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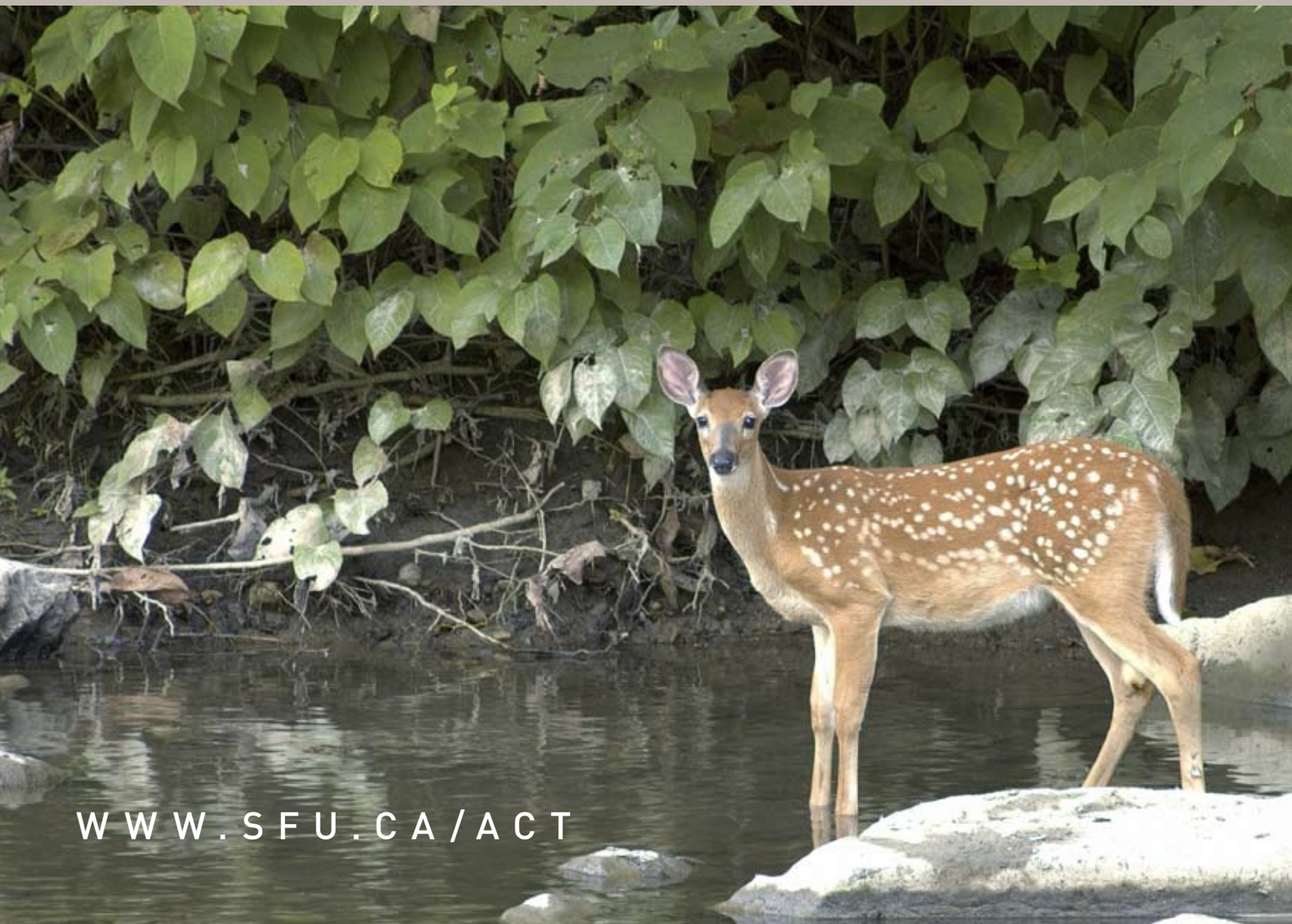
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# ACT

ADAPTATION TO  
CLIMATE CHANGE TEAM

BACKGROUND REPORT

## CLIMATE CHANGE ADAPTATION AND BIODIVERSITY



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BACKGROUND REPORT  
**CLIMATE CHANGE  
ADAPTATION AND  
BIODIVERSITY**

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# ACKNOWLEDGEMENTS

This Background Report is the accompaniment to ACT's first set of policy findings: **Climate Change Adaptation and Biodiversity: Transitioning to an Ecosystem-based Economy in British Columbia**, by Jon O'Riordan, a former Deputy Minister of the Ministry of Sustainable Resource Management in the BC provincial government.

**Eric Kimmel** is a policy analyst who specializes in socioeconomic impact assessments as well as policy development and analysis. Eric designs and conducts baseline studies, impact assessments, policy development and evaluation, and stakeholder consultations, with a primary focus on environmental and natural resource policy. He has worked as a policy analyst and consultant for local governments, First Nations, private industry, and policy research institutes, and produced the first non-market valuation of wetland ecological goods and services in Alberta as part of a broader assessment of regional land use planning options. Eric's work played an integral role in informing and guiding the decision-making process by assigning economic values to wetland ecosystem functions. He is also the author of Annex A – Economic Value of BC's Natural Capital, included in the accompanying Summary Recommendations document.

ACT would like to extend special thanks to **Dr. Stewart Cohen** for reviewing this report. Dr. Cohen is a senior researcher with the Adaptation and Impacts Research Division of Environment Canada, and an Adjunct Professor with the Department of Forest Resources Management at The University of British Columbia (UBC). His research interests are in climate change impacts and adaptation, and exploring how climate change can affect sustainable development. Dr. Cohen has been a member of the author team of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007. He teaches a course on climate change at UBC, and has been an adviser, reviewer, and lecturer for various research and training programs in Canada and other countries.

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ACT (the Adaptation to Climate Change Team) is a five-year series of six-month sessions that brings leading experts together with decision-makers and experts from industry, community, academia, and government to explore risks posed by climate change, and generate policy recommendations for sustainable adaptation. This first set of findings is partly based on information gathered during ACT's first conference, **Communities in Jeopardy: Plant, Animal and Human**, held March 31-April 1, 2008 as part of the six-month session on biodiversity and adaptation to climate change.

**The Wilburforce Foundation** was the key sponsor for this six-month research session and policy recommendations report.

**The Bullitt Foundation** was the key sponsor for the Communities in Jeopardy: Plant, Animal and Human conference.

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# INTRODUCTION

*“Humans have an amazing ability to accept the condition of the world in which they grow up as normal and natural. Our vanishingly short life spans cause each generation to lower its expectations. We’re constantly accepting reduced levels of biodiversity, social harmony, green space, cultural diversity, and economic justice as normal....If every generation is born into a world with more natural resources, more widespread wealth, more community beauty, more social harmony than the generations before, our collective standards and expectations will constantly rise...”*

Cunningham, 2008

The Intergovernmental Panel on Climate Change (IPCC) confirms that “most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations”.<sup>1</sup> Furthermore, the IPCC concludes, climate change has begun and is projected to exert additional pressures on all features of biodiversity.<sup>2</sup> Biological diversity is essential to maintaining ecosystem functions that provide vital support systems that in turn sustain all human, plant, and animal life and the socioeconomic systems that sustain all human life. Climate change in conjunction with existing human-driven stressors poses a significant threat to the state of biological diversity and ecosystem functions in British Columbia. This hazard forces us to fundamentally change the approach we use to manage our natural capital assets such as our forests, grasslands, wetlands, and alpine regions, along with our living and working environments such as our cities, towns, and working landscapes. Exploring the linkages between climate change and biodiversity is an important endeavour for three reasons. First, biodiversity provides a suite of valuable direct and indirect economic benefits to human societies, such as life support systems and the provision of material goods and services. Second, human enterprise has been exerting enormous pressure on our natural environment, resulting in an extraordinary loss of biodiversity and its ability to sustain ecosystem functions, and climate change will likely increase the strain on existing vulnerable systems. Third, BC is Canada’s most biologically diverse province, featuring over 3600 species and subspecies, of which over 1/3 are listed as endangered, threatened, or species of concern.<sup>3</sup>

Mitigation and adaptation are the two broad policy responses that address sources contributing to climate change and their related impacts. Mitigation refers to policy measures that stabilize or reduce atmospheric concentration of greenhouse gases (GHGs) to levels that do not dangerously interfere with the climate system. Adaptation refers to adjusting or accommodating to climate change-induced impacts, which includes minimizing negative consequences and enhancing opportunities. Adaptation responses are essentially planned or unplanned policy responses designed to increase the resiliency of our natural, socioeconomic, and built environments. Adaptation is becoming an increasingly important public policy response for two reasons. First, even if mitigation measures achieve successful reductions in human-caused GHG emissions, the excessive concentration of GHGs already in the atmosphere will continue to force changes to climatic conditions and alter the state of biodiversity in BC over the course of the next century.<sup>4</sup> Second, the current structure of BC’s governance framework responsible for managing land and natural resources does not effectively address the impending challenges of climate change-induced impacts on our natural, human, and built environments.

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1 IPCC (2007)

2 Gitay, H., Suárez, A., Watson, R.T., Dokken, D.J. (2002)

3 David Suzuki Foundation and Sierra Legal (2007). This number is a gross underestimate that does not include poorly understood and inventoried species such as fungi, lichens, and most insects. The report excludes populations, marine species, non-vascular plants, accidentals, introduced species, and species listed as no status by the BC Conservation Data Centre. Austin, M.A., et al. (2008) estimate over 50 000 species reside in BC but only 3800 of them have been assessed for their conservation status.

4 Gayton, D. (2008)



This report synthesizes information compiled from input contributed by ACT's *Communities in Jeopardy: Plant, Animal and Human* conference participants in April 2008, along with a review of publications from leading authorities researching climate change impacts on biodiversity, and adaptation responses. The purpose of this report is to provide a background summary on the following points of discussion:

- Observed and projected climate changes in BC;
- Observed and expected climate change-induced impacts on biodiversity in BC and northern temperate regions;
- An overview of the state of biodiversity in BC;
- A discussion on the link between biodiversity, ecosystem functions, and the value of natural capital;
- An overview of vulnerable natural and socioeconomic systems in BC;
- An outline for a general adaptation framework that addresses ecosystem resiliency and examines the challenges and opportunities associated with launching adaptation measures in BC.

We intend to use this synthesis of information as a background document to substantiate ACT's policy recommendations addressing the need to restructure BC's land and resource governance framework, with the ultimate goal of increasing ecosystem and community resiliency against the current and projected climate change impacts on biodiversity.

## 2. CLIMATE CHANGE IMPACTS ON BRITISH COLUMBIA'S BIODIVERSITY

### 2.1 GLOBAL AND REGIONAL CLIMATE CHANGE PATTERNS

#### 2.1.1 OBSERVED CHANGES IN CLIMATE

Recent IPCC publications provide evidence supporting observed changes in global atmospheric concentration of greenhouse gases and aerosols, and changes in the earth's climate (e.g. temperature, precipitation, sea level, sea ice, and extreme weather events).<sup>5</sup> The global atmospheric concentration of carbon dioxide (CO<sub>2</sub>) increased by 31% from 1750 to 2000, primarily due to fossil fuel combustion and land use changes. During the course of the last century, average global temperatures increased by 0.06°C, with the 1990s being the warmest decade and 1998 the warmest year. Mid to high latitudes of northern regions experienced the largest increases in average temperatures, and night-time temperatures increased more than daytime temperatures. Table 1 illustrates key observed changes in the earth's atmosphere and climate systems.

**Table 1: Observed global atmospheric and climate conditions**

ATMOSPHERIC CONDITIONS	OBSERVED CHANGES	TIME PERIOD
Concentration of CO <sub>2</sub>	31% increase	1750-2000
Concentration of CH <sub>4</sub>	151% increase	1750-2000
Concentration of N <sub>2</sub> O	17% increase	1750-2000
Concentration of O <sub>3</sub>	35% increase	1750-2000
Concentration of HFCs, PFCs and SF <sub>6</sub>	General increase	Last 50 years
CLIMATE CONDITIONS	OBSERVED CHANGES	TIME PERIOD
Average land temperatures	0.6°C increase	20 <sup>th</sup> Century
Land temperatures in northern hemisphere	Increased	20 <sup>th</sup> Century
Night-time land temperatures	Faster increase than day temps	
Diurnal temperatures	Decreased	1950 to 2000
Hot days	Increased	
Cold/frost days	Decreased	20 <sup>th</sup> Century
Continental precipitation – northern hemisphere	5-10% increase	20 <sup>th</sup> Century
Heavy precipitation events – northern hemisphere	Increased	

Source: IPCC (2007)

Assessments of historical trends in precipitation and temperature across BC indicate changes have occurred in the last 50 years.<sup>6</sup> Most regions in BC experienced an increase in average temperatures with some regional variations. For example, average temperatures increased in coastal areas, the interior, and northern BC by 0.6°C, 1.1°C, and 1.7°C respectively. Table 2 summarizes changes in temperature and precipitation for different regions in BC over the course of the last century. Figure 1 provides a graphical illustration of changes in temperature and precipitation from 1900 to 2000.

<sup>5</sup> Spittlehouse, D.L. (2008)

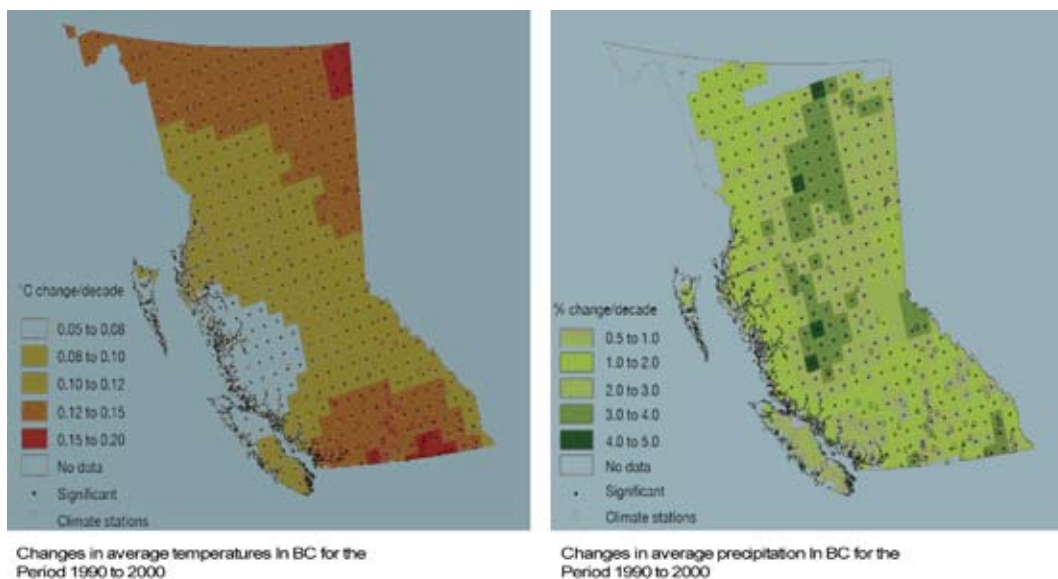
<sup>6</sup> Fraser, J. (2002)

**Table 2: Observed temperature and precipitation trends for the southern, northern, and coastal regions of BC**

REGION	OBSERVED TEMPERATURE CHANGES	OBSERVED PRECIPITATION CHANGES
BC	<ul style="list-style-type: none"> <li>• Increased warm temperature extremes</li> <li>• Decreased extreme cold days</li> <li>• Decreased frost days</li> <li>• Increased extreme warm nights and days</li> <li>• Increased frost-free periods</li> </ul>	<ul style="list-style-type: none"> <li>• Increased precipitation days</li> <li>• Decreased consecutive dry days</li> <li>• Decreased average daily precipitation</li> <li>• More rain, less snow during cold season</li> <li>• Increased total annual precipitation</li> </ul>
Southern BC	<ul style="list-style-type: none"> <li>• Interior warmed more than the coast</li> <li>• Warming trend in spring and winter</li> </ul>	<ul style="list-style-type: none"> <li>• Wetter winter periods</li> <li>• Decreased annual snowfall</li> <li>• More rain than snow in Okanagan</li> <li>• Decreased snow pack in spring and at lower elevations</li> </ul>
Northern BC	<ul style="list-style-type: none"> <li>• Warmer winters</li> <li>• Cooler fall temperatures</li> <li>• Warmer average annual temperatures</li> </ul>	<ul style="list-style-type: none"> <li>• Increased snowfall since the 1950s</li> <li>• Wetter periods in all seasons</li> </ul>
Coastal BC	<ul style="list-style-type: none"> <li>• Warmer in spring and fall</li> <li>• Coast warmed less than interior</li> </ul>	<ul style="list-style-type: none"> <li>• Decreased snow</li> <li>• 40% less snow in some regions</li> <li>• Wetter in winter – more rain</li> </ul>

Source: Walker, I.J. & Sydneysmith, R. (2008)

**Figure 1: Changes in average annual temperature and precipitation in BC for the period 1900 to 2000**

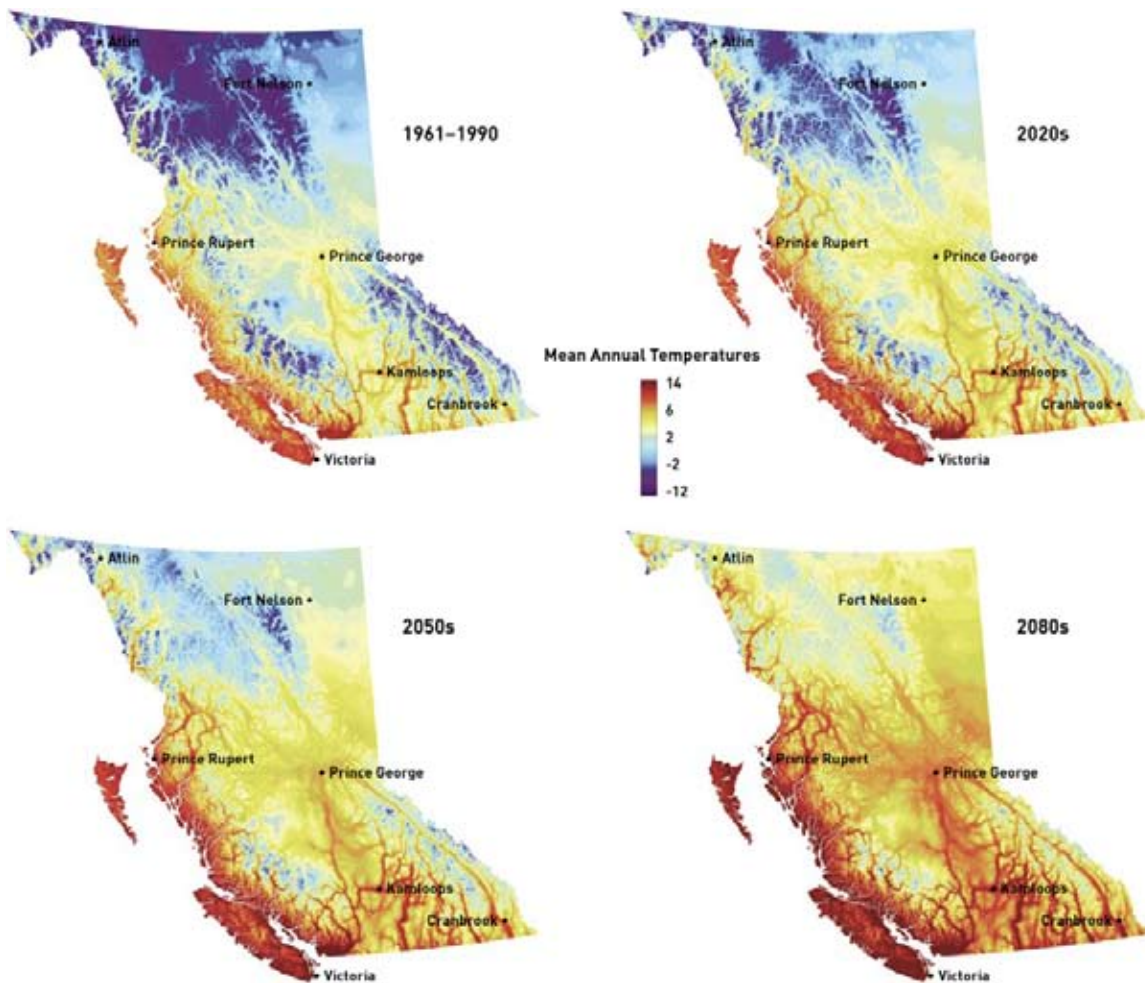


Source: Walker, I.J. & Sydneysmith, R. (2008)

### 2.1.2 PROJECTED CHANGES IN CLIMATE

Researchers apply a variety of Global Climate Models (GCMs) to estimate future climate conditions. GCMs incorporate parameters that represent variations in atmospheric conditions (greenhouse gas concentrations), physical systems (glaciers, ice sheets, land surface components), and socioeconomic conditions (rate of economic development).<sup>7</sup> The IPCC uses these parameters to construct scenarios that might materialize in the future: for example, a suite of six emission scenarios based on social, economic, and technological development assumptions<sup>8</sup> that estimate a range of projections for greenhouse gas emissions. These estimates, along with additional climate predictors, are used to estimate changes for future climate conditions. Spittlehouse (2008) provides estimates for changes in temperature and precipitation for different regions in BC (see Table 3). Figures 2 and 3 provide the estimated average temperature and precipitation changes for 2020, 2050, and 2080 compared to average temperature and precipitation changes from 1961 to 1990.

**Figure 2: Estimated average annual temperature changes in BC for the years 2020, 2050, and 2080 compared to average annual temperature changes from 1961 to 1990**

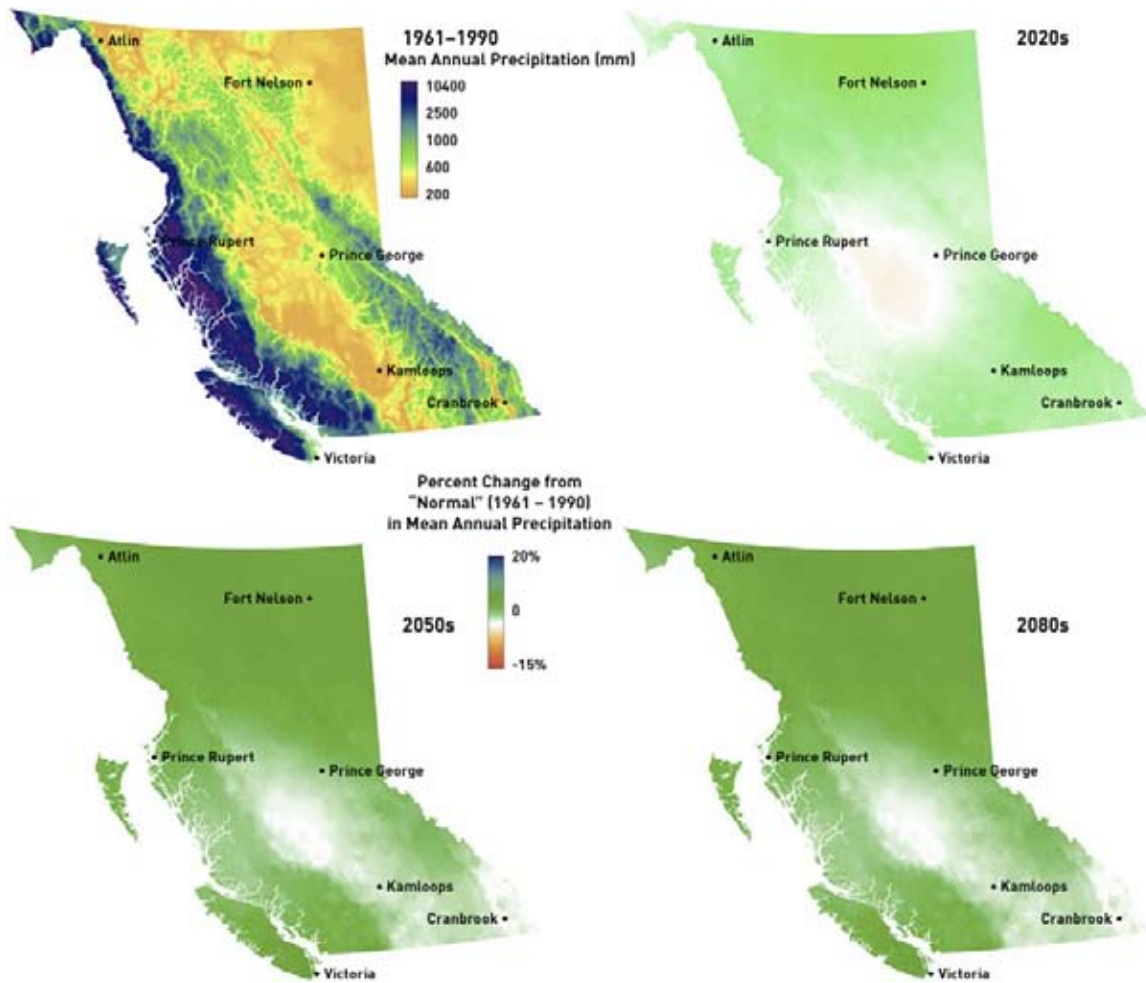


Source: Retrieved from Spittlehouse, D.L. (2008)

7 Spittlehouse, D.L. (2008)

8 Gitay, H., Suárez, A., Watson, R.T., & Dokken, D.J. (Eds). (2007)

Figure 3: Estimated average annual precipitation changes in BC for the years 2020, 2050, and 2080 compared to average annual precipitation changes from 1961 to 1990



Source: Retrieved from Spittlehouse, D.L. (2008)

**Table 3: Projected changes in temperature and precipitation for southern, northern, and central BC regions for the years 2020, 2050, and 2080**

	2020		2050		2080	
	Temperature (°C)	Precipitation % Change	Temperature (°C)	Precipitation % Change	Temperature (°C)	Precipitation % Change
Southern BC						
Winter	0 to 2	-5 to +15	1.5 to 3.5	0 to +20	2 to 7	0 to +25
Summer	0.5 to 2	-30 to +5	1.5 to 4	-35 to 0	2.5 to 7.5	-50 to 0
Central BC						
Winter	0 to 2	-5 to +15	1.5 to 4	0 to +30	2.5 to 6	+5 to +40
Summer	0.5 to 1.5	-10 to +5	1.5 to 4	0 to +30	2.5 to 6	+5 to +40
Northern BC						
Winter	0 to 2.5	0 to 20	1.5 to 5.5	0 to +25	2.5 to 9	0 to +45
Summer	0.5 to 1.5	-10 to +10	1.5 to 3.5	-10 to +15	2 to 6	-15 to +25

Source: Spittlehouse, D.L. (2008)

**Summary of climate change projections for BC<sup>9</sup>**

- Estimated temperature and precipitation changes in BC will be greater than the global average
- A variety of models and emission scenarios applied to estimate future changes in temperature indicate a continued warming trend
- Increasing temperatures in BC will likely be greater in the northern region of the province relative to other parts of the province
- Minimum winter temperatures will likely increase the most
- Southern and central British Columbia will likely experience drier conditions in the summer
- Northern regions of the province will likely experience wetter conditions

**2.2 BIODIVERSITY**

**2.2.1 WORKING CONCEPT OF BIODIVERSITY**

It is important to recognize the difficulty in operationalizing the conception of “biodiversity”, ecological diversity, and ecosystems using a specific metric.<sup>10</sup> Defining biodiversity in concrete and quantitatively measurable terms is challenging because it is an elusive concept rather than a distinct, tangible item. Biodiversity is often equated to species richness, which is the number of a particular species in a given area. The numbers of species at risk may be an indication of changes in biodiversity. BC’s Ministry of the Environment defines biodiversity as essentially all life forms on earth, including the habitats and natural processes that support them.<sup>11</sup> Given the challenge inherent in explicitly defining biodiversity, it is

9 Summary points provided by Spittlehouse, D.L. (2008) unless indicated otherwise. Alternative sources such as Fraser, J. (2002), Walker, I.J. & Sydneysmith, R. (2008), and IPCC reports were reviewed to corroborate and support various propositions.

10 Adaptation to Climate Change Team Conference (2008)

11 BC Ministry of Environment. <http://www.env.gov.bc.ca/wld/>

generally most practical to focus on the constituent components of diversity in the biological realm where researchers have the ability to provide workable quantitative and qualitative measurements.

A commonly accepted definition of biodiversity is “the variety of species and ecosystems on Earth and the ecological processes of which they are a part – including ecosystem, species, and genetic diversity components”.<sup>12</sup> Diversity within the biological realm refers to: species richness – the actual number of species present within a given area; species evenness – the relative abundance of a given species; species composition – particular types of species present in an area; and species interaction – the relationship between species in an ecosystem.<sup>13</sup> Ecological diversity is the product of the diverse range of genes, species, and ecosystems that are all essential components sustaining the structural and functional integrity of various ecosystems.<sup>14</sup> Biodiversity within the context of this report focuses on terrestrial plants (e.g. tree species) and animal species (e.g. yellow-bellied marmot), as well as ecosystem functions and structures (e.g. wetlands and their ability to cycle nutrients) in British Columbia and northern temperate regions (e.g. North America and Europe).

Ecosystems are naturally occurring, structural organizations where organisms interact with each other and their physical and biological environments.<sup>15</sup> We define an ecosystem as “a natural unit consisting of all plants, animals, [humans] and micro-organisms (biotic) in an area functioning together with all of the non-living physical factors (abiotic) of the environment”.<sup>16</sup> Ecosystems are units that share similar biological characteristics (e.g. soil conditions and vegetative cover) and climatic conditions (e.g. precipitation, temperature, rate of evaporation) and perform similar ecosystem functions. Humans and their associated activities are an inseparable part of ecosystems’ structures and functions; human populations depend on ecosystem functions to sustain all life on earth, including the socioeconomic systems that sustain human life. Human populations extract and transform natural resources such as timber and minerals to build their cities and house their populations. Urban and rural centres use wetlands and aquifers to store and retain water to grow their crops and assimilate their waste. Communities use alpine regions and forests to entertain families, inspire their hearts, and nurture their souls. This report does not attempt to preclude human societies and their activities from natural processes. On the contrary, we embrace the notion that human species are integral organisms within the fabric of biological systems thanks to the simple fact that biodiversity supports all life forms, and provides ecosystem functions that contribute to human well-being.

### 2.2.2 THE STATE OF BC’S BIODIVERSITY

BC has the distinctive privilege of being Canada’s most biologically diverse province, hosting 76% of Canada’s bird species, 70% of its freshwater species, 66% of its butterfly species, 60% of its conifer species, 56% of its fern species, and 41% of its orchids. BC contains over 3600 species and subspecies.<sup>17</sup> There are 1348 species or subspecies that have been identified as at risk in BC by the Conservation Data Center (CDC).<sup>18</sup> This number is only based upon a select portion of species in BC that have been assessed (i.e. vertebrates, a few well-known groups of invertebrates, vascular plants, and mosses). This number will be an underestimate of the total, as there are many lesser-known groups of invertebrates, as well as lichens and fungi, which have not been assessed. The CDC indicates a number of species in BC are presumed extinct, possibly extirpated, critically impaired, imperilled, or vulnerable. Table 4 illustrates the conservation status of species and subspecies within major wildlife groups in BC.

12 Vold, T. & Buffett, D.A. (2008)

13 Chapin III, F. (2000)

14 Gray, P.A. (2005)

15 Millennium Ecosystem Assessment. (2005)

16 Christopherson, R.W. (1997)

17 David Suzuki Foundation and Sierra Legal (2007). This number is a gross underestimate that does not include poorly understood and inventoried species such as fungi, lichens, and most insects. The report excludes populations, marine species, non-vascular plants, accidentals, introduced species, and species listed as having no status by the BC Conservation Data Centre. Austin, M.A., et al. (2008) estimate over 50 000 species reside in BC, but only 3800 of them have been assessed for their conservation status.

18 David Suzuki Foundation and Sierra Legal (2007)

**Table 4: Conservation of native species and subspecies within major wildlife groups in BC**

	PRESUMED EXTINCT OR EXTIRPATED	POSSIBLY EXTIRPATED	CRITICALLY IMPAIRED	IMPERILLED	VULNERABLE	APPARENTLY SECURE	SECURE
Amphibians	0	0	3	2	4	7	3
Birds	4	0	15	23	44	107	120
Freshwater fish	1	2	12	15	16	22	51
Terrestrial mammals	3	0	23	6	10	18	24
Reptiles and turtles	3	0	2	1	4	3	2
Butterflies	2	1	7	9	51	40	91
Dragonflies and damselflies	0	0	5	5	12	17	47
Freshwater and terrestrial molluscs	1	10	5	12	21	24	68
Vascular plants	4	18	203	347	442	656	677
Total	18	31	275	420	604	894	1083
% of Total	0.5%	0.8%	7.5%	11.4%	16.4%	24.3%	29.5%

Source: David Suzuki Foundation and Sierra Legal (2007)

An assessment of the data reveals that over 1/3 of assessed species and subspecies among major wildlife groups in BC face a moderate to extreme risk of extirpation. Over 40 species and subspecies are presumably extinct or extirpated, or possibly extirpated. Fewer than 25% of species and subspecies are widespread and abundant in the province. These estimates point towards cause for concern, especially considering the added element of climate change-induced impacts combined with conventional environmental stressors such as fragmentation, habitat loss, invasive species, and pollution. Furthermore, a certain proportion of species and subspecies considered “at risk” or “apparently secure” will likely be naturally restricted in range or low in numbers or have a high intrinsic vulnerability.

The major biodiversity “hotspots” in the province are primarily assembled in four areas located in the southern part of the province – the Lower Mainland, the southern part of Vancouver Island, the Rocky Mountain Trench, and the Okanagan Valley.<sup>19</sup> These areas have high concentrations of human populations exerting intense development pressures, meaning that a large proportion of natural habitat has been converted for alternative land uses such as agriculture and urban infrastructure. A significant number of species at risk in BC are located within these zones of concentrated human

19 David Suzuki Foundation and Sierra Legal (2007)



activity. For example, the Okanagan–Shuswap region has an estimated 251–275 species at risk, making it one of the foremost biodiversity hotspots in the province.<sup>20</sup> At the same time, Okanagan cities such as Kelowna are experiencing unprecedented development in combination with growing demand for local recreational amenities.

The distribution of BC’s parks and protected areas demonstrates a significant “spatial disconnect”<sup>21</sup> between the location of biodiversity hotspots and protected areas in BC. For instance, in the southern section of BC, where the numbers of at-risk terrestrial and freshwater species range from 100 to 275, the actual area of protected land base does not coincide with the number of species at risk prevailing in southern regions. The same scenario unfolds in the northwest region of the province. The Skeena forest district encompasses a large area of land in the northwest corner of BC that has between 126 and 150 species at risk.<sup>22</sup> The district contains two protected areas in a region that is home to a high concentration of species at risk and is also subject to significant resource development activities.

Most species in BC are found outside protected areas in “working landscapes” – large parcels of Crown land administered by a variety of government agencies, statutes, and land and resource plans used for multiple purposes such as forestry, mining, recreation, oil and gas, transportation, and agriculture. Species at risk residing outside legally established parks and protected areas do not receive considerable protection; the provincial and federal government do not afford any legal protection to 87% of BC’s species at risk under the existing legislative framework.<sup>23</sup> Figure 5 compares the levels of legal protection afforded to BC’s species at risk under current legislation.

Biodiversity BC considers the diversity of ecosystems in BC to be vulnerable to human driven stressors and changing climatic conditions:<sup>24</sup>

- At the broad scale, four biogeoclimatic zones<sup>25</sup> – coastal Douglas fir, interior Douglas fir, ponderosa pine, and bunchgrass – representing approximately 5% of British Columbia’s land base, are of provincial conservation concern.
- At the fine scale, more than half of the ecological communities described in British Columbia are of provincial conservation concern.
- British Columbia has the majority of the global range for six of the 16 biogeoclimatic zones that occur in the province – coastal Douglas fir, interior cedar-hemlock, montane spruce, mountain hemlock, sub-boreal pine-spruce, and sub-boreal spruce.
- The coastal Douglas fir biogeoclimatic zone is the rarest such zone in British Columbia and is of great conservation concern.
- Low-elevation grassland communities are the rarest land cover type in British Columbia and are concentrated in the biogeoclimatic zones of conservation concern.
- Significant areas of wetlands in British Columbia have been converted or degraded, particularly in the two major drainage areas of greatest conservation concern (those of the Columbia River and Fraser River). Estuaries are of concern in British Columbia because of their rarity and the level of human impacts on them.

20 David Suzuki Foundation and Sierra Legal (2007)

21 Faisal Moola, Director of Science, David Suzuki Foundation. Personal Communication, June 2008.

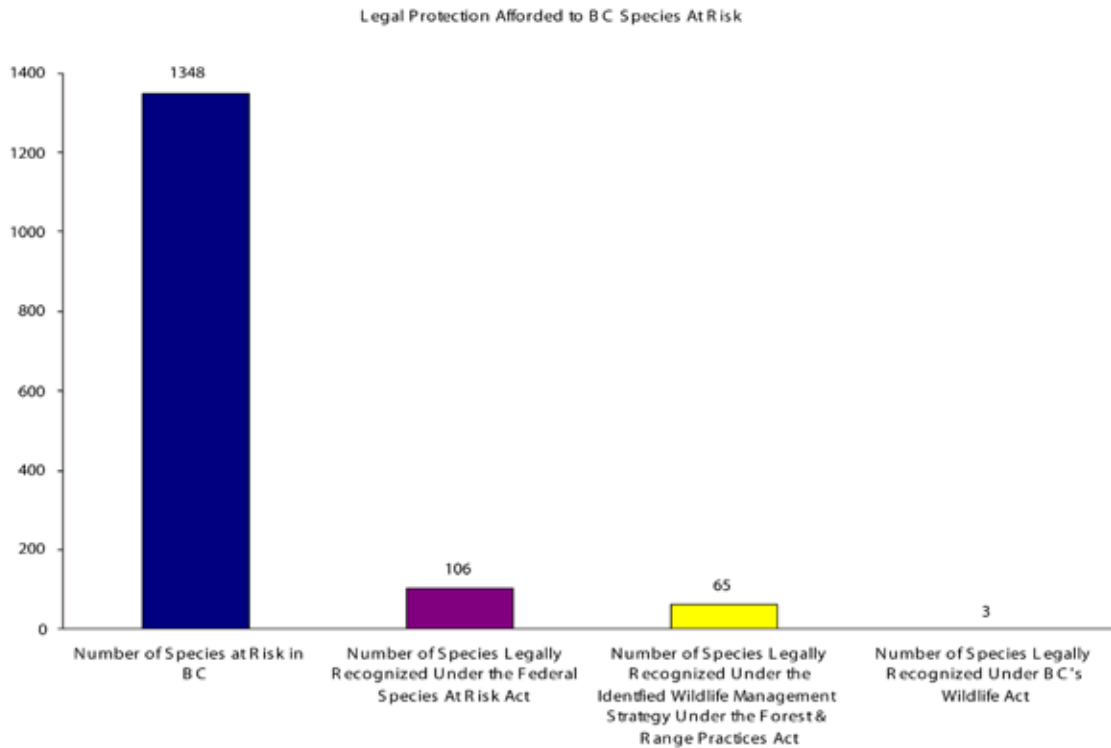
22 David Suzuki Foundation and Sierra Legal (2007)

23 David Suzuki Foundation and Sierra Legal (2007)

24 Austin, M.A. et al. (2008)

25 Geographic areas representing similar vegetation and climate.

Figure 4: Number of species assessed at risk in BC that are afforded legal protection



Source: David Suzuki Foundation and Sierra Legal (2007)

### 2.2.3 HUMAN-DRIVEN PRESSURES ON THE STATE OF BIODIVERSITY

Before climate change became a “hot” policy issue ingrained in the collective consciousness of national political discourse, natural and evolutionary processes combined with human activities consistently transformed the state of biodiversity.<sup>26</sup> There is a well-founded consensus that climate change, along with conventional environmental stressors, will change the range, abundance, and life-cycle events of many species and fundamentally change the range as well as the biological structure and functions of many ecosystems found within BC.<sup>27</sup> We are indeed witnessing a significant shift in climatic conditions that deserves our full attention. However, global climate change is only one feature amongst a variety of complex, interlinked variables that influence the structure and composition of biological diversity. Climate change is certainly cause for great concern and will likely exacerbate existing stresses upon biodiversity; however, direct human-driven activities are responsible for the major causes of biodiversity loss and stress on ecosystem functions: habitat destruction, habitat fragmentation, habitat degradation and pollution, invasive species, and overexploitation.<sup>28</sup> It is therefore important to identify and examine the human pressures that drive changes to biodiversity other than climate change variables. Biodiversity BC identified 13 different categories considered to exert major impacts on BC’s biodiversity (see Table 5).<sup>29</sup>

26 Parmesan, C. (2006)  
 27 Root, T.L. et al. (2002)  
 28 Primack, R.B. (2006)  
 29 Gayton, D. & Forrex (2007)

**Table 5: Major human-driven stressors on biodiversity in BC**

MAJOR IMPACTS	DESCRIPTION OF MAJOR IMPACT ON BIODIVERSITY IN BC
Urban sprawl	Conversion from a native ecosystem to a developed urban one implies a loss of biodiversity. Sprawl creates direct loss of species and habitat, and indirect losses from increased pollution, habitat fragmentation, predation, road kill, disruption of surface water flow, etc.
Pollution	Anthropogenic discharge of substances that have deleterious biophysical effects, such as toxic biochemicals, heavy metals, excessive nutrients, etc.
Fresh water use	The use of surface and ground water through individual, industrial, and agricultural consumption. Direct impacts on biodiversity include excessive drawdown of surface water sources, with consequent disruption of aquatic and riparian habitats.
Water body alteration	Damming, diking, channelizing, or culverting lakes, rivers, or streams for the purposes of hydroelectric power, flood control, transportation, agriculture and land development, etc. Dams extirpate riparian and valley bottom habitats, which typically support high levels of biodiversity. They hamper movement of migratory and anadromous fish species, and reduce the transfer of marine-derived nutrients into interior ecosystems, change turbidity and sediment levels to which species and ecosystems are adapted, and trap nutrients which normally deposit in estuaries and deltas downstream.
Energy use	The consumption of fossil fuel and hydroelectric energy for industry, transportation, space heating, and other uses. Impacts include: hydroelectric dam effects; marine fuel and oil spills; roads, seismic lines, water use, and water pollution associated with oil and natural gas drilling; pipeline and transmission corridors; physical extirpation of ecosystems and habitats from open pit coal mining; fouling of soil and fresh water through oil and fuel spills and leaks; and the atmospheric emissions from vehicles propelled by fossil fuel combustion.
Invasive species	Species not native to British Columbia that have invaded and established themselves in our terrestrial and aquatic ecosystems. There are some instances of direct predation, but the biggest impact is the displacement or competitive exclusion of native species by occupying habitats, capturing resources and interfering with reproduction. Invasive herbaceous plants exhibit the greatest variety and extent, followed by birds, marine invertebrates, and insects.
Forest harvesting	The removal of forest trees for timber or pulp plus associated ground disturbance (e.g. roads). Impacts on biodiversity include: fragmentation of habitat and disruption of movement corridors; alteration of seral stage distribution; alteration of age-class distribution, tree species distribution, and stand structure; and loss of key habitat elements such as veteran trees, snags, and downed trees.
Roads, transmission lines, pipelines, seismic lines	Highways, secondary roads, logging and access roads, high voltage electrical transmission lines, natural gas pipelines and seismic exploration lines can fragment habitat; impede the movement of native species; facilitate the invasion of alien species; disrupt surface and subsurface water flow; alter predator-prey relationships; and cause mortality through collisions with vehicles.
Mineral, gravel, oil, coal, and gas extraction	Mining, gravel extraction, and oil/gas extraction are lumped together here since they create similar impacts, such as: surface and subsurface soil disturbance; aquatic, terrestrial, and atmospheric pollution; erosion and sedimentation from overburden and waste rock disposal.
Agriculture	Impacts resulting from the cultivation of field crops, orchard crops, horticultural crops, vineyards, livestock ranching, and feedlots. Impacts are habitat loss and fragmentation, pollution from animal waste, fertilizer and pesticides, grazing impacts on native plant communities, and noxious weed spread.
Recreational activities	The proliferation of back-country recreation, heli-skiing, ATV use, mountain biking, mud-bogging, rock climbing, lodge and cottage developments, etc. Primary biodiversity impact is in the form of human interference with normal animal behavior; secondary impacts are habitat fragmentation, soil disturbance, erosion and the introduction of non-native species.
Fishing and fish farming	Commercial and recreational fisheries, including salmonids, groundfish, herring, shellfish, tuna, and other species. Impacts are largely through overfishing, disruption of spawning, and pollution.
Fire suppression	The conversion of previously fire-maintained grasslands and associated savanna forests to dense and/or closed forest communities, as a result of fire suppression. A correlated process of forest encroachment, where trees encroach on areas that were traditionally grassland, occurs for the same reason. The biodiversity impacts result from the reduction or elimination of herbaceous vegetation, together with the suite of fauna that rely on that vegetation.

## 2.2.4 BIODIVERSITY WITHIN THE CONTEXT OF NATURAL CAPITAL

Natural capital is the stock of natural resources that yields environmental goods and services over time.<sup>30</sup> Natural capital provides essential ecosystem functions that sustain human existence, such as the air we breathe, the water we drink, the land we reside on, the food we grow, and the products we consume. Just as human capital provides benefits in the form of wages, and physical capital provides benefits in the form of consumer products and investment returns, natural capital provides a flow of valuable environmental goods and services that benefit human societies as well. Environmental goods and services come in the form of tangible, marketable items that directly benefit communities, such as timber, minerals, fish, agriculture, and recreational amenities. Additionally, natural capital provides for the benefit of communities a stream of indirect environmental goods and services whose values are not easily recognized or captured. Indirect environmental goods and services include nutrient recycling, waste assimilation, carbon sequestration and retention, and the stabilization of hydrological flows. These services are often given too little weight in policy decisions because their economic values are not fully quantified and monetized in comparison to other commercial services and manufactured goods produced in the broader economy. For this reason, many decisions result in the inefficient allocation of scarce resources. In other words, natural resources are not used in a manner that is in the best collective economic interest of human societies.<sup>31</sup>

The provision of environmental goods and services derived from our stock of natural capital is inextricably linked to the diversity of our biological resources – it is the glue that holds everything together. The loss of biodiversity and the ensuing effects on ecosystem functions occurs at three different levels.<sup>32</sup> First, altered biodiversity may change the productivity of ecosystems, disrupting the flow of valuable environmental goods and services such as timber supply, soil fertility, climate regulation, carbon sequestration, and water purification. Second, changes to biodiversity may reduce the resiliency of ecosystems to withstand the introduction of invasive species, consequently increasing the frequency and magnitude of disturbance regimes such as wild fires and pest outbreaks. Third, and most important, biological diversity enhances resiliency, which allows ecosystems to adapt to changing environmental conditions. Ecosystem productivity, resiliency, and adaptability permit the sustainable provision of environmental goods and services to BC communities. Choosing resource use options that reduce or alter biodiversity may adversely affect ecosystems' functions and diminish the value of the services they provide. Under this scenario, the well-being of communities would decrease and/or governments would have to expend substantial public funds to replace the degraded services. For that reason, retaining biodiversity is essential to preserving and enhancing economic and environmental benefits contributing to the well-being of BC communities.

An unavoidable reality of our natural environment is that our stock of natural capital is limited and finite, yet we systematically erode resources drawn from our limited natural capital to fulfil competing human desires. In many instances, government agencies permit uses of land and the development of resources without accounting for the true costs of their decisions. What is more, resource use decisions do not factor in the foregone economic benefits associated with biodiversity loss. The role of economic valuation is to inform and guide the decision-making process with the purpose of allocating scarce resources to achieve a desired state of nature that reflects societal preferences.<sup>33</sup> Valuing biodiversity takes on different interpretations. Intrinsic value refers to something that has value on its own, not derived from its use.<sup>34</sup> Alternatively, an instrumental value is derived from contribution to human well-being. Placing an economic value on biodiversity measures the instrumental contribution that biodiversity provides to the well-being of human societies in dollar terms. An economic value is simply a monetary measurement of something that contributes to human well-being. We know that biodiversity's economic value is not zero and we know it is not an infinite amount. The motivation for conducting an economic valuation is to estimate the benefits and costs associated with alternative resource use options.

30 Primack, R.B. (2006)

31 Costanza, R. & Folke, C. (1997)

32 Vold, T. & Buffett, D.A. (2008)

33 Wagner, J.E. (1998)

34 Champ, P.A., Boyle, K.J. & Brown, T.C. (2004)

The option that produces the greatest net benefits is the most economically viable. We emphasize that economic valuation is one criterion that guides the decision making process. Decision makers must also consider greater strategic societal objectives such as ecosystem resiliency, economic development, social needs, and community resiliency.

Natural resource managers and local governments do not intentionally exclude the forgone benefits or the costs associated with their policy or operational decisions, and many provincial and municipal bureaucrats are genuinely concerned about the fact that their decisions may lead to the unsustainable erosion of our stock of natural capital. However, there are three reasons why decision makers often exclude the economic costs associated with resource decisions. First, many environmental goods and services are non-marketable and not traded in formal market structures; therefore, decision makers have to undertake complex assessments in order to ascribe monetary values. Second, disentangling and quantifying the impacts between climatic, biological, and ecosystem functions and then transforming those results into a monetary value is an extremely challenging endeavour,<sup>35</sup> and models used to accurately establish causal relationships between changing climatic parameters and biodiversity with a very high degree of certainty at a regional level are still in their infancy.<sup>36</sup> Table 6 provides a conceptual overview of the different scenarios that may emerge from making decisions that contribute to the erosion of natural capital and the subsequent costs imposed on society. The illustration demonstrates the links between losses in biodiversity and the alteration of ecosystem functions, which in turn leads to a disruption in the flow of environmental goods and services, subsequently imposing costs upon society.

**Table 6: Conceptual overview of the links between changes to biodiversity, ecosystem goods and services, and the associated economic implications**

1.	Over time, we expect human activities, natural processes, and human-driven climate change to alter the state of biodiversity. Changes may proceed gradually over time (a). For example, grassland habitat in the Okanagan may slowly diminish, resulting in the loss of native plant species. Alternatively, grassland habitat and native plant species may gradually decline because of urban expansion, until a particular threshold exceeds the tolerance level of a plant species to adapt to new environmental conditions, at which point species richness begins to sharply decrease (b).
2.	Changes to biodiversity may alter ecosystem functions that provide a range of environmental goods and services to BC communities. Incremental changes to biodiversity may induce incremental changes to ecosystem functions gradually or abruptly. Alternatively, change may initially occur gradually to the point where certain ecological thresholds are reached, triggering rapid changes in ecosystem services (c).
3.	Changes to ecosystem functions may affect the quantity or quality of environmental goods and services provided to BC communities. Depending on their resiliency and capacity to adapt to negative impacts associated with changes to the provision of environmental goods and services, BC communities may incur economic costs. These may occur gradually and impose a substantial cost to society (a) or impose minor costs (b). Costs may become larger over time due to an incremental change in ecosystem functions (c). Severe changes in biodiversity (e.g. changes in species composition such as forest pests) may create substantial economic costs for maintaining the provision of goods and services at usual levels, resulting in a steep cost increase (d). Alternatively, a resource may become depleted to the point where the cost to society cannot be quantified or is infinite (e). This may be the case where the value or benefit derived from a resource cannot be replaced, or would require significant expenditure to replace (e.g. drinking water cannot be substituted with another product, and requires significant expenditures to import from other regions). This scenario implies that segments of society would be deprived from consuming resources for their desired uses.

Source: Chapin III, S.T. et al. (2000)

35 Nunes, P. & Van den Bergh, J. (2001)

36 Parmesan, C. (2006)

The considerable policy attention recently given to conserving and restoring natural capital assets goes beyond satisfying environmental, aesthetic, or moral aspirations; it considers the economy, our jobs, the material well-being of our families, and the development of healthy, wealthy, and resilient communities. There are profound business implications to preserving, restoring, and renewing BC’s natural capital assets. A greater, resilient stock of natural capital will unequivocally create more resilient communities by increasing the yield of marketable products and ecosystem services, creating more jobs and prosperity, and providing healthy and vibrant natural amenities for recreational and cultural uses. The same concept is applicable to personal investment decisions. More capital in your savings account will increase annual interest payments in perpetuity; on the other hand, if you draw down investment capital, you will receive less interest in perpetuity. In the event of macroeconomic instability affecting employment prospects, a greater amount of diversified capital investment implies greater resiliency to adverse economic impacts. The same holds true with natural capital. Biological diversity creates resilient ecosystems that increase the adaptive capacity of species to adjust to new environmental conditions. The direct and indirect economic contributions stemming from our natural capital are therefore significant. The following examples provide a summary of economic values for natural capital in Canada’s boreal region (Table 7):

**Table 7: Summary of economic values for natural capital in the boreal region of Canada**

NATURAL CAPITAL	MARKET VALUES	NON-MARKET VALUES
Forests	<ul style="list-style-type: none"> <li>\$14.9 billion in market value-related GDP</li> </ul>	<ul style="list-style-type: none"> <li>\$5.4 billion for pest control services</li> <li>\$4.5 billion for nature-related activities</li> <li>\$1.85 billion for annual net carbon sequestration</li> <li>\$ 5.75 million in subsistence value for Aboriginal peoples</li> <li>\$79 million in non-timber forest products</li> <li>\$18 million for watershed service</li> <li>\$12 million for passive conservation value</li> </ul>
Wetlands and peatlands		<ul style="list-style-type: none"> <li>\$77 billion for flood control and water filtering by peatlands</li> <li>\$3.4 billion for flood control, water filtering, and biodiversity value by non-peatlands</li> <li>\$383 million for estimated annual replacement cost value of peatlands sequestering carbon</li> </ul>
Minerals and subsoil assets	<ul style="list-style-type: none"> <li>\$14.5 billion in GDP from mining and oil &amp; gas related activities</li> </ul>	
Water resources	<ul style="list-style-type: none"> <li>19.5 billion in hydroelectric generation</li> </ul>	
<b>Total Economic Value</b>	<b>\$37.8 billion</b>	<b>\$93.2 billion</b>

Source: Anielski, M. & Wilson, S. (2006). Values are per annum in 2002 dollars.

There is no comprehensive inventory and valuation of ecosystem goods and services produced in BC. Using Wilson and Hebda’s (2008) assessment, we can categorize a suite of ecosystem goods and services to illustrate the range of direct and indirect benefits created by BC’s vast stock of natural capital. Table 8 summarizes a suite of potential ecosystem goods and services provided by land cover type and ecosystem function in BC. Ecosystem functions consist of provisioning services, support and regulating services, and cultural services. Land cover types include forests, grasslands, wetlands, and alpine areas. Given the significance of First Nation peoples and culture in terms of historical uses and occupation of land in BC, and the authority and influence they exercise in the design and management of BC’s natural capital, we believe First Nations merit a discrete category. Natural capital yields environmental goods and services such as land, natural resources, and wild species, used by the tripartite treaty participants as a combined reconciliatory instrument

to address historical injustices as well as land and resource disputes. These goods and services provide a societal benefit for two reasons: First, they offer a means to address historical injustices perpetrated against BC’s First Nations peoples. Second, they give an element of stability and certainty to BC’s land and resource rights and uses, which cultivates a business environment conducive to promoting investment and development.

**Table 8: Potential ecosystem goods and services provided by land cover types in British Columbia<sup>37</sup>**

ECOSYSTEM GOODS AND SERVICES		FORESTS	GRASSLANDS	WETLANDS	ALPINE
<b>Provisioning Goods</b>					
Timber	Harvestable timber bought and sold in international markets	X			
Food	Provision of food; harvest of wild species	X	X	X	X
Fuel wood	Wood and other biological materials used for energy	X	X		
Fibre	Materials such as wood and hemp		X		X
Medicines	Ecosystems produce a range of medicine and food additives	X			
Fresh water supply	Ecosystems filter, retain and store fresh water for human consumption	X		X	X
<b>Regulating and Supporting Services</b>					
Air quality maintenance	Ecosystems contribute and extract chemicals in the atmosphere	X			
Regulate global climate patterns	Ecosystems emit or sequester carbon	X		X	X
Regulate regional climate patterns	Land uses may affect local temperature and precipitation patterns	X	X		
Storm and flood protection	Ecosystems reduce the damage caused by storm surges, heavy precipitation events and rapid water runoff			X	
Erosion control	Vegetation cover stabilizes slopes, and reduces soil erosion and sediment transport	X	X	X	X
Pest regulation	Ecosystems change the prevalence of crop and livestock pests and diseases	X	X		

<sup>37</sup> Classification table derived from Wilson & Hebda (2008). Description of ecosystem goods and services provided by the Millennium Ecosystem Assessment (2005). Segment on First Nations based on the author’s assessment.

ECOSYSTEM GOODS AND SERVICES		FORESTS	GRASSLANDS	WETLANDS	ALPINE
Process waste	Ecosystems may filter out and decompose organic waste and excessive nutrients			X	
Sediment retention	Ecosystems retain sediment from soil erosion and alternative land uses	X	X	X	
Cycle nutrients	Ecosystems store and recycle nutrients which maintain healthy soils and productive ecosystems	X	X		
<b>Cultural Services</b>					
Recreational amenities	Ecosystems provide natural habitat which supports a variety of human activities (e.g. skiing)	X	X	X	X
Spiritual, cultural, and aesthetic values	Natural landscapes and features provide aesthetics, cultural and spiritual fulfilment, scientific knowledge	X	X	X	X
<b>Natural Capital Used For First Nation Reconciliation</b>					
Land and resource assets used for reconciliation	Valuable ecosystems are situated within the boundaries of the traditional territory of First Nation communities. Many features of various ecosystems such as extractable resources, wild species and land base used for development, spiritual grounds, hunting and gathering are subject to negotiation under the formal treaty process or interim measure agreements. The resolution of Aboriginal rights and title disputes collectively benefits all parties involved, which adds value to society				

Source: Wilson, S.J. & Hebda, R.H. (2008)



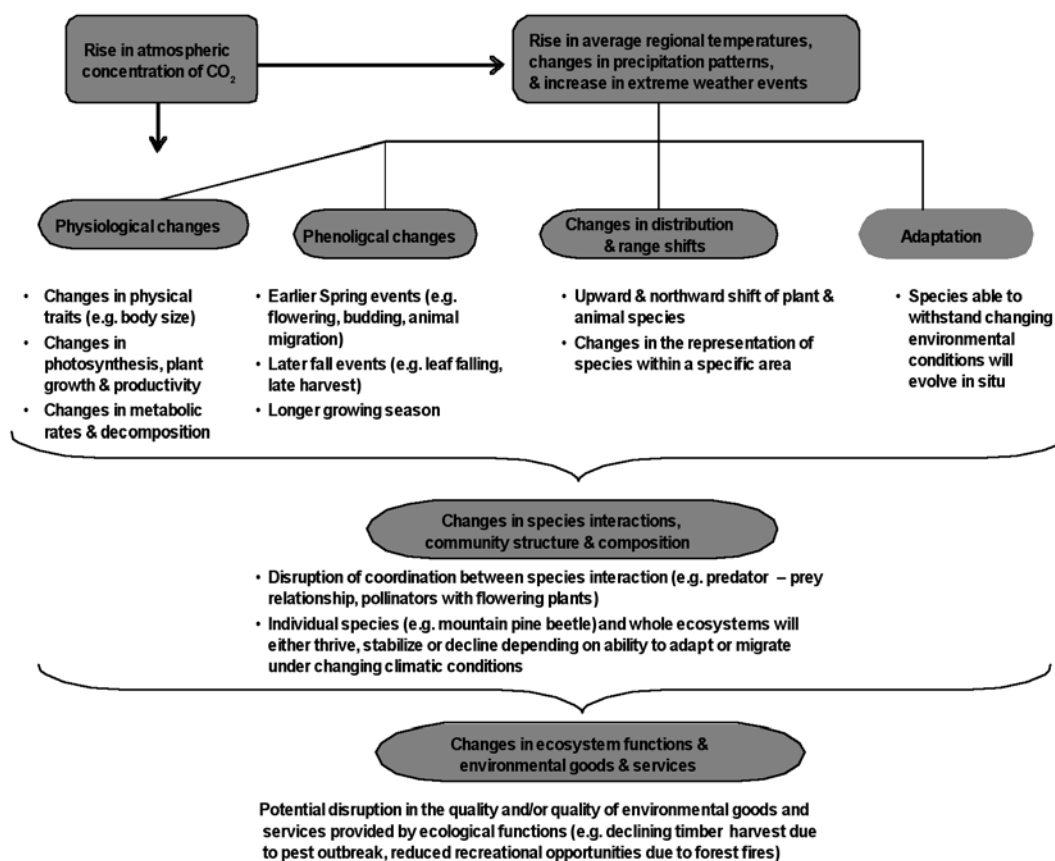
# 3. CLIMATE CHANGE IMPACTS ON TERRESTRIAL PLANTS, ANIMALS, AND ECOSYSTEMS

## 3.1 OBSERVED IMPACTS FOR NORTHERN TEMPERATE REGIONS

Recent studies that explore the relationship between responses of terrestrial plant and animal species to recent climate change provide a generally accepted proposition: human-induced global warming has had an impact on terrestrial plant and animal species.<sup>38</sup> The earth’s species and ecosystems have continually evolved, adapted, or become extinct in response to changing environmental conditions. However, the rapid rate of global warming (an increase of 0.6°C over the last century) has been greater than at any other time over the last 1000 years.<sup>39</sup> Furthermore, human activities, urban settlements, habitat fragmentation, and invasive species will impede the capability of many species to migrate to climate-suitable habitat.<sup>40</sup>

Researchers detect climate change-induced impacts (observed changes and future projections) on terrestrial plant and animal species by focusing on four broad categories: effects on physiology, effects on range distribution, effects on phenology, and adaptation. The majority of the research focuses on temperature changes and associated impacts on plant and animal phenology and distribution. The diagram in Figure 5 describes each category and illustrates the relationships within it.

**Figure 5: Areas of consideration when tracking climate change impacts on plant and animal species**



Source: Hughes, L. (2000)

38 Parmesan, C. & Yohe, G. (2003), Jump, A.S., & Penuelas, J. (2005), Walther, G.R., et al. (2002), and Root et al. (2003). It is worth noting that these publications do not exclusively focus on terrestrial plant and animal species.

39 Walther, G.R. et al. (2002)

40 Jump, A.S. & Penuelas, J. (2005)

### 3.1.1 CHANGES IN PHENOLOGY

Phenology refers to the timing and occurrence of biological events for plant and animal species. Temperature is a key determinant, considered the most responsive element of nature to changes in climatic conditions.<sup>41</sup> Seasonal biological processes such as plant growth and flowering, and animal migration patterns and timing of reproduction, are dependent on temperature. Many plant and animal species are sensitive and vulnerable to climatic changes. Plant life cycles such as budding, leafing, and flowering are primarily triggered by temperature and photoperiod.<sup>42</sup> Changes in the timing of spring activities include the early arrival of migrant birds, the early appearance of birds and butterflies, and budding and flowering of plants. There is growing evidence to support the claim that the timing of seasonal activities, such as spring and fall events, has already changed because of a warming climate.<sup>43</sup> There is a common expectation that rising temperatures will advance the timing of plant and animal life cycles. Some general expectations include:<sup>44</sup>

- The positive relationship with rising temperatures suggests advanced flowering and budburst of many species in the spring;
- Tree species in temperate zones require chilling of seedlings prior to budburst; rising temperatures may alter this process. If buds are not sufficiently chilled, additional warm days and a prolonged process will be required for budburst to occur;
- Autumn events such as leaf colour and leaf fall events are expected to occur later;
- A combination of changes in spring and autumn is expected to extend the greening season;
- Impact on plant phenology is anticipated to be more sensitive at higher altitudes;
- Arctic and alpine zones are expected to experience an increase in primary productivity and growing season;
- Insects are expected to pass through their juvenile stages at a faster rate, resulting in smaller body size;
- Food supplies will appear earlier for some animal species, which may result in mismatches between food supply and animal migration.

Researchers have documented a collection of changes in phenological events for plant and animal species that are likely attributable to recent climate change. Table 9 provides an overview of these changes in plant and animal phenology. Table 10 provides a synopsis of recent studies that document changes in phenological events for species over the last 100 years.

**Table 9: Estimated average changes for plant and animal phenology. Estimates categorized according to major life cycle events.**

CHANGES IN PLANT PHENOLOGY (PER DECADE)	
Leaf fall	1-2 weeks delayed
Leaf unfolding	1-4 weeks advanced
Flowering	1 week advanced
Growth season	3 weeks extended
CHANGES IN ANIMAL PHENOLOGY (PER DECADE)	
Appearance and activities	1-2 weeks advanced
Spring migration	1-2 weeks advanced
Fall migration	1-2 weeks delayed
Breeding season	1-2 weeks extended

Source: Penuelas, J. & Filella, P. (2001)

41 Walther, G.R. (2003)

42 Root, T.L & Hughes, L. (2005)

43 Parmesan, C. & Yohe, G. (2003) and Root, T.L. et al. (2003)

44 Root, T.L & Hughes, L. (2005)

**Table 10: Observed changes in plant and animal phenology. Changes occurring in response to modest warming of the past few decades. Selection used to illustrate the accumulation of evidence to demonstrate recorded phenological changes for different geographical areas in northern temperate climates outside British Columbia.**

SPECIES	PHENOLOGICAL EVENT	OBSERVED CHANGE	TIMEFRAME (YEARS)
20 bird species	Breeding earlier	8.8 days	20
3 bird species	Breeding earlier	3-9 days	25
Pied flycatcher	Breeding earlier	13 days	24
Tree swallow	Breeding earlier	5-9 days	33
Great tit	Breeding earlier	11.9 days	27
2 bird species	Breeding earlier	30 days	35
4 bird species	Early migration	11.9 days	50
39 bird species	Early migration	5.5 days	50
American robin	Early migration	14 days	19
19 bird species	Early migration	4.4 days	61
Yellow-bellied marmot	End of hibernation	23 days	23
6 wildflower species	Early flowering	19.8 days	50
36 species	Early flowering	8.2 days	61

Source: McCarty, J.P. (2001)

### 3.1.2 CHANGES IN SPECIES RANGE SHIFTS AND COMPOSITION

Climate is a large factor in determination of the composition and distribution of biomes – geographical regions containing natural communities or habitats of plants and animals that adapt to local environmental conditions (e.g. desert).<sup>45</sup> Plants and animals reside and function in habitats or biomes that enjoy climates suitable for their survival and regeneration. If a climate within a habitat changes, plants and animals will respond by migrating and tracking a suitable climate habitat, adapting to changing local conditions, or becoming extinct. It is likely that change in climatic conditions will change the margins or boundaries of species ranges. In other words, a changing climate will force plant and animal species to migrate to new geographical locations, and the boundaries of existing biomes will adjust.<sup>46</sup> Recent studies show that such range shifts are already occurring. As expected, species are generally migrating northward and upwards beyond their existing range boundaries. Table 11 illustrates observed species range shifts and composition for northern temperate climates.

45 Walther, G.R. (2003)

46 Walther, G.R. (2003)

**Table 11: Observed species range shifts for northern temperate climates. Changes consist of upward shift in altitude and northward shift in latitude.**

SPECIES	RANGE SHIFT	OBSERVED CHANGE	LENGTH OF RECORD EXAMINED (YEARS)
59 bird species	Latitudinal	18.9km	20
Edith's checkerspot butterfly	Latitudinal	92km	100
Speckled wood butterfly	Latitudinal	88-149km	55
22 butterfly species	Latitudinal	35-240km	30-100
9 plant species	Altitudinal	70-360m	70-90
White spruce	Altitudinal	10-20 surface m and 2-5 altitude m	150 <sup>a</sup>
Siberian larch	Altitudinal	100-500 surface m and 20-30 altitude m	Since 1920 <sup>a</sup>
White birch, Norway maple, mountain ash, Norway spruce, Scots pine, willows	Altitudinal	120-375 altitude m	50 <sup>a</sup>
Balkan pine	Altitudinal	130 altitude m	30 <sup>a</sup>
Noble fir	Altitudinal	10 m	30 <sup>a</sup>

Source: McCarty, J.P. (2001); <sup>a</sup>Walther, G. (2003) – lengths of records examined are approximations

### 3.1.3 DETECTING SPECIES AND ECOSYSTEM RESPONSES TO CLIMATE CHANGE

Researchers use three lines of evidence to estimate how biodiversity responds to changes in climatic conditions:<sup>47</sup> theories derived from past observations; known mechanistic links between climate parameters and species responses; and direct observations. Evidence collected from past observations consists of drawing inferences from paleological studies and biogeographic theory and models, and applying them to current conditions. Researchers have a general idea of how some species and ecosystems responded to historical climatic changes, and this knowledge offers some insight in projecting biological responses to current and future climate changes. Evidence derived from mechanistic links includes controlled field experiments that test the physiological tolerances of species to a range of climatic parameters. Evidence derived using current observations relies on the signal that change is already under way. Inferences are typically drawn from statistically significant correlations rather than causation, or observing a species' response to regional climate change over time without specifically attributing a species' response to a specific climatic parameter. The difficulty of ascribing causal

47 Parmesan, C. & Galbraith, H. (2004)

factors to an observed species range shift arises from the issue of confounding factors.<sup>48</sup> Conventional stressors such as land use changes have dramatically altered species' distribution in conjunction with rising temperatures. The challenge of separating the cumulative influence of conventional stressors from temperature changes is a challenging endeavour that may never be sufficiently resolved in order to render conclusive evidence used to guide policy development.<sup>49</sup>

There is a generally accepted proposition among leading researchers that climate change is likely affecting natural systems. However, the support of this claim is based on inferences derived from correlation relationships rather than causal relationships. That is to say, researchers have observed biotic responses (i.e. phenology, range shifts) for various types of plant and animal species and linked these to observed changes in climate (i.e. temperature). This may reduce the legitimacy of or challenge the conclusions rendered from numerous studies claiming climate change-induced impacts on natural systems. The political establishment relies on objective, scientific facts to make informed policy decisions, and temperature is only one facet of the complex biological processes and of human activities that affects the structure and composition of plant and animal species. As noted, precipitation, extreme weather events, humidity levels, elevated concentrations of atmospheric CO<sub>2</sub>, and human activities all contribute to and affect the structure and composition of ecological systems. To overcome this barrier, researchers are seeking explanations (causation) for the recent observed changes (correlation) in plant and animal species, with an emphasis on how temperature affects the underlying mechanics of certain species. Researchers already have a general idea of the causal mechanics underlying the effect of climate on plant and animal physiology.

Parmesan and Galbraith (2004) substantiate the claim that climate has a probable role in affecting plant and animal species, by predicting the effects of climate changes on species based on a general understanding of the causal mechanisms and tolerance levels of species involved in the study. The authors conclude that about half of the 1600 species included in the study exhibited significant phenological and distributional changes in the last 20 to 140 years.<sup>50</sup> The authors go on to say that “these changes are not random; rather they are systematically in the direction expected from regional changes in the climate.”<sup>51</sup> These conclusions provide significant evidence attributing changes in species' range and phenology to climate change, because they include multiple species and ecosystems on a large geographical scale.

### 3.1.4 OBSERVED CHANGES IN BRITISH COLUMBIA

Numerous studies make the link between observed changes with recent climate change and the behavioural patterns of certain species in northern temperate climates. Regrettably, research for specific species in BC is minimal; however, recent publications have documented a variety of climate change-induced impacts on physical and biological components specifically for BC.<sup>52, 53</sup>

- Daily temperatures are increasing in BC with significant regional variation;
- On average, annual precipitation has increased by about 22%, with significant regional variation;
- Snow pack has decreased over the past 50 years, with significant regional variation;
- Spring runoff/snowmelt-fed rivers are occurring earlier;
- Water temperatures are increasing;
- The fire season is longer with more fire activity in the boreal forest;
- Flowering time and bud break in aspens are occurring earlier;
- Loss of forest habitat caused by the outbreak of mountain pine beetle and the intensification of the dothistroma needle blight have been linked to climate change;

48 Parmesan, C. & Galbraith, H. (2004)

49 Parmesan, C. & Galbraith, H. (2004)

50 Parmesan, C. & Galbraith, H. (2004)

51 Parmesan, C. & Galbraith, H. (2004)

52 Wilson, S.J. & Hebda, R.H. (2008)

53 Gayton, D. (2008)

- Six bird species expanded their range northwards and now occupy the northern portion of their current range more densely;<sup>54</sup>
- Lower reproductive rates of salmon have been attributed to warmer water off the coast of BC;
- Warming sea surface temperatures have been linked to a reduction in marine productivity, as well as the marine distribution and migration patterns of salmon;
- There is a possible link between rising sea surface temperatures and the observed decline in Cassin's auklet.

Perhaps the most apparent biological response to climate change in BC is the prolific expansion of the mountain pine beetle (MPB) infestation.<sup>55</sup> The mountain pine beetle is a native species inhabiting forests from northern Mexico to British Columbia that consumes tissues beneath the bark of pine tree species. Within a small spatial and temporal scale, the damage inflicted by the MPB is usually manageable. However, beetle populations may intermittently expand their range and populations, killing millions of trees over a large land area. The mountain pine beetle has infested BC forests in the past; however, the current outbreak is 10 times larger than any previous infestation.<sup>56</sup> Two conditions produce an environment conducive for the proliferation of the mountain pine beetle:<sup>57</sup> an abundant supply of large, mature pine trees inhabiting BC forests, and consistently warm summers and mild winters. Historically, BC forest management practices have engaged in fire suppression that favours the protection of mature (approximately 80 years old) lodge pole pines. These management practices are primarily responsible for sustaining a mature pine forest three times larger than existed in any other period of the last century.

Climate is a key determinant for the survival and proliferation of the mountain pine beetle:<sup>58</sup>

- Warm summers allow beetles to reproduce and mild winters allow their offspring to survive;
- Hot and dry summers provide drought conditions that increase the susceptibility of pine trees to beetle attack;
- Consistent cold winter temperatures reduce or eliminate beetle reproduction.

Figure 6 shows that the range of MPB climate-suitable habitat has increased between 1951 and 2000, providing the MPB with a greater area to expand and the potential to inflict damage on a wider scale. The MPB has now infested 13.5 million hectares of BC forest in most areas of the province – Figure 7 provides an overview of affected areas.<sup>59</sup>

54 Compass Resource Management (2007)

55 Walker, I.J. & Sydneysmith, R. (2008)

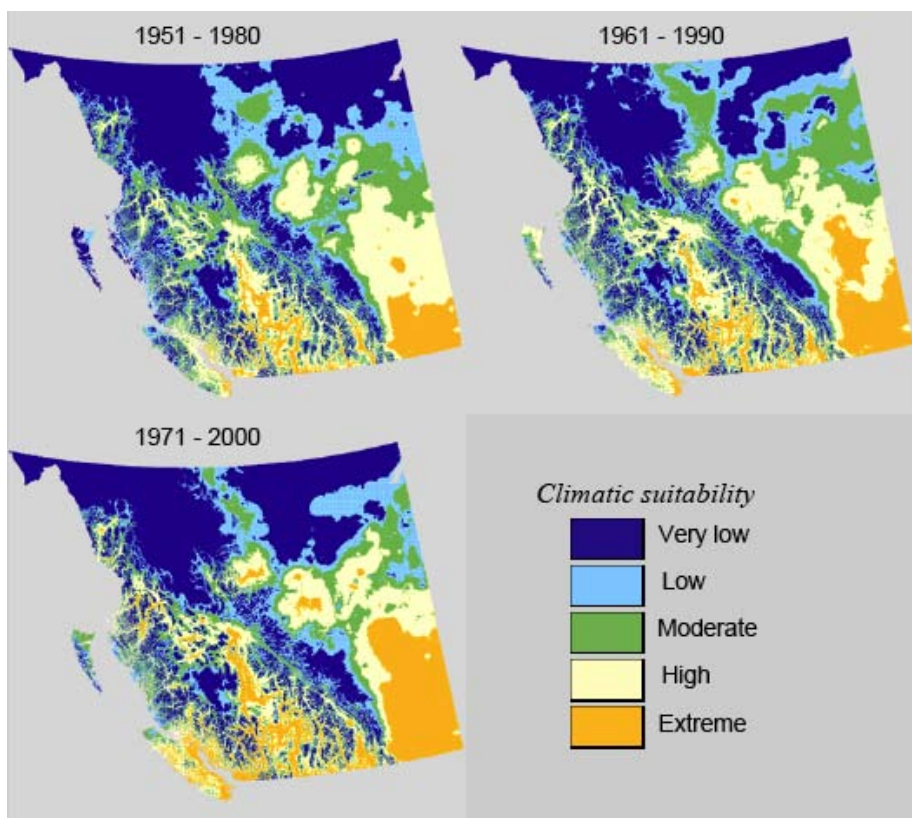
56 Walker, I.J. & Sydneysmith, R. (2008)

57 Walker, I.J. & Sydneysmith, R. (2008)

58 BC Ministry of Forests and Range. Mountain Pine Beetle Facts (2008)

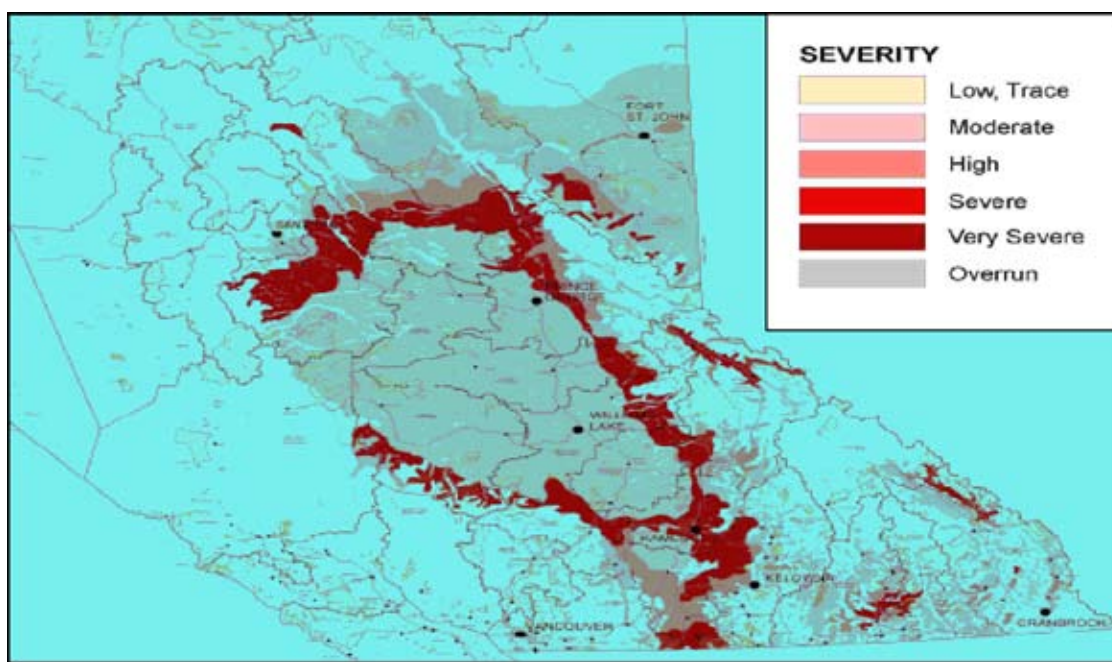
59 BC Ministry of Forests and Range. Mountain Pine Beetle Facts (2008)

**Figure 6: Historical distributions of climate-suitable habitat for the expansion of the mountain pine beetle in BC**



Source: Carroll, A.L., Taylor, S. W., & Regniere, J. (2004)

**Figure 7: Map of the mountain pine beetle infestation in British Columbia for 2007**

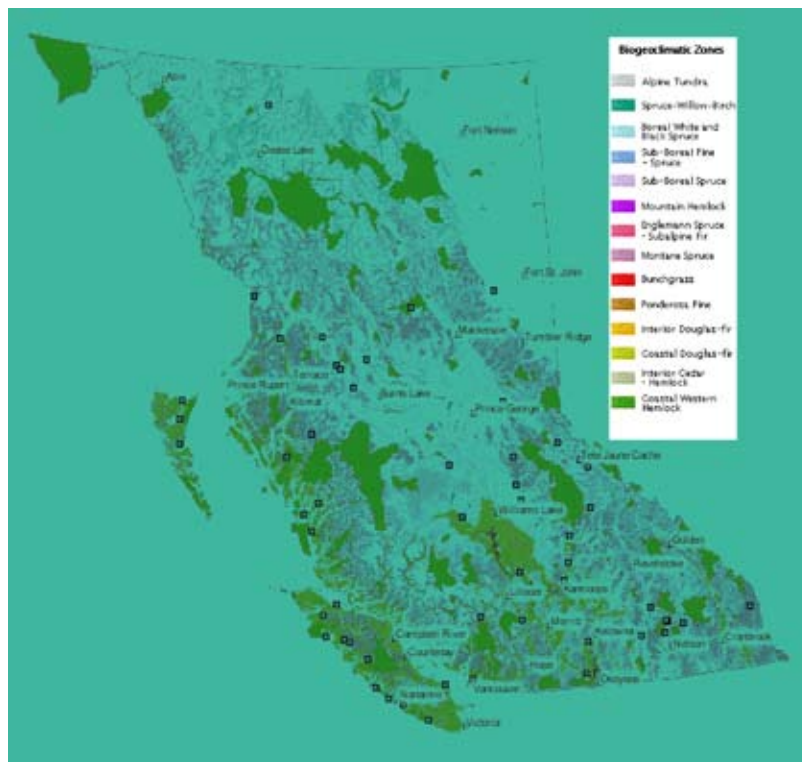


Source: BC Ministry of Forests and Range (2008)

### 3.1.5 PROJECTED CHANGES IN BRITISH COLUMBIA

In light of the lack of studies examining current observed biological responses to climate change, researchers in BC have applied different models to project climate change impacts for different ecosystems. Recent studies by Hamann and Wang (2006) provide an assessment for the potential impacts on terrestrial ecosystems categorized by biogeoclimatic (BEC) zones (see Figure 8). BEC zones are a classification system that divides BC into 14 zones and 97 subzones. A BEC zone is a geographical area with a relatively uniform macroclimate, characterized by a mosaic of vegetation, soils, and to a lesser extent animal life, reflecting that climate. A BEC zone may contain smaller vegetation and environmentally more uniform ecosystems (subzones) that reflect differences in regional climate, soil moisture, soil nutrient status, and environmental disturbance.<sup>60</sup> Table 12 provides an overview of the potential impacts at the level of BEC zones in response to regional climate change.

**Figure 8: Biogeoclimatic (BEC) zones in BC. Dark green areas overlapped on BEC zones represent protected areas.**



Source: BC Forest Information (2008)

60 Definition retrieved from <http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0000752>



**Table 12: Biogeoclimatic zones in BC: Projected changes under changing climatic conditions**

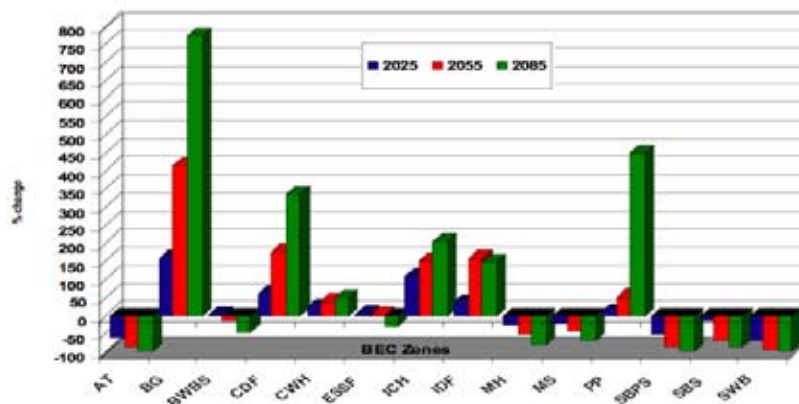
<b>COASTAL WESTERN HEMLOCK ZONE (CWH)</b>
Douglas fir may replace western red cedar as dominant tree species
Fire activity is likely to increase and provide a catalyst for the alteration of CWH to a Douglas fir-dominated forest
CWH will remain an intact forest; characteristics will likely change. Magnitude of change will depend on how an increase in precipitation will offset rising temperatures and rates of evaporation
Oceanic parts of the CWH, such as the west side of Vancouver Island and the central coast, are less likely to be affected
<b>COASTAL DOUGLAS FIR ZONE (CDF)</b>
Rapid expansion of the Coastal Douglas fir zone (an increase of 336%)
Zone was more extensive under warm and dry climatic conditions
Garry oak may increase substantially over next century under warm and dry conditions
<b>MOUNTAIN HEMLOCK ZONE (MHZ)</b>
Zone may potentially decline (79% decrease)
Warmer conditions may increase fire frequency and intensity
Decline in snow pack may exacerbate decline of this zone
Drought tolerant species such as Douglas fir may expand in this zone (Estimate provided by Hebda, R.H. (1997).
Hemlock will grow much better at higher elevations.
<b>COASTAL WESTERN HEMLOCK ZONE (CWH)</b>
Zone may experience a substantial increase in productivity as a result of warming
<b>BUNCHGRASS ZONE (BG)</b>
Climate impact models predict major expansion of grassland climate in the southern interior of BC in valley bottoms and contiguous lower slopes
Grasslands may expand by 150% by 2025; 400% by 2055; 800% by 2085
<b>INTERIOR DOUGLAS FIR AND PONDEROSA PINE ZONES (IDF &amp; PP)</b>
Potential for large increases in suitable climate for both zones and large increase for IDF zone throughout central BC as well as large increase for PP zone throughout Peace region
Rate of spread over large distances is uncertain
Increase in fire activity and pest outbreak may hinder expansion
<b>INTERIOR CEDAR – HEMLOCK ZONE (ICH)</b>
Review of fossil records projected decrease for zone; impact models estimate 200% increase by 2085
Projected decline in western red cedar in southern BC

<b>NORTHERN SPRUCE FOREST, SUB-BOREAL PINE SPRUCE (SBPS)/SUB BOREAL SPRUCE (SBS)/BOREAL BLACK &amp; WHITE SPRUCE (BWBS) ZONES</b>
Northern spruce forests projected to decrease by at least 50% by 2055 and 80% by 2085
Boreal forest (BWBS) projected to decrease by 50% by 2085
Fire frequency and pest outbreaks may perpetuate decline
Changes in forest will likely change ungulate populations
<b>MOUNTAIN SPRUCE AND ENGELMANN SPRUCE – SUB-ALPINE FIR ZONES (MS &amp; ESSF)</b>
ESSF expect to remain stable as gains in the north will offset losses in the south
Mid-elevation montane spruce zone expected to decline over course of century and be replaced by interior forest hemlocks and dry conifer forests
<b>ALPINE TUNDRA (AT)</b>
Climate-suitable areas for alpine ecosystems may decline by 60% by 2025 and 97 % by 2085
Treelines projected to rise by 168m by 2025 and 542m by 2085; alpine climates will likely persist Alpine and sub-alpine ecosystems situated in southern BC are especially vulnerable
<b>SPRUCE-WILLOW BIRCH ZONE (SWB)</b>
Northern sub-alpine zone may largely disappear by 2055
Zone may be the most affected area in BC
<b>GARRY OAK &amp; ASSOCIATED ECOSYSTEMS (GO)</b>
GO is not formally recognized as a BEC but merits consideration because it is an ecologically significant habitat for many species.
Large expansion of ecosystem expected – may spread up the coast to the Nass and Skeena river valleys in mountain rain shadows

Source: Descriptions derived from Wilson, S.J. & Hebda, R.H. (2008) and Hamman, A. & Wang, T. (2006)

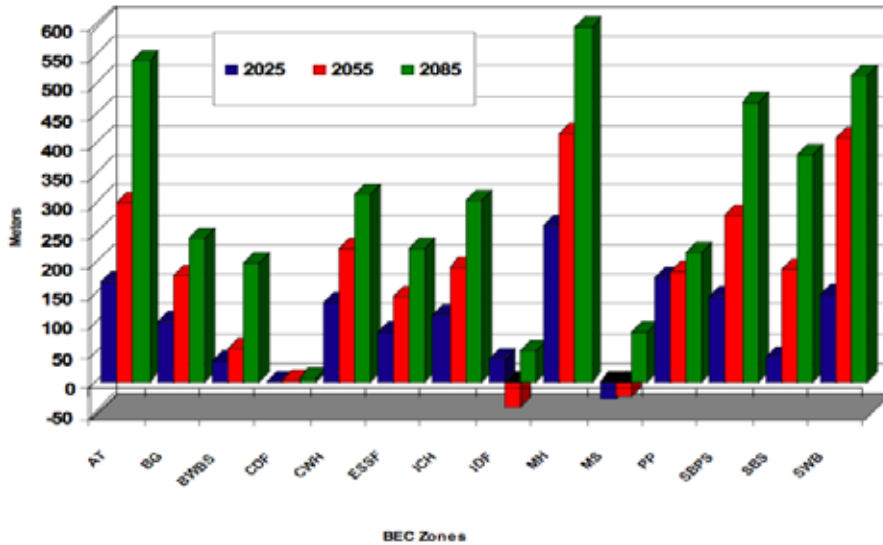
Researchers estimate that the climate envelope of BEC zones will shift their ranges northward in latitude, upward in altitude, and expand or contract their existing geographical boundaries. Figures 9–11 provide a graphical illustration of the projected changes in the area, altitude, and latitude of BEC zones for the years 2025, 2055, and 2085 in BC.

Figure 9: Projected area changes of BEC Zones for the years 2025, 2055, and 2085



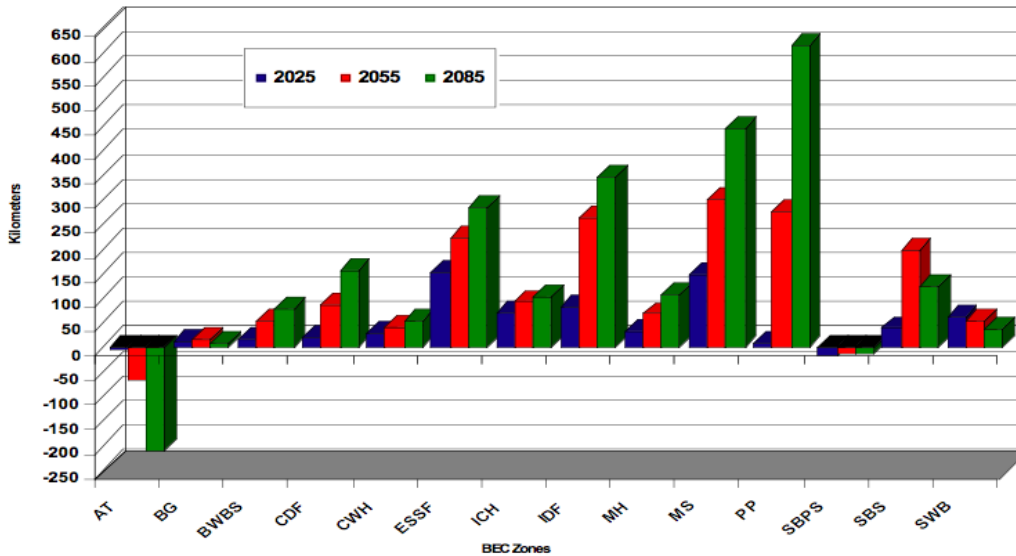
Source: Hamman, A. & Wang, T. (2006). Refer to Table 12 for abbreviations.

Figure 10: Projected changes in the distribution of BEC zones for the years 2025, 2055, and 2085. Climate change will shift the climate envelope of certain BEC zones upwards in elevation.



Source: Hamman, A. & Wang, T. (2006). Refer to Table 12 for abbreviations.

Figure 11: Projected changes in the distribution of BEC zones for the years 2025, 2055, and 2085. Climate change will shift the climate envelope of certain BEC zones northwards.



Source: Hamman, A. & Wang, T. (2006). Refer to Table 12 for abbreviations.

Biodiversity BC’s report “Taking Nature’s Pulse” provides a thorough assessment of the status of biodiversity in BC. The report compiled a list of projected changes attributed to regional climate change in species and ecosystems. Table 13 synthesizes the impacts specifically for terrestrial biodiversity.

**Table 13: Climate change impacts focusing on terrestrial biodiversity in BC**

PROJECTED IMPACT	DESCRIPTION
Increase in the frequency and intensity of insect pest outbreaks	Warmer temperatures increase number of growing degree days, which enhances the life cycle of forest pests.
Increase in the frequency and intensity of extreme weather events	Fires, droughts, and storms projected to increase, consequently damaging BC forests.
Large mammals' ranges expected to shift	Ecosystems expected to shift 500-600m upwards in elevation in Glacier and Mt. Revelstoke National Parks – this may alter competitive species interaction.
Wetlands may become inundated	An increase in runoff from glacial melt may inundate wetland areas in Glacier and Mt. Revelstoke National Parks.
Expansion of invasive species	Warmer temperatures will provide suitable habitat for invasive species to expand their range. The Russian thistle and knapweed are expected to expand their range in Kootenay National Park.
Reduction of available salmon will negatively impact terrestrial species	Warmer sea temperatures will enhance competitors of salmon and increased runoff could impact spawning beds. Bears and eagles in Gwaii Haanas National Park Reserve will be adversely impacted as a result.
Loss of native riparian vegetation	Warmer temperatures may reduce water tables, potentially adding water stress to riparian vegetation with poor drought resistance.
Potential extirpation of shorebirds	Sea level rise and extreme weather events may be destructive to shorebird nesting sites. Nest loss due to flooding is expected to increase in the Georgia depression.
Reduction in food for seabirds	Increased runoff and precipitation will increase coastal water turbidity, reducing the availability of fish in areas fed on by piscivorous shorebirds. Plants foraged on by other seabirds may be submerged to deeply for access due to sea level rise.
Two identified species – streaked horned lark and alpine anemone – are likely to be extirpated in the Lower Mainland; six others may experience range shifts.	Climate change may reduce the availability of habitats and act synergistically with other stressors such as habitat loss occurring due to other factors.
Rare mosses will undergo range contraction and possibly be extirpated	Drier summer conditions in BC could reduce the suitability of coastal forests as habitat for rare mosses and other bryophytes. These may undergo range expansions into the Yukon.
Cold-blooded invertebrates will shift ranges or face extirpation	Cold-blooded species will be vulnerable to projected changes in temperature. If these species are unable to migrate to climate-suitable habitat, they will face extirpation.
Increase in new parasites and diseases	Warmer temperatures will provide suitable habitat for parasites and diseases that were previously limited by colder temperatures.
Ungulates may experience range and abundance shifts	Warmer temperatures are expected to result in snow that is denser and more difficult for ungulates to travel through. This could alter ungulate distributions.
Small mammals may experience range expansion or contraction	Small mammals at the northern limit of their range in BC are likely to expand their ranges and benefit as a result of warmer temperatures. Those at the southern limit of their ranges may be able to colonize habitats at higher altitudes.
Treeline shift	Alpine tundra ecosystems are expected to shift higher with corresponding loss of populations and species.
Shrinkage of wetland area in southern and central interior BC	With moisture loss, wetland areas in southern and central BC are expected to shrink. Native species may decline or be extirpated, allowing invasive weeds to thrive.

Source: *List of Impacts Adopted from Biodiversity BC. Major Impacts: Climate Change. Compass Resource Management, May 2007. Identified impacts are only a select list that focuses on terrestrial species. Please refer to original report for an exhaustive review.*

## 4. ADAPTATION TO CLIMATE CHANGE

### 4.1 UNDERSTANDING CLIMATE CHANGE ADAPTATION POLICIES

Mitigation and adaptation are the primary policy responses for management of current and future risks associated with climate change, and related impacts on human, built, and natural environments. Mitigation refers to the reduction in atmospheric concentration of greenhouse gases and aerosols to a level that does not dangerously interfere with the climate system.<sup>61</sup> Adaptation to climate change refers to actual public policy adjustments and changes in the decision-making process with the objective of reducing vulnerability or enhancing resiliency in response to observed or expected changes in climate, extreme weather events, and associated impacts on physical, biological, and socioeconomic sectors.<sup>62</sup> The purpose of adaptation policy is to reduce or avoid damage, minimize risks, and exploit beneficial opportunities. Adaptation responses take place in the physical, biological, and socioeconomic realms, which involves transforming social, political, economic, and environmental practices that are consistent with a new climate paradigm.

Adaptation is the process whereby people, communities, businesses, governments, and entire societies explore options that will help them cope with the impacts of climate change along with additional human-driven stressors. Adaptation is not a new planning process. Since time immemorial, individuals and societies have adapted to changing social, economic, and environmental conditions. What is new is the concept of formally institutionalizing adaptation strategies in policy development and government decision-making.<sup>63</sup> The logic behind pursuing adaptation responses to climate change is the growing realization that climate change is undeniably occurring; leading researchers have observed and documented global and regional impacts on our built, natural, and socioeconomic systems; CO<sub>2</sub> emissions are already higher than those used to project the IPCC’s worst case scenarios; and in the absence of any concrete national and international measures to reduce or stabilize global emissions, GHG atmospheric concentration will continue to rise.<sup>64</sup> Adaptation planning is particularly relevant in BC because of the vast stock of natural capital used to support economic activity and provide a significant source of public revenues; in addition, BC is one of the most biologically rich and diverse regions in North America. Before discussing major elements of adaptation and vulnerability assessments, it is useful to clarify some key concepts (see Table 14).

**Table 14: Definition of key concepts: Vulnerability, resilience, and adaptive capacity**

Vulnerability	The degree to which a natural or human system is susceptible to or unable to cope with adverse effects of climate change and additional human-induced pressures. The vulnerability of a system is determined by the magnitude and rate of climate change to which a system is exposed, its sensitivity, and its adaptive capacity.
Sensitivity	The degree to which a system is affected, either adversely or beneficially, by a climate-related stressor or human-induced pressure.
Resilience	The amount of change a system can undergo without changing state, or the degree to which the system is able to rebound or recover from a stressor or driver.
Adaptation	Refers to adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects and/or impacts.
Adaptive Capacity	The ability of a system to adjust to climate change and moderate potential damages, take advantage of opportunities, or cope with the consequences.

Source: Munasinghe, M. & Swart, R. (2005)

61 United Nations Framework Conventions on Climate Change (2008).

62 Adger, W.N. (2007)

63 UNDP (2005)

64 Burton, I. et al. (2002)

We examine the vulnerability of a system by assessing its sensitivity to climatic changes and capacity to adapt. Vulnerability is essentially “a function of the magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”.<sup>65</sup> Adaptive capacity is a central feature in the design and implementation of adaptation policy because it is an expression of a system’s ability to respond successfully to climate change. Adaptation refers to policy intervention, with the objective of reducing adverse impacts or exploiting beneficial consequences induced by climate-related stressors on human and/or natural systems, in the form of direct government legislation, regulations, planning, and policy processes.

## 4.2 FRAMEWORK FOR THE IDENTIFICATION AND EVALUATION OF KEY VULNERABILITIES

Formulating adaptation policies that address or minimize climate change impacts requires a basic understanding of what constitute key vulnerabilities. All systems (physical, biological, socioeconomic) are to a certain extent vulnerable to climate change impacts. Deciding what impacts are more salient or deserve more attention relative to others is primarily based on objective assessments (i.e. based on measurable scientific data), but the decision-making process also contains highly subjective elements (i.e. our judgments are based on values). We must decide and select which components of that system we consider “key”. In other words, which vulnerabilities do we consider the most salient that merit a policy response (i.e. adaptation)? We suggest we explore this question because this will essentially guide the analysis – our policy problem asks the question, “Why are we doing this? Why are we addressing these vulnerabilities, relative to others?” Policy makers need to design and apply a defensible framework that supports their decisions. In other words, an evaluation framework would assist decision makers with identifying and evaluating the degree to which physical, biological, and socioeconomic systems are susceptible to climate change, and narrow down which vulnerabilities and risks merit particular attention.

Several factors may help us to clarify or define what we mean by key vulnerabilities. We need to elucidate this concept and develop a framework that establishes these boundaries. The IPCC completed some work on this and in doing so devised a generic framework; we may incorporate some elements of this and modify, add, or remove some aspects depending on which policy context is under consideration. Table 15 illustrates a set of criteria with brief descriptions that analysts may use to identify key vulnerabilities and allow us to systematically evaluate their salience. It is important to recognize that the assessment of vulnerabilities to climate change is highly variable across different sectors and communities. Adaptation policies specifically designed to reduce vulnerabilities for a specific sector or community will therefore not be applicable for all situations. Vulnerability assessments and the subsequent design of adaptation strategies are generally context-specific. For example, a community with an economic base that is largely reliant on the forest industry will experience different vulnerabilities than one with a diversified economic base such as the Lower Mainland.

65 Munasinghe, M. & Swart, R. (2005)

**Table 15: Key Vulnerability Assessment Framework**

CRITERIA	DESCRIPTION
Magnitude of impacts	The magnitude of an impact is determined by scale and intensity. An impact is considered to be key if it crosses geographical boundaries at an accelerated rate relative to isolated impacts that develop slowly
Timing of impacts	Dangerous impacts emerging in the near future merit immediate consideration relative to impacts developing in the distant future
Likelihood/probability	An impact is considered to be key if it has a higher likelihood of unfolding relative to other impacts
Potential for adaptation (i.e. adaptation capacity)	The lower the availability and feasibility of effective adaptation to climate change impacts, the more likely such impacts will be considered “key vulnerabilities”
Importance of the system at risk	The degradation of an ecosystem affecting the well-being of large populations may be considered key relative to an isolated system at risk affecting sparsely populated communities
Distributional impacts	Vulnerabilities that negatively affect different regions, sectors and demographics with equal intensity will in all likelihood be regarded as key compared to an isolated disturbance (one affected sector experiencing profound impacts may hold a disproportionate level of political clout)
Persistence and reversibility of impacts	Harmful impacts that are persistent or not easily reversible will likely attract more attention relative to impacts that are easily managed

Source: Schneider, S.H. (2007)

### 4.3 VULNERABILITY OF NATURAL AND SOCIOECONOMIC SYSTEMS

Using the key vulnerabilities assessment framework (Table 15), the IPCC considers terrestrial ecosystems and biodiversity as key vulnerabilities<sup>66</sup> based on the irreversibility, magnitude, low adaptive capacity, persistence, rate of change, and confidence of the impacts,<sup>67</sup> concluding with very high confidence that many ecosystems are already affected by global temperature increases.<sup>68</sup> At this time, there is no comprehensive assessment of key vulnerabilities for climate change-induced impacts to ecosystems and biodiversity in BC using a systematic evaluation framework such as that depicted in Table 14. However, there is growing research that identifies climate change impacts to major ecosystems and socioeconomic sectors in BC. The information summarized below is a valuable starting point to identify key vulnerabilities.

#### 4.3.1 FORESTS AND FORESTRY

British Columbia contains approximately 60 million hectares of forest and ranges that provide a suite of resources for human and natural uses. The forest industry harvests approximately 0.3% of BC forests annually and the supply of BC wood products for the next 50–100 years is already planted, with little consideration of climate change impacts.<sup>69</sup> In fact, fire protection is the only forest management practice in place.<sup>70</sup> Forests provide habitat for aquatic and terrestrial wildlife, recreational areas, reserves for endangered species, and cultural and spiritual uses. Moreover, BC forests provide natural resources for human uses: wood-based products such as lumber, paper, and other harvestable products such as mushrooms, berries, and botanicals. There is a profound connection between BC forests and range and First Nations

66 Schneider, S.H. (2007)

67 Schneider, S.H. (2007)

68 Schneider, S.H. (2007)

69 Spittlehouse, D.L. (2008)

70 Walker, I.J. & Sydneysmith, R. (2008)

communities across BC; forests provide a valuable natural resource base that supports economic opportunities, fulfils many spiritual and cultural traditions, and is a key asset used in land and treaty negotiations.

British Columbia’s forest industry generates over \$18 billion in annual sales revenues, which constitute 13% of BC’s gross domestic product (GDP) and 43% of BC’s total manufacturing shipments.<sup>71</sup> Industry operations provide over \$3.732 billion total payments to governments and employ over 234 000 workers.<sup>72</sup> BC’s forest industry is at the epicentre of the provincial economy. Disruptions in the industry will almost certainly have adverse economic implications felt on a province-wide scale, especially in rural communities where the bulk of the industry operates. This explains why we consider the industry a key vulnerability to climate change impacts. Climate change will likely affect BC’s forest sector in terms of productivity, access to timber and harvest, reforestation, and forest disturbance regimes (see Table 16).

**Table 16: Projected impacts on BC’s forest sector**

PRODUCTIVITY
Losses in productivity are expected to occur in warmer and drier regions of the south while modest gains are expected in the north
Climate change will likely alter optimal growth conditions for tree species and local populations Changes will likely alter rotation age, wood quality, wood volume, and size of logs
Technological change, trade disputes, exchange and interest rate fluctuations, combined with changes in consumer preferences, will alter productivity along with climate change stressors
BC’s international competitors, such as the South American and Oceanian forest industries, will likely experience production benefits as a result of climate change further stressing BC’s forest sector
ACCESS TO TIMBER AND HARVEST SCHEDULES WILL CHANGE
Warmer and/or wetter winters will likely limit site access for winter logging
Warmer and/or drier summers will likely limit access due to increased fire hazards
Expected higher rainfall intensities will impact road maintenance and road design
An expected increase in extreme weather events on the coast will increase the probability of mud slides and debris flow
Projected increase in warming in the north will likely increase permafrost melt and risk of landslides
REFORESTATION
Selection of species and genotypes is based on climate and soil; changing climate therefore infers changing plants for appropriate sites
Tree species with northern range limits could gain climate-suitable habitat at a rate of 100km per decade
Common hardwood appear to be less sensitive to climate change; conifer species may lose a large portion of climate-suitable habitat
Increases in competition from species more suited to changing climate will require an increase in current stand management activities
DISTURBANCE REGIMES
Wildfires and pest outbreaks will likely impact BC forests more greatly than the effects of changes in tree species and productivity
Age distribution of BC forests is skewed towards older trees, making them more susceptible to pest and fire disturbances
Increase in disturbances will lead to younger forests, affecting forest growth, species composition, and wildlife habitat
Changes in fire regimes will likely affect the safety of people and property

Source: Spittlehouse, D.L. (2008)

71 Council of Forest Industries (2007), estimates for 2004

72 Council of Forest Industries (2007), estimates for 2004



### 4.3.2 WETLANDS

Wetland ecosystems perform biochemical, hydrological and ecological functions. They: purify water resources by retaining excessive nutrients and preventing other pollutants from entering aquatic bodies; provide natural flood protection by regulating water flows; maintain the quality and quantity of water resources by recharging surface and groundwater supplies; provide habitat for plant and animal species, many of them endangered; and sequester carbon.<sup>73</sup> Changes to wetland ecosystems will likely be altered through changes in hydrology, temperature, and land uses.<sup>74</sup>

Temperature and precipitation are the climatic parameters most likely to affect the hydrology of individual wetlands.<sup>75</sup> The hydrology of bogs is most dependent on precipitation, and to some extent groundwater recharge. An increase in evaporation rates and a decrease in precipitation rates may be the main factor contributing to ecosystem change. Unlike bogs, wetlands such as fens, marshes and floodplains receive additional water inputs from surrounding water basins. Climate change impacts on these wetland ecosystems should be assessed within the broader hydrological context of the surrounding water basin. Changes in the input sources external to the wetland itself are an important factor to consider when determining climate change impacts. Temperature controls different physiological and functional aspects of wetland ecosystems. Rising climatic temperatures will likely contribute to the drying of wetland ecosystems and likely affect ecosystem functions. However, few studies exist to substantiate this claim. It is currently unclear which wetlands are the most vulnerable and how ecosystem functions will be affected.<sup>76</sup>

Despite the lack of evidence available to enable efficient assessment of climate change impacts on wetland functional services, sufficient knowledge does exist about the carbon storage capacity of BC's peatlands – a type of wetland that contains thick deposits of peat. Peatlands cover approximately 6% (5.4 million hectares) of BC's total land base, mostly situated in the boreal and sub-arctic regions of the province.<sup>77</sup> BC's peatlands store an estimated 6.8 billion tonnes (Gt) of carbon and sequester an estimated 1.5 million tonnes of carbon per year.<sup>78</sup>

### 4.3.3 GRASSLANDS

The Okanagan valley is considered one of the most biologically diverse areas in Canada, providing habitat for 23 plant and animal species that are federally listed as endangered, threatened, or species of concern.<sup>79</sup> Grassland ecosystems are vulnerable to human-induced stressors such as agricultural activities and urban development; an estimated 16% of BC's grasslands have already been converted for alternative land uses.<sup>80</sup> Even though a large proportion of BC grasslands remains intact (approximately 84%), 90% of these continue to be stressed by overgrazing, grazing by domestic livestock, and intrusion of invasive species.<sup>81</sup>

There is a high probability that BC's south-central interior grasslands will expand their range under future climate change conditions.<sup>82</sup> Paleo-ecological studies suggest that changing climate scenarios, such as warmer and drier summers, will cause a reduction in the number of tree species within ponderosa pine (PP) and interior Douglas fir (IDF) forest ecosystems, and an increase in grasslands and juniper woodland ecosystems.<sup>83</sup> This expansion of grasslands will likely increase the frequency and intensity of wildfire outbreaks. Climate change will also influence the composition and productivity of grassland ecosystems, and may produce conditions that facilitate the proliferation of invasive grass

73 Brouwer, R., Langford, I.H., Bateman, I.J. & Turner, R.K. (1999)

74 Wilson, S.J. & Hebda, R.H. (2008)

75 Fischlin, A. et al. (2007)

76 Fischlin, A. et al. (2007)

77 Wilson, S.J. & Hebda, R.H. (2008)

78 Wilson, S.J. & Hebda, R.H. (2008)

79 Hebda, R.H. (2007)

80 Wilson, S.J. & Hebda, R.H. (2008)

81 Wilson, S.J. & Hebda, R.H. (2008)

82 Hebda, R.H. (2007)

83 Hebda suggests IDF and PP zones will drastically reduce their range, decreasing the diversity of tree species. Keep in mind that Hamman, A. & Wang, T. (2006), and Wilson, S.J. & Hebda, R.H. (2008) project substantial expansion for both IDF and PP BEC zones.

species over traditional sagebrush communities. Physiological projections suggest that a warmer and drier climate may drive reductions in mammal and bird species and gains in reptile and amphibian communities.

Grassland ecosystem functions provide important environmental goods and services such as soil conservation, habitat for diverse plant and animal species, and genetic resources.<sup>84</sup> Moreover, grasslands capture large amounts of carbon in their soils – the conversion of native grasslands to agricultural lands contributes an estimated 8–20 tonnes of CO<sub>2</sub> per hectare.<sup>85</sup> Extensive use of grasslands for a variety of human uses along with climate change-related stressors would likely reduce the resiliency of grassland ecosystems, even with the projected expansion of their range. This may jeopardize the quality and quantity of environmental goods and services (e.g. carbon sequestration) provided for the benefit of BC communities.

#### 4.3.4 MOUNTAINS AND ALPINE REGIONS

BC's alpine and mountain ecosystems are particularly vulnerable to climate change due to their limited geographic range.<sup>86</sup> Many tree and animal species respond to a warming climate by shifting their range upwards in elevation. However, the loss of suitable climate habitat combined with a limited geographic range could potentially drive the first extinctions of species and/or reduce substantial habitable areas. For example, pikas in the western United States have already experienced large population extinctions at their lower mountain elevational boundaries, induced by climatic stressors.<sup>87</sup> The projected decline in climate-suitable habitat for alpine regions in BC is 60% by 2025 and 97% by 2085 (see Table 11). The Canadian Rockies on the Alberta/British Columbia border experienced an estimated 25% decrease in glacier coverage and an upslope increase in alpine treeline levels in the 20<sup>th</sup> century.<sup>88</sup> In British Columbia, glaciers are receding more rapidly than at any other time in the past 8000 years; snow packs have also shown a significant decrease in the last 50 years.<sup>89</sup> These two impacts have serious implications for existing and future water demands associated with energy, agriculture, residential and industrial consumption, wetlands, and riparian area ecosystems. Recent recession of glaciers has also caused an increase in physical hazards to populations and development in communities situated in alpine and mountain areas,<sup>90</sup> including avalanches, landslides, slope instability, floods from moraine- and glacier-dammed lakes, and altered channel and floodplain patterns of rivers draining mountain ranges. The full extent of climate change impacts on alpine ecosystems is not thoroughly documented and current research exploring these linkages is still in its infancy.<sup>91</sup> However, we are acutely aware that alpine environments are particularly vulnerable to climate change.

#### 4.3.5 TOURISM AND RECREATION

BC's tourism sector generates \$9.4 billion (2004) in annual revenues and employs 117 000 workers (7% of BC's total employment), making it the second largest economic sector next to forestry.<sup>92</sup> Tourists are attracted to a number of destinations across BC, from urban centres such as the Vancouver metropolitan area and the capital regions of Victoria, to the vineyards and lakes of the Okanagan, the surf and ancient old-growth forests of western Vancouver Island, and the numerous ski and golf resorts proliferating from the Coast Mountains to the Selkirk range. The abundance of wild and natural landscape enables backcountry outfitters to provide a wide range of wilderness-based tourism opportunities: heli- and cat-skiing, fishing, hunting, snowmobiling, hiking, wildlife viewing, rafting, etc. Wilderness-based tourism contributed \$1.55 billion in revenues in 2001, with most of the activities occurring in parks, protected areas, and resort destinations. Climate change impacts on the tourism industry will vary according to region, season, and tourist activ-

84 Wilson, S.J. & Hebda, R.H. (2008)

85 Wilson, S.J. & Hebda, R.H. (2008)

86 Pauli, H., Gottfried, M. & Grabherr, G. J. (2003)

87 Parmesan, C. (2006)

88 Luckman, B. & Kavanagh, T. (2000)

89 Wilson, S.J. & Hebda, R.H. (2008), and Walker, I.J. & Sydneysmith, R. (2008)

90 Evans, S.G. & Clague, J.J. (1994)

91 Parmesan, C. (2006)

92 Walker, I.J. & Sydneysmith, R. (2008)

ity. Drier conditions in BC's southern interior have already created drought conditions and wildfires, closing major transportation routes and devastating orchards and vineyards, as well as affecting visitation rates to vineyards, orchards, and regional accommodation.

#### 4.3.6 PARKS AND PROTECTED AREAS

BC currently has 893 parks and protected areas, covering 13.8% or 13.09 million hectares of the province's land area.<sup>93</sup> Assessment of climate change implications from shifting BEC zones, species migration, and changes to ecosystem integrity, is still in its infancy. Recreational activities, park operations, research, and traditional First Nations practices are the predominant uses currently occurring within parks and protected area boundaries. The following climate change impacts have the potential to alter these uses of parks and protected areas:<sup>94</sup>

- Rising temperatures will induce decline and fragmentation of subalpine and alpine ecosystems;
- An increase in extreme weather may potentially increase impacts of natural hazards such as avalanches, droughts, windstorms, storm surges, and landslides;
- Species migration and competition from invasive species will impact biodiversity and population sustainability;
- Most vulnerable parks and protected areas are located in or in close proximity to areas experiencing elevated development pressures and concentrated human activities.

#### 4.3.7 FIRST NATIONS COMMUNITIES

Spiritual and cultural values are important defining characteristics for the social fabric of many First Nations people and communities. However, the simplification of ascribing spiritual and cultural values as the dominant concerns of First Nations' communities underestimates the potential implications that climate change impacts may have for the current and future welfare of First Nations communities in BC, and the state of the new relationship between BC's First Nations and the provincial government.

The Government of BC has a lawful obligation to consult with aboriginal groups when issuing decisions affecting the management of provincial lands and resources within the traditional territory of First Nations groups. If a provincial government decision infringes on aboriginal rights and interests, the Crown must reasonably accommodate the infringement of those rights and interests. An important element of the consultation and accommodation process is the requirement that the provincial government engage in and negotiate an agreement with First Nations communities in good faith – which implies government must inform itself about the potential impacts an activity may have on aboriginal rights and interests. An activity that reduces the resiliency of ecosystems must therefore be determined within the context of projected changes to climatic conditions. Precluding this information may disrupt the negotiation process, resulting in costly litigation and delays.

The BC government is currently engaged in treaty negotiations with a variety of First Nations groups. The three major treaty provisions subject to negotiation are the disposition of land and resource interests (ownership, prescribed and prohibited uses of property, extractable resources); the rights to self-government (form and operate a government independently); and traditional rights such as hunting and gathering. Treaty negotiations often result in massive land and resource transfers from Crown agency control to First Nations governments. The negotiated quantity and allowable uses of the land-base under consideration is usually determined by the productive value of the property asset. A common method to assess land values is to calculate the potential stream of future benefits derived from using that land within its designated uses. If an assessor appraises a parcel of land under certain assumptions, and climate change effectively nullifies or changes those assumptions, the initial assessment will likely provide an inaccurate value of the negotiated land agreement. Reopening final agreements to modify particular clauses of an agreement, or settling disputes through costly litigation, may strain future relations between the BC government and First Nations communities, and undermine the

93 BC Ministry of the Environment (2008). <http://www.env.gov.bc.ca/bcparks/facts/stats.html>.

94 Spittlehouse, D.L. (2008)

tripartite treaty process. Provincial government and First Nations negotiators should therefore consider the vulnerability of ecosystems and their adaptive capacity under changing climate scenarios in order to accurately calculate productive land values used in contemporary settlement agreements, interim measure agreements, and land agreements.

#### **4.4 OVERVIEW OF ADAPTATION POLICY FRAMEWORK**

Adaptation to climate change is a policy process whereby strategies are developed and implemented to minimize and cope with the negative consequences and take advantage of any beneficial consequences of climate change.<sup>95</sup> Designing adaptation strategies is a long-term, iterative policy process that requires the diligent application of systematic methods. The fundamental objective of climate change adaptation policies is synonymous with environmental or sustainable development policies: to increase the resiliency of natural systems to a variety of natural and/or anthropogenic stressors in order to preserve a consistent stream of environmental goods and services for the collective benefit of communities. Furthermore, the policy development process shares similar basic characteristics with environmental or sustainable development policies. First, identify and prioritize vulnerable natural and socioeconomic systems and explore the conditions contributing to their vulnerability; second, estimate the probable environmental and socioeconomic consequences under a range of climate and development scenarios; third, formulate alternative adaptation options that address vulnerabilities and enhance opportunities. The process then assesses adaptation options using a systematic evaluation framework that incorporates the key principles of “smart” adaptation objectives: increasing resiliency and adaptive capacity, and reducing vulnerabilities. The final stage is to select a governing body that will be accountable for the implementation, monitoring, and enforcement of policy options.

All these steps require deeply complex analysis, and policy evaluation frameworks will vary according to sector and political jurisdiction. In 2005, the United Nations Development Programme (UNDP) released a technical report that offers a comprehensive adaptation policy framework which policy makers could use as a planning guide to design, evaluate, implement, and monitor adaptation policies for a wide range of sectors at the provincial or local government level. We provide an overview of the suggested steps and components involved in the adaptation policy process below.<sup>96</sup> It is worth noting that the successful application of an adaptation policy framework is reliant on integration of stakeholder engagement at every step of the process, which implies seeking stakeholder involvement during every stage of the process.

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95 UNDP (2005)

96 UNDP (2005)

## Step 1: Scoping and designing a scenario-based adaptation framework

### OBJECTIVES

Ensuring that a policy, plan or project at any scale or scope is well-integrated into national policy planning and development processes. The purpose is to put in place an effective plan so that adaptation strategies, policies, and measures can be implemented effectively.

### GUIDING QUESTIONS

1. What are the future climate change risks?
2. What is the development objective or outcome sought? What is the scope for the policy, plan or project and what are the priority systems?
3. What key policy processes are related to this objective?
4. What groups are particularly threatened by climate change and how can they engage in the policy, plan or project design process as stakeholders?
5. What information is available related to current and future climate change vulnerability and hazards, and what does this information suggest about policy, plan, or project risks and responses (a preliminary overview)?
6. What is the proposed approach and method for the policy, plan or project formulation (hazards-based, vulnerability-based, adaptive capacity, or policy-based)?
7. What is the policy, plan, or project outline and plan?

### ACTIONS

- Clarify objectives and scope of the policy, plan or project.
- Establish a stakeholder process.
- Review available information on vulnerability and adaptation.
- Outline the policy, plan or project.

## Step 2: Assess current vulnerabilities within the context of socioeconomic and environmental objectives

### OBJECTIVE

Establishing the baseline - Where does the system stand today with respect to vulnerability to climate risks? What are the factors that determine current vulnerability? How successful are efforts to adapt to current climate risks? Current methods for coping with climate risks should be built upon in the policy, plan or project, and existing factors of vulnerability addressed.

### GUIDING QUESTIONS

1. What are the current major climate-related hazards?
2. What are the current major impacts/outcomes of these climate-related hazards?
3. What currently determines the type and severity of the impacts/outcomes (vulnerability)?
4. What measures and policies currently relate to relevant climate risks, impacts and selected development outcomes? How effective are they? Do development policies increase these risks?

### ACTIONS

- Assess current climate risks and impacts (relevant to the policy, plan or project).
- Establish current socioeconomic conditions.
- Assess current vulnerability of the relevant system.
- Assess current adaptive capacity/adaptation.
- Assess current policies related to climate risk and vulnerability and policy needs.

**Step 3: Assess future climate change risks to socioeconomic and environmental objectives**

OBJECTIVE
Focus on the analysis of scenarios of future climate, vulnerability and socioeconomic and environmental trends as the basis for understanding future climate risks. The policy, plan, or project design should consider both current as well as future risks and vulnerability.
GUIDING QUESTIONS
<ol style="list-style-type: none"> <li>1. How is the priority system sensitive to climate change?</li> <li>2. What is the relevant planning horizon (10, 20, 50 years)?</li> <li>3. What are the trends (observed) and projected (future) major climate-related hazards? Over what time scale? What is the range of severity of these hazards (accounting for uncertainty)?</li> <li>4. What future socioeconomic or other factors will determine the type and severity of the impacts/outcomes? (Future vulnerability based on socioeconomic scenarios).</li> <li>5. What are the projected impacts/outcomes of these hazards (based on selected scenarios and impact models)?</li> <li>6. What are the barriers to, and opportunities for, adaptation? What aspects of national decision-making processes pose barriers or present opportunities for integrating climate change risks (e.g. institutional arrangements and authority, participation, and decision-making pathways)?</li> </ol>
ACTIONS
<ul style="list-style-type: none"> <li>• Identify relevant climate variables and assess trends (observed) and projections (modeled) (e.g. temperature, precipitation, stream flow, growing season, min. temperature, etc., depending on the system).</li> <li>• Assess socioeconomic trends (relevant to the policy, plan or project).</li> <li>• Assess trends in natural resources and environment, including anthropogenic drivers of environmental stresses.</li> <li>• Assess barriers to adaptation to climate risks and opportunities for adaptation.</li> </ul>

**Step 4: Formulate an adaptation strategy**

OBJECTIVE
In response to current and future vulnerability and risks, policy options and measures should be identified and selected, and from the options, a cohesive, integrated policy, plan or project strategy developed.
GUIDING QUESTIONS
<ol style="list-style-type: none"> <li>1. What are the existing methods for managing climate risks and adaptation? Are these viable in the future; can they be built upon?</li> <li>2. What other interventions can be utilized to reduce impacts and improve development outcomes?</li> <li>3. Can these adaptation interventions be undertaken? What are the barriers?</li> <li>4. What are the costs, impacts and barriers of each option (based on agreed criteria)?</li> <li>5. How do the options compare through ranking?</li> <li>6. What suite of policies and measures constitutes a cohesive approach to development and adaptation?</li> </ol>
ACTIONS
<ul style="list-style-type: none"> <li>• Synthesize previous steps, studies and existing adaptation options.</li> <li>• Identify policy, plan or project options for adaptation, characterize costs, benefits, and barriers of each.</li> <li>• Prioritize and select policy, plan or project options for adaptation.</li> <li>• Formulate an adaptation strategy.</li> </ul>

**Step 5: Continuing the adaptation process through monitoring and evaluation**

<b>OBJECTIVE</b>
Involves implementing, monitoring, evaluating, improving and sustaining initiatives launched by the adaptation policy, plan or project.
<b>GUIDING QUESTIONS</b>
<ol style="list-style-type: none"> <li>1. What are the channels for integrating the policy, plan or project into development plans and policies? What barriers exist, including capacity?</li> <li>2. What are the necessary management, oversight, implementation and support structures?</li> <li>3. What are the indicators of progress, and over what time scale and how should they be tracked?</li> <li>4. What is the strategy for reviewing, monitoring and evaluating impacts?</li> </ol>
<b>ACTIONS</b>
<ul style="list-style-type: none"> <li>• Incorporate adaptation policies and measures into development plans.</li> <li>• Implement the adaptation strategy and institutionalize follow-up.</li> <li>• Review, monitor and evaluate effectiveness of policies and measures.</li> </ul>

Step 4 describes the relevant components involved in formulating adaptation options to address vulnerabilities. A critical part of the policy process is designing an evaluation framework that provides a systematic approach which can be used to assess the different dimensions of the options laid out to decision makers. Policy evaluation is the heart of policy development because it highlights and examines all the salient dimensions of the objectives in terms of measurable criteria used to rationalize the selection of a particular policy alternative. The evaluation criteria used in the policy analysis reflect and address important factors that must be taken into account. The information subsequently derived from the evaluation guides and informs the decision-making process. For example, one of the primary goals of adaptation policy is increasing the resiliency and adaptive capacity of vulnerable systems. Options designed to address ecosystem resiliency must also take into account other considerations such as fiscal constraints, economic costs and benefits, political viability, and synergies with sustainable development goals and climate-change mitigation policies.

There is no “one size fits all” framework applicable for all situations because the criteria used to evaluate adaptation options are typically a function of place, time, objectives, and adaptive capacity. For the most part, an evaluation framework that assesses all the salient dimensions of adaptation options will be project-specific. That being said, there is a minimum set of criteria decision makers could use to assess adaptation options (see Table 17).

**Table 17: Potential evaluation framework to assess viability of adaptation options**

CRITERION	DESCRIPTION
Stakeholder involvement	Are adaptation options salient to the concerns of affected groups within the political jurisdiction where options will be implemented?
Political support	Is the political establishment willing to support options? Do they have the necessary political capital to execute plans? Is there a “policy window” to advance proposals? Do you have political allies?
Public awareness	Does the public have a clear understanding of the issues and the policies proposed to resolve problems? Are they willing to embrace proposed options? Do you have allies on the ground?
Alignment with strategic government objectives	Ensure policies align within the greater strategic context of the province (e.g Climate Action Plan, Energy Plan, Forest Conservation Framework).
Linkages with mitigation efforts	Do adaptation strategies contribute to climate change mitigation strategies (i.e. stabilize or reduce GHGs)?
Linkages with sustainable development strategies	Will adaptation options address additional sustainable development objectives?
Linkages with economic development strategies	Will adaptation options provide renewed economic development opportunities?
Ancillary benefits	Do proposed options provide ancillary benefits (i.e. win-win options).
Risks and uncertainty	Do proposed options address risks and uncertainty associated with climate and ecological model projections (i.e. no regrets options)?
Maximize economic benefits	Are all the potential costs and benefits of proposed options identified and accounted for (this should include non-market values of natural capital)?
Effective at increasing resiliency	Will the adaptation responses effectively decrease the vulnerabilities of affected systems and/or increase resiliency?
Endurance and persistence	Could the options be easily rescinded? Will strategies withstand the ebb and flow of politic life (e.g. are they recession-proof)?
Regional acceptance	Are options compatible with or do they infringe upon policies of neighbouring jurisdictions? Are there allies in neighbouring jurisdictions?
Adaptive management	Are there mechanisms in place to allow policies to change in light of changing information on climate change impacts and system vulnerabilities?

Source: Kimmel, E. (2008)



## 4.5 ASSESSMENT OF CHALLENGES AND OPPORTUNITIES FOR AN ADAPTATION POLICY FRAMEWORK IN BRITISH COLUMBIA

### 4.5.1 CHALLENGES FOR AN ADAPTATION POLICY FRAMEWORK IN BC

#### Legal Framework Governing Biodiversity in BC

The province of BC and local governments have numerous statutes, regulations, and policies administered by different government agencies responsible for the governance and management of natural capital. An exhaustive review of BC's legal framework governing the use of land and resources is beyond the scope of this report. However, an assessment of the key pieces of legislation and policies currently managing BC's lands and resources merits consideration. Many environmental problems occur because of governance frameworks that fail to produce sustainable development outcomes.<sup>97</sup> In many instances, inadequate, legally defensible statutory requirements directly contribute to an unsustainable erosion of natural capital (e.g. biodiversity loss).<sup>98</sup> BC's legislative framework, such as the Wildlife Act and the Forest and Range Practices Act (FRPA), has provisions that allow for the protection of vulnerable species and ecosystems across BC's working landscape. For example, the FRPA provides measures to address the habitat requirements for vulnerable species located in harvestable forests; however, habitat protection cannot "unduly" interfere with commercial commodity production. The same legislative framework that provides measures to protect biodiversity manages the use of land and development of resources that may be incompatible with protecting habitat for vulnerable species and ecosystems. To further complicate matters, local governments and regional districts exercise planning authority stipulated in official community plans, land use bylaws, and comprehensive strategic land and resource management plans that may provide development outcomes inconsistent with retaining critical habitat to support biological diversity and ecosystem functions. Many parcels of land situated in municipal and regional jurisdictions are not subject to local bylaws and regional statutory plans. For example, BC Hydro, the Ministry of Transportation, the Integrated Land Management Bureau (ILMB), and the Agricultural Land Commission retain control and authority over land uses situated within municipal boundaries that are outside their legislative jurisdiction. These Crown agencies may designate land uses or develop natural resources without the consent of local governments and may be inconsistent with regional management plans.

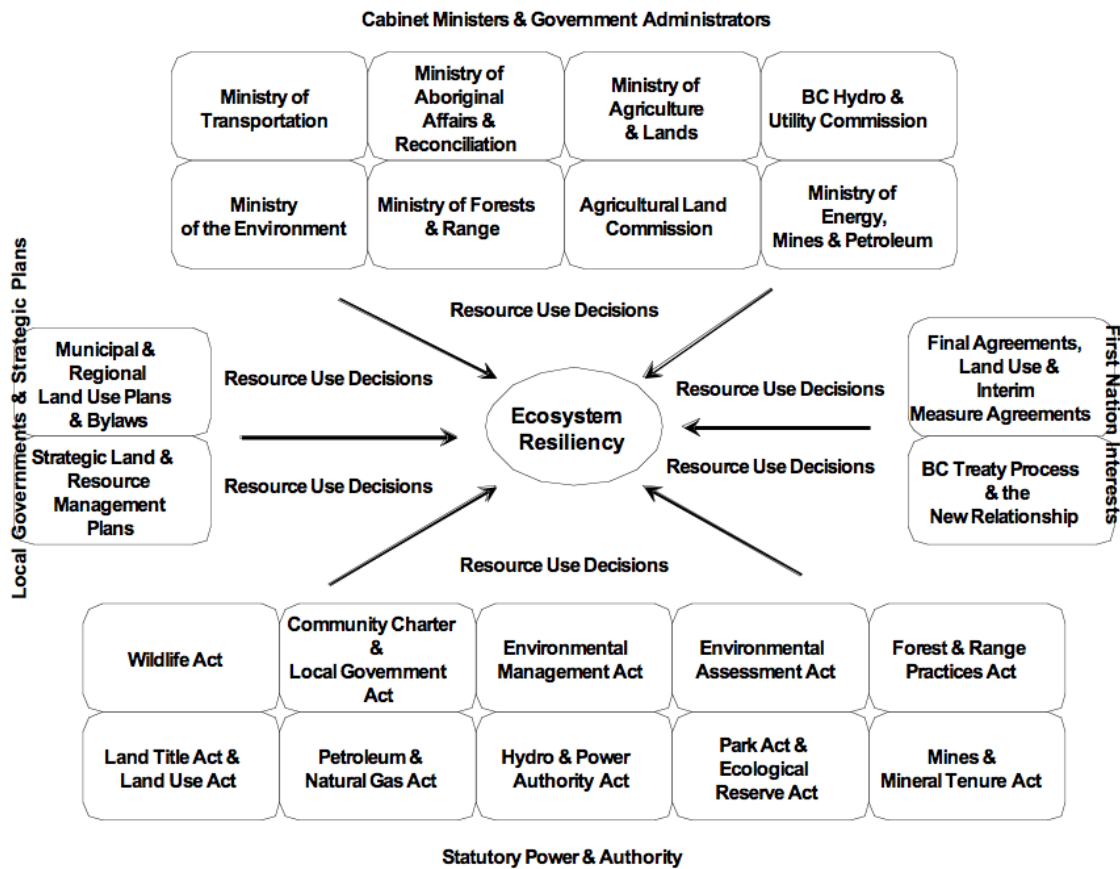
The majority of land- and resource-use decisions involving Crown land involve direct First Nations participation and consent. Indeed, there is a moral imperative, a legal obligation, and an economic justification to negotiate land and resource agreements with First Nations communities. However, the negotiated agreements may not necessarily produce sustainable development outcomes that maintain or improve ecosystem resiliency. Figure 12 provides an overview of the major constituent parts of the governance framework responsible for land- and resource-use decisions that affect ecosystem resiliency.<sup>99</sup> Government ministries, local governments, strategic land and resource management plans, First Nations interests, and the provincial legislative framework form the decision-making apparatus responsible for land and resource uses allocated to serve different socioeconomic and environmental objectives. The outcome is a government system that works in isolation to meet the respective objectives of each organization while maintaining relationships entrenched in statutes and informal relationships. One commonality is: decisions are not made, and lands and resources are not managed, according to province-wide strategic environmental objectives that incorporate principles and standards of ecological sustainability, cumulative impacts, ecosystem resiliency, and the changing range of natural variability.

97 Boyd, D.R. (2003)

98 Boyd, D.R. (2003)

99 For the sake of brevity, this is not an exhaustive list of all the ministries, statutes, policies, institutions, and stakeholders responsible for influencing decisions that affect ecosystem resiliency. Federal agencies, statutes, and policies were deliberately excluded.

Figure 12: Governance framework managing natural resources and the effects on ecosystem resiliency<sup>100</sup>



Three categories broadly define the legal and policy context under which land and resource management and biodiversity protection operate:<sup>101</sup>

1. Management of lands and resources outside parks and protected areas;
2. Lands and resources inside parks and protected areas;
3. Management of lands and resources using strategic land-use planning processes, municipal bylaws, and official community plans.

## 1. LEGAL FRAMEWORK GOVERNING WILDLIFE AND HABITAT ON WORKING LANDSCAPES OUTSIDE PROTECTED AREAS

### Overview of the Forest and Range Practices Act (FRPA):<sup>102</sup>

- The FRPA is the primary legislative instrument used to maintain and protect ecosystem processes and habitat on working landscapes (i.e. Crown land, forest range) that do not receive protection or attention from alternative acts or government policies.<sup>103</sup>
- The FRPA allows the Ministry of the Environment (MOE) to design and employ an Identified Wildlife Management Strategy (IWMS) for the purpose of addressing the habitat requirements of species that deserve

<sup>100</sup> Figure was designed by the author (2008).

<sup>101</sup> David Suzuki Foundation and Sierra Legal (2007)

<sup>102</sup> BC Ministry of the Environment (2004)

<sup>103</sup> BC Ministry of the Environment (2004)

more attention. The IWMS provides direction and guidance to relevant stakeholders aimed at minimizing the adverse consequences associated with forest and range practices on identified wildlife.

- The FRPA authorizes the Ministry of Environment (MoE) to establish two categories of wildlife as requiring special management attention to address the impacts of forest and range activities on Crown land – species at risk and regionally important wildlife, which are referred to as “identified wildlife”:
  - i. The species-at-risk category constitutes endangered, threatened, or vulnerable species of vertebrates and invertebrates, and plant species that are endangered, threatened, or adversely affected by forest activities on Crown land.
  - ii. The regionally important wildlife category includes species that are considered important to a region and rely on associated habitat, that are not otherwise protected under the FRPA or other government acts or policies (e.g. the Wildlife Act), and that may be adversely affected by forest and range practices.
- Policy responses may include maintaining limited habitat through current and/or historic ranges by restoring previously occupied habitat. Policy responses are designed to reduce the impacts of forest and range management on identified wildlife within targeted social and economic constraints – current government policy uses a 1% annual allowable cut threshold.
- Identified wildlife may be managed by establishing wildlife habitat areas (WHA), general wildlife measures within WHA (GWM), and wild life habitat features (WHF). It is important to note that these measures are not intended to address habitat supply, connectivity corridors, or population viability. These issues must be addressed through a strategic land use planning process.

#### Limitations of the FRPA:<sup>104</sup>

- FRPA provisions do not legally require the government or forest tenure holders (i.e. industry) to design, implement, monitor, and enforce Identified Wildlife Management Strategies. The act provides for ministerial discretion rather than legally binding requirements.
- FRPA or ministerial policy does not provide for a standardized, systematic evaluation framework to assess biodiversity impacts from forest management practices and operations.
- The ministry established an arbitrary threshold of 1% annual allowable cut at the forest district level – for example, an IWMS may not designate a WHA if the measure reduces the supply of timber that exceeds 1% of the annual allowable cut for a particular area. The preservation of a consistent flow of timber supply is the primary objective without any clear commitment to balancing alternative resource use objectives, such as protecting and maintaining identified wildlife.
- The majority of vulnerable species resides on working landscapes (e.g. Crown land) outside the boundaries of provincial parks and protected areas. The FRPA is one of the key pieces of legislation authorizing the government to protect vulnerable species on working landscapes. However, the primary objective of the MOFR is to govern and regulate the forest industry to ensure the efficient supply of timber in order to meet economic objectives such as employment, income generation, and tax revenues.
- The FRPA does not operate within the context of climate change impacts, mitigation, or adaptation. The current decision-making framework at the ministerial level does not provide any provisions for climate change-induced impacts or any requirements to factor in mitigation and/or adaptation strategies and ecosystem resiliency within its forest operational plans.
- Biodiversity management applies only to FRPA and not to any other provincial enactments, so under the Land Act or the Oil and Gas Act, decisions can be made to impact WHAs even where they have been legally established.

104 BC Ministry of the Environment (2004)

**Overview of the Wildlife Act:<sup>105</sup>**

- The Wildlife Act is a key piece of legislation that provides measures intended to protect biodiversity (i.e. protect vulnerable species). However, the provisions in the act address the regulation and management of hunting activities, with only two provisions explicitly addressing vulnerable species.
- The Act authorizes Cabinet the “discretion” to designate a species at risk and allows Cabinet to carry out appropriate protection measures for a designated species. The protection measures afforded by the act are prohibitions rather than actual habitat protection. Prohibited activities include the *transportation, ownership, or commercial trade of a designated species at risk or the destruction of a species residence of a species at risk.*

**Limitations of the Wildlife Act:<sup>106</sup>**

- The act does not contain any statutory provisions forcing the government (i.e. MOE) to designate a species or ecosystem at risk.
- MOE is not required to legally designate a “species at risk” once “BC’s Conservation Data Centre” (CDC) identifies species and ecosystems at risk. *The CDC’s mandate is to identify BC’s most vulnerable species based on objective assessments that can assist the government in protecting species and ecosystems at risk.*
- There is a disconnect between the assessments produced by the CDC and the Government of BC’s statutory requirements to act upon those assessments.
- There are no provisional requirements forcing government to launch recovery programs if, under the discretion of the MOE, it legally designates a species at risk. Legislation precludes any standardized process on how to proceed once a species is designated at risk.
- There are no statutory requirements to protect critical habitat, implement recovery plans, or establish specific timelines.
- Cabinet is authorized to eliminate or limit the prohibitions enacted to protect a designated species at risk.
- There is no provisional requirement that binds the government to assess the cumulative impacts on critical habitat and/or species at risk when issuing permits or entering into agreements.
- There is no provision that requires the government to incorporate climate change impacts and climate change mitigation and adaptation responses into the decision-making framework.

**Overview of the Environmental Assessment Act:<sup>107</sup>**

- Primary piece of legislation governing the environmental impact assessment process in BC.
- Framework designed to assess the potential adverse impacts on health, the environment, socioeconomic systems, and First Nations communities.
- BC’s environmental assessment (EA) process is a mechanism to ensure that major projects meet environmental, economic, and social sustainability objectives. The assessment process is also designed to address the issues and concerns of the public, First Nations, interested stakeholders, and government agencies.
- The act applies to “reviewable projects” – projects that tend to be large in scope and magnitude, and have the potential to inflict significant environmental impacts (e.g. major mining projects, waste management facilities, industrial operations etc.).

105 West Coast Environmental Law (2004). Backgrounder. BILL 51: WILDLIFE AMENDMENT ACT, 2004

106 West Coast Environmental Law (2004). Backgrounder. BILL 51: WILDLIFE AMENDMENT ACT, 2004

107 BC Ministry of the Environment (2003)

**Limitations of the Environmental Assessment Act:<sup>108</sup>**

- The EA process is discretionary rather than a statutory requirement. A project listed under the reviewable projects regulation – the schedule that identifies what constitutes a reviewable project – does not automatically invoke an environmental assessment under the act; it triggers an internal decision process to determine whether or not an environmental assessment is necessary.
- An appointed executive director has the discretion to determine if a reviewable project is likely to have any adverse socioeconomic, environmental, and health effects.
- The Act does not provide a systematic evaluation framework to guide the internal decision-making process or contain any provisions that require the MOE to introduce internal policy guidelines.
- The reviewable projects regulation only applies to large projects and excludes the revision of minor projects.
- The act only applies to major projects that meet prescribed thresholds where some of these thresholds are seemingly arbitrary, i.e. not founded on any basic scientific principles (e.g. the expansion of a mineral mining project will invoke the EA process only if it has the potential to disturb 750 hectares of land).
- The determination to proceed with an EA process is not determined by an independent committee but by Cabinet members and appointed government employees.

**LAND USE PLANNING PROCESSES****Overview and Limitations of the Land Act and the Strategic Land and Resource Management Plans (SLRMPs)**

- Generally applies to administration of Crown lands. But, under section 93.4, the minister responsible for ILMB can set objectives on the land base that direct Forest Stewardship plans under FRPA. The EBM objectives for the Central and North Coast LRMPs are established under this section. They can have a biodiversity basis and can go beyond the default regulations under FRPA. There is no provision in the Act to apply the same biodiversity criteria to other legislation. This was contemplated in Section 93.1 of the Act but has not been proclaimed.
- ILMB has a responsibility to set landscape objectives under FRPA. It now does this only on a business case basis (e.g. for tourism developments or mining development, but not for conservation). It does not have the staff capacity to analyze the case for conservation and government is more interested in tenure revenues than in conservation.
- Species at risk can be named under the Wildlife Act; however, habitat management will be covered under the conservation strategy. There is no legislation to implement the conservation strategy unless section 93.1 is proclaimed.
- SLRMPs are subject to amendment again on a business case basis. That said, the LRMPs and the SRMPs are potential tools for implementing climate change adaptation policies but at this point there are no provisions that address climate change and adaptation strategies.

**2. PARKS AND PROTECTED AREAS****Overview of Parks Act and Ecological Reserves Act:**

The legal framework managing Protected Areas in British Columbia mainly consists of the Parks Act and Ecological Reserves Act.<sup>109</sup> These acts afford legal protection for significant natural and cultural amenities by restricting personal interests and the removal of natural resources within designated areas.<sup>110</sup> The Park Act regulates the development of a park to meet specific purposes that must conform to a zoning plan, which specifically outlines restrictions and permitted uses of a park. The Ecological Reserves Act affords legal protection to designated Crown lands for the purpose of scientific research, preserving representative samples of natural ecosystems, preserving the natural habitat of rare or

108 West Coast Environmental Law (2004). Background. BILL 38: THE NEW ENVIRONMENTAL ASSESSMENT ACT

109 BC Ministry of the Environment. Parks and Protected Areas Program (2007)

110 West Coast Environmental Law (2003). Brief on PARKS AND PROTECTED AREAS STATUTES AMENDMENT ACT

endangered species, and preserving disturbed areas for scientific studies. Provisions of the Act are highly prohibitive and restrict the removal and extraction of natural resources.

#### Critical Assessment of Parks Act and Ecological Reserves Act:

- Most BC parks and ecological reserves are not located in areas where vulnerable species reside – there is a disconnect between the location of vulnerable species and the geographical boundaries of protected areas. Provisions of the Act are highly prohibitive.
- The Park Act does not provide any clear guiding principles or mandate to protect biodiversity within its boundaries. The legislative intent of the act is ambiguous – it does not address a particular issue. The Park Act is purely a legal tool to guide the procedural and administrative requirements embodied in the Act. The Act does not enshrine any substantive legal requirements that directly address environmental problems such as changes to biodiversity.
- Species at risk that do reside in parks are not threatened by development pressures to the same extent as species residing outside park boundaries.
- The primary function of BC Parks has been to conserve natural amenities, offer recreational opportunities, and provide scenic beauty.
- There are no stipulations that explicitly address climate change impacts or adaptive measures.

The statutory and policy framework responsible for governing BC's biodiversity faces some serious challenges and may be ineffective in achieving the optimal level of protection while concurrently fulfilling socioeconomic objectives. BC legal and policy framework share common challenges:

1. The legal framework is widely discretionary – it lacks legally binding standards and objectives.
2. The legislative and policy framework does not enshrine any environmental or socioeconomic principles that clarify the government's position and intentions.
3. There is no systematic or comprehensive decision-making framework to guide government, industry, First Nations, and communities in terms of consideration for impacts upon biodiversity.
4. The assessment process does not operate under an environmental strategic context. Each project that may have identifiable probable impacts on natural, built, and socioeconomic systems are analyzed in isolation rather than in an integrated provincial, national, and international strategic context. Individual agencies operate their respective mandates legally but there are no provisions to evaluate the cumulative effects of discrete actions on biodiversity and ecosystem resiliency.
5. Economic expansion and project certainty are the dominant objectives when conducting assessments. Adverse environmental and socioeconomic impacts are avoided, accepted, and/or mitigated.
6. There are minimal legal boundaries used to guide and inform developers and authorizing agencies that define an acceptable level of environmental impact. Ecological thresholds are not clearly defined.

#### RISK AND UNCERTAINTY

Policy makers frequently make profound policy decisions despite uncertainty. It is important to recognize that one of the underlying principles inherent in all decision-making frameworks is that our knowledge of scientific and social structures and processes is incomplete. We especially will never grasp the full extent of social knowledge and processes because the social environment in which decisions are based is constantly changing and varies widely across regions and over time.<sup>111</sup> All public policy decisions require carrying out judgments regarding complex societal problems in the face of uncertainty. If uncertainty were not a factor, the adaptation decision-making process in the realm of public policy would be a relatively straightforward task. The knowledge of increasing atmospheric concentration of GHGs, the

111 Becker, H.A. & Vanclay, F. (2003)

related changes in global climatic conditions, and the associated impacts on built, natural, and socioeconomic sectors will require policy decisions to enhance opportunities and minimize deleterious impacts. However, these decisions necessitate making choices between adaptation options within the context of uncertainty. The important issue is what to do, given our uncertainty in interpreting present conditions and predicting future events in general, and the prevalent uncertainty in predicting future climatic scenarios and related environmental conditions in particular.

Dealing with the “unknown” in the public policy domain requires managing uncertainty at every step of the policy development process. That is to say, policy analysts must identify, investigate, and communicate all aspects of uncertainty while defining the problem and issues, assessing system vulnerabilities, designing adaptation strategies to address vulnerabilities, evaluating adaptation strategies against a range of evaluation criteria, and implementing and monitoring adaptation strategies. The concepts of “risk” and “uncertainty” mean different things to different people; however, within the context of climate change adaptation the following definitions clarify these concepts:<sup>112</sup>

### **Risk**

*Risk is the combination of the probability of a consequence and its magnitude. Therefore, risk considers the frequency or likelihood of occurrence of certain states or events (often termed “hazards”) and the magnitude of the likely consequences associated with those exposed to these hazardous states or events.*

### **Uncertainty**

*Uncertainty exists where there is a lack of knowledge concerning outcomes. Uncertainty may result from an imprecise knowledge of the risk, i.e. where the probabilities and magnitude of either the hazards and/or their associated consequences are uncertain. Even when there is a precise knowledge of these components, there is still uncertainty because outcomes are determined probabilistically. Simply put, uncertainty reflects the quality of our knowledge (or lack thereof) pertaining to risk.*

Risk is the combination of knowledge pertaining to the probability of a consequence and the magnitude of its impact. Uncertainty conveys the lack of knowledge that policy makers find pertinent to make informed decisions about the risks associated with climate change impacts and adaptation options. Uncertainty in designing adaptation policy emerges from our limited ability to estimate the probabilities and the associated consequences pertaining to climate change-induced impacts. For example, the IPCC ascribes different levels of confidence in its assertion that rising temperatures will lead to a range of species extinctions. However, the probability of a particular species becoming extinct is unknown and the precise magnitude and consequences of that event materializing in the biological realm are indeterminate. For the most part, the “uncertainty factor” consumes the attention of most decision makers when designing policy options, for the simple reason that decision makers are not willing to subject themselves to political fallout by making the wrong decision that could potentially involve significant public expenditures and opportunity costs. Climate change mitigation and adaptation policies involve a planning cycle of 20, 50, 80 years into the uncertain future, compared to electoral and policy cycles that have an average planning horizon of 2-5 years. Moreover, the public would be less than willing to support policy decisions that address distant and uncertain consequences that are disproportionately distributed across time and space, especially when significant budgetary outlays are diverted from dealing with immediate public issues. The IPCC is confident about the estimates and understanding of climate change and the related impacts to human, built, and socioeconomic environments, without explicitly knowing the probability of those events occurring.

Dealing with and addressing uncertainty is an integral part of the decision-making process, which is why it is vitally important to know the sources of uncertainty contributing to our lack of knowledge that inhibit our ability to make precise judgments about the outcome of adaptation policies:<sup>113</sup>

112 Willows, R.I. & Connell, R.K. (2003)

113 Walker et al. (2003)

1. **Statistical Uncertainty:** Despite our well-developed knowledge and understanding of the underlying mechanics of a specific policy area, the manifestation of certain events can only be explained using probabilities. Any attempt to form assumptions and hypotheses about human behaviour and scientific relationships using statistical methods will always contain elements of natural randomness. It is virtually impossible to estimate social and scientific relationships without measurement errors. Statistical inferences do not provide absolute proofs; inferences derived from statistical modelling provide a range of probable outcomes based on specific assumptions that reflect our interpretation of the world. For the most part, researchers will never be able to determine and operationalize all the factors that may contribute to a particular event.
2. **Recognized Uncertainty:** Recognized uncertainty arises from our inability to completely grasp the underlying mechanics and functional relationships pertaining to complex interrelated social or scientific issues under study. Recognized uncertainty is categorized into reducible and irreducible ignorance. Reducible ignorance refers to our cognitive limitations in fully understanding the dimensions of an issue and its implications. However, analysts may overcome these limitations by committing more time and resources to expanding our knowledge base pertaining to a particular issue. For example, increasing minimum riparian area setbacks provides a range of environmental benefits. A rudimentary review of the literature suggests that increasing minimum riparian area setbacks may stabilize hydrological flows, reduce in-stream sedimentation, and increase wildlife connectivity. However, there is an element of uncertainty associated with predicting the environmental impacts for a specific urban environment. We do have the ability to substantially *reduce our ignorance* and increase our knowledge by commissioning detailed ecosystem studies for a specified riparian area. Irreducible ignorance signifies our inability to expand our knowledge to a level of specificity that is required to make an informed policy decision. For example, the information required in selecting and planting the optimal tree species for the upcoming spring planting season that would increase the resiliency of harvestable timber for the north coast in 80 years is practically impossible.
3. **Scenario Uncertainty:** Policy analysts use and develop scenarios to help them construct and envision a future state of natural, built, and socioeconomic conditions that may *possibly materialize* under specific conditions. Scenarios do not predict future outcomes using probabilities but rather anticipate possible future outcomes using a range of plausible assumptions describing key relationships and driving forces. For example, the IPCC uses a range of emission scenarios based on plausible socioeconomic, environmental, and technological assumptions. Climatologists employ scenarios to indicate what the future world will look like under a suite of plausible conditions used as a backdrop to evaluate the effectiveness of GHG reduction strategies. The uncertainty associated with designing scenarios emerges from our lack of information to verify our assumptions about the future. Predictions derived from statistical probabilities incorporate the element of uncertainty as a measurable estimate. That is, we quantify our ignorance, the level of our ignorance, and the variance of our ignorance as a measurable term, which we may use to evaluate policy options.

Uncertainty emerges in every aspect of climate change policy. “There is uncertainty about what values various parameters should have, uncertainty about the structure of the models, uncertainty about the options available to decision-makers, uncertainty about the methodology, etc.”<sup>114</sup> There is also uncertainty on how to proceed once the appropriate models are selected and estimates calculated. The IPCC asserts with a very high degree of confidence that further increases of greenhouse gases will continue to change global atmospheric conditions contributing to biological responses that will affect ecosystem functions. However, we are unable to project with a high level of confidence exactly how climate will change.<sup>115</sup> Additionally, it is almost impossible to identify and quantify, with a high level of specificity, the nature and magnitude of impacts to our natural and socioeconomic systems.<sup>116</sup> Uncertainty emerges from our

114 Dessai, S. & Hulme, M. (2007)

115 Editorial (2007)

116 Gitay, H., Suárez, A., Watson, R.T. & Dokken, D.J. (2007)



limited capacity to project climate changes and the resulting biological and physical responses with a high degree of precision. That is, most climate models are not particularly well suited to project climate changes at high spatial resolutions, which are typically needed to inform planning processes at regional levels.<sup>117</sup> There are models available that do project ecosystem and biome shifts at the regional or global level. Yet these models do not effectively predict changes to biodiversity at the species level because the underlying model assumptions project whole ecosystems retaining the same functional and structural characteristics as they shift.<sup>118</sup>

Managing the risks and uncertainty used to guide and inform policy development and analysis involves two separate but related processes: first, the identification and quantification of risks, and second, the level of risk that decision makers and the public consider acceptable.<sup>119</sup> Risk assessment and analysis is the process of identifying and quantifying potential hazards and exposure and vulnerability to defined receptors, as well as eliciting the public's perception of risk and the values they ascribe towards pursuing options that reduce or manage risks in combination with attaining other societal objectives. Risk assessment in the realm of climate adaptation policy consists of appraising the vulnerability of particular systems that are susceptible to changes in climatic conditions and extremes, and deciding which systems are considered salient to these that merit our attention (see Table 15). Vulnerability assessments involve applying and integrating scientific and social science methods, which tend to embody research methodologies that exhibit objective and subjective standards.

The information gathered in a risk assessment does not have any particular value unless we apply it to inform and influence the decisions we make about choosing adaptation strategies aimed at reducing or eliminating vulnerabilities associated with a climate hazard. Decision making requires selecting a policy option that contains the “highest expected value” or the “best possible outcome” among a set of relevant alternatives, including the choice not to act.<sup>120</sup> Decision makers consider a range of alternatives and choose the one that has the best chance of meeting adaptation goals and objectives, while considering an uncertain climate and socioeconomic future. The question is: *How do we make decisions, given the inherent risks and uncertainties associated with adaptation policies, that may help us ease the collective sense of anxiety associated with making big policy decisions with incomplete information?* A systematic and comprehensive evaluation of adaptation options that considers the sources and potential implications of risks and uncertainty should provide reliable information that decision makers could use to substantiate policy recommendations with a high level of confidence.<sup>121</sup> Decision analysis frameworks should provide the following minimum requirements:<sup>122</sup>

- Risks, benefits and costs associated with each adaptation option;
- The key parameters influencing the outcome of the option, including sensitivities under different assumptions and key uncertainties;
- The distribution of impacts on relevant groups and areas associated with each option.

Table 18 provides an overview of useful evaluation frameworks that policy analysts could implement to support the decision-making process and address most components of risks and uncertainty.<sup>123</sup>

117 Gitay, H., Suárez, A., Watson, R.T. & Dokken, D.J. (2007)

118 Gitay, H., Suárez, A., Watson, R.T. & Dokken, D.J. (2007)

119 Tietenberg, T. (2003)

120 Willows, R.I. & Connell, R.K. (2003)

121 Willows, R.I. & Connell, R.K. (2003)

122 Willows, R.I. & Connell, R.K. (2003)

123 Dessai, S. & Van Der Sluijs, J. (2007)

**Table 18: Decision analysis models/criteria used to assess risk and uncertainty for adaptation policy development**

DECISION-MAKING MODEL/ CRITERIA	DESCRIPTION
Deterministic benefit-cost	Estimates the benefits and costs of adaptation options in economic or monetary terms and selects the one with the highest overall net benefit.
Probabilistic benefit-cost	As for deterministic benefit-cost, but uncertainties are incorporated probabilistically, and the greatest expected value of the resulting uncertain net benefit is selected.
Bounded cost or regulatory-budget approach	Aims to achieve the greatest level of climate adaptation possible within the imposed budgetary constraints.
Maximum multi-attribute utility	Rather than using monetary value as the evaluation measure, multi-attribute utility involves specifying a utility function that evaluates outcomes in terms of all the attributes identified as being important for the decision. These attributes may include risks and uncertainties. The option with the greatest utility is then selected.
Cost effectiveness	A desired level of adaptation performance is selected, perhaps on non-economic grounds, and then the adaptation option selected that achieves the desired level of performance at the lowest cost is selected.
Zero risk	Independent of the benefits and costs, and of how big the risks are, eliminate the risks and do not allow their reintroduction. Applying the precautionary principle in its strongest sense is an example of a zero-risk criteria. Zero-risk approaches cannot be applied to the management of climate risks, since these risks cannot be eliminated. However, choices over climate adaptation options may include other consequent risks that may be considered unacceptable
Bounded or constraint risk	Independent of the costs and benefits, constrain the level of risk so that it does not exceed a specific level or, more generally, so that it meets a set of specified criteria. Applying the precautionary principle in a less strong sense is an example of a criterion based on constrained risk.
Public involvement, focus groups, and workshops	The cultural plurality in risk attitudes implies that the question of how society ought to deal with risks can only be answered in public debate – a debate in which people will necessarily discuss their perception of risks and risk management from different points of view, different conceptual and ethical frameworks, and different epistemological stances (Dessai, S. & Van Der Sluijs, J. 2007)

Source: Willows, R.I. & Connell, R.K. (2003)

The interpretation of the estimates and information derived from the decision analysis frameworks cited above will vary according to people’s attitudes towards and perceptions of risk and uncertainty.<sup>124</sup> Attitudes towards risks differ across people, cultures, time, and experience. Some people have a risk-seeking attitude whereas others have a risk-averse attitude. Deciding what is an appropriate level of risk, and choosing adaptation options that address those risks, partially depends on attitudes towards and perceptions of risk and uncertainty of the actors who are involved, and who influence the adaptation policy process and the socioeconomic and political dynamics where policy development occurs.<sup>125</sup> This implies that public engagement, focus groups, and workshops play an integral part in identifying and interpreting acceptable levels of risk that will ultimately shape the design of adaptation responses to climate change.

**Lack of Technical Capacity and Knowledge to Effectively Support Adaptation Responses**

This report refers to a myriad of studies highlighting observed and projected climate change impacts upon terrestrial plant and animal species, which provide sufficient information to justify adaptation policies. However, our current knowledge is insufficient to formulate effective adaptation policy and planning. We know of some of the impending impacts and the need to take action; however, we are not clear on how to evaluate adaptation options in terms of reducing risks and vulnerability or building adaptive capacity.<sup>126</sup> Most of the research on adaptation rarely goes beyond identifying adaptation because there is little research or actual policy applications that systematically evaluate options.

124 Dessai, S. & Van Der Sluijs, J. (2007)  
 125 Dessai, S. & Van Der Sluijs, J. (2007)  
 126 European Environment Agency (2005)

It is not because we do not know how, but rather that we lack the scientific knowledge to form objective assessments, and we do not clearly understand how the dynamics of adaptation policy play out in social, economic, and political systems. Therefore, substantial gaps in knowledge hinder our ability to effectively evaluate options in terms of reducing risk, increasing capacity, and measuring benefits and costs.

### **Community Fiscal Constraints**

Local governments and communities across BC may have inadequate financial resources to invest in adaptation measures to increase the resiliency of natural, built, and socioeconomic sectors. Local governments typically have limited revenue sources at their disposal to raise the needed capital to support adaptation responses, from policy formulation to the implementation and monitoring of adaptation programs. Commercial and residential property taxes are usually the largest sources of revenue for most municipal budgets and are set according to planned expenditures for the fiscal year. An increase in municipal annual tax rates to fund adaptation strategies designed to address uncertain future impacts may prove to be a contentious political manoeuvre. Increasing ecosystem resiliency against the effects of climate change typically involves setting aside developable land for the purpose of increasing connectivity corridors, preserving or restoring critical habitat for species at risk, and increasing riparian area setbacks. Reducing the supply of developable land poses two challenges. First, reducing the supply of land available for development will invariably decrease public revenues unless tax rates increase or new sources of revenue are established. Second, land is needed to meet a variety of economic and societal objectives such as housing, transportation, public facilities, natural resources, agriculture, and business development and retention.

The uncertainty associated with climate change projections and subsequent ecosystem impacts provides an even greater challenge to the justification of allocating scarce government resources to address a problem that is difficult to isolate. Local governments may face resistance from local constituents who feel that public funds would be better spent on the immediate needs of the community, rather than on future impacts that are difficult to conceptualize. Local governments may have to launch pervasive community awareness campaigns in an effort to elicit public support. One creative approach to overcome fiscal constraints is to incorporate adaptive measures in areas that do not require immediate public expenditures. For example, local governments may revise local bylaws and official community plans that incorporate adaptation evaluation frameworks within their planning processes. For example, the approval of commercial developments located near known species migration routes may be contingent upon dedicating land used for establishing green space to promote connectivity corridors. The local government treasury would not incur any immediate financial outlays, and employing environmental reserve dedications as a planning instrument is consistent with provincial legislation.

## 4.5.2 OPPORTUNITIES FOR AN ADAPTATION POLICY FRAMEWORK IN BC

### New BC Government Strategies

*Global warming is the challenge of our generation. How we respond will shape the future of not just our environment, but also our economy, our society, our communities, and our way of life. British Columbia is taking decisive action to ensure these changes are positive...*

BC Climate Action Plan, 2008<sup>127</sup>

The Government of BC recently developed and released a comprehensive suite of bold and innovative policy responses to address climate change while proposing initiatives to enhance the expected opportunities. The government's strategy includes a combination of fiscal policy, market-based instruments, regulatory measures, technological investments, education, and outreach programs. The following summarizes the major government initiatives that address climate change:

#### 1. Climate Action Plan and Legislation

The Climate Action plan outlines the government's strategy to reduce GHG emissions using the following measures:

- Establish target reductions for GHG emissions and entrench these targets into legislation. The legally binding targets call for a 33% reduction in GHG emissions compared to 2007 levels by 2020.
- Introduce legislative measures to establish a regional cap and trade system, carbon-neutral government operations, revenue-neutral carbon tax, vehicle emission standards, landfill gas emissions regulations, low carbon fuel standards, and the promotion of green community development.
- Develop a new "Green Building Code" that produces the highest national energy efficiency standards.
- Implement a \$14-billion Provincial Transit Plan to build infrastructure with the objective of doubling ridership in BC by 2020, and support all communities in having anti-idling policies in place by 2012 to reduce GHG emissions and local air pollution.
- Engage in educational and outreach programs to raise the level of awareness about climate change and the related adaptation and mitigation responses.

#### 2. Live Smart BC

*Live Smart BC* is a new provincial initiative launched in early 2008 that provides incentives for consumers to make smart choices aimed at saving energy, water, fuel, time, and money.<sup>128</sup> The objective of these programs is to control urban sprawl and reward developments that create affordable housing, green spaces, and people-friendly neighbourhoods. British Columbians will be able to choose their own approach to cut their GHG emissions, increase efficiency, and save money related to transportation, home energy use, and other aspects of daily life. Incentives offered by the Live Smart strategy include:

- Financial compensation for the installation of energy-efficient gas water heaters, increasing attic insulation, and the purchase of fuel-efficient cars;
- Tax exemptions on energy-efficient products.

#### 3. BC Energy Plan

The BC Energy Plan introduces climate action measures that will make a significant contribution to the province's GHG reduction strategy. Some of the key commitments include:<sup>129</sup>

- Electricity self-sufficiency by 2016;

127 BC Climate Action Plan (2008)

128 Living Water Smart (2008)

129 BC Climate Action Plan (2008)

- New electricity generation facility that will produce zero net GHG emissions;
- Elimination of all oil and gas flaring by 2016;
- Conservation targets that will account for 50% of the province's incremental demand increase.

#### 4. BC Conservation Framework

The BC Conservation Framework is a MOE initiative that addresses the conservation of species and ecosystems in the age of climate change.<sup>130</sup> The Conservation Framework sets out to contribute to global efforts for species and ecosystem conservation, prevent species and ecosystems from becoming at risk, and maintain the diversity of native species and ecosystems. The Framework applies systematic scientific-based evaluation frameworks to assess and identify priorities and subsequently design effective conservation management programs. It incorporates climate change impacts in its decision-making framework in order to prioritize and respond to species and ecosystem that are more likely to be at risk because of climate change-related impacts. The Conservation Framework is potentially in a position to support increasing ecosystem resiliency.

The Framework has three goals:

- Contribute to global efforts for species and ecosystem conservation;
- Prevent species and ecosystems from becoming at risk;
- Maintain natural diversity of species and ecosystems.

The risk analysis approach is based on the following four steps:

- Determine priorities for ecosystem action based on each of the three goals;
- Assign species management to primarily one of the goals;
- Determine management activities;
- Align resources and activities to implement management activities.

The initiative is led by MOE but there is collaboration with other provincial agencies, notably Integrated Land Management Bureau, Forests and Range, Energy and Mines, and Aboriginal Affairs and Reconciliation. These five ministries now form a Resource Management Board that advises the Premier's office on all land and resource policy and is in the process of integrating their respective business plans.

#### 5. Living Water Strategy

Living Water sets out the BC Government's vision to address water management issues within the context of climate change, economic development, and a growing population. The strategy proposes a shift to an ecosystem-based approach to water management with an emphasis on maintaining or restoring healthy streams and watersheds. The proposed strategies include:<sup>131</sup>

- Integrating impacts on water resources into community development, protecting drinking water sources, and implementing flood protection measures as adaptation responses to climate change;
- Ensuring the protection and rehabilitation of wetlands, waterways, and water resources from land development and activities;
- Modernizing BC's water legislation framework that addresses the provision of adequate stream flows, ecosystem health, community involvement, and groundwater protection;
- Reducing water consumption by establishing enduring water efficiency targets and working with all sectors of the province;
- Improving science and information so British Columbians can better prepare for the impacts of climate change.

130 BC Ministry of the Environment. BC Conservation Framework (2008)

131 Living Water Smart (2008)

## 6. Future Forest Ecosystem Initiative (FFEI)

FFEI is an initiative established by the Ministry of Forests and Range (MFOR) in response to climate change impacts to forestry. The scope of FFEI is bound to the MFOR's jurisdiction and the environmental aspects associated with forest and range management. FFEI sets out to accomplish the following objectives:<sup>132</sup>

- Establish baseline assessments by examining functional constraints for key species and ecological processes;
- Estimate the range of climate change scenarios and the impacts on key species and ecological processes;
- Monitor key species and ecological processes to detect changes and assign causal factors;
- Evaluate existing and new forest and range management practices in terms of ecosystem resiliency and the benefits under changing ecological conditions;
- Adapt the forest and range management framework to maintain and enhance ecological resilience and ecosystem products, services, and benefits under changing ecological conditions.

### Economic Development Opportunities

Market opportunities exist for the development and implementation of adaptation responses to climate change. Every effort needs to be made to frame adaptation policies within the context of greater societal objectives such as renewed economic development opportunities – the emphasis should be on growth rather than threats, limits, constraints, and uncertainty. Market opportunities materialize from taking advantage of emerging business prospects. Adaptation options should be packaged as economic development opportunities and extol the societal benefits rather than focusing on cost constraints associated with uncertain outcomes. For example, preserving natural habitat on private or public land does not necessarily imply tradeoffs between conservation and economic opportunities. Decisions about conservation do not always have to be reduced to either/or options. We should do away with conventional decision-making processes that tend to assess trade-offs in absolute terms (e.g. good or bad, yes or no, costs and benefits, equitable and inequitable) and incorporate a framework that advocates economic development objectives that are compatible with environmental policy objectives along with other societal objectives. It seems highly improbable that citizens would emphatically support government policies that essentially threaten their economic security and impose constraints on their ability to improve their material well-being. Economic development within our contemporary society is, without a doubt, the only avenue to attain economic prosperity, material well-being, and socioeconomic security. However, achieving the goal of economic prosperity and security does not inevitably imply systematically eroding our stock of existing natural capital that sustains our human existence and our economic systems. Is it possible to establish ski resorts while concurrently protecting grizzly habitat? Is it possible to selectively harvest old-growth trees without clear-cutting entire ancient coastal temperate rain forests, and still generate a healthy profit margin? Is it possible to develop subdivisions and conserve critical wetland habitat? Is it possible to expand urban dwellings while protecting habitat corridors?

The BC government is advancing strategies that align with the notion of integrating adaptation policies within the greater context of economic development and renewal:

### Community Development Trust<sup>133</sup>

The Community Development Trust is a \$129 million provincial program designed to provide new opportunities for forest sector workers experiencing difficult market conditions. The program's objectives are to create new job opportunities, help forest workers upgrade their skills, and enable older workers who wish to retire to create opportunities for junior workers.

132 British Columbia Ministry of Forest and Range. Future Forest Ecosystems Initiative (2008)

133 BC Ministry of Community Development (2008)

### BC's Bio-Energy Plan<sup>134</sup>

BC's Bio-Energy Plan outlines a strategy to capitalize on the economic opportunities associated with BC's vast sources of biomass while contributing to climate mitigation and adaptation objectives. By building and expanding bio-energy capacity, the province has the opportunity to address policy issues such as energy efficiency, air quality, and GHG emission reductions, to create local economic development opportunities and jobs, to diversify local economies and industry, and to create resilient communities. The heart of the plan sets out to advance the following measures:

- Provide funding to invest in bio-energy projects and technology, and advance bio-diesel production;
- Commit to using bio-fuels to meet 50% of the province's renewable fuel requirements by 2020;
- The provincial government plans to establish BC as the centre of biomass production and create economic development opportunities and renewal for forestry, agriculture, municipalities, and First Nations

### Win-Win and No-Regrets Policy Responses

The concept of win-win adaptation responses refers to the ancillary benefits derived from implementing planned adaptation responses to minimize the adverse consequences of climate change.<sup>135</sup> The additional benefits associated with adaptation responses could be in the form of policy that addresses social, environmental, economic, and even political objectives. It could be either planned or unplanned. The purpose behind designing adaptation responses that address other policy objectives is twofold. First, it is easier to design adaptation responses that find synergistic opportunities with other societal objectives because in many instances adaptation measures fit into a broader sustainable development framework. Second, adaptation responses designed to provide ancillary benefits and address a range of policy issues will most likely resonate with a broader political constituency. For example, conserving new connectivity corridors will increase the adaptive capacity of species seeking climate-suitable habitat. Strategically selecting conservation areas may provide recreational amenities for the benefit of the greater public, and concurrently preserve wetlands, grasslands, and forested areas which function as carbon sinks, in an effort to stabilize atmospheric concentration of GHGs.

Forming "no-regrets policy" responses addresses the uncertainty factor by providing benefits under all plausible climate change scenarios and corresponding changes to ecosystems.<sup>136</sup> Climate and ecosystem model estimates provide a range of probable outcomes that identify vulnerable systems. Designing adaptation strategies to address vulnerabilities using a no-regrets approach justifies a particular course of action that address sector vulnerabilities even if climate and ecosystem model projections do not actually materialize. Using the previous example, conserving connectivity corridors will facilitate species migration under a specific climate change scenario. Even if the projected climate change scenario does not materialize, and species are not forced to migrate, the natural habitat remains conserved, which alleviates non-climatic pressures on the state of biodiversity. Public expenditures used to finance conservation initiatives will still provide societal benefits, regardless of the outcome. Framing options using a no-regrets approach allows decision makers to spread the risks associated with uncertainty. However, framing adaptation responses within a win-win or no-regrets strategy is not a straightforward task. Designing these strategies requires highly effective, cross-ministerial coordination, in contrast to the silo-based structure that currently characterizes government strategic policy and planning.

134 Ministry of Energy, Mines & Petroleum Resources (2008)

135 European Environment Agency (2005)

136 European Environment Agency (2005)

## 5. INCREASING ADAPTIVE CAPACITY

### 5.1 BIODIVERSITY CONSERVATION

Conserving biodiversity is a fundamental goal for BC, especially relevant because BC is the most biologically diverse province in the country<sup>137</sup> and this is the key policy response for increasing the adaptive capacity of BC's biodiversity. Biological systems including genetic, species, and ecosystem diversity are all essential to ecosystem function; however, we should strive for conservation at the level of ecological diversity. The focus on conserving biodiversity is amplified by the realisation that climate change will likely have drastic and rapid effects on ecosystems as we know them, and that systems with greater diversity are more resilient to change and have greater potential to adapt.<sup>138</sup> We have also finally begun to acknowledge the *need* to conserve ecological systems and the importance of considering biodiversity in doing so. This need has been recognized through economic analyses of ecosystem services, ecosystem collapse, and fear that current climate change projections could result in widespread ecosystem transition to less functional system states. If we hope to maintain the resilience of BC's ecosystems, and the services and inherent value they possess, we must determine what impacts climate change is exerting on ecosystems, and what adaptations are and are not taking place. Management and protection strategies must then be adjusted accordingly.<sup>139</sup> We consider the following principles and strategies to be important first steps towards reframing natural resource management within the climate change context:<sup>140</sup>

### 5.2 CONSIDERATIONS TO GUIDE THE DESIGN AND IMPLEMENTATION OF ADAPTATION POLICIES

#### 1. EMBRACE CHANGE AND RECOGNIZE THAT SOME EXISTING MANAGEMENT PARADIGMS HAVE LIMITED VALUE

Resource management practices were designed under the assumption of a stable, natural range of variability within ecosystem structures and functions over time. Our governance framework rests on the assumption that constant and persistent environmental conditions will prevail in the long run. Changes in climate variations will essentially violate all the assumptions that form the basis of our statutory and policy framework that in turn governs the use of natural capital, including BC's strategic land and resource management plans. Climate change will fundamentally alter the phenology, distribution, composition, and interaction of species outside the range of assumptions embodied within BC's governance framework. Resource managers must therefore accept changing climate regimes and ecosystem parameters, and design policies and planning processes accordingly.

#### 2. ACCEPT UNCERTAINTY AS A PREMISE FOR DECISION MAKING

Models designed to predict species and ecosystem changes because of global change are available to resource managers. However, models produce a wide range of estimates and uncertainty will always be a concern. We will never have sufficient knowledge to predict future outcomes with the highest degree of precision. Policy makers are typically risk-averse – they feel uncomfortable with designing planning options based on imperfect information. Dealing with uncertainty usually implies “spreading the risks” or “hedging your bets”. Resource managers may design policy responses according to a narrowly defined future outcome based on the strength of the information at their disposal; that is to say, placing their bets on one policy response when the success of the policy depends on the outcome of your prediction. On the

137 BC Market Outreach Network (2007)

138 Hooper et al. (2005)

139 Scott, D.J. & Lemieux, C.J. (2007)

140 Millar, C. (2008)



other hand, we recognize the inherent uncertainty in designing policies to address future outcomes. Therefore, decision makers should design policies that spread the risks in an attempt to address the inherent uncertainties in predicting changes to ecosystems.

### **3. PROMOTE RESILIENCE TO CHANGE**

The fundamental principle guiding climate change adaptation strategies is promoting resilience to change. This approach is premised on the fact that healthy and diverse ecosystems and species are more resilient to change. This implies taking a proactive and preventive approach to increasing resiliency rather than reacting to changes. Policy makers should devote their attention to managing high value assets that are the most susceptible to climate change impacts. High value assets are ecologically significant, economically beneficial, and culturally valuable. Susceptible or vulnerable species or ecosystems are either currently, or projected to be, vulnerable, threatened, or endangered. Resource management plans should formulate adaptation strategies by identifying and prioritizing high-risk and high-value natural capital assets, and mobilizing the necessary responses to increase resilience to change.

### **4. ASSIST ECOSYSTEMS AND RESOURCES TO RESPOND TO CHANGE**

This strategy assumes that natural resource managers face limitations in their ability to effectively predict the impact climate change will have on species and ecosystems. In other words, we acknowledge the fact that we don't really know what scenarios might materialize in the future. However, what we can do under the assumption of uncertainty is manage natural capital in a way that assists the ability of species and ecosystems to make a transition to climate-suitable habitat, using the information gathered from climate and ecosystem models while acknowledging the constraints of incomplete information. Enabling species and ecosystems to respond to change implies:

- Providing support to species and ecosystems following climate-suitable habitat;
- Planning for anticipated risks;
- Performing controlled experiments to determine species responses;
- Increasing, restoring, and renewing biological diversity;
- Promoting connectivity corridors.

### **5. RE-ALIGN CONDITIONS TO REFLECT CURRENT AND FUTURE CONDITIONS**

Adaptation strategies should align with current conditions rather than continuing to attempt to form policies according to historical conditions. Species and ecosystems are currently experiencing climate conditions outside their natural range of variability. Strategies to increase biological diversity and thereby increase resiliency should therefore be performed within the context of current and future climate conditions.

### **6. ALLEVIATE THE EFFECTS OF NON-CLIMATIC STRESSORS**

Policies should realistically reflect that, prior to the rise in awareness of the climate change issue, human-induced stressors other than climate change impacts were already affecting the state of BC's biodiversity and ecosystem functions. A viable policy response to increase ecosystem resiliency would be to reduce or alleviate non-climatic stressors. The two leading causes that adversely affect biodiversity are: habitat destruction, which is a direct result of growing human populations and their related activities that support their socioeconomic systems; and habitat fragmentation.<sup>141</sup> Addressing those two underlying causes of decline in biodiversity would in all probability increase the resiliency and adaptive capacity of natural systems to adjust to the impending climate change.

141 Lister, N.E. (1997)

## 7. APPLY STRATEGIC MONITORING SYSTEMS TO TRACK CHANGES

One of the first questions likely to arise when discussing adaptation options to increase adaptive capacity and decrease ecosystem vulnerabilities to climate change is *adapt to what?*<sup>142</sup> This query is directly attributed to our lack of knowledge about the extent and nature of impacts climate change will have on ecosystem functions. As our first objective, we should institute a monitoring program in order to systematically evaluate ecosystem responses to climate change. Ecosystems will have highly diverse and dynamic responses to climate change,<sup>143</sup> some ecosystems will respond before others and are more suited as indicators. Monitoring should be established in these ecosystems; if we see change in the most sensitive areas, change in other areas will likely follow close behind. Identification of the best indicators is still ongoing, but the following areas have characteristics that make them excellent candidates: alpine and sub-alpine ecosystems, grasslands, riparian areas, inter-tidal communities, wetlands, and continuing monitoring of phenological and distributional changes of major species.

## 5.3 THE ECOSYSTEM MANAGEMENT APPROACH

An ecosystem management approach is defined as “managing areas at various scales in such a way that ecological services and biological resources are conserved while appropriate human uses are sustained.... It focuses on ecological systems as a whole rather than on just some of their parts, includes public involvement in the goal-setting process, [and] integrates conservation into economic activity”.<sup>144</sup> An ecosystem management approach is a paradigm shift from the conventional, top-down, command and control, linear management approach to a nonlinear, adaptive management, bottom-up approach that fosters collaborative decision making and planning.

The ecosystem management approach has recently re-emerged as a viable policy and planning tool that for a variety of reasons is aptly suited to address climate change-induced impacts along with non-climatic stressors to biodiversity:<sup>145</sup>

1. Climate change affects a variety of ecosystems at a pace that may exceed natural adaptation while ecosystems are becoming less resilient at the very time they need to be more resilient. There is a growing awareness that ecosystems are healthy and resilient to stress if they maintain stability and sustainability. If human societies are going to maintain their well-being, they must ensure that the biological and ecological systems on which their existence and economy depend are resilient.
2. Given the sheer size of BC’s land base, isolating and addressing large-scale climate change impacts on BC’s forests, wetlands, grasslands, and alpine regions in a meaningful way would prove to be a challenging and difficult undertaking. For example, apart from major commercial tree species and some animal species, most forest and range plants and animals will likely adapt by themselves free from any human intervention.<sup>146</sup> The best chance for species and ecosystem to adapt to climate change is to increase resiliency by reducing the stressors contributing to existing and future vulnerabilities.<sup>147, 148</sup>
3. Apart from climate change drivers, biological and ecological diversity continues to be vulnerable to human-induced stressors. Species and ecosystems are at risk on a broad geographical scale crossing numerous political jurisdictions.
4. Environmental laws and policies have not adequately addressed biodiversity loss arising from increases in population and consumption.

142 ACT Conference (2008)

143 Hamann, A. & Wang, T. (2006)

144 Brussard, P.F., Reed, J.M. & Tracy, C.R. (1998)

145 List retrieved from Voora, A.A. & Venema H.D. (2008) with some derivations to highlight relevant points in BC.

146 Spittlehouse, D.L. (2008)

147 Gayton, D. (2008)

148 Parmesan, C. (2004)

5. Economic development often trumps the issue of biodiversity loss and fails to incorporate the public in resource-use decisions in any meaningful way.
6. Humans will have to change the governance framework to protect ecosystem services; otherwise, they will have to pay for them in the future.
7. There needs to be a consistent approach to decision making about water and lands by all government agencies to maintain ecosystem resiliency.
8. Decisions need to be risk-based, with the most attention being paid to decisions in high-value ecosystems with high-value resource revenues.
9. There is curiosity about developing and shaping a new governance framework to establish a new relationship with our natural environment.

Introducing an ecosystem management approach to govern resource uses requires fundamental, province-wide organizational change at every level of government. Goals and objectives for commodity production, environmental protection, urban planning, watershed management, and wildlife management have to be established in an integrative manner within the greater strategic context of reducing impacts that create biodiversity loss and impede ecosystem functions.

There are many examples of integrated resource management approaches already extensively applied across BC, such as land and resource management plans. However, there are few examples of governments applying ecosystem management approaches in their purest form, with the exception of the north and central coast in BC. The provincial government, the Haida Gwaii, and First Nations communities, local governments, and NGOs in the north and central coast of BC entered into an agreement to implement an ecosystem-based management (EBM) framework for achieving healthy and fully functioning ecosystems and human communities. The North and Central Coast EBM framework outlines the following principles and goals,<sup>149</sup> which contain characteristics similar to those in the conceptual frameworks promoted in the literature.<sup>150</sup>

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149 Coast Information Team (2004).

150 Convention on Biological Diversity (2007)

## PRINCIPLES:

1. Ecological Integrity is Maintained
2. Human Well-being is Promoted
3. Cultures, Communities, and Economies are Sustained within the Context of Healthy Ecosystems
4. Aboriginal Rights and Titles are Recognized and Accommodated
5. The Precautionary Principle is Applied
6. EBM is Collaborative
7. People Have a Fair Share of the Benefits from the Ecosystems in which They Live

### GOAL #1

Maintain the ecological integrity of terrestrial, marine, and freshwater ecosystems

#### OBJECTIVES

1. Represent the biological diversity of the region in a system of protected areas according to the principles of conservation biology.
2. Maintain the natural diversity of species, ecosystems, seral stages, and ecosystem functions, including biological legacies (e.g. bear dens, wildlife trees, snags, coarse woody debris).
3. Restore damaged or degraded ecosystems.
4. Ensure that stream flow, channel characteristics, and water quality are within the range of natural variability.
5. Protect or restore red- and blue-listed species and their habitats and protect red- and blue-listed and regionally-rare ecosystems.
6. Maintain viable populations of all native species, including genetic variants, across their range.
7. Conserve soil productivity and maintain slope failures within natural rates.

### GOAL #2

Achieve high levels of human well-being

#### OBJECTIVES:

1. Achieve the health, wealth, and education status required for a high-quality and secure life for both aboriginal and non-aboriginal people.
2. Build stable, resilient, well-serviced, and peaceful communities in coastal BC.
3. Create a strong and diverse mix of businesses and overall economy within communities and across the region.
4. Create a strong and diverse mix of non-profit and voluntary organizations and a vibrant set of traditional, cultural, and non-market activities within communities and across the region.
5. Ensure a fair distribution of benefits, costs, and risks across all parts of coastal BC, including aboriginal and non-aboriginal people.

## REFERENCES

- Adaptation to Climate Change Team (2008). Communities in Jeopardy Conference. March 31 – April 1, 2008. Simon Fraser University, Vancouver, Canada.
- Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smith B. & Takahashi, K. (2007). *Assessment of adaptation practices, options, constraints and capacity. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge, UK: Cambridge University Press, 717-743.
- Anielski, M. & Wilson, S. (2006) Counting Canada's Natural Capital. Assessing the real value of Canada's boreal ecosystems. Ottawa: Canadian Boreal Initiative the Pembina Institute.
- Austin, M.A., Buffett, D.A., Nicolson, D.J., Scudder G.G.E., & Stevens, V. (Eds.). 2008. Taking Nature's Pulse: The Status of Biodiversity in British Columbia. Biodiversity BC, Victoria, BC. 268 pp. Available at: [www.biodiversitybc.org](http://www.biodiversitybc.org).
- Becker, H.A. & Vanclay, F. (2003). The International Handbook of Social Impact Assessment. Northampton, MA: Edward Elgar.
- Boyd, D.R. (2003). Unnatural Law: Rethinking Canadian Environmental Law and Policy. Vancouver, BC: UBC Press.
- British Columbia Climate Action Plan (2008). Retrieved September, 2008, from, [http://www.livesmartbc.ca/attachments/climateaction\\_plan\\_web.pdf](http://www.livesmartbc.ca/attachments/climateaction_plan_web.pdf).
- British Columbia Forest Information (2008). Retrieved September, 2008, from, <http://www.bcforestinformation.com/maps/frames.htm>
- British Columbia Market Outreach Network (2007). British Columbia's Forest Diversity. Retrieved 2008, from, <http://www.bcforestinformation.com/Assets/PDF/FSA-060-E.pdf>
- BC Ministry of Community Development (2008). Community Development Trust. Retrieved October 8, 2008 from [http://www.cd.gov.bc.ca/ministry/whatsnew/community\\_development\\_trust.htm](http://www.cd.gov.bc.ca/ministry/whatsnew/community_development_trust.htm)
- British Columbia Ministry of Energy, Mines and Petroleum Resources. (2008). BC Bioenergy Strategy. Retrieved October, 2008, from, [http://www.energyplan.gov.bc.ca/bioenergy/PDF/BioEnergy\\_Plan\\_005\\_0130\\_web0000.pdf](http://www.energyplan.gov.bc.ca/bioenergy/PDF/BioEnergy_Plan_005_0130_web0000.pdf)
- British Columbia Ministry of the Environment (2008). BC Conservation Framework. Retrieved October, 2008, from, <http://www.env.gov.bc.ca/conservationframework/index.html>.
- British Columbia Ministry of the Environment (2008). BC Parks. BC Parks Statistics. Retrieved October 2008, from, <http://www.env.gov.bc.ca/bcparks/facts/stats.html>.
- British Columbia Ministry of the Environment (2007). BC Parks. Parks and Protected Areas Program. Retrieved September, 2008, from, <http://www.env.gov.bc.ca/bcparks/info/legis.html>.
- British Columbia Ministry of the Environment (2004). Procedures for Managing Identified Wildlife. Retrieved June, 2008, from, <http://www.env.gov.bc.ca/wld/frpa/iwms/procedures.html>.
- British Columbia Ministry of the Environment (2003). Environmental Assessment Office. A Guide to the Environmental Assessment Process. Retrieved June, 2008, from, <http://www.eao.gov.bc.ca/guide/2003/>
- British Columbia Ministry of Forests and Range (2008). Mountain Pine Beetle Facts. Retrieved June, 2008, from, [http://www.for.gov.bc.ca/hfp/mountain\\_pine\\_beetle/maps/magnitudeMap200107.pdf](http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps/magnitudeMap200107.pdf)
- British Columbia Ministry of Forest and Range. Future Forest Ecosystems Initiative (2007). Retrieved October, 2008, from, [http://www.for.gov.bc.ca/hts/Future\\_Forests/](http://www.for.gov.bc.ca/hts/Future_Forests/)
- Brouwer, R., Langford, I.H., Bateman, I.J. & Turner, R.K. (1999). A meta-analysis of wetland contingent valuation studies. *Regional Environmental Change*: 1(1), 47- 57.
- Brussard, P.F., Reed, J.M. & Tracy, C.R. (1998). Ecosystem management: what is it really? *Landscape and Urban Planning*: 40, 9-20.
- Burton, I., Huq, S., Lim, B., Pilifosova, O. & Schippe E.S. (2002). From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy*: 2 (2-3), 145-159.
- Carroll, A.L., Taylor, S. W. & Regniere, J. (2004) Effects of Climate Change on Range Expansion by the Mountain Pine Beetle in BC (Draft). Canadian Forest Service.
- Champ, P.A., Boyle, K.J. & Brown, T.C. (2004). A Primer on Nonmarket Valuation. Norwell, MA: Kluwer Academic Publishers.
- Chapin III, S. F., Zavaleta, E. S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., Hooper, D.U., Lavorel, S., Sala, O.E., Hobbie, S.E., Mack, M.C. & Diaz, S. (2000). Consequences of changing biodiversity. *Nature*: 405, 234-242.
- Christopherson, Robert W. (1997). *Geosystems: An Introduction to Physical Geography*, 3rd edn., Upper Saddle River, NJ: Prentice Hall.
- Coast Information Team (2004). Ecosystem Based Management Framework. c/o Cortex Consultants Inc., 3A-1218 Langley St. Victoria. Retrieved, October, 2008, from, <http://www.citbc.org/c-ebmf-fin-03May04.pdf>
- Compass Resource Management (2007). Major Impacts: Climate Change. Submitted for the Biodiversity BC Technical Support Committee for the Report on the Status of Biodiversity in BC. Retrieved, April, 2008, from, <http://www.biodiversitybc.org/assets/Default/BBC%20Major%20Impact%20Climate%20Change.pdf>
- Convention on Biological Diversity (2007). Ecosystem Approach Principles. Retrieved October, 2008, from, <http://www.cbd.int/ecosystem/>

- Costanza, R. & Folke, C. (1997). Valuing Ecosystem Services with Efficiency, Fairness and Sustainability as Goals. In: Daily, G.C. (Ed.), *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press, 49–68.
- Council of Forest Industries (2007). BC Forest Industry at a Glance. Retrieved September, 2008, from, [http://www.cofi.org/forest\\_industry\\_BC/documents/October%202006%20PWC%20stats%20summary.pdf](http://www.cofi.org/forest_industry_BC/documents/October%202006%20PWC%20stats%20summary.pdf)
- David Suzuki Foundation and Sierra Legal (2007). Rich Wildlife, Poor Protection. The Urgent Need for Strong Legal Protection of British Columbia's Biodiversity. Retrieved July, 2008, from, <http://www.davidsuzuki.org/files/SWAG/DSFrchpoorWEB2.pdf>
- Dessai, S. & Hulme, M. (2007). Assessing the robustness of adaptation decisions to climate change uncertainties: a case study on water resources management in the east of England. *Global Environmental Change*: 17(1), 59–72.
- Dessai, S. & Van Der Sluijs, J. (2007). Uncertainty and climate change adaptation – scoping report. Coerpernicus Institute. Research Institute for Sustainable Development and Innovation. Retrieved October, 2008, from, [http://www.nusap.net/downloads/reports/ucca\\_scoping\\_study.pdf](http://www.nusap.net/downloads/reports/ucca_scoping_study.pdf)
- Editorial (2007). Editorial on uncertainty and climate change. *Global Environmental Change*: 17, 1–3 H.
- European Environment Agency (2005). Vulnerability and Adaptation to Climate Change in Europe. EEA Technical Report, No. 7. Retrieved April, 2008, from, [http://reports.eea.europa.eu/technical\\_report\\_2005\\_1207\\_144937/en/EEA\\_Technical\\_report\\_7\\_2005.pdf](http://reports.eea.europa.eu/technical_report_2005_1207_144937/en/EEA_Technical_report_7_2005.pdf)
- Evans, S.G. & Clague, J.J. (1994). Recent climatic change and catastrophic geomorphic processes in mountain environments. *Geomorphology*: 10(1–4), 107–128.
- Fraser, J. (2002). Indicators of Climate Change for British Columbia.
- BC Ministry of Water, Land and Air Protection. Victoria, BC, pp. 5–35. Retrieved, May, 2008, from, <http://www.gov.bc.ca/wlap>
- Fischlin, A., Midgley, G.F., Price, J.T., Leemans, R., Gopal, B., Turley, C., Rounsevell, M.D.A., Dube, O.P., Tarazona, J. & Velichko, A.A. (2007) Ecosystems, their properties, goods, and services. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge, UK: Cambridge University Press, 211–272.
- Gayton, D. (2008). Impacts of climate change on British Columbia's biodiversity: A literature review. Forrex Forest Research Extension Partnership, Kamloops, BC. Forrex Series 23. Retrieved, September, 2008, from, <http://www.forrex.org/publications/forrexseries/fs23.pdf>
- Gayton, D. & Forrex. (2007). Major Impacts to Biodiversity (Excluding Climate Change). Retrieved May, 2008, from, <http://www.biodiversitybc.org/assets/Default/BBC%20Major%20Impacts%20Other.pdf>
- Gitay, H., Suárez, A., Watson, R.T. & Dokken, D.J. (Eds). (2007). *Climate Change and Biodiversity*. IPCC Technical Paper V, Geneva, Switzerland. pp 85. Retrieved April, 2008, from, <http://www.ipcc.ch/pdf/technical-papers/climate-changes-biodiversity-en.pdf>
- Gray, P.A. (2005). Impacts of climate change on diversity in forested ecosystems: Some examples. *Forestry Chronicle*: 81, 5.
- Hamann, A. & Wang, T. (2006). Potential effects of climate change on ecosystem and tree species distribution in British Columbia. *Ecology*: 87, 2773–2786.
- Hebda, R. (2007). *Ancient and future grasslands. Climate change and insights from the fossil record and climate models*. BC Grasslands: Retrieved April, 2008, from, <http://www.bcgrasslands.org/archivemagazine.htm>
- Hooper, D.U., Chapin III, F.S., Ewel, J.J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A.J., Vandermeer, J., Wardle, D.A. (2005). Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological Monographs*: 75, 1.
- Hughes, L. (2000). Biological consequences of global warming: is the signal already apparent? *Tree*: 15(2).
- IPCC (2007). Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge, UK: Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. H. Gitay, A. Suárez, R.T. Watson, D.J. Dokken (Eds).
- Jump, A.S. & Penuelas, J. (2005). Running to stand still: adaptation and the response to rapid climate change. *Ecology Letters*: 8, 1010–1020.
- Lister, N. & Marie E. (1997). A systems approach to biodiversity conservation planning. *Environmental Monitoring and Assessment*: 49, 123–155.
- Living Water Smart (2008). Retrieved October, 2008, from, <http://www.livingwatersmart.ca/>.
- Luckman, B. & Kavanagh, T. (2000). Impact of climate fluctuations on mountain environments in the Canadian Rockies. *Ambio*: 29(7), 371–380.
- McCarty, J.P. (2001). Ecological consequences of recent climate change. *Conservation Biology*: 15(2), 320–331.
- Millar, C. (2008). Natural Resource Strategies and Climate Change. (June 16, 2008). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. <http://www.fs.fed.us/ccrc/topics/natural-resource.shtml>
- Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well being: A framework for Assessment*. Retrieved May, 2008, from <http://www.millenniumassessment.org/en/index.aspx>
- Munasinghe, M. & Swart, R. (2005). *Primer on Climate Change and Sustainable Development: Facts, Policy Analysis and Applications*. Cambridge, UK: Cambridge University Press.
- Nunes, P. & Van den Bergh, J. (2001). Economic valuation of biodiversity: sense or non-sense. *Ecological Economics*: 39, 203–222.
- Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change. *Annus. Rev. Ecol. Evol. Syst.*: 37, 637–669.

- Parmesan, C. & Galbraith, H. (2004). Observed Impacts on Global Climate Change. U.S. Pew Center on Global Climate Change. Arlington, V.A.
- Parmesan, C. & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*: 421, 37-42.
- Pauli, H., Gottfried, M. & Grabherr, G. (2003). Effects of climate change on the alpine nad nival. vegetation of the Alps. *J. Mt. Ecolz*: 7 (Sppl.), 9-12
- Peñuelas, J. & Filella, P. (2001). Phenology: responses to a warming world. *Science*: 294, 793-795.
- Root, T.L & Hughes, L. (2005). Present and Future Phenological Changes in Wild Plants and Animals. In Lovejoy, T.E., and Hannah, L. (Eds). *Climate Change and Biodiversity*. Yale University Press.
- Root, T.L., Price, J.T., Hall, K.R., Schneider, S.H., Rosenzweig, C. & Pounds, J.A. (2003). Fingerprints of global warming on wild animals and plants. *Nature*: 421, 57-60.
- Schneider, S.H., Semenov, S., Patwardhan, A., Burton, I., Magadza, C.H.D., Oppenheimer, M., Pittock, A.B., Rahman, A., Smith, J.B., Suarez, A. and Yamin, F. (2007). Assessing key vulnerabilities and the risk from climate change. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge, UK: Cambridge University Press, 779-810.
- Scott, D.J. & Lemieux, C.J. (2007). Climate change and protected areas policy, planning and management in Canada's boreal forest. *The Forestry Chronicle*: 83, 3.
- Primack, R.B. (2006). *Essentials of Conservation Biology*. Sinauer Associates: Sunderland, MA.
- Spittlehouse, D.L. (2008). *Climate Change, Impacts, and Adaptation Scenarios: Climate Change and Forest and Range Management in British Columbia*. Ministry of Forests and Range Science Program.
- Tietenberg, T. (2003). *Environmental and Natural Resource Economics*. 6th Ed. Toronto: Addison Wesley.
- United Nations Development Programme (2005). *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*. Lim, B., Spanger-Siegrfried, E., Burton, I., Malone, E. & Huq, S. (Eds.). Cambridge, UK: Cambridge University Press.
- United Nations Framework Conventions on Climate Change (2008). Article 2. Retrieved April, 2008, from, [http://unfccc.int/essential\\_background/convention/background/items/1353.php](http://unfccc.int/essential_background/convention/background/items/1353.php)
- Wagner, J.E., Luzadis, V.A. & Floyd, D.W. (1998). A role for economic analysis in the ecosystem management debate. *Landscape and Urban Planning*: 40, 151-157.
- Walker, W.E., Harremoes, P., Rotmans, J., van der Sluijs, J.P., van Asselt, M.B.A., Janssen, P.H.M. & von Krauss, M.P.K., 2003. Defining uncertainty: a conceptual basis for uncertainty management in model-based decision support. *Integrated Assessment*: 4, 5-17.
- Walker, I.J. & Sydneysmith, R. (2008). British Columbia. In, *From Impacts to Adaptation: Canada in a Changing Climate 2007*, Lemmen, D.S., Warren, F.J., Lacroix, J., & Bush, E (Eds.). Government of Canada, 329-386.
- Walther, G.R. (2003). Plants in a warmer world. *Perspectives in Plant Ecology, Evolution and Systematics*: 6/3, 169-185.
- Walther, G.-R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.-M., Hoegh-Guldberg, O., & Bairlein, F. (2002). Ecological responses to recent climate change. *Nature*: 416, 389-395.
- West Coast Environmental Law (2004). Background. BILL 38: THE NEW ENVIRONMENTAL ASSESSMENT ACT. Retrieved June, 2008, from, <http://www.wcel.org/deregulation/bill38.pdf>
- West Coast Environmental Law (2004). Background. BILL 51: WILDLIFE AMENDMENT ACT. Retrieved June, 2008, from, <http://wcel.org/deregulation/bill51.pdf>
- West Coast Environmental Law (2003). Brief on PARKS AND PROTECTED AREAS STATUTES AMENDMENT ACT. Retrieved September, 2008, from, [http://www.wcel.org/deregulation/bill\\_84.pdf](http://www.wcel.org/deregulation/bill_84.pdf)
- Willows, R.I. & Connell, R.K. (Eds.). (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report. Oxford, UK: UKCIP.
- Wilson, S.J. & Hebda, R.H. (2008). *Mitigating and Adapting to Climate Change Through the Conservation of Nature*. Land Trust Alliance of BC.
- Vold, T. & Buffett, D.A., (Eds.) 2008. *Ecological Concepts, Principles, and Applications to Conservation*, BC. 36 pp. Available at: [www.biodiversitybc.org](http://www.biodiversitybc.org)
- Voora, A.A. & Venema H.D. (2008). *The Natural Capital Approach: A Concept Paper*. International Institute for Sustainable Development. Retrieved October, 2008 from [www.iisd.org](http://www.iisd.org)

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