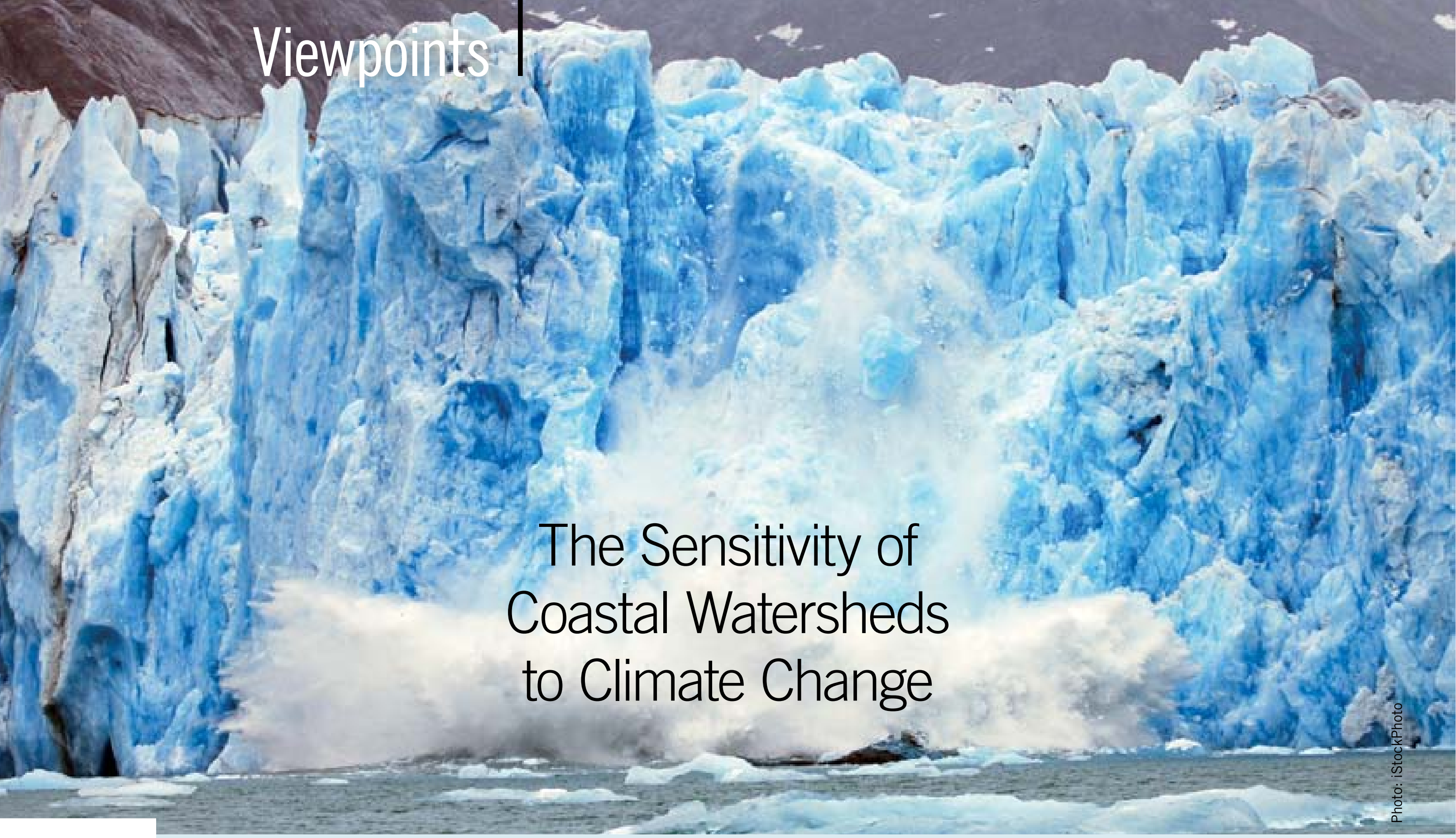

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The Sensitivity of Coastal Watersheds to Climate Change

THE MOST PRESSING QUESTION FOREST PROFESSIONALS FACE regarding climate change is “how are we going to adapt our professional practices and management strategies?” To adapt, we need to know which areas are the most resilient to climate change and which areas are going to be impacted soonest and to the greatest degree. Because many coastal watersheds sit within the rain-snow interface, any warming or cooling trends, coupled with alteration of precipitation rates, can result in drastic changes to snow levels.

Snow-packs are critical as they play a primary role in many hydrological functions, such as:

- Storage and release of water in the spring and summer (a “free” natural reservoir) to streams for ecological services, domestic water supply, industrial uses, hydro-electric power generation, etc;
- Act as a buffer during short duration extreme rain events, when the snow-pack is sufficiently deep and cold (>2m) to absorb rainfall and energy; and
- Potential to intensify flood and/or landslide events, especially when snow-packs are shallow and can readily melt (rain-on-snow).

Russell Creek Experimental Watershed (Floyd 2010), a Ministry of Natural Resource Operations (MNRO) long-term research installation located on northern Vancouver Island (50° 20’ – 126° 22’) helps to illustrate the potential impacts of a warming climate on coastal snow-packs. A climate dataset from 2007-2008 combined with modelling shows that even minor increases in average temperature can have major effects on snow-water-equivalent, especially at lower elevations. A warming of less than 1 C results in a 38% percent reduction of peak snow-water-equivalent at the lowest elevations. A 2.1 C warming of the 2007-2008 dataset results in a 60 to 80% reduction in peak snow-pack, with lower elevations being completely snow free by the end of February. When we apply a warming of 3 C, the peak snow-water-equivalent in the alpine (1500m a.s.l.), occurs 3 months earlier and is reduced by 72%, with the lower and middle elevation snow-packs becoming largely transient. This is illustrated in the graphs in Figure 1.

However, this is not the case everywhere. Similar analysis at Penticton Creek, another of MNRO’s long term research installations located in the southern Interior, indicates that interior snow-packs are more resilient to comparable changes in temperature due to the colder winter climate (Spittlehouse 2006).

There are numerous implications to such large changes in coastal snow-packs. The most obvious would be a severe reduction in spring and summer stream flow in watersheds with traditionally deep snow-packs. Combine the above with a prediction of warmer and drier summers and water shortages could become the norm.

In addition, as snow shifts to rain, we will see more frequent mid-winter high intensity rain events, with shallower snow-packs contributing to stream flow rather than buffering rain and energy inputs. In the 2007-08 example from Russell Creek, there was one rain event in which more than 100 mm of rain fell over a 24 hour period over the entire watershed. This intensity is often associated with increased landslide rates and peak stream flows. When we apply a warming of 3 C to the same circumstances and snow shifts to rain, the number of such events triples (data not shown). The implications of this are obvious – more landslides, more peak flow events, increased sediment transport and downstream impacts such as damage to fish habitat, bridge failures, reservoir infilling and flooding.

As a general rule, forest harvesting in watersheds frequented by rain-on-snow events has a higher potential to increase peak flow hazard than in watersheds dominated by either rain or snowmelt processes. As portions of watersheds shift from snow to rain-on-snow dominated, watershed level harvest limits may have to decrease to mitigate the potential increase in frequency of peak stream flow events. On the other hand, as rain-on-snow dominated watersheds shift to rain dominated regimes, additional harvesting opportunities may arise due to a reduction in potential for harvesting to increase peak flow hazard.

Viewpoints

By Bill Floyd, RPF, MSc

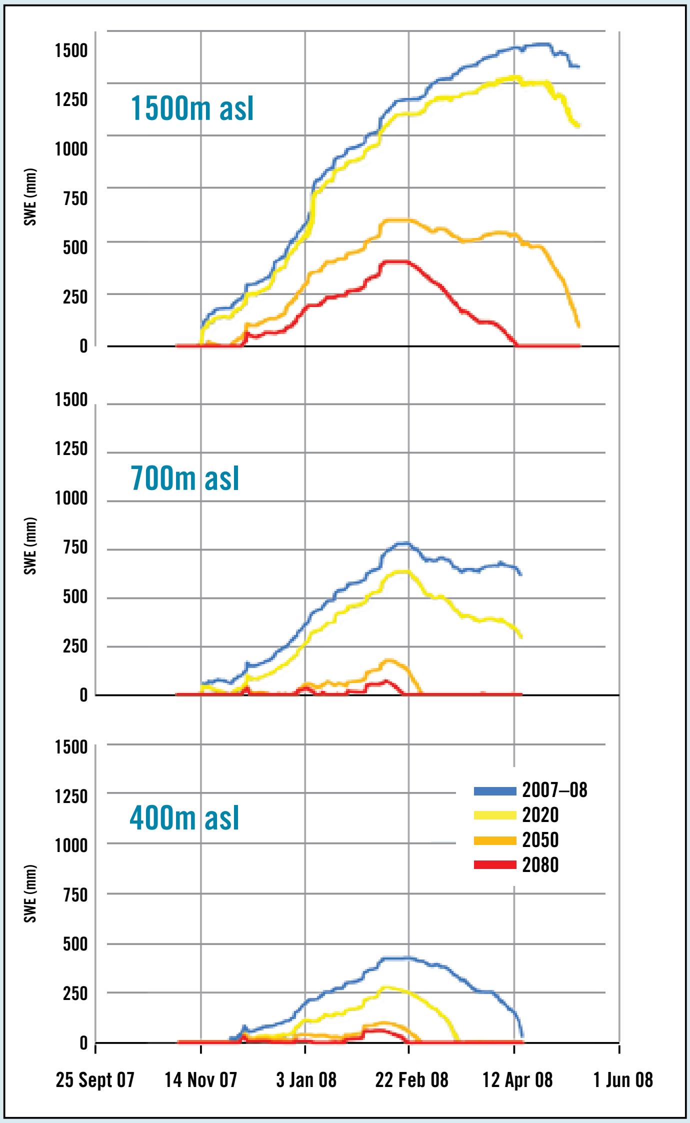

Figure 1. Snow accumulation and melt using the Cold Region Hydrological Model (Pomeroy et al, 2007) and ClimateBC (Wang et al, 2006) outputs for the 2020's (+0.7 C), 2050's (+2.1 C) and 2080's (+3.0 C) to project temperature changes from a 2007-2008 dataset from Russell Creek Experimental Watershed. Model runs for 2007-2008 were validated against snow depth and snow-water-equivalent (SWE) data from 400m and 700m above sea level (ASL) weather stations. Snow-water-equivalent is the depth of water that would result if a column of snow was melted. We were not able to model a complete melt season due to lack of data in the late spring. It is important to note that the changes illustrated in this example are only for one year of data and results should not be considered absolute, but rather as an indicator of snowpack sensitivity to changing temperatures.

There will be other significant changes to plan for. As the number of large precipitation events increase, slope stability assessments may need to evolve to account for increased landslide hazard. As more sediment moves from hillslopes to stream channels and the frequency of peak stream flow increase, bridges may have to be redesigned and road drainage structures increased in number and capacity. It is also likely that road maintenance costs will rise, especially at elevations where rain and rain-on-snow is projected to increase. In addition, as the population increases, there will be more demand for water resources and pressure to build in areas with already high or increased flooding and landslide hazard. With limited resources, it will be important to plan for these changes over time by identifying priority watersheds and targeting infrastructure and harvest planning to mitigate problems associated with climate change.

Currently, forest professionals deal with an immense amount of uncertainty. This makes it difficult to make management decisions, especially when outcomes must be projected 20 to 100 years into the future. A changing climate will only increase this uncertainty. Adapting to climate change will require risk-based analysis to identity areas where change will occur. As change occurs, a robust monitoring and research network must be in place to capture our knowledge and experience and apply it to other areas of the province that are resilient in the short term, but will become more susceptible in the long term.

Russell Creek provides an excellent example illustrating the sensitivity of coastal watersheds to changes in temperature. Unfortunately, there are limited areas within BC that have the data required to run models such as the Cold Region Hydrological Model used in the analysis presented here (Pomeroy et al, 2007). Further, we do not have an adequate monitoring network in many areas fo the province to track changes, verify/validate predictions and refine models.

In a results-based framework, the buck stops with the forest professional. Thus it is imperative for all of us to address the strengths and weakness surrounding our current science, policy and practice to ensure the proper management of water resources in the face of climate change. A critical step in improving our ability to adapt to climate change involves advocating, both as individuals and as an association, for increased support of current research by government, universities and industry, including, acquisition of resources to expand the existing research and monitoring network. Knowledge gained through this increased investment can then be used as the basis of sound climate change related policy and practice. ❧

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