Fraser Basin Council

Backgrounder – Preparing for Climate Change in the Fraser Basin: How Can our Water Management Systems Adapt?

Prepared by the Fraser Basin Council

October, 2007

Introduction

The release of the fourth Intergovernmental Panel on Climate Change (IPCC) report this spring re-affirmed the growing acceptance that climate change is occurring as a result of human-related activities.

Decision-makers are increasingly incorporating responses to climate change into their policy and decision-making processes. Decision makers are faced with two types of responses to climate change: mitigation and adaptation.

Mitigation strategies include activities that reduce the amount of greenhouse gases emitted into the atmosphere (Peart, Patton & Riccius, 2007). Decisions based on mitigation strategies include actions such as promoting alternative transportation, increasing building energy efficiency and using alternative energy sources. Adaptation strategies include activities that respond to the results of changed climatic patterns (Peart *et. al.*, 2007). Decisions based on adaptation strategies include actions such as building infrastructure to protect communities against sea level rise. Adaptation actions can also be directed at ecosystems, such as by creating protected corridors to allow for animal and plant migrations in response to climate change.

Globally, more emphasis has been placed on mitigation strategies. The Kyoto protocol, which aims to reduce global greenhouse gases to 5.2% below 1990 levels, is perhaps the best-known mitigation target. In BC the current provincial climate change action plan focuses on setting mitigation targets and strategies.

Decision-makers will need to implement a mixture of mitigation and adaptation strategies to effectively respond to the threats posed by climate change. The impacts of human-emitted greenhouse gases are predicted to warm the planet and increase sea levels for the next 1,000 years because released gases will remain in the atmosphere and contribute to positive feedback in climatic systems (IPCC, 2007) (Figure 1). In other words, climate change will occur to a certain extent regardless of mitigation efforts, and there is a need to adapt to its impacts.

Adaptation strategies are built on assessing a community's vulnerability to potential climate change impacts. Future social, economic and environmental projections are often used as a key tool in vulnerability assessments (C-CIARN, 2006). Once a vulnerability assessment is completed, a community can begin implementing policies that may increase its capacity to cope with climate change impacts (C-CIARN, 2006).

Backgrounder — Climate Change Scenarios

Climate change scenarios are one of the tools available to decision-makers to help plan for climate change impacts. Scenarios are hypothetical projections of what the climate may be in the future. Scenarios are constructed through a computer-run simulation that analyzes various climatic data and produces projected climate models (PCIC, 2007). Sometimes scenarios are presented as a map to compare a present climatic condition to a possible future climatic condition, for example, the current average annual temperature versus the projected temperature in 2070 (Figure 2).

Scenarios are built on two types of climate models: Global Climate Models (GCMs) and Regional Climate Models (RCMs). Global Climate Models present climate projections at a coarse scale and cover a large geographic area (Murdock & Bennett, 2007). However, climate change impacts will be felt on a local level and will vary regionally (C-CIARN, 2006). Regional Climate Models take into account local conditions such as topography and vegetation cover to produce more detailed climate projections for a specific region (Murdock & Bennett, 2007).

Research on scenarios has been ongoing for over a decade (Warren *et. al.*, 2004). The first IPCC report, published 17 years ago, projected a temperature rise of 0.15-0.3°C per decade until 2005. The actual recorded temperature increase has been observed to be 0.2°C per decade which is within the temperature projected by scenarios included in IPCC's first report (IPCC, 2007).

As confidence in climate change scenarios increases, it is important to remember that a climate change scenario is not an exact prediction, but rather a presentation of one possible future. The multitude of climate change scenarios available is an indication that no one scenario claims to predict exact future climatic conditions.

International & National Scenarios

International Global Climate Models range from best- to worst-case climate change scenarios and project an average of 2.4-6.4°C global temperature increase by 2099 (IPCC, 2007). Additionally, scenarios compared in the IPCC report include projected sea level rises between 0.18-0.59 m by the end of the century. Included in these scenarios are projections of reduced snow cover, shrinking sea ice, increased heat waves, more frequent heavy precipitation and an increase in typhoons and hurricane intensities. (IPCC, 2007) The IPCC's projections are considered to be conservative estimates of sea level rise and temperature increases, with other models projecting more dramatic changes by the end of this century (Vancouver Sun 2007 b, Rees pers. comm.).

Due to Canada's higher latitude, temperature increases are expected to be greater than the global averages presented in the IPCC report (Warren *et. al.*, 2004). As well, Canadian winters are expected to be wetter and summers are expected to be drier (Warren *et. al.*, 2004). The actual impacts of climate change, such as temperature increases and precipitation patterns, will vary regionally across Canada (Cohen, pers. comm.).

The BC Context

BC climate change scenarios project that average temperatures will increase in the next century; however, precipitation patterns are more difficult to analyze. Precipitation pattern changes will vary across different parts of BC, but generally the scenarios project wetter winters and drier summers, with increasing extreme precipitation events (Murdock, pers. comm.).

A Pacific Climate Impacts Consortium (PCIC) scenario projects a 2-2.5°C temperature increase by 2080 in southern BC and up to a 6.5°C temperature increase in northern BC. In the interior, the snow pack may be reduced by 20%, and throughout the coast it may be reduced by up to 80% (Vancouver Sun, 2007). Another scenario developed for the Okanagan projects an increase of 1.5-4°C in winter temperatures by the 2050s. (Nelitz M. *et.al.*, 2007).

Although most scenarios present changes in annual average temperature and average precipitation, it is important to remember that humans do not directly experience climate averages. Instead people live with daily temperature maximums and minimums, and climate change is expected to lead to increases in the frequency and/or severity of certain types of weather and climate extreme events, such as heat waves and storms (Murdock pers. comm.). To better analyze weather extremes, PCIC developed a set of maps for the Royal BC Museum to illustrate the projected changes in daily minimum winter temperatures and daily maximum summer temperatures. (Figure 3)

Many scenarios exist for BC as a whole and some exist for specific regions. However, one can get lost examining the differences between scenarios. What is important to remember is that no one scenario presents the "correct" future climatic conditions for BC. Rather each scenario presents a plausible future based on specific assumptions and a set of data used to construct the scenario.

Climate Change Impacts in the Fraser Basin

If projected temperature rises, precipitation changes and sea level rise occur, the impacts for the Fraser Basin could be substantial. The basin's vegetation zones may shift with climate change. For example, grasslands are projected to expand across the interior of the basin (Figure 4). Similarly the basin may support different types of agricultural such as expanded corn, tomato and apple cultivation opportunities (PCIC, 2007 b).

Residents along the river could experience greater health hazards from potentially more frequent floods and heat waves. Infrastructure may need reconstruction or design upgrades to accommodate changed climatic patterns in the basin.

In the Fraser River, shifts in stream flow are projected to occur as the climate changes. The river may peak earlier in the season due to warmer temperatures, but the peak would be reduced as a result of decreased snowpacks (Morrison, *et. al.,* 2002). Changes in flow may increase the frequency of floods and water shortages. Higher water temperatures could also impact various fish populations in the river (Morrison, *et. al.,* 2002).

Climate Change Impacts on Water Resources

Hydrological cycles are especially sensitive to temperature and precipitation changes resulting from climate change (Warren *et. al.*, 2004). Predicted impacts of climate change on water resources include the melting of glaciers, permafrost and sea ice, decreasing lake levels, and drying of wetlands and soils (Warren *et. al.*, 2004 and Mehdi *et.al.*, 2003).

In BC warming temperatures and precipitation pattern changes are expected to impact stream flow patterns. Warmer winter temperatures may increase mid-winter snowmelts and the frequency of rain, thus increasing winter flow volumes. The diminishing snow accumulation, due to warmer temperatures, may reduce the amount of water stored in the snow pack at the beginning of the summer. With a smaller snowpack and less summer precipitation, stream flows may be lower during summers. (Warren *et. al.*, 2004)

As a result of stream flow changes, water shortages are expected to become more common across BC. Already 17% of surface water in the province is close to or at its maximum use capacity (Warren *et. al.*, 2004).

A reduction in water quantity could be exacerbated by a reduction in water quality and lead to greater water shortages. If reduced stream flows and warmer water temperatures occur, they would contribute to increasing dissolved concentrations of pollutants in water sources. Decreasing water quality would lead to a reduction of potable water available and add to water shortages brought on by the projected reduction in summer stream flows (Warren *et. al.*, 2004).

Beyond decreasing water quality, temperature increases may further compound water shortages by increasing the demand for water. During periods of hotter temperatures, irrigation, space cooling, domestic lawn watering – to name a few – all increase and result in higher demands on water supplies (Warren *et. al.*, 2004; Cohen & Neale, 2006). The combination of lower steam flows, poorer water quality and greater water use could all combine to reduce available water resources in BC, especially if no further water demand management strategies are implemented.

If climate change projections are correct and water supplies are reduced, the impacts would go beyond direct water shortages. One of the obvious impacts includes reduced agricultural productivity due to reduced irrigation capacity. Recreational, commercial and industrial practices would also be impacted and may need to change operations that rely on specific stream flows and water supplies. (Mehdi *et.al.*, 2003)

Beyond impacting human systems, hydrological changes are also predicted to impact ecological system dynamics. The impacts of climate change on salmon are one of the better-studied examples of wider climate change impacts on ecosystems. Both temperature increases and reduced water flows have been identified as threats to salmon populations. In the Fraser River there has been some indication that warmer water temperatures have delayed migration of Sockeye Salmon (Nelitz M. *et.al.*, 2007). Some scientists predict that, if reduced water flows become the norm, salmon may have more difficulty accessing and navigating their river migration routes (Nelitz M. *et.al.*, 2007). The impacts for both salmon and salmon fisheries could be far reaching if climate change impacts are overlooked.

A brief review of climate change impacts on water resources illustrates the need to incorporate adaptation strategies into water policy decisions and governance. The impacts of climate change on water resources include both the direct changes on hydrological cycling and the indirect impacts that result from changes in water use patterns due to climate change. Effective adaptation strategies need to address both types of impacts.

Water Management Adaptation Strategies

Water-related adaptation strategies often fall into two categories: water supply solutions and water demand management solutions. Some examples of water supply adaptation strategies include building upstream storage infrastructure, exploiting groundwater sources, storing rainwater and increasing protection of wetlands and riparian areas (Cohen & Neale, 2006; Shaw *et.al.*, 2007). Demand management adaptation strategies often include public education to promote water conservation, higher efficiency appliances / irrigation systems, water metering, and water recycling technologies (Cohen and Neale, 2006; Shaw *et.al.*, 2007). A mixture of different solutions will likely be needed in any adaptation strategy to address a range of climate change impacts.

The specific adaptation strategies adopted will depend on the local community, climatic changes and current water supply. However, adaptation strategies would benefit from supportive high-level policies. Integrating adaptation to climate change in water governance is difficult because water jurisdictions often fall to more than one level of government and / or more than one agency within a single level of government (Levina & Adams, 2006). A collaborative approach will be needed to effectively develop adaptation strategies within the water resource sector.

Conclusion

Mitigation strategies have led the way in climate change policy, but there is a new understanding of the need to couple mitigation with adaptation strategies. While interest in adaptation strategies increase and confidence in climate change scenarios grows, it is important to remember that scenarios present multiple possible future climate conditions.

Although climate change scenarios vary depending on the scale of the projection and data used to construct the scenario, there is reasonable agreement that average annual temperatures will rise globally and the incidences of extreme weather events will increase. Canada will experience warmer temperatures than the projected global trends because of its northern latitude. In BC the degree of warming will vary regionally, while BC winters are expected to be wetter and summers are expected to be drier.

The impacts of climate change on the Fraser Basin and water resources have been highlighted to illustrate the need to integrate adaptation strategies into governance structures. In BC climate change is expected to increase water shortages through decreasing summer stream flows and increasing water demands. Changes in the hydrological cycle will go beyond water shortages to impact other ecosystem cycles and economic sectors.

Adaptation strategies in the water sector will require both supply side and water demand management solutions. For adaptation strategies to be successfully integrated into water governance policies and practices, there will be a need for multi-stakeholder collaboration because various levels of government and agencies govern water resources.

References

C-CIARN (Canadian Climate Impacts and Adaptation Research Network). 2006. Adapting to Climate Change An Introduction for Canadian Municipalities. [Mehdi, B. (ed.), Mrena, C, Douglas A., Connolly-Boutin, L., Sydneysmith, R., Parlee, K., Morneau, F., Leroux, G., Shirley, J., Streicker, J. and McKenzie, K.].

Cohen, S. and Neale T. (eds.) 2006. Participatory Integrated Assessment of Water Management and Climate Change in the Okanagan Basin, British Columbia. Vancouver: Environment Canada and University of British Columbia.

IPCC (Intergovernmental Panel on Climate Change). 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 University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (Intergovernmental Panel on Climate Change). 2001. Summary for Policymakers. Based on draft prepared by Watson, R., Albritton, D., Barker, T., Bashmakov, I., Canziani, O., Christ, R., Cubasch, U., Davidson, O., Gitay, H., Griggs, D., Halsnaes, K., Houghton, J., House, J., Kundzewicz, Z., Lal, M., Leary, N., Magadza, C., McCarthy, J., Mitchell, J., Moreira, J., Munasinghe, M., Noble, I., Pachauri, R., Pittock, B., Prather, M., Richels, R., Robinson, J., Sathaye, J., Schneider, S., Scholes, R., Stocker, T., Sundararaman, N., Swart, R., Taniguchi, T., Zhou, D., and many IPCC authors and reviewers.

Levina, E. and Adams, H. 2006. Domestic Policy Frameworks for Adaptation to Climate Change in the Water Sector. Draft. OECD/IEA Project for the Annex 1 Expert Group on the UNFCC.

Mehdi, B., Hovda, J. and Madramootoo C. 2003. Impacts of Climate Change on Canadian Water Resources. Brace Centre for Water Resources Management.

Morrison, J., Quick, M. and Foreman, M. 2002. Climate change in the Fraser River watershed: flow and temperature projections. Journal of Hydrology. 263: 230-244.

Murdock, T. 2007. Personal communication.

Murdock, T. and Bennett, K. 2007. Development of an Interactive Climate Impacts Modeling Tool and Scenarios for Atlin Region. Presentation given.

Nelitz, M., Wieckowski, K., Pickard, D., Pawley, K. and Marmorek, D. 2007. Helping Pacific Salmon survive the impact of climate change on freshwater habitats: Pursuing proactive and reactive adaptation strategies. Prepared for Pacific Fisheries Resource Conservation Council.

PCIC (Pacific Climate Impacts Consortium). 2007. Preliminary Analysis of Climate Variability and Change in the Canadian Columbia River Basin: Focus on Water Resources. Columbia Basin Trust.

PCIC (b). 2007. Royal BC Museum Maps. Available at http://www.pacificclimate.org/impacts/rbcmuseum/index.cgi?forest

Peart, B., Patton, S. and Riccius E. 2007. Climate Change, Biodiversity and the Benefit of Healthy Ecosystems. Canadian Parks and Wilderness Society.

Rees, B. 2007. Personal communication.

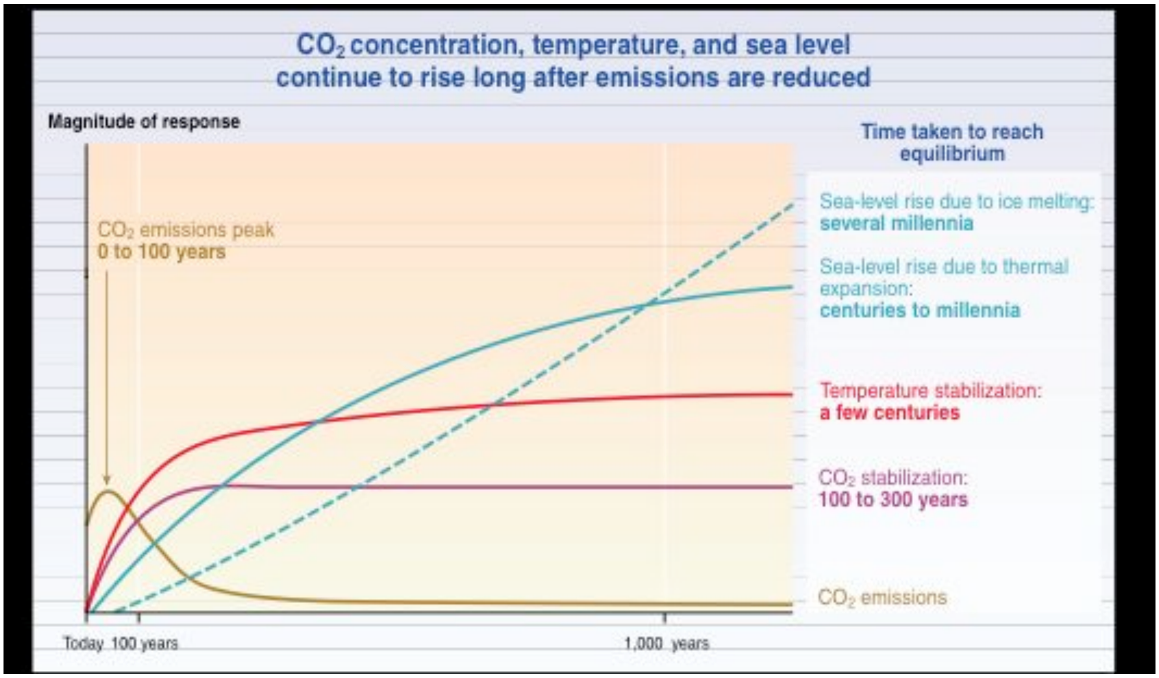
Shaw, R., Colley, M., and Connell, R. 2007. Climate change adaptation by design: a guide for sustainable communities. TCPA, London

Warren, F., Barrow, E., Schwartz, R., Andrey, J., Mills, B. and Riedel, D. 2004. Climate Change Impacts and Adaptation: A Canadian Perspecitve. Lemmen D. and Warren F. (eds.). Natural Resources Canada.

Vancouver Sun. 2007. BC 2050 Our Changing Climate. June 2, 2007.

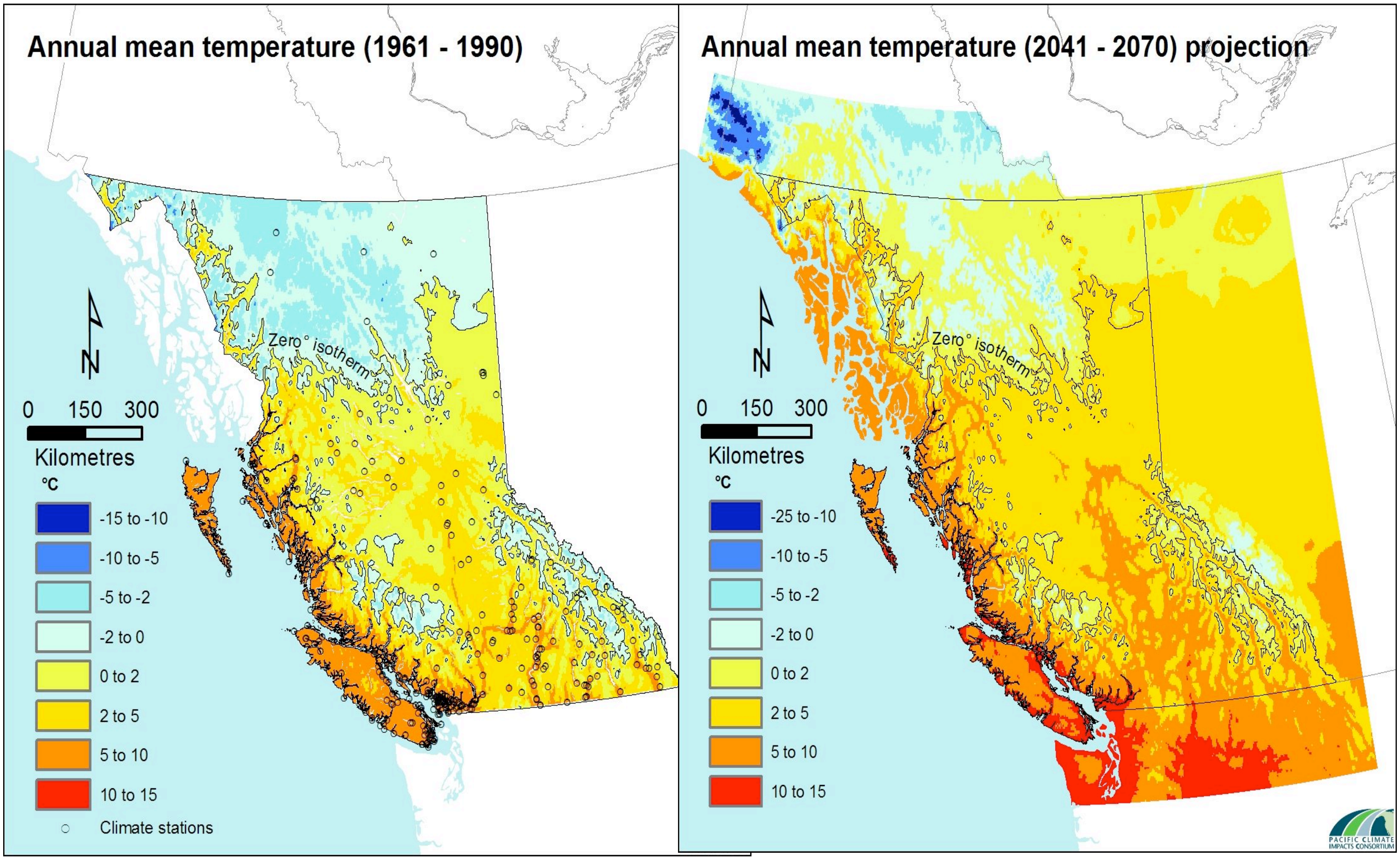
Vancouver Sun. 2007 b. Municipal Leaders Get Climate Warning. September 27, 2007.

Figure 1: Projected Impacts of Current CO_2 Emissions for the next 1,000 years



Source: IPCC, 2001

Figure 2: Sample Scenario Projecting Annual Mean Temperature in BC

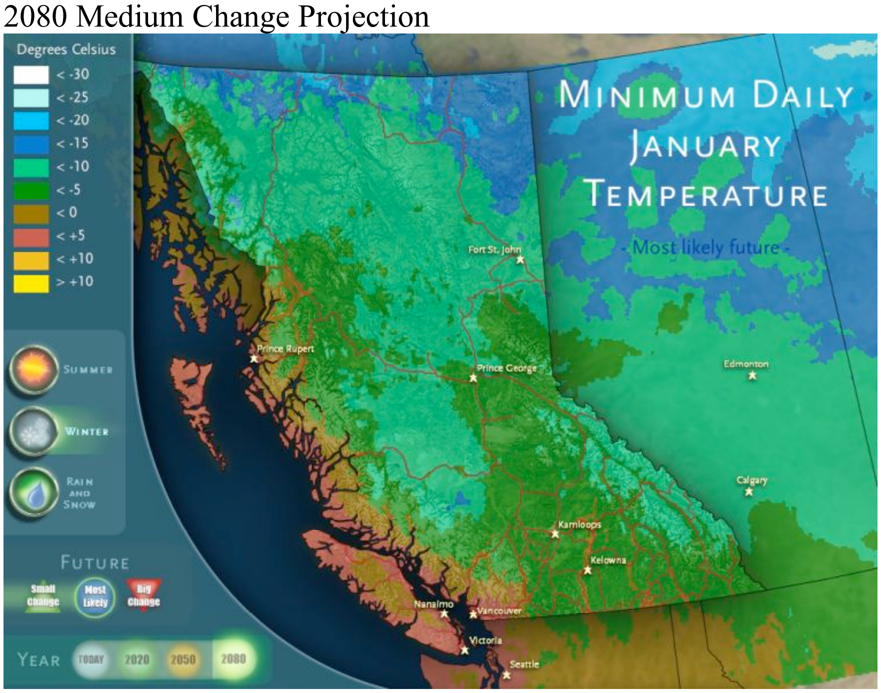


Source: Pacific Climate Impacts Consortium (PCIC)

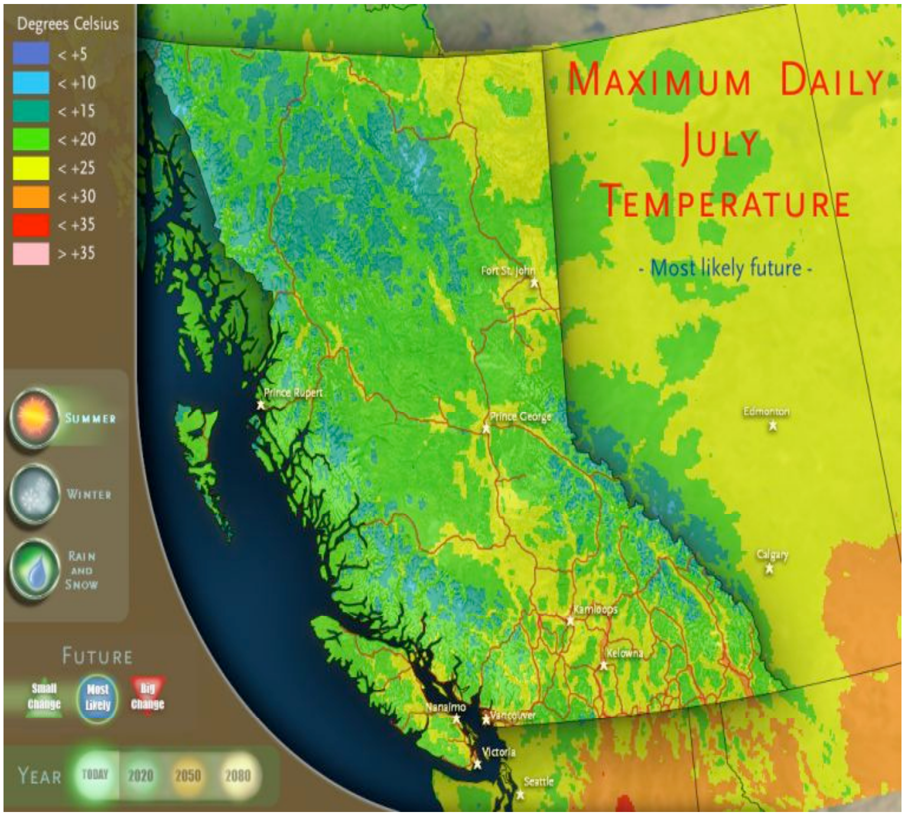
Figure 3: Present and Projected Minimum Winter Temperatures and Maximum Summer Temperatures for BC

Present

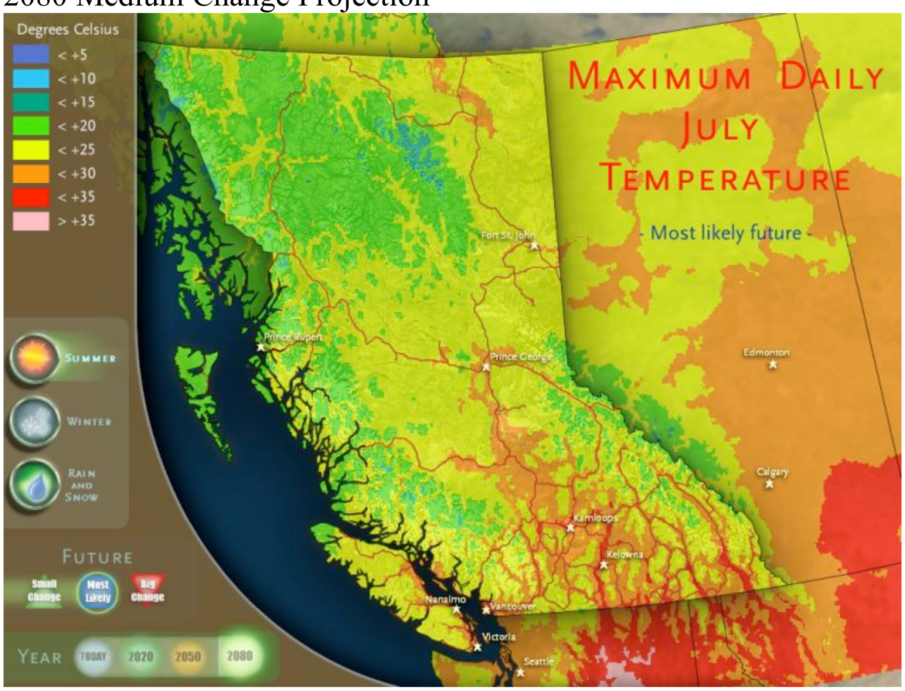
2080 Medium Change Projection



Present



2080 Medium Change Projection

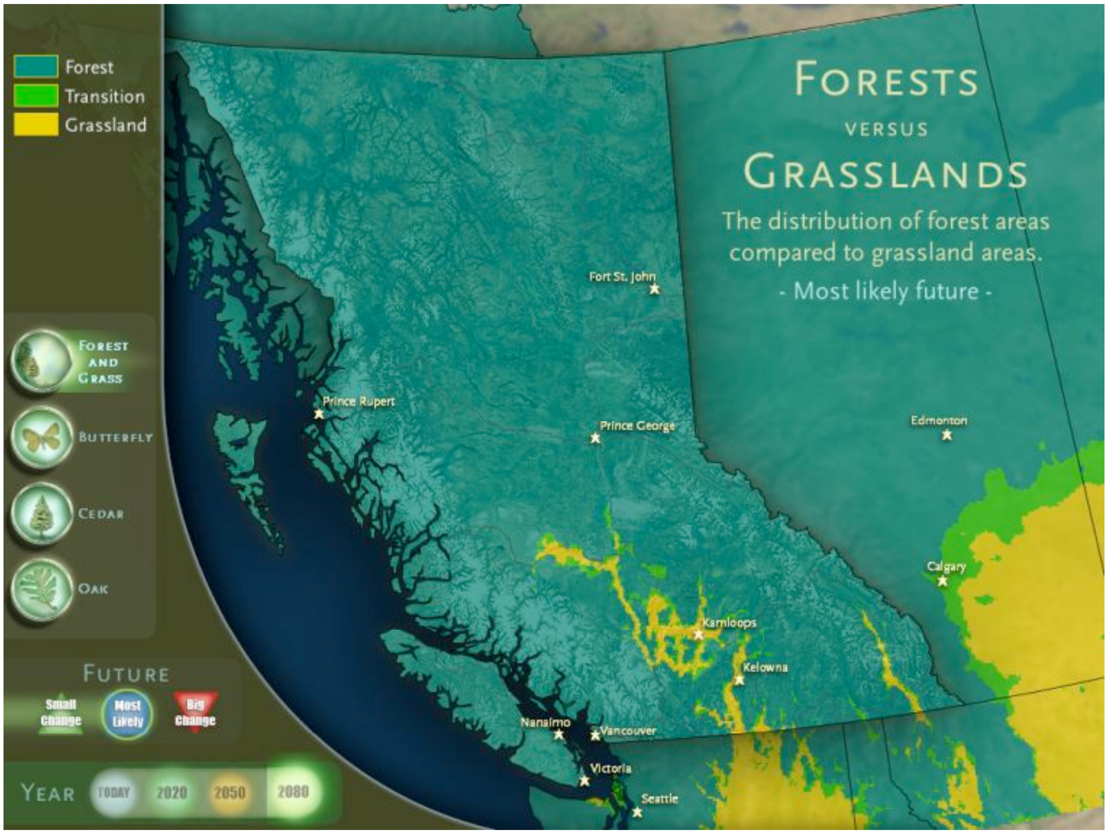


Source: Pacific Climate Impacts Consortium (PCIC), available at http://www.pacificclimate.org/impacts/rbcmuseum/

Figure 4: Present and Projected Forest and Grass Cover for BC

Present

2080 Medium Change Projection



Source: Pacific Climate Impacts Consortium (PCIC), available at http://www.pacificclimate.org/impacts/rbcmuseum/