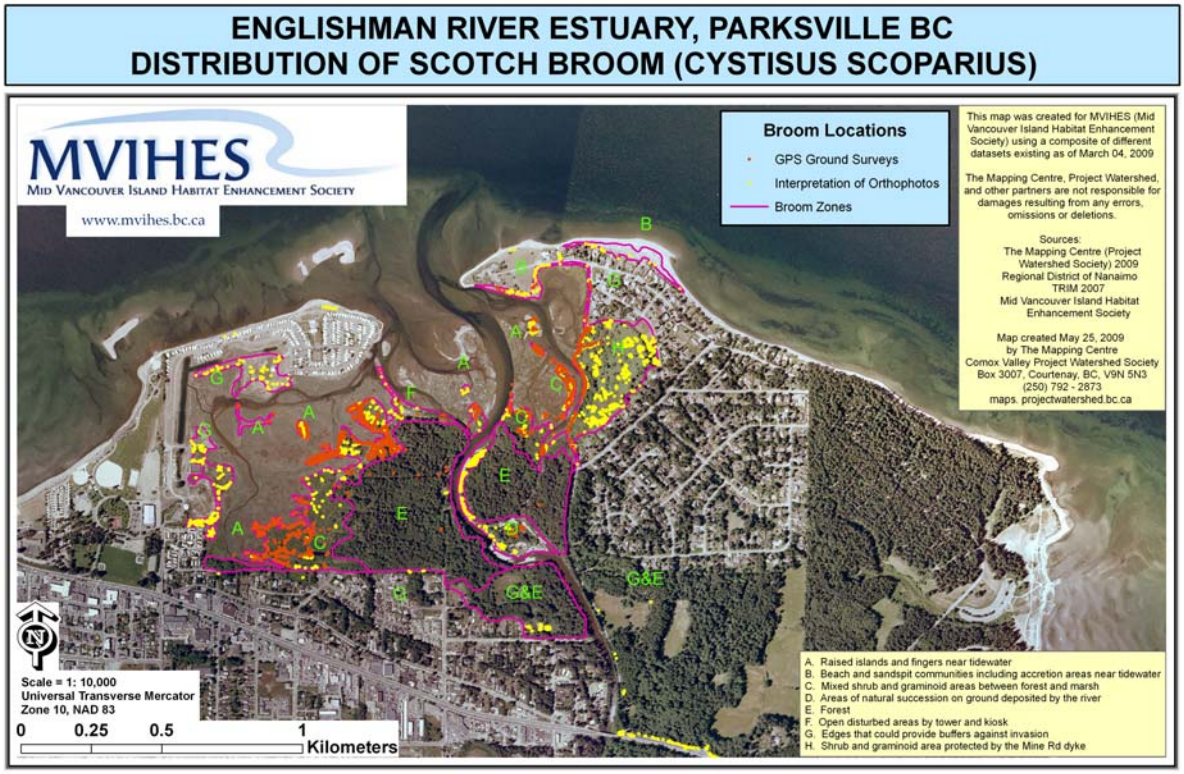
By Karen Hunter and Holly Clermont

Invasion of natural habitats by non-indigenous species varies over time and space as a result of local physical, biological and anthropogenic factors. Variation in local level effects generated by the spatial dominance of an invading species results in change to native species distribution and assemblages. Their management tend to cost communities many thousands of dollars and account for immeasurable person/volunteer hours. In MABR and adjacent areas, there are a number of invasive plans and animals in both terrestrial and marine habitats that are of concern. This section will briefly discuss many of the invasive species that are considered important for the MABR and describe a monitoring program initiated by the Mount Arrowsmith Biosphere Foundation for invasive tunicates, a group of marine fouling organisms.

BC Parks has in recent years mapped and progressively removed invasive species in the provincial parks. MVIHES documented more than 30 invasive plant species on the Englishman River estuary, and mapped many of them (e.g., Figure 54).

Carpet Burrweed (*Soliva sesilis*) has been aggressively managed in Rathtrevor Beach Provincial Park. Control of Scotch Broom (*Cystisus scoparius*) in protected areas and elsewhere in MABR is managed by many individuals, organizations and agencies. Broombusters is a local group dedicated to broom eradication http://www.broombusters.org/index.html. The Arrowsmith Naturalists, Nanoose Naturalists, the Nature Trust of BC, MVIHES, Mount Arrowsmith Biosphere Foundation and others have organized work parties to remove broom and other invasive plant species from protected areas.

Figure 54. Scotch Broom (*Cystisus scoparius*) on the Englishman River estuary (MVIHES, 2009).



The Invasive Plant Council of BC is a central repository for invasive plant information in BC at http://www.invasiveplantcouncilbc.ca/. The organization is facilitating the development of an Invasive Species Strategy for BC.

The Coastal Invasive Plant Committee (CIPC) is a registered non-profit society serving the geographic areas of Vancouver Island, the Gulf Islands and the Regional Districts of Powell River, Mount Waddington and Strathcona. The CIPC works with communities and land managers to provide education on impacts of invasive plants, and assist and promote coordinated and integrated invasive plant management. The CIPC has documented invasive plant species of concern for the MABR region (Figures 55 and 56). Among other resources, they provide extensive information on their website at about each species and their management.

Figure 55. Invasive plant species to prevent from establishing and eradicate if found. Retrieved December 12, 2011 from http://www.coastalinvasiveplants.com/invasive-plants/priority-plants

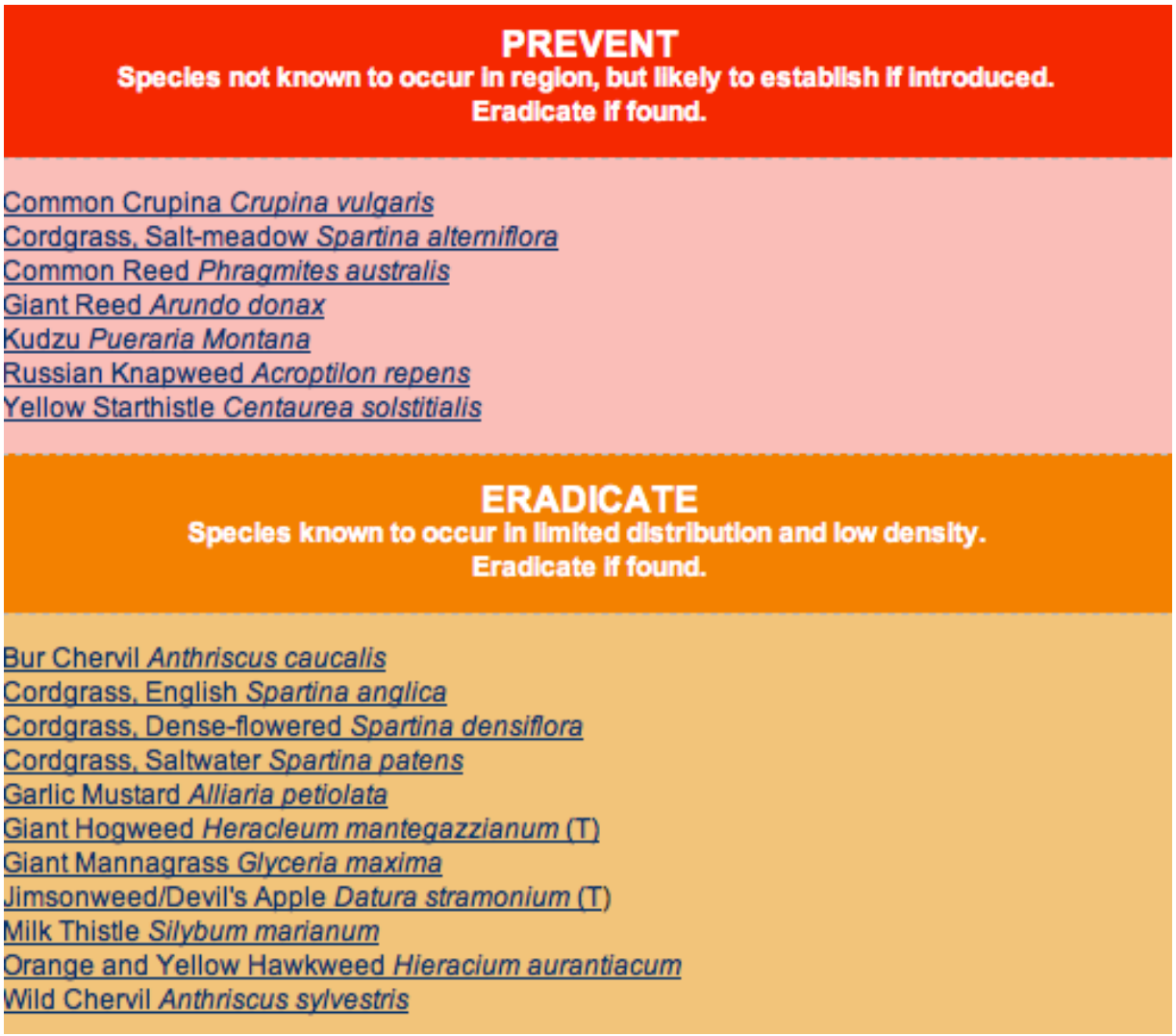


Figure 56. Invasive plant species to contain and control. Retrieved December 12, 2011 from http://www.coastalinvasiveplants.com/invasive-plants/priority-plants

The French Creek Giant Hogweed Project is an initiative of the Invasive Alien Plants Program (IAPP) of the BC Ministry of Forests and Range Coastal Invasive Plant Specialist, with assistance from Raincoast Applied Ecology. Additional information can be found at http://frenchcreekhogweed.ca/.

Local estuaries were surveyed in 2010 to detect invasive cordgrasses (*Spartina spp.*). A BC *Spartina* response plan was prepared in 2010 (Dresen, Scott & Williams, 2010).

Some terrestrial animal species that are non-indigenous *and* invasive present in MABR are American Bullfrog (*Phasianus colchicus*), Gray Squirrel (*Sciurus carolinensis*), Eastern Cottontail (*Sylvilagus floridanus*), rats (*Rattus spp.*), House Sparrow (*Passer domesticus*), and European Starling (*Sturnus vulgaris*).

Monitoring and management of populations are proposed to maintain integrity of native habitats and their inhabitants. The BC MoE and MFLRNO have active management programs to control Gray Squirrels, and individuals have been captured in the forests of the Englishman River estuary and adjacent neighbourhoods. The species is also a subject of research at Vancouver Island University and the University of Victoria. As a relatively recent invader, the American Bullfrog is also receiving considerable attention (e.g., http://www.bullfrogcontrol.com/).

Members of the Guardians of Mid-Island Estuaries began a Canada Goose (*Branta canadensis*) egg sterilization program in 1999, aimed at reducing Vancouver Island populations. Canada Geese as a species are not exotic per se´, in that some subspecies have always migrated through the reserve. However, the progeny of non-native subspecies introduced to the region for hunting and wildlife viewing purposes are now well-established and locally overabundant. (See **Monitoring and Research** in **Fauna** above.) In 2007, the group initiated a mark-re-sight program for Canada Geese; by 2010, twelve geese were leg-banded and 85 were collared at the Little Qualicum River estuary. Eighteen geese were leg-banded and 70 were collared at the Englishman River estuary. Monitoring is ongoing. Additional information is available at http://web.me.com/guardiansmie/Guardians_of_Mid-Island_Estuaries/The_Project.html.

The establishment of Aquatic Invasive Species (AIS) is a potentially irreversible impact on a marine ecosystem. Rated by the World Conservation Union (IUCN), AIS are considered one of the four greatest threats to the world's oceans and as important as land-based pollution, over-exploitation of resources, and destruction of habitat. In BC's marine environment, AIS may pose ecological and economic risks to the shellfish farming industry and other marine stakeholders (BC Shellfish Growers Association, 2007).

There are 26 known non-indigenous species in the BC South Coast/Strait of Georgia marine environment (Table 15). Several of these species are invasive and of special concern for the MABR. Specifically, tunicates, cordgrass (mentioned above) and New Zealand Mud Snail (*Potamopyrgus antipodarum*) are being monitored actively in the vicinity of the biosphere reserve.

The New Zealand Mud Snail was discovered in nearby Port Alberni several years ago (Davidson et al., 2008).

In collaboration with DFO and as a pro-active measure, MABF has engaged in a monitoring project for marine AIS within the MABR. This project is based on existing evidence that invasive tunicates are present in the Strait of Georgia and the marine portion of the MABR. Data from this project will aid marine stakeholders be aware of colonization and spread of tunicates and other AIS so that these species may be controlled.

In June, a series of 3 collector plates (Figure 57) were affixed to floating docks at 4 marinas near or inside the boundary of the MABR. Collector plates have been successfully used to monitor and collect marine AIS in previous studies (Gartner, 2010). Collector plates were left for a period of months before they are pulled momentarily from the water. Digital photographs were then taken to document animals that have settled onto the collector plates. Golden Star Tunicates were found at all locations in August (Figure 58).

Figure 57. Collector plates used for monitoring invasive tunicates species in MABR.

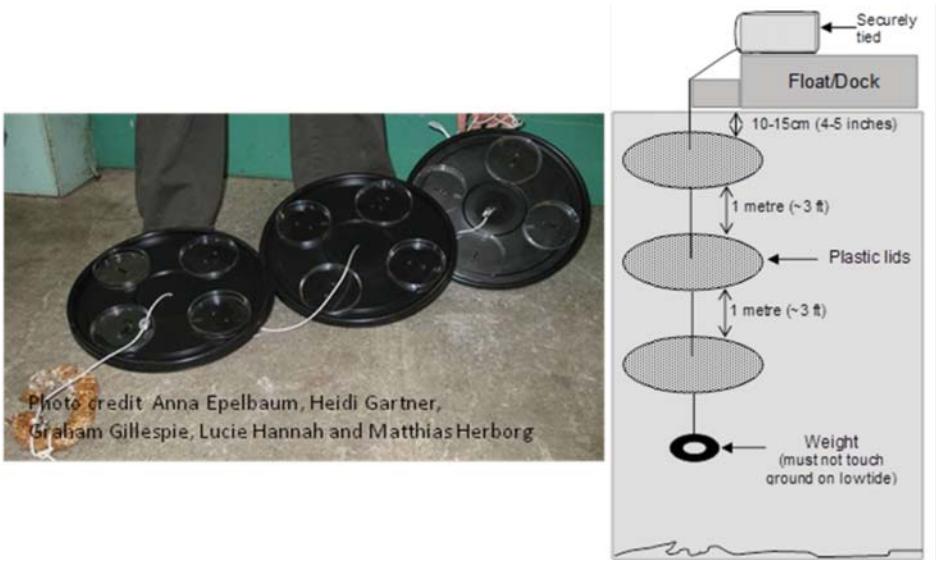


Figure 58. Golden star tunicate (Botryllus schlosseri) on collector plates at Deep Bay, Vancouver Island, August, 2011. The Golden Star Tunicate was present in each of the four monitoring locations. The Deep Bay monitoring site is just north of MABR.

Figure 59. Some invasive species in MABR. Note: Giant Cow Parsnip is actually Giant Hogweed (*Heracleum mantegazzianum*).

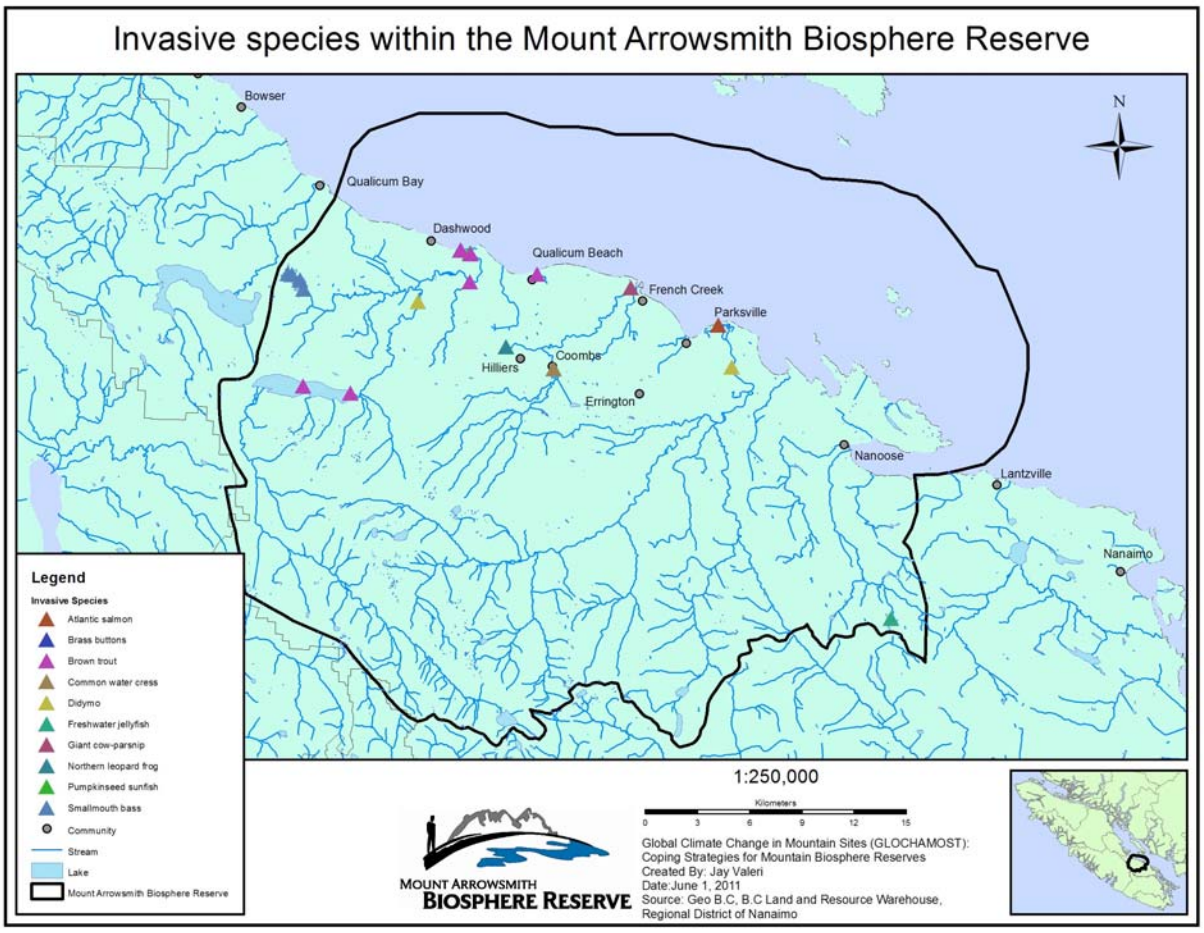


Table 15. Non-indigenous, intertidal species found in BC (Gillespie et al., n.d.). Species with distribution within or near the MABR are indicated with an asterisk. Only some of these are considered invasive.

INTERTIDAL NON-INDIGENOUS SPECIES	DISTRIBUTION
Plants	
Wireweed *(Sargassum muticum)*	Common in all South Coast areas*
Salt Meadow Cordgrass *(Spartina alterniflora)* English Cordgrass *(Spartina anglica)* Saltwater Cordgrass *(Spartina patens)*	Comox, Baynes Sound*, Boundary Bay
Dwarf eelgrass *(Zostera japonica)*	Primarily Salish Sea*
Gastropods	
New Zealand Mud Snail *(Potamopyrgus antipodarum)*	Port Alberni*
Japanese False Cerith *(Batillaria attramentaria)*	Relatively few locations in the Salish Sea
Manchurian Cecina *(Cecina manchurica)*	BC, not specified
Convex Slippersnail *(Crepidula convexa)*	Boundary Bay
Atlantic Slippersnail *(Crepidula fornicata)*	BC, not specified
Japanese Nassa *(Nassarius fraterculus)*	Boundary Bay
Mouse-ear Snail *(Myosotella myosotis)*	Boundary Bay, recent records from Nanaimo*
Eastern Mudsnail *(Nassarius obsoletus)*	Boundary Bay
Japanese Oyster Drill *(Ocinebrina inornata)*	In MABR* and other locations (Gillespie et al.,
Atlantic Oyster Drill *(Urosalpinx cinerea)*	BC, not specified
Bivalves	
Pacific Oyster *(Crassostrea gigas)*	Throughout Salish Sea*
Eastern Oyster *(Crassostrea virginica)*	Boundary Bay

INTERTIDAL NON-INDIGENOUS SPECIES	DISTRIBUTION
European Flat Oyster *(Ostrea edulis)*	Salish Sea*
Green Mussel *(Musculista senhousia)*	Salish Sea*
Blue Mussel *(Mytilus edulis)*	Ubiquitous*
Mediterranean Mussel *(Mytilusgallo provincialis)*	BC, not specified
Softshell Clam (*Mya arenaria)*	Ubiquitous*
Quadrate Trapezium *(Neotrapezuim liratum)*	BC, not specified
Varnish Clam *(Nuttallia obscurata)*	Salish Sea*
False Angelwing *(Petricolaria pholadiformis)*	Boundary Bay
Manila Clam *(Venerupis philippinarum)*	Salish Sea*
Naval Shipworm *(Teredonavalis sp.)*	BC, not specified
Tunicates	
Violet Tunicate *(Botrylloides violaceus)*	Northern Vancouver Island*
Golden Star Tunicate *(Botryllus schlosseri)*	Salish Sea*

Chapter 5

Economy

Current Status and Trends

The regional economy is shifting from extraction and processing of natural resources to sales and services.

Census information from 2006 is available from BC Stats and Statistics Canada, for each regional district electoral area and urban community. These include: labour force activity, unemployment rate by age and gender, broad and detailed occupational categories, top 8 industries by labour force, employment income, total income, after-tax income, family income, household income, and prevalence of low income.

More recent information is available for the RDN as a whole, for the second quarter of 2011 at http://www.bcstats.gov.bc.ca/pubs/qrs/rd21.pdf. However, the City of Nanaimo skews the economic data and its use for MABR.

Data for indicators of economic hardship are available for Local Health Area 69 (See map in **Health** below) at www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf. These include income levels (and the disparity between wealthy and poor), households paying 30% or more on housing, and percent of employable people 15+ years-old receiving income assistance. Indicators of labour market issues include labour demand by sector and key occupations (e.g., teachers), labour supply (level of education and field of study), Employment Insurance beneficiaries, and average employment income.

Given sufficient time and funding, the aforementioned statistical data can be secured for MABR alone.

EMPLOYMENT

A characterization of employment in MABR is provided in Table 16 (Reed, Mendis-Millard & Francis, 2011).

Table 16. Employment and changes in employment in key sectors in Parksville and Qualicum Beach, 2006 (Reed, Mendis-Millard & Francis, 2010).

SECTOR	Parksville 2006 (# people)	Parksville: % Change since 2001	Qualicum 2006 (# people)	Qualicum: % Change since 2001	% Change in B.C. since 2001
Total population	**10,993**	**6.5**	**8,502**	**22.8**	**5.3**
Accommodation, food and beverage	415	-17.8	265	1.9	7.7
Government, education and health*	930	38.2	665	6.9	4.6
Public administration[1]	190	-13.6	115	9.5	-2
Educational services[2]	265	35.9	240	14.3	9.2
Health care and social assistance[3]	475	15.9	310	-3.1	6.5
Retail trade	500	-25.4	310	10.7	6.9
Construction	415	9.2	290	45	39.9
Natural Resources (forestry, fisheries, agriculture)**	275	-93.2	155	-38.2	1.2
Agriculture, Food and Beverage[4]	25	-72.2	30	-53.8	5.8
Fishing and Food Processing[5]	15	-62.5	10	-33.3	-3.3
Logging and Forest Products[6]	170	-2.9	90	-28	-14.7
Mining and Mineral Products[7]	65	44.4	25	-37.5	17.1
Farms	20	-63.6	10	-81.8	5.2
Support activities for farms	-	-	-	-	11.3
Forestry and logging	55	22.2	45	50	-10
Support activities for forestry	25	No change	-	-100	-21.5
Manufacturing (including food processing)	225	-2.2	130	-16.1	-2.7
Transportation and warehousing	215	115	65	44.4	0.6

Source: B.C. Stats, Regional and Community Factsheets, 2006

*Aggregate of 1, 2 and 3. Percentages averaged. ** Aggregate of 4, 5, 6, and 7. Percentages averaged.

TOURISM

By Blain Sepos, Executive Director, Oceanside Tourism Association

For the fifth year in a row, combined accommodation revenue from Parksville, Qualicum Beach, and the RDN broke all time records. Room revenue increased 1.48% in 2010 to $21,244,281. Using a research tested formula, this equates to a total of over $106 million in direct spending by visitors on food & beverage, retail, local transportation, entertainment, and attractions in our communities. Oceanside Tourism's accommodation revenue forecast for 2011 is a cautious 3% increase from 2010 budget levels.

Observed trends include:

1. Last minute travel planning - Advance booking of accommodation and other visitor services is shrinking.

2. Shorter trips closer to home - The Parksville and Qualicum Beach region is well established in our regional getaway markets so we may take advantage of this trend more than other areas.

3. Discounting - With the rise of dedicated discount travel websites, groupon, and other daily deal services, many visitors choose their getaways based solely on where they can get the best deal.

Combination of 1, 2 & 3 - As the Parksville and Qualicum Beach region relies primarily on regional getaway markets, potential visitors may look at the weather forecast on Tuesday or Wednesday and make a decision on a weekend getaway from then based on where they can stretch their budget the most. As a result, bad weather has more impact than ever.

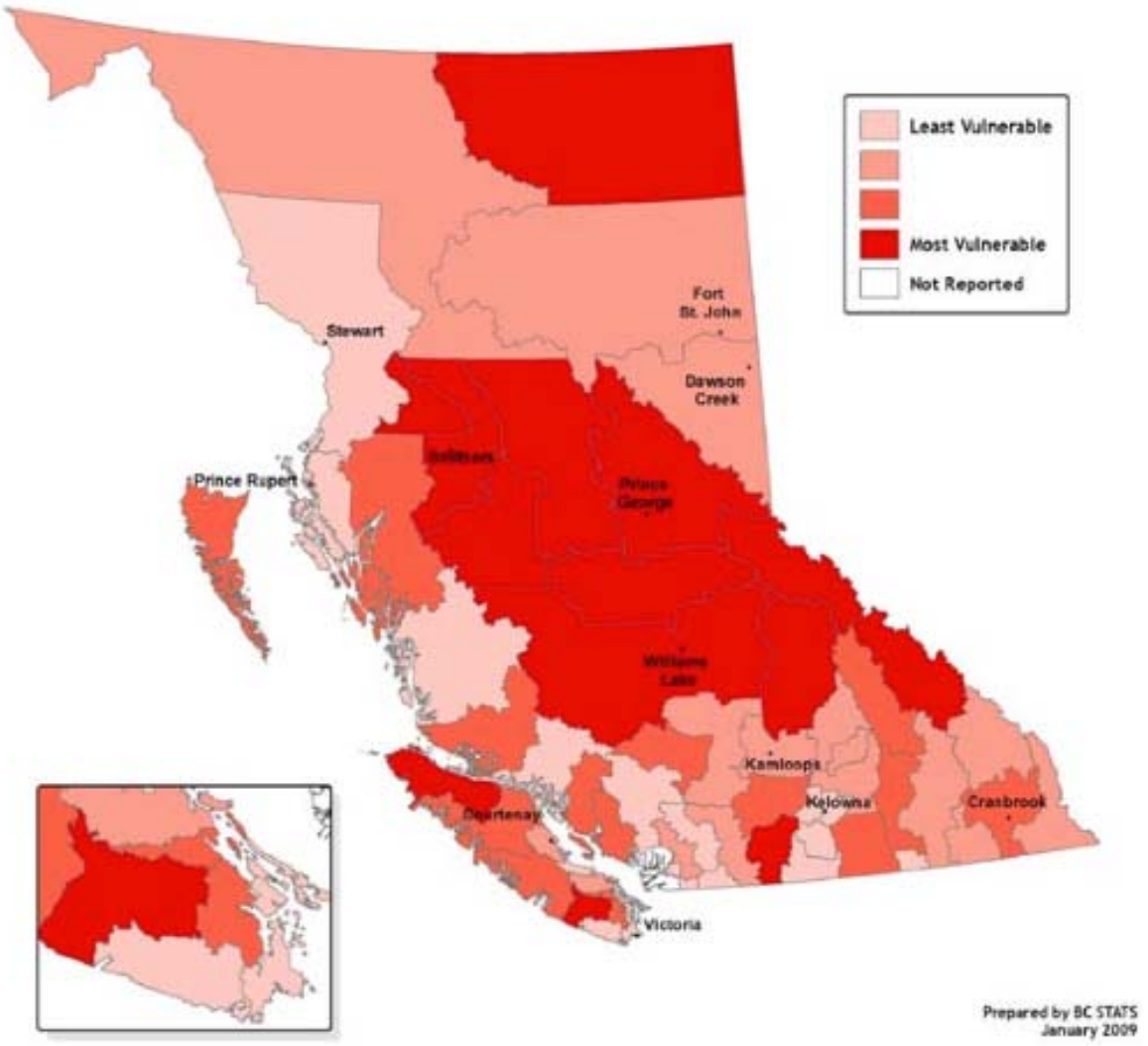
In early 2012, Oceanside Tourism will revisit the visitor and conversion research that was conducted in 2007. Updating this valuable research will ensure Oceanside Tourism and its stakeholders are well positioned to take advantage of current and emerging tourism trends.

FORESTRY

MABR's forests have historically or presently contributed to lumber, pulp and paper, value-added wood products and non-timber forest products such as floral greens and mushrooms.

In BC, forestry is regarded as one of the most important natural resource industries, contributing billions annually to the economy. In recent years, the sector has experienced one of the worst downtowns in history, affected by the slumped United States housing market, historically low lumber prices and a high Canadian dollar. Exports to China have helped to offset declines in exports to the United States. The downturn combined with mechanization and modernization initiatives have resulted in dramatic drops in forest-based employment. Within the province, MABR is an area noted to be least vulnerable to forest sector economic downturn (Figure 60) (BC Forests, Mines and Lands, 2010).

Figure 60. Regional sensitivity to forest sector economic downturn. The vulnerability index is based on the percentage of income from timber-based industries and on the diversity of basic income sources. Vulnerability is high where a large share of local income derives from the forest sector and the local economy is not highly diversified (BC Forests, Mines and Lands, 2010).



First Nations and Forestry

In BC, the Province provides economic opportunities to First Nations by way of forest tenures and silviculture contracts (BC Forests, Mines and Lands, 2010). Such opportunities are limited in MABR, due to the small amount of Crown forests. The recent provision of timber harvesting opportunities in Nanoose Bay (i.e., DL33) resulted in an injunction to remove protesters intent on protecting an imperiled ecosystem (Oceanside Star, December 2011), and a petition by an nearby

resident to bring attention to the sale of the logs to an Sustainable Forestry Initiative (SFI)-certified company (PQB News, December 2011).

FISHERIES

The Province maintains industry statistics at http://www.env.gov.bc.ca/omfd/fishstats/. Table 17 and Figures 61 and 62 show a sampling of available data. The site links to a series of fisheries and seafood statistical publications regarding fisheries on BC's coast. For example, GSGislason & Associates (2010) reported that the groundfish trawl fishery contributes $6 million in direct economic impacts to mid-Vancouver Island.

Table 16. BC seafood wholesale value by species group, 2001-2010. Retrieved December 11, 2011 from http://www.env.gov.bc.ca/omfd/fishstats/.

B.C. Seafood Wholesale Value ($millions) 2001-2010										
Species	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Wild Salmon	161.9	198.6	188.4	220.1	218.6	225.7	182.1	138.1	143.5	237.8
Cultured Salmon	323.0	338.9	302.0	287.2	375.8	450.4	469.3	495.2	493.5	559.9
Groundfish	224.2	235.6	279.8	257.9	292.8	315.1	338.0	321.7	301.3	275.1
Wild Shellfish	182.4	181.3	192.7	190.0	171.8	155.4	155.6	157.0	176.3	188.0
Cultured Shellfish	25.6	28.4	30.7	26.3	30.2	33.7	32.8	28.3	30.3	32.5
Herring	112.6	129.4	109.5	97.6	89.1	59.9	57.1	48.3	65.3	35.8
Other Wild	24.6	23.3	24.4	41.3	35.1	38.9	32.9	51.2	49.3	74.9
Other Cultured	1.3	1.8	2.6	2.4	3.1	5.2	5.6	9.8	8.1	13.8
Total	**1,055.6**	**1,137.3**	**1,130.1**	**1,123.0**	**1,216.5**	**1,284.3**	**1,273.4**	**1,249.6**	**1,267.6**	**1,417.8**

Figure 61. BC seafood landings by species group, 2001-2010. Retrieved December 11, 2011 from http://www.env.gov.bc.ca/omfd/fishstats/.

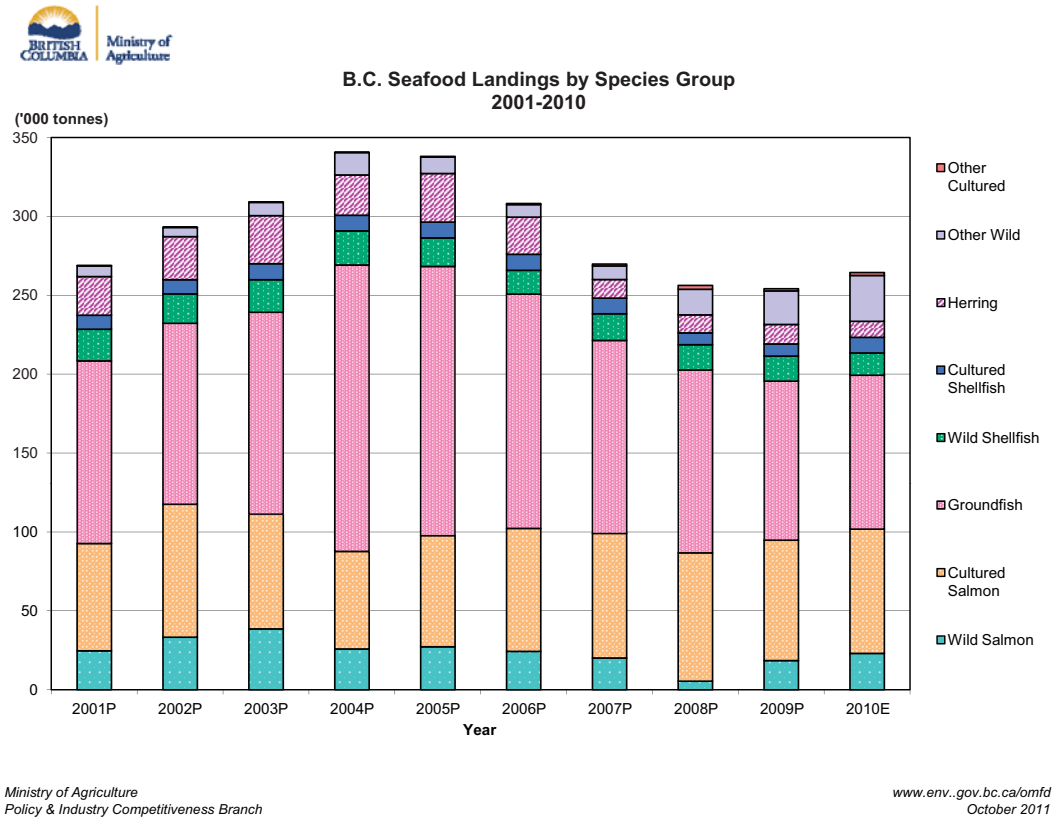
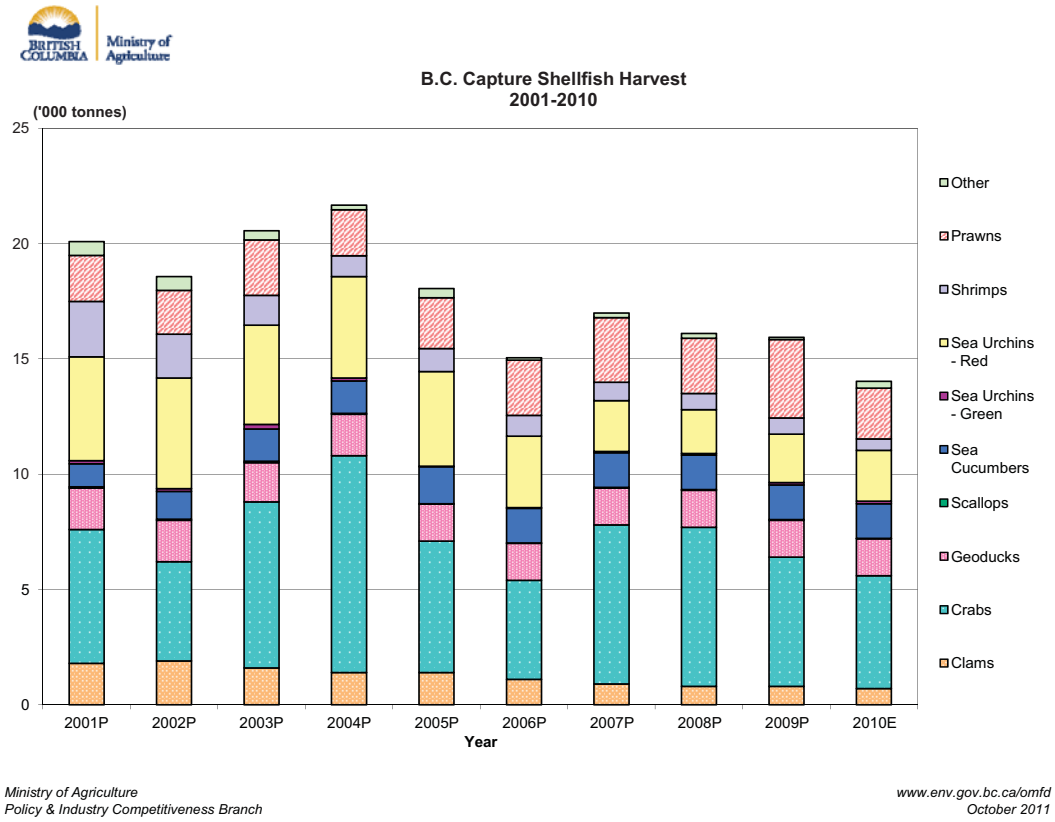


Figure 62. BC capture shellfish harvest by species, 2001-2010. Retrieved December 11, 2011 from http://www.env.gov.bc.ca/omfd/fishstats/.



AGRICULTURE

Agriculture in Brief, at http://www.agf.gov.bc.ca/resmgmt/sf/Publications.htm#agstats, provides agricultural statistics for the RDN as a whole. Included are total area farmed, farm land use, crop types, livestock, and total farm capital.

Eating Local

With rising food prices and a growing awareness that very little of the Island's food is home-grown, there are numerous initiatives in the region encouraging people to eat more locally grown and produced food. "Let's Eat Local" was an event held in Parksville in October 2011 to support local food producers, encourage chefs to use more local products, and facilitate the growth of a culinary tourism industry, while improving food security and reducing greenhouse gas emissions (PQB News, October 2011).

Chapter 6

Culture and Demographics

Current Status and Trends

Census information from 2006 is available for each regional district electoral area and urban community. These include: population, area, and population per square km, an age pyramid (and comparisons with BC), age and gender distributions, number of households, family structures including marital status and number of children in families, age of children and other dependents, affordability of dwellings vs. household income, type of dwelling, tenure and age of dwelling, ethnicity, mother tongue, other languages spoken, mobility (i.e., whether they have moved in the last year and from whence they came), and mode of transportation to and from work.

Parksville's 2007 community profile is a guide for companies, organizations and individuals interested in learning more about the city (City of Parksville, 2007). The community profile for the Town of Qualicum Beach has been adapted from the RDN Planning Strategy and is available at http://www.qualicumbeach.com/cms.asp?wpID=298. A community profile for the Nanoose (Snaw-Naw-As) First Nation is provided at http://www.nanoose.org/community-about.htm.

POPULATION

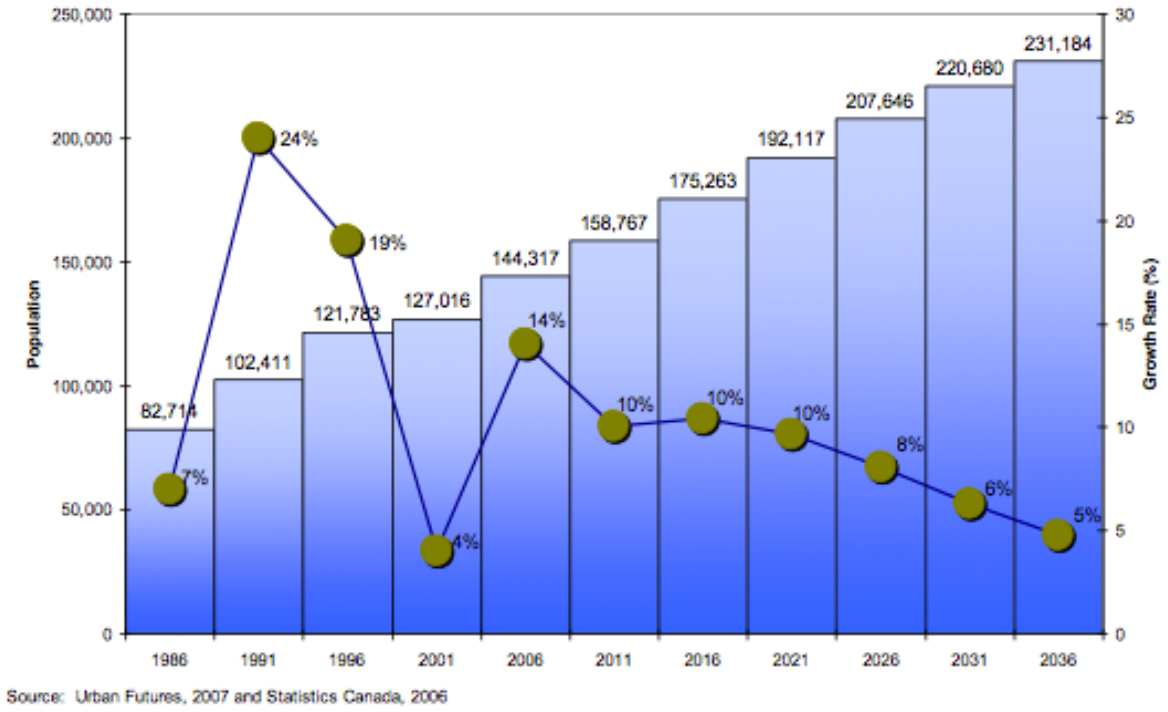
All of the large communities and electoral areas of MABR experienced growth rates that exceeded the average in BC (i.e., 5.3% for the same time period) (Table 18) (Reed, Mendis-Millard & Francis, 2010). The RDN's population is projected to grow 60% between 2006 and 2036 (Figure 63) (RDN, 2011)

The Nanoose (Snaw'Naw'As) First Nation includes more than 210 members on the reserve (immediately outside of MABR's boundaries), and more than 60 off-reserve. Thirty-nine per cent of the Nation is 18 years or younger, 43% are 19-50 years, and 18% are more than 50 years (Nanoose First Nation, n.d.). In 2003, there were 106 members of the Qualicum First Nation (Aboriginal Canada Portal, 2004). The Qualicum First Nation reserve is just north of MABR.

Table 18. Population of communities within MABR, in 2001 and 2006 (Reed, Mendis-Millard & Francis, 2010). Source: Census of Canada and BC Stats 2006 Census Profile - Summary Version. * Changes in boundaries since 2001 Census.

CENSUS AREA	2001	2006	% change
RDN Area E: Nanoose Bay	4,820	5,462	13.3
RDN Area F: Coombs	5,246	6,680	20.4
RDN G: French Creek*	6,113	7,023	14.9
City of Parksville	10,323	10,993	6.5
Town of Qualicum Beach*	7,849	8,502	8.3
REGIONAL TOTAL	34,351	38,660	12.5

Figure 63. Projected population growth within the RDN (RDN, 2011).



Age Distribution

The fastest growing age group in the RDN between 1986 and 2006 was the group over 65 years (RDN, 2011). By 2006, the median age for Parksville residents was 55 years; in Qualicum Beach it was 61 years, considerably older than the median age for British Columbians of 41 years (Reed, Mendis-Millard & Francis, 2010). Through 2036, the greatest growth in the population of the RDN is projected to be in the over 55 cohort. In fact, growth in the over 55 group is expected to exceed other areas of the country due to the continued migration of retirees to the area. This is expected to lead to a reduced labour supply and greater demands on social and health services (RDN, 2011). The exception may be lie in the area's First Nation communities, which are also growing and are considerably younger in composition.

HEALTH

Local Health Area 69 is larger than MABR (Figure 64). Some indicators of health are provided in Figures 65 to 67. Additional indicators, including those for children and youth at risk, and for immigrants are available at w.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf. Economic indicators are provided above in **Economy**.

Figure 64. Qualicum Local Health Area 69 boundaries. Retrieved December 11, 2011 from ://www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf.

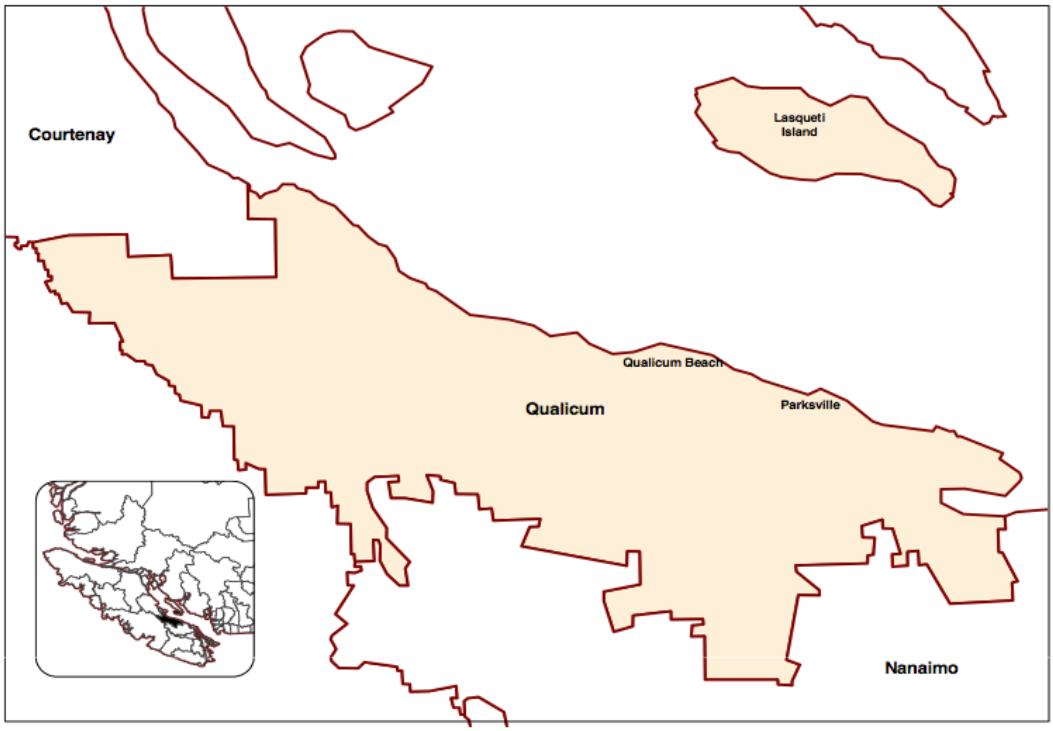


Figure 65. Life expectancy at birth. Retrieved December 11, 2011 from ://www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf.

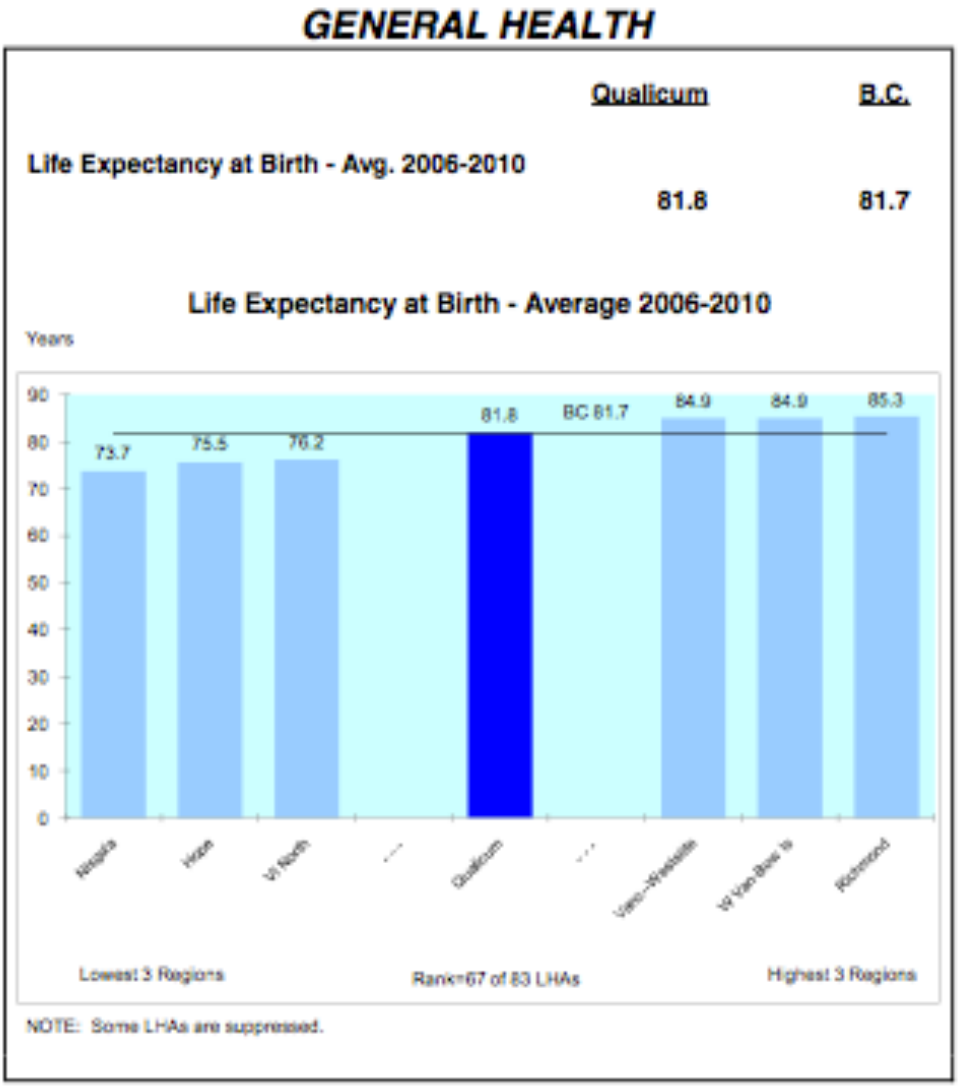


Figure 66. Potential years of life lost due to natural and accidental causes. Retrieved December 11, 2011 from ://www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf.

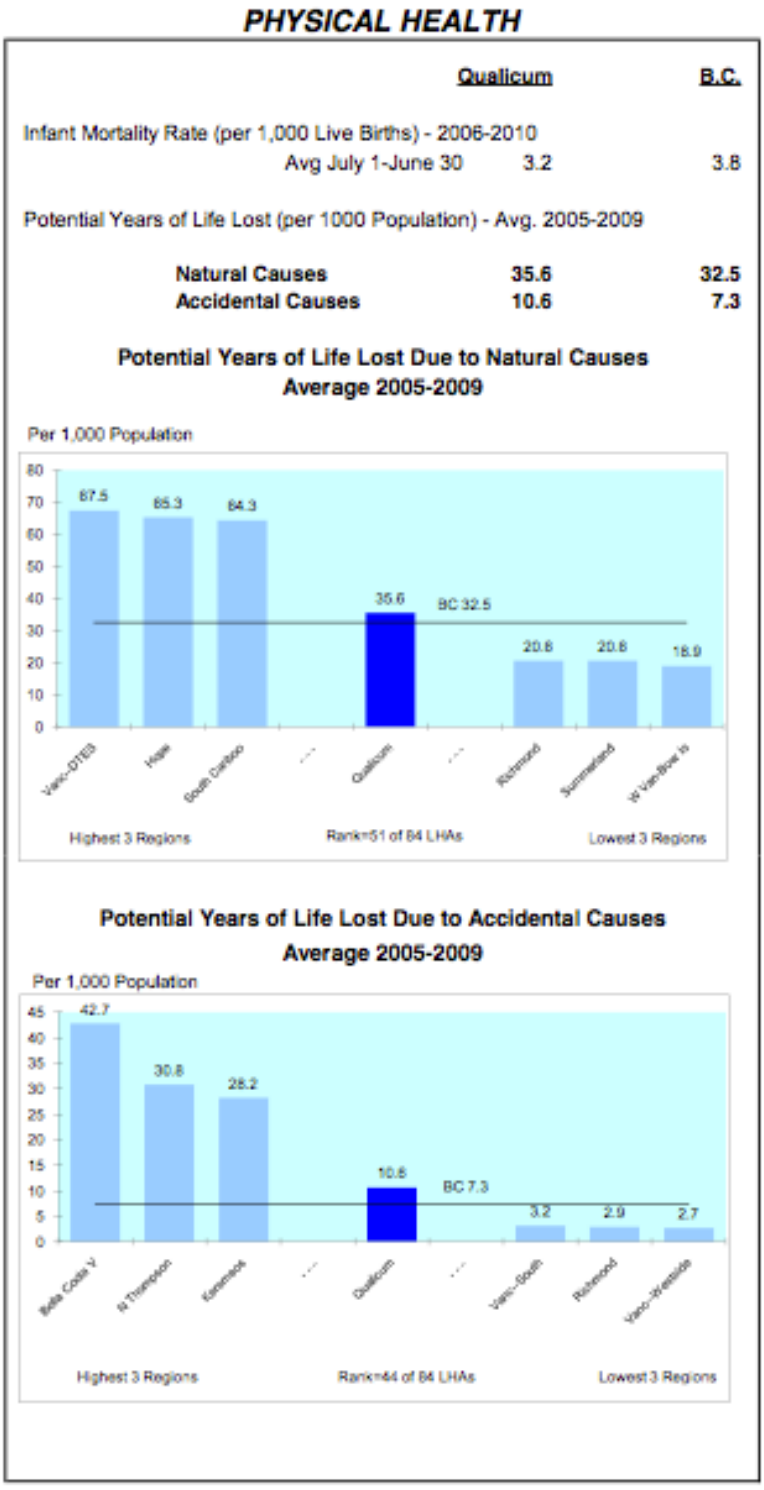
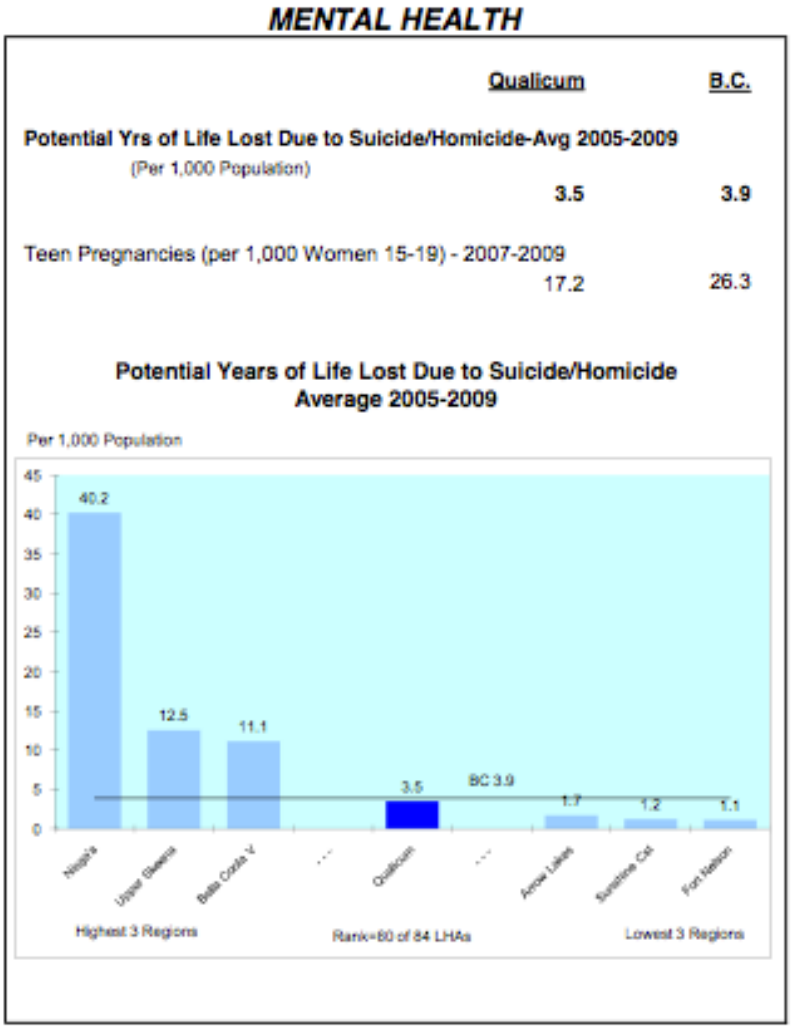


Figure 67. Potential years of life lost due to suicide or homicide. Retrieved December 11, 2011 from ://www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf.



Emergence of Tropical Disease

Beginning in 1999, *Cryptococcus neoformans var. gattii,* typically a tropical or subtropical organism, was isolated in immunocompromised humans and animals in MABR. Its appearance may be related to climate. A series of wetter and then drier than normal winters was related to high air concentrations of *Cryptococcus* in 2002-2003 (Bartlett et al., 2004). More recent information can be obtained from http://www.cher.ubc.ca/cryptococcus/new/topics.htm.

EDUCATION

MABR's boundaries encompass all schools in School District 69 with the exception of Bowser and False Bay on Lasqueti Island. The census information from 2006 includes education (field of study) and level of education. The Ministry of Education reports student achievement and demographics in the Kindergarden to Grade12 education system, by school district. These are available from http://www.bced.gov.bc.ca/reporting/district_data_summary.php. Student transitions to BC public post-secondary institutions are available, for public and independent schools combined, at http://www.bced.gov.bc.ca/reports/pdfs/postsectrans/prov.pdf. Teacher statistics are available from http://www.bced.gov.bc.ca/reports/pdfs/teacher_stats/public.pdf. Indicators of education concerns are provided for Local Health Area 69 at www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf, including percent of population without high school and post-secondary education or credentials; percent of 18-year-olds who did not graduate from high school; grade 12 provincial exam non-completion rate, and percent of students below provincial assessment standards.

CRIME

The following crime statistics are for the Qualicum Local Health Area 69 (Figures 68 and 69).

Figure 68. Serious crime rates in Qualicum Local Health Area 69.

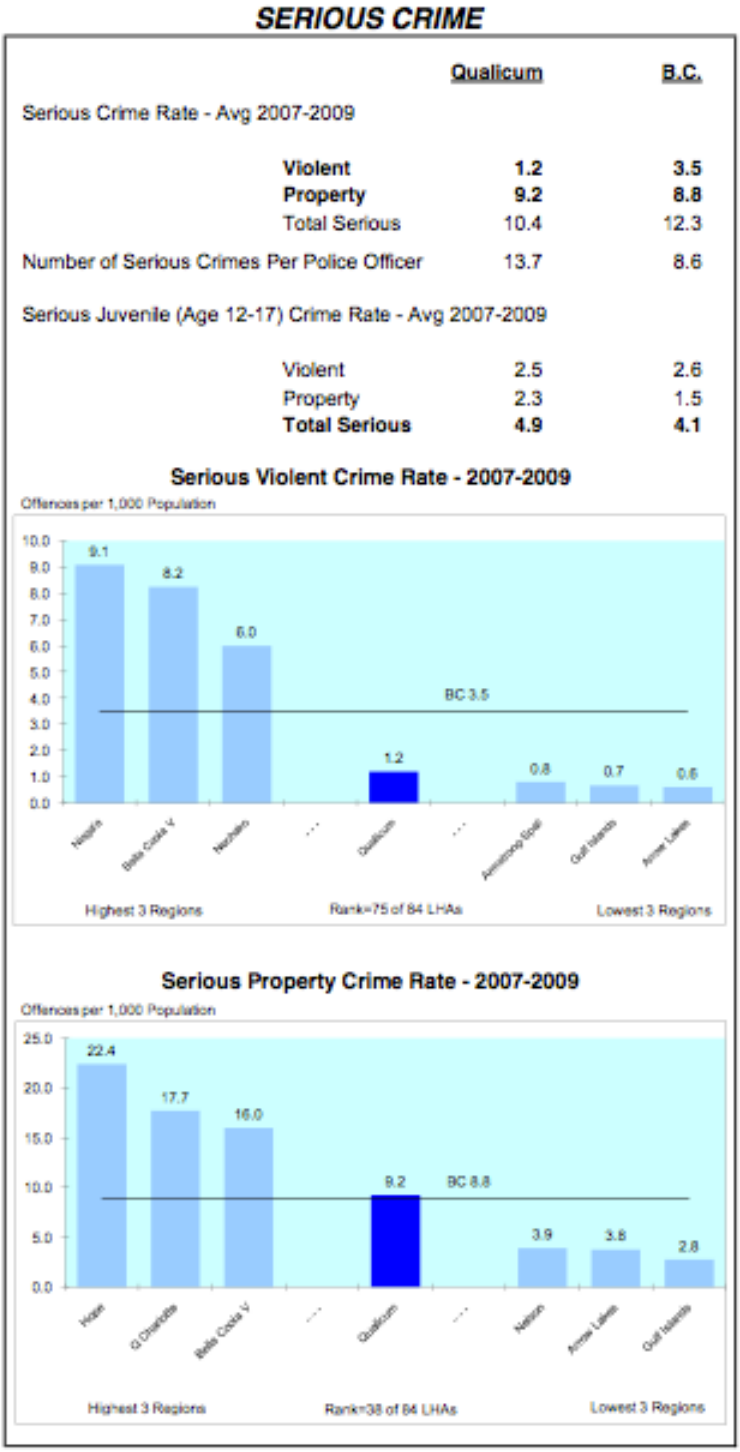
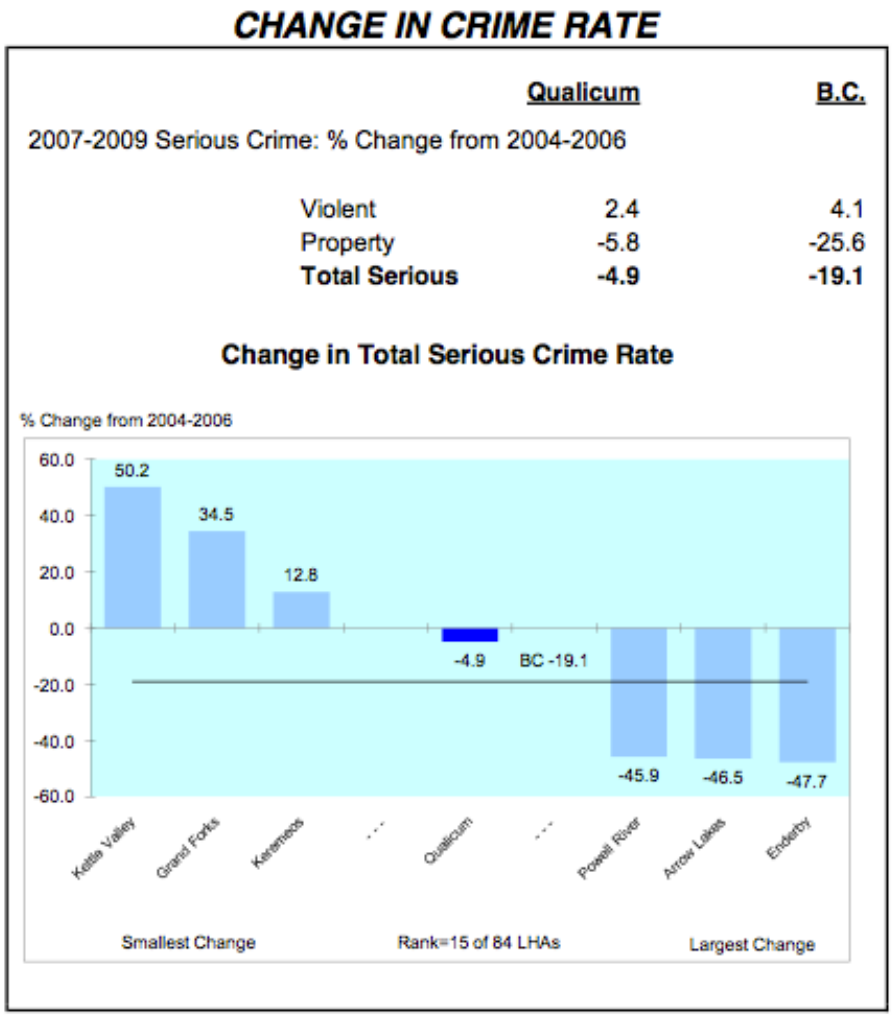


Figure 69. Change in crime rate in Qualicum Local Health Area 69. Retrieved December 11, 2011 from http://www.bcstats.gov.bc.ca/data/sep/lha/lha_69.pdf.



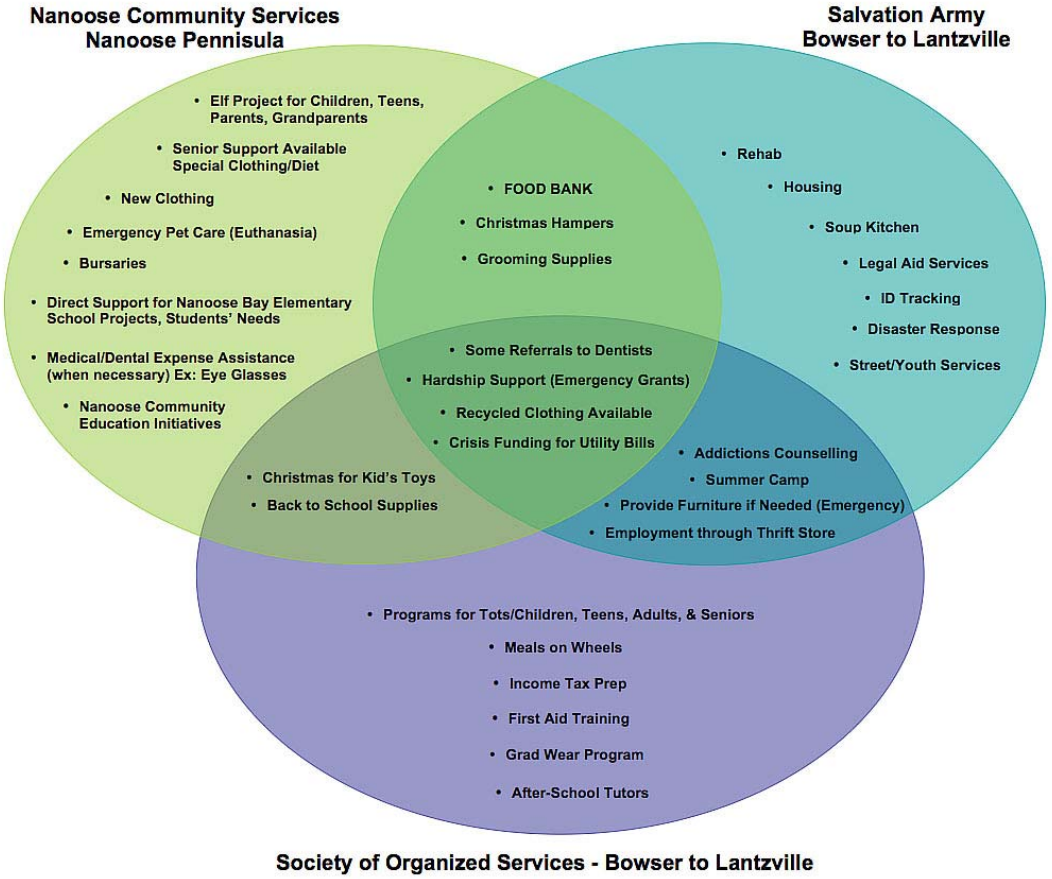
CIVIL SOCIETY

There are more than 125 non-profit organizations in MABR (Reed, Mendis-Millard & Francis, 2010). They provide environmental education, facilitate recreational activities, help people in need (Figure 66), and more. Contact information can be obtained for most organizations through the RDN *Active Living Guide* Community Directory at http://www.rdn.bc.ca/cms/wpattachments/wpID1613atID4315.pdf.

Serving the Poor

MABR's food banks have experienced a steady increase in clients in recent years. The Nanoose Bay Community Cupboard serves about 100 clients each month, while the Salvation Army helps an average of 822 people each month in the Parksville-Qualicum Beach area. While neither food bank has statistics to offer, the high cost of housing in the area is believed to be a key driver. The food banks are known to serve young families, seniors, single mothers, university students, and people working in retail and service industry jobs. Many do not outwardly show their financial struggle (PQB News, August 2011).

Figure 70. Mandates of local giving organizations. Retrieved December 11, 2011 from http://www.nanoosecommunityservices.com/6.html.



Literature Cited

Aboriginal Canada Portal. (2004). First Nation Connectivity Profile, 2003, Qualicum First Nation. Retrieved December 11, 2011 from http://www.aboriginalcanada.gc.ca/abdt/apps/connectivitysurvey.nsf/vAllCProfile_en/976.html.

Akin, S.K., Grossman, E.E., Lekanof, D., & O'Hara, C. (2009). Coast Salish and U.S. Geological Survey: Tribal Journey water quality project. Coast Salish Gathering Report 2009-001. 58 pp. Retrieved December 10, 2011 from http://walrus.wr.usgs.gov/reports/reprints/TJWQP.pdf.

Alpine Club of Canada and Federation of Mountain Clubs of BC. (n.d.). Blue-listed plants on Mount Arrowsmith. Retrieved December 10, 2011 from http://www3.telus.net/Mount_Arrowsmith/plants.html.

Annand, C., Hillaby, A., & Naylor, J. (1993). Englishman River etsuary.

Arrowsmith Mountain Bike Club. (2011). Home page. Retrieved November 18, 2011, from http://www.arrowsmithmtbclub.com/

Arrowsmith Water Service. (2011, June 24). Public Information Report: Englishman River water intake, treatment facilities and supply mains conceptual planning, budgeting and scheduling. Retrieved November 19, 2011 from http://www.arrowsmithwaterservice.ca/aws_documents/aws_publicinformationreport%20_june24_2011.pdf

Austin, M.A., Buffett, D.A., Nicholson, D.J., Scudder, G.G.E., & Stevens, V. (Eds.). (2008). Taking Nature's Pulse: The Status of Biodiversity in British Columbia. Biodiversity BC, Victoria. 268 pp. Retrieved December 10, 2011 from http:/www.biodiversitybc.org.

Axys Environmental Consulting (Axys). (2005). Redigitizing of Sensitive Ecosystems Inventory polygons to exclude disturbed areas. Summary report prepared for Canadian Wildlife Service, Delta, BC. Retrieved December 10, 2010 from http://a100.gov.bc.ca/appsdata/acat/documents/r2124/SEI_9914_rpt03_1121372905029_38e5303b86224411aaa1a8ae539da434.pdf.

Barlak, R., Epps, D., & Phippen, B. (2010). Water quality assessment and objectives for the Englishman River Community Watershed: technical report. BC Ministry of Environment, Environmental Protection and Watershed Stewardship Divisions. Retrieved November 19, 2010, from http://www.env.gov.bc.ca/wat/wq/englishman/wqo-technical-englishman.pdf

Bartlett, K.H., Macdougall, L., Mak, S., Duncan, C., Kidd, S., & Fyfe, M. (2004). Cryptococcus gattii, a tropical pathogen emerging in a temperate climate zone. Proceedings 16th Conference on Biometeorology and Aerobiology; 2004. Aug 25–26; Vancouver, British Columbia, Canada. Boston: American Meterological Society. Abstract no. 5.5.

Biogeoclimatic Ecosystem Classification (BEC). (n.d.). Alpine classification. Retrieved December 10, 2011, from http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/alpine/index.html.

Blood, D.A. & Associates. (1976). Lower Englishman River environmental - social assessment. Preapred for BC Department of Environment.

Bodtker, K.M., Pellatt, M.G., & Cannon, A.J. (2009). A bioclimatic model to assess the impact of climate change on ecosystems at risk and inform land management decisions. Report for the Climate Change Impacts and Adaptation Directorate, CCAF Project A718. Parks Canada Agency, Western & Northern Service Centre Publication, Vancouver, B.C.

Bravender, B., Annand, C., Hillaby, A., & Naylor, J. (1996). Results of a survey of fish, juvenile salmon diets and epibenthic invertebrates in the Englishman River estuary. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2387. Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo.

Bravender, B., Annand, C., Hillaby, A., & Naylor, J. (1997). Fish species, juvenile Chinook diets and epibenthos in the Engishman River estuary. Canadian Data Report of Fisheries and Aquatic Sciences 1021, Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo.

BC Conservation Data Centre (BC CDC). 2011. BC Species and Ecosystems Explorer. B.C. Minist. of Environ. Victoria, B.C. Retrieved November 21, 2011 from http://a100.gov.bc.ca/pub/eswp/.

BC Ministry of Environment (BC MoE). (n.d.). Observation well network. Retrieved November 19, 2011 from http://www.env.gov.bc.ca/wsd/data_searches/obswell/

BC Ministry of Environment (BC MoE). (n.d.a). Designation of Sensitive Streams under the Fish Protection Act. Retrieved December 10, 2011, from http://www.env.gov.bc.ca/habitat/fish_protection_act/sensitive_streams/documents/senstrms-designation.pdf.

B.C. Ministry of Environment (BC MoE). (2002). Sensitive Ecosystems Inventory Update. Retrieved December 10, 2011, from http://www.env.gov.bc.ca/sei/van_gulf/oct02/index.html

BC Ministry of Forests and Range, Integrated Land Management Bureau (ILMB). (2009). 250,000 hectares added to old-growth management areas. News release 2009FOR0037-000150. Retrieved December 7, 2011 from http://www2.news.gov.bc.ca/news_releases_2009-2013/2009FOR0037-000150.htm.

BC Ministry of Forests, Mines and Lands. (2010). The state of British Columbia's forests, 3rd ed. Forest Practices and Investment Branch, Victoria, BC. Retrieved December 11, 2011, from http://www.for.gov.bc.ca/hfp/sof/index.htm#2010_report.

BC Shellfish Growers Association. (2007). Reference currently unavailable

Cadrin, C. (2011). Paving paradise: Status of Coastal Douglas-fir and associated ecosystems. BC Conservation Data Centre presentation, March 10, 2011.

City of Parksville. (2011). Parksville Plan 2020: A vision for our future. Retrieved November 18, 2011 from http://www.parksville.ca/cms.asp?wpID=340

City of Parksville. (2007). Community profile. Retrieved December 11, 2011 from http://www.parksville.ca/cms/wpattachments/wpID200atID3507.pdf.

Daily News. (2011, October 20). Acidification may hurt local shellfish. Retrieved December 7, 2011, from http://www.canada.com/Acidification+hurt+local+shellfish/5572003/story.html.

Daily News. (2011, December 6). District wants to implement new fee to aid parks. Retrieved December 9, 2011 from http://www.canada.com/District+wants+implement+parks/5817070/story.html.

Davidson, T.M., Brennels, V.E.F., de Rivera, C., Draheim, R., & Gillespie, G.E. (2008). Northern range expansion and coastal occurrences of the New Zealand mud snail (*Potamopyrgus antipodarum*) (Gray, 1843) in the northeast Pacific. Aquatic Invasions, 3 (3), 349-353. Retrieved December 10, 2011 from http://www.aquaticinvasions.ru/2008/AI_2008_3_3_Davidson_etal.pdf.

Dawe, N.K. (1976). Biological inventories of National Wildlife Areas in British Columbia: Flora and fauna of the Marshall-Steveson Unit, Qualicum National Wildlife Area, August, 1976.

Dawe, N.K. 1980. Ecological inventories of National Wildlife Areas in British Columbia: Flora and fauna of the Marshall-Stevenson Unit, Qualicum National Wildlife Area (update to June 1979). Canadian Wildlife Service.

Dawe, N.K. (1986). Some aspects of the vegetation ecology of the Nanoose-Bonnell estuary, Vancouver Island, British Columbia. *Canadian Journal of Botany*, 64, 27-34.

Dawe, N.K. & White, E.R. (1982). Some aspects of the vegetation ecology of the Little Qualicum River estuary, Vancouver Island, British Columbia. *Canadian Journal of Botany*, 60, 1447-1460.

Dawe, N.K., Martin, T., & D.E.C. Trethewey. (1994). Bird use of the Englishman River estuary, Vancouver Island, British Columbia. Technical Report Series No. 208, Canadian Wildlife Service, Pacific and Yukon Region.

Dawe, N.K., & Buechert, R. (1995). Bird use of the Little Qualicum River estuary, Vancouver Island, British Columbia, 1975-1979. Technical Report Series Number 240, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Dawe, N.K. & McIntosh, J.D. (1993). Vegetation change following dyke breaching on the Englishman River estuary, Vancouver Island, British Columbia: A multivariate analysis. Technical Report Series No. 175, Canadian Wildlife Service, Pacific and Yukon Region.

Dawe, N.K., & Stewart, A.C. (2010). The Canada Goose (*Branta canadensis*) on Vancouver Island, British Columbia. *Journal of the British Columbia Field Ornithologists*, 20, 24-40.

Demarchi, D.A. (2011). The British Columbia Ecoregion Classification. Third Edition. Ecosystem Information Section, Ministry of Environment, Victoria, British Columbia. Retrieved November 21, 2011 from http://www.env.gov.bc.ca/ecology/ecoregions/index.html

Dresen, K., Scott, L., & Williams, G. (2010). BC *Spartina* Response Plan. Prepared for Ducks Unlimited Canada. Retrieved December 10, 2010, from http://www.birdsonthebay.ca/spartina/BC_Spartina_Response_Plan%202010.pdf.

Environment Canada. (2011). Wise Water Use. Retrieved November 19, 2011 from http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=F25C70EC-1

Environment Canada. (2008). Working Together for the Georgia Basin 2003 - 2008. Georgia Basin Action Plan Five Year Update. Retrieved November 27, 2011 from http://www.ec.gc.ca/Publications/49D1F4E5-A311-47E2-80F2-07F558D90E62/web1GBAPfiveyearupdatee.pdf

Environment Canada. (1990). Marine weather hazards manual: A guide to local forecasts and conditions, 2nd ed.

Erickson, W. (1995 or 1996). Classification and Interpretation of Garry Oak (Quercus garryana) Plant Communities and Ecosystems in southwestern British Columbia, Masters thesis, University of Victoria.

Erickson, W. and Meidinger, D.V. (2007). Garry Oak (Quercus garryana) plant communities in British Columbia: A guide to identification. Technical Report 040, BC Ministry of Forests and Range, Research Branch, Victoria, BC. Retrieved December 10, 2010 from http://www.for.gov.bc.ca/hfd/pubs/docs/tr/tr040.pdf.

Fisheries and Oceans Canada (DFO). (2011). Shellfish contamination - Pacific Region Area 14. Retrieved December 6, 2011 from http://www.pac.dfo-mpo.gc.ca/fm-gp/contamination/sani/area-secteur-14/area-secteur-14-eng.htm

Fisheries and Oceans Canada (DFO). (2002). Toward an insshore rockfish conservation plan: A structure for continued consultation. Retrieved December 9, 2011 from http://www.pac.dfo-mpo.gc.ca/consultation/fisheries-peche/ground-fond/intdial/consstrat/docs/doc-discussion-eng.pdf.

Forest Practices Board. (2011). Establishment of conservation areas for old growth and wildlife habitat in the Squamish and Chilliwack Forest Districts. Special Investigation Report 21.

Gartner. (2010). Reference currently unavailable.

Gaydos, J.K., Dierauf, L., Kirby, G., Brosnan, D., Gilardi, K., & Davis, G.E. (2008). Top 10 principles for designing healthy coastal ecosystems like the Salish Sea. *EcoHealth,* 5, 460-471. doi: 10.1007/s10393-009-0209-1. Retrieved November 27, 2011 from ww.springerlink.com/content/b8k15814655622g3/fulltext.pdf.

Gillespie, G.E., Phillips, A.C., Paltzat, D.L., & Therriault, T.W. (n.d.). Distribution of non-indigenous intertidal species on the Pacific Coast of Canada. Presentation, Pacific Biological Station, DFO, Nanaimo.

GSGislason & Associates. (2010). Economic impacts from a reduced groundfish trawl fishery in British Columbia. Retrieved December 11, 2011 from http://www.env.gov.bc.ca/omfd.reports/groundfish-trawl-fishery-economic-impacts.pdf.

Hamaan, A., & Wang, T.L. (2006). Potential effects of climate change on tree species and ecosystem distribution in British Columbia . *Ecology*, 87, 2773-2786.

Hebda, R.J. (2004). Paleoecology, climate change and forecasting the future of species at risk. In Lofroth, E.C. and T.D. Hooper (editors). Proceedings of Species at Risk Pathways to Recovery, Victoria, BC.

Hansard. (2004, March 24). Official Report of Debates of the Legislative Assembly. Volume 22, Number 7. Retrieved November 27, 2011 from http://www.leg.bc.ca/hansard/37th5th/h40324p.htm#9697.

Henigman, M. (2011, March 3). Riparian Area Regulation update. Ministry of Natural Resource Operations workshop, Nanaimo, BC.

Henigman, M. (2006). Securing present and future Bald Eagle nest trees on the Nanoose Peninsula, Vancouver Island, British Columbia [Masters thesis].

Hul'qumi'num Treaty Group. (n.d.). The Great Land Grab in Hul'qumi'num territory. Retrieved April 13, 2011 from http://www.hulquminum.bc.ca/pubs/HTGRailwayBookSpreads.pdf.

Important Bird Areas (IBA). (2011). Home page. Retrieved December 9, 2011 from http://www.ibacanada.ca/index.jsp?lang=en.

Jamieson, G. (2005). Global climate change and some potential implications on species in British Columbian estuaries [Unpublished report].

Jungen, J.R. (1985). Soils of Southern Vancouver Island. Victoria: Ministry of Environment Technical Report 17 and Report No. 44 of the BC Soil Survey.

Kennedy, K.A. (1982). Plant communities and their standing crops on estuaries of the east coast of Vancouver Island. Master's thesis, University of British Columbia.

Kingzett, B. (2011, September 30). Ocean acidification - an important video to watch. Vancouver Island University Deep Bay Marine Field Station Updates. Retrieved December 7, 2011 from http://viudeepbay.com/2011/09/30/ocean-acidification-an-important-video-to-watch/#more-840.

Lanarc. (2007). Drinking water and watershed protection action plan. A report to the Board of the RDN by the Drinking Water-Watershed Protection Stewardship Committee. Retrieved November 19, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID1585atID2075.pdf

Laroque, C.P., & Smith, D.J. (2005). Predicted short-term radial-growth changes of trees based on climate on Vancouver Island, British Columbia. *Dendrochronologia,* 22, 163-168.

Leslie, A. & Warman, L. (2007). Ecological baseline and monitoring team, Vancouver Island, Kootenay and Okanagan. The Nature Trust of BC/BC Conservation Corps.

Lister, D.B., Harris, G.D., & Hickey, D.G. (1979). Juvenile salmon downstream migration study at Little Qualicum River, British Columbia. Prepared for DFO.

Living Rivers Georgia Basin Vancouver Island (Living Rivers). (2008), July 8). Salmon and steelhead in the Little Qualicum River on Vancouver Island will have more water to swim in this summer. News 2008LR-GB/VI-0006. Retrieved November 19, 2011 from http://www.livingrivers.ca/gbvi/dox/Microsoft%20Word%20-%20Cameron%20Lake%20Storage.pdf

Madrone Environmental Services (Madrone). (2008). Terrestrial Ecosystem Mapping of the Coastal Douglas-fir biogeoclimatic zone. Prepared for the BC Integrated Land Management Bureau. Retrieved December 10, 2011 from EcoCat http://www.env.gov.bc.ca/ecocat/.

Mackenzie, W.H. & Moran, J.R. (2004). Wetlands of British Columbia: A guide to identification. Research Branch, BC Ministry of Forests, Victoria. Handbook No. 52. Retrieved December 10, 2011 from http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh52.pdf.

Mather, M., Chatwin, T., Cragg, J., Snclair, L., & Bertram, D.F. (2010). Marbled Murrelet nesting habitat suitability model for the British Columbia Coast. BC Journal of Ecosystems and Management, 11(1&2), 91-102. Retrieved December 10, 2011 from http://www.env.gov.bc.ca/esd/distdata/species_and_ecosystems_at_risk/MAMU/MAMU%20Nesting%20Habitat%20Suitability%20Model%20for%20the%20BC%20Coast/MAMU%20Nesting%20Habitat%20Suitability%20Model%20JEM%20Paper.pdf.

McIntosh, J.D. (1986). Comparative bird and insect use of two old field habitats. Technical Report Series No. 12, Canadian Wildlife Service, Pacific and Yukon Region.

McPhee, M., Ward, P., Kirkby, J., Wolfe, L., Page, N., Dunster, K., Dawe, N.K. & Nykwist, I. (2000). Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands 1993-1997. Canadian Wildlife Service, Technical Report Series Number 345.

Mid Vancouver Island Habitat Enhancement Society (MVIHES). (2009). Caring for the Englishman River estuary: A bio-inventory and volunteer monitoring project.

Mitchell, S.J. (1998). Review of January 1, 1997 Windthrow in MacMillan Park. Prepared for BC Ministry of Environment, Lands and Parks. Retrieved November 27, 2011 from http://www.env.gov.bc.ca/bcparks/planning/mgmtplns/macmillan/mitchelll_rep_1998.pdf

MABR. (1998). Nomination documents. Retrieved from http://www.mabr.ca.

Nanaimo News Bulletin. (2011, November 4). Province announces review of BC transit. Retrieved December 10, 2011 from http://www.nanaimobulletin.com/news/133190048.html.

Nanoose First Nation. (n.d.). Our community. Retrieved December 11, 2011, from http://www.nanoose.org/community-about.htm.

Newton, P., & Gilchrist, A. (2010). Technical summary of intrinsic vulnerability mapping methods for Vancouver Island: Vancouver Island Water Resources Vulnerability Mapping Project - Phase 2. Retrieved November 19, 2011 from http://web.viu.ca/groundwater/PDF/VI_DRASTIC_Summary_Phase2_2010.pdf.

Oceanside Star. (2011, December 1). Activists disheartened by order to stay out of DL33. Retrieved December 11, from http://www2.canada.com/oceansidestar/news/story.html?id=91ce97da-f5ec-448f-aee8-fdd186b326bf.

Parksville Qualicum Beach News (PQB News). (2011, December 9). Petition started against logging. Retrieved December 11, 2011 from http://www.pqbnews.com/news/135294228.html.

PQB News. (2011, October 11). Sink your teeth into food exhibition. Article by B. Gough. Retrieved December 11, 2011 from http://www.pqbnews.com/business/131521223.html.

PQB News. (2011, August 9). Faced with steep rent, many turn to food banks. Article by A. Ruvinsky. Retrieved December 11, 2011 from http://www.bclocalnews.com/news/127275683.html?mobile=true.

Pirani, Z., & Bryden, G. (1996). Qualicum River Water Allocation Plan. Written for BC Ministry of Environment, Lands and Parks. Retrieved November 19, 2011 from http://www.env.gov.bc.ca/wsd/water_rights/wap/vi/qualicum_river/qualicum_wap.pdf

Reed. M., Mendis-Millard, S., & Francis, G. (2010, August). Mount Arrowsmith Biosphere Reserve Periodic review. Retrieved from http://www.mabr.ca.

RDN. (2011). *Shaping Our Future.* Regional Growth Strategy. Retrieved November 18, 2011 from http://www.rdn.bc.ca/cms.asp?wpID=436

Regional District of Nanaimo (RDN, 2011, June). Surfside Water Service Area Annual Report 2010. Retrieved November 19, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID901atID4231.pdf

RDN. (2010). Watershed snapshot report 2010. Retrieved November 19, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID1748atID4237.pdf

RDN. (2010a). Overcoming barriers to green buildings. Prepared by HB Lanarc Consultants with Michel Labrie, Architect. Retrieved November 23, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID1046atID3747.pdf

RDN. (2006). Prospering today, protecting tomorrow: The state of sustainability of the Regional District of Nanaimo. Retrieved November 23, 2011, from http://www.rdn.bc.ca/cms/wpattachments/wpID433atID1503.pdf.

RDN. (2005). Regional Parks and Trails Plan 2005-2015. Written by Lanarc Consultants Ltd. with the assistance of Professional Environmental Recreation Consultants. Retrieved November 23, 2011 from http://www.rdn.bc.ca/cms/wpattachments/wpID766atID822.pdf

RDN Wastewater Services. (2011). Treatment process. Retrieved December 6, 2011, from http://www.rdn.bc.ca/cms.asp?wpID=1164

Schweigert, J. (2011). Stock assessment for Pacific herring: facts and fallacies. Pacific Biological Station, DFO, Nanaimo. Presentation in Parksville, BC, February 2011.

Swerhun, K., Jamieson, G., & Smith, D.J. (2009). Establishing GLORIA long-term alpine monitoring in southwestern British Columbia, Canada. *Northwest Science,* 83(2), 101-116.

Taylor, W.A. (1975). Crown land grants: A history of the Esquimalt and Nanaimo railway land grants, the railway belt and the Peace River block. Crown Land Registry Services, BC Ministry of Environment, Lands and Parks, Victoria, British Columbia. [4th Reprint, 1997]. Retrieved April 13, 2011 from http://www.ltsa.ca/data/img/publication/Crown-Land-Grants-A-History-of-the-E-and-N.pdf.

Thomson, R.E. 1981. Oceanography of the British Columbia coast. Can. Spec. Publ. Fish. Aquat. Sci. 56: 291 p.

Tinis, S.W. (2011). Storm surge almanac for southwestern British Columbia: Fall/Winter 2011-2012. Pre-season discussion of tidal and climate conditions affecting extreme water levels on the BC coast. Prepared for DFO and BC MoE. Retrieved November 27, 2011 from http://www.pac.dfo-mpo.gc.ca/sci/juandefuca/storm_surge/Almanac_2011-12.pdf

Town of Qualicum Beach. (2010). Sustainability Plan. Bylaw No. 590.03. Retrieved November 18, 2011 from https://qualicumbeach.civicweb.net/Documents/DocumentList.aspx?ID=1036

Tutty, B.D., Raymond, B.A., & Conlin, K. (1983). Estuarine restoration and salmonid utilization of a previously dyked slough in the Englishman River estuary, Vancouver Island, British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1689, DFO.

UNESCO. (2011). Global and Climate Change in Mountain Sites (GLOCHAMOST). Retrieved December 12, 2011 from http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/specific-ecosystems/mountains/glochamost/.

UNESCO. (2006). Global Change and Mountain Regions Research Strategy. A. Björnsen Gurung (Ed.), Mountain Research Initiative, Switzerland. Retrieved December 12, 2011 from http://unesdoc.unesco.org/images/0014/001471/147170E.pdf.

Valeri, J. (2011). RDN groundwater study: An analysis of well and septic system density. Unpubl. report for Vancouver Island University Geography 428.

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth and C. Cadrin. 1998. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands, 1993 - 1997. Volume 1: Methodology, Ecological Descriptions and Results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Weston, S., Guthrie, R., & McTaggart-Cowan, J. (2003). The vulnerability of Lower Englishman River to modeled climate change. *Canadian Water Resources Journal*, 28 (4), 657-672. Retrieved November 19, 2011 from http://pubs.cwra.org/doi/pdf/10.4296/cwrj2804657

Whitfield, P.H., Wang, J.Y., & Cannon, A.J. (2003). Modelling future streamflow extremes - Floods and low flows in Georgia Basin, British Columbia. *Canadian Water Resources Journal*, 28(4), 633-656.

Williams, R.E. (2011). Understanding stakeholder perspectives: The case of Mount Arrowsmith Massif Regional Park and the Mount Arrowsmith Biosphere Reserve [Master's thesis].

Zacharias, M.A., Howes, D.E., Harper, J.R., & Wainwright, P. (1998): The British Columbia marine ecosystem classification: Rationale, development, and verification. *Coastal Management*, 26:2, 105-124. Retrieved from http://dx.doi.org/10.1080/08920759809362347