Climate Disruption and Ecosystems of the Northwest Columbia: A Brief Overview

G. Utzig, P.Ag. 3-11-16

Introduction

Recent reports by the International Panel on Climate Change (IPCC) confirm that global climate disruption is underway, and likely to accelerate over the coming decades. Climate data confirms that climatic changes are occurring in this province. Visible evidence of changes in climate are also becoming increasingly apparent to local people in the Columbia Basin – witnessed through a wide range of changes in broad variety of indicators.

The British Columbia government has recognized that the uncertainties associated with climate disruption demand a new approach to forest management. With the establishment of the Future Forest Ecosystems Initiative (FFEI) in 2006, the province began a move toward looking for ways to adapt the forest and range management framework with respect to potential future climates. The province established the Future Forest Ecosystem Scientific Council (FFESC) in 2008 to deliver research grants to support the objectives of the FFEI. This report is partially based on findings from a West Kootenay project that was funded by the FFESC in 2010. That initial work has been further refined and expanded with support from two environmental organizations: Conservation Northwest and Wildsight. Further information on climate disruption in the Kootenay-Columbia region, including reports, methodology, references and adaptation strategies can be found at the website: www.westkootenayresilience.org.

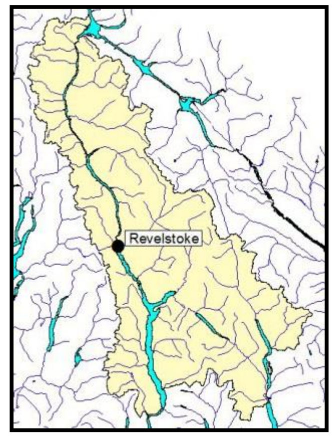

Figure 1. NW Columbia.

This report summarizes climate change information relevant for the northern Selkirk Mountains and adjoining portions of the Monashee, Purcell and Rocky Mountains – an area dominated by the northerly "big bend" of the Columbia River system or here designated as the Northwest Columbia (see Figure 1). The projected shifts in bioclimate envelopes shown in Figures 4 and 5 show a wider area to provide a broader regional context.

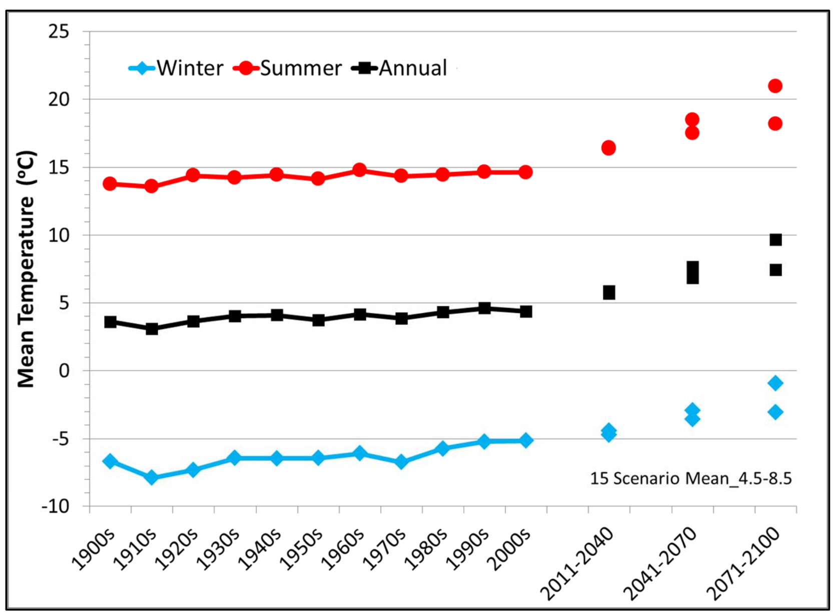

Figure 2. Past and projected temperatures.

Projected Changes in Seasonal Climate

To explore the range of climate projections for the Columbia Basin in general, a range of climate scenarios and climate data sources were consulted during the preliminary investigation. These included data from ClimateBC/WNA, Environment Canada weather stations, and a range of climate projections from

General Circulation Models (GCMs) and greenhouse gas (GHG) emission scenarios. The projections reviewed included a representive cross-section of historical and projected changes in seasonal temperature and precipitation. The results presented here are based on 3 recommended GCM/emission scenarios from the IPCC's 4th Assessment Report (AR4) that cover the broad range of projected outcomes, and an ensemble mean of 15 models with 2 emission scenarios from the IPCCs 5th Assessment Report (AR5) that also cover a similar range of outcomes. The graphs and tables of temperature and precipitatin in this report are based on data from ClimateBC and the 15 model mean, calculated from a 1 km grid for the area shown in Figure 1, below 1500m in elevation. Due to the long planning horizons associated with forest management, the report focuses on projections for the 2080s (2071-2100).

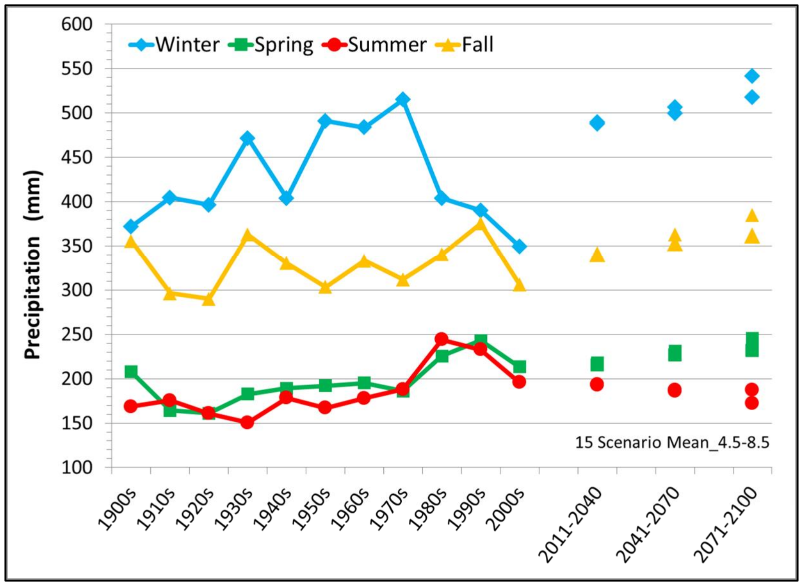

Figure 3. Past and projected precipitation.

As shown in Figures 2 and 3, climate has varied over the past century, especially in relation to precipitation. Temperature has shown an increasing trend, and the trend has begun to steepen over the recent decades, especially in the winter. Winter, spring and summer precipitation had been increasing since early in the last century until late in the century, then began to decrease, while fall precipitation showed less of a trend.

Table 1. Historical and projected seasonal temperatures for the Northwest Columbia subregion.

	Normals 1961-90	Decade 2001-10	Projected Increases from 1961-90 Normals 2050s	2080s
Winter	-6.2	-5.2	+2.6 to 3.3	+3.2 to 5.3
Spring	4.1	4.0	+3.1 to 3.8	+3.7 to 5.6
Summer	14.5	14.6	+3.0 to 4.0	+3.7 to 6.4
Fall	3.9	4.0	+2.2 to 3.1	+2.9 to 5.0
Annual	4.1	4.4	+2.7 to 3.5	+3.3 to 5.6

Table 2. Historical and projected seasonal precipitation for the Northwest Columbia subregion.

	Normals 1961-90	Decade 2001-10	Projected Changes from 1961-90 Normals 2050s	2080s
Winter	467	349	+7 to 9%	+9 to 18%
Spring	202	213	+9 to 14%	+14 to 24%
Summer	203	196	-2 to -11%	-7 to -16%
Fall	328	306	+7 to 13%	+10 to 9%
Annual	1201	1065	+5 to 7%	+7 to 12%

Future projections for the study area estimate that by the 2080s, winter, spring and fall will be warmer by about 3 to 5°C, and summer will be warmer by 3.5 to 6.5°C, when compared to 1961-90 normals (Figure 2 and Table 1). Precipitation is projected to increase by 10-20% in the winter, spring and fall, and to decrease by 5 to 15% in the summer (Figure 3 and Table 2).

The most obvious trend shown by the models is an increase in summer moisture stress. Figure 4 shows that summer climatic moisture deficit, the difference between evaporative demand and precipitation, has begun to increase in recent decades and is projected to continue to increase. Increased winter, spring and fall temperatures can also increase the likelihood that precipitation will fall as rain rather than snow, especially at lower elevations, which can have implications for water availability later in the growing season, as well as streamflow timing. Increasing temperatures are increasing the melt rate in glaciers, and ultimately, once a glacier is reduced to a critical size, will result in late summer/fall streamflow decreases and water temperature increases for watersheds with significant glacial extent today.

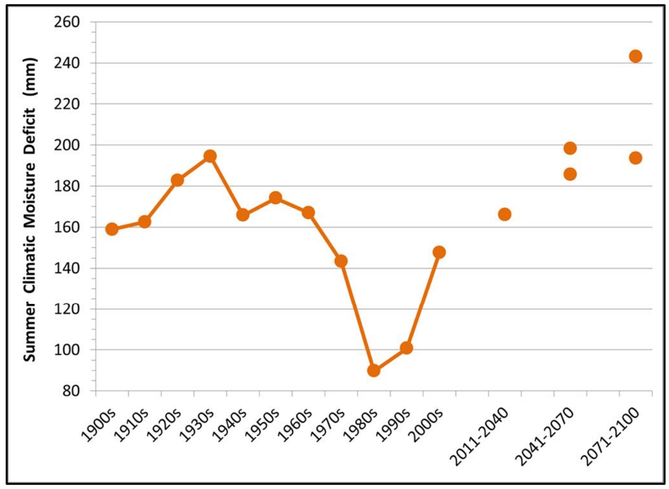

Figure 4. Past and projected moisture deficit.

Extreme Events

In addition to changes in long term mean temperatures and precipitation. climate disruption is also affecting the frequency and magnitude of extreme events, including heat waves, storm events, spring thaws and late frosts. Extreme and prolonged heat waves, especially when coincident with low precipitation, can lead to drought stress on ecosystems, and in some cases mortality. Some species are particularly susceptible to premature bud burst, also constributing to stress. Extreme precipitation events can lead to flooding, landslides, debris floods, damage to aquatic habitat and infrastructure.

Bioclimate Envelope Modeling

Three climate scenarios that generally illustrate the range of climate projections for BC were selected for ecosystem bioclimate envelope modeling. Bioclimate envelopes are multi-dimensional "envelopes" of climate variables that are associated with the occurrence of specific ecosystems – or in this case broad vegetation zones. Using the results of future climate projections, a model was used to define what types of climate envelopes may exist in the study area in the future, and then attempted to find where similar climate envelopes exist in western North America today. The model then reports out on the vegetation types that presently occur in those projected envelopes. Knowing what vegetation types exist in those similar climate envelopes today, is then used to help picture what the environment in the study area may be like in the future. The results of the modeling are shown in Figures 5 and 6.

The three scenarios include combinations of three GCMs and GHG emission scenarios: a "**Warm/Moist**" scenario with low emissions, a **"Hot/Wet"** scenario with high emissions, and **"Very Hot/Dry"** scenario with moderate emissions. The upper left insets in Figures 5 and 6 show the 3 selected scenarios (purple rings) in relation to 40 other scenarios with regard to annual temperature and precipitation changes for BC in the 2050s. The range between the 3 selected scenarios approximate the full range of uncertainty between the other 40 scenarios, and therefore it is assumed that the actual outcome is likely somewhere between these 3 scenarios.

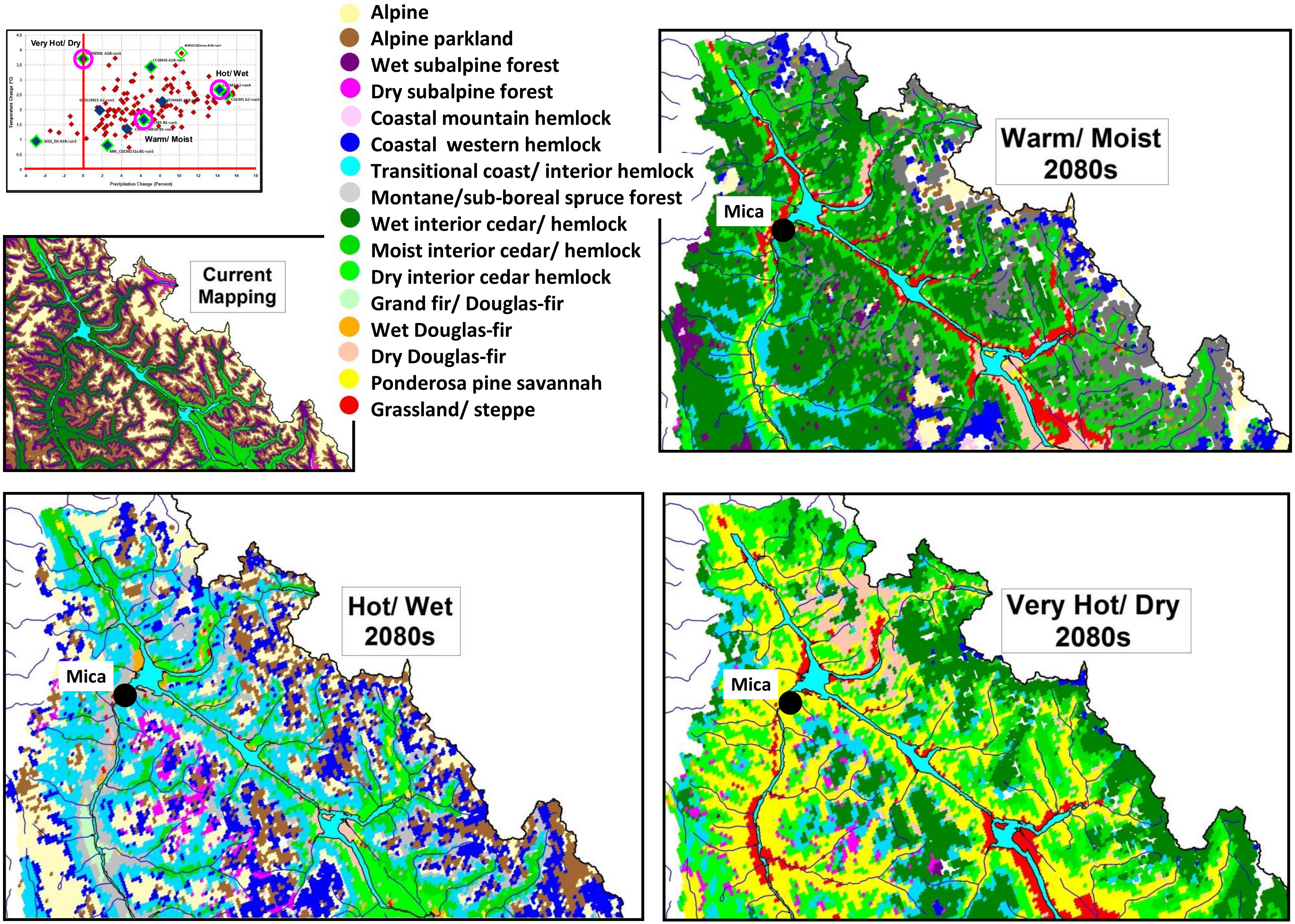

Figure 5. Projected bioclimate envelope shifts for the northern portion of the study area.

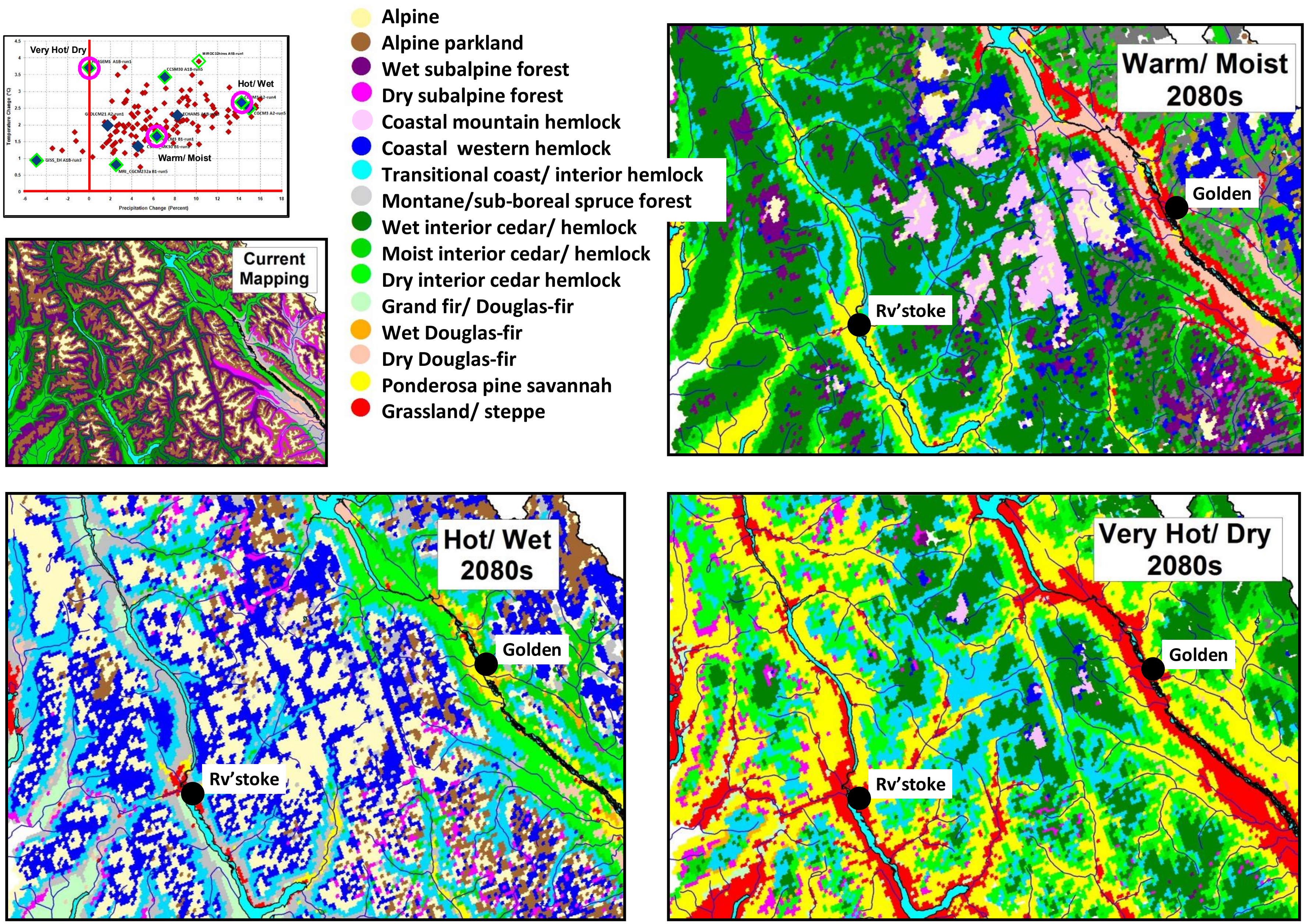

Figure 6. Projected bioclimate envelope shifts for the southern portion of the study area

All three of the scenarios project an increase in temperature for all seasons by the 2080s. All of the scenarios project increases in winter, spring and autumn precipitation, with lesser increases or decreases in summer. The Very Hot/Dry scenario is distinct from the other scenarios in its projection for much hotter and drier summers and warmer springs and autumns.

Across all of the study area, all three scenarios project bioclimate envelope shifts that reflect decreasing moisture availability at the lower elevations – with scenarios differing in the magnitude of change, but not the direction. At the lowest elevations all of the scenarios project shifts from Interior Cedar- Hemlock (ICH) bioclimate envelopes to grassland-steppe, Ponderosa pine savannah, Grand fir or Montane Spruce envelopes. At the mid and upper elevations the results are more variable, with the Warm/Moist scenario projecting a shift to wetter ICH climate envelopes at upper elevations and coastal transition ICH/CWH (Coastal Western Hemlock) types at mid elevation. The Hot/Wet scenario projects a shift to a warmer/wetter environment with coastal transition ICH/CWH envelopes dominating at mid elevations and CWH envelopes at the upper elevations. The third Very Hot/Dry scenario shows a dramatic shift to semi-arid Ponderosa pine savannah envelopes extending into the mid elevations, and the occurrence of limited moist and coastal transition ICH/CWH and wetter/drier ICH envelopes at the higher elevations. All of the scenarios project virtual elimination of Engelmann Spruce-Subalpine Fir (ESSF) and parkland/woodland bioclimate envelopes, except in few isolated locations.

At the very highest elevations, which are presently occupied by Alpine Tundra and Parkland there is also some uncertaintly. Under the Warm/Moist scenario the highest elevations are projected to be dominated by envelopes consistent with wet ICH, CWH, Alpine Tundra and Mountain Hemlock (MH). The Hot/Wet scenario projects increased area of Alpine Tundra envelopes, with patches of CWH and parkland envelopes, likely due to heavy snow loads at high elevations. The Very Hot/Dry scenario projects moist and wet ICH envelopes for the highest elevations. However, due to steep slopes and a lack of soil, these mountain top sites are unlikely to develop productive forests in the medium term regardless of climatic changes.

The current locations of the bioclimate envelopes that are projected for the study area in the 2080s are found as far south and east as Colorado and Kansas, throughout BC and north to coastal Alaska. The reference period grassland/steppe, savannah and dry forest bioclimate envelopes from the western US are generally projected for lower elevations in the East Kootenay portion of the study area and south of Revelstoke, except in the Hot/Very Dry scenario, where they extend sporadically north to the Wood River. The bioclimate envelopes from coastal transition locations are generally projected for mid and upper elevations, mostly in the wetter scenarios.

The Alaskan tundra bioclimate envelopes are projected for the highest elevations in some of the scenarios.

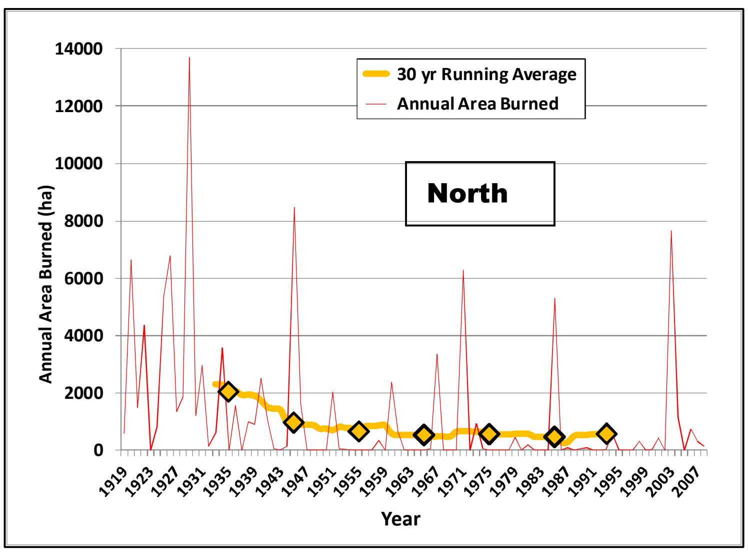

Figure 7. Annual area burned in northern W. Kootenays with 30-year means (diamonds).

It cannot be over-emphasized that the results presented in this work are only three of many possible futures.

Additional bioclimate modeling of common tree species' ranges also projects shifts in individual trees species envelopes that are consistent with the projected changes in ecosystem envelopes. Drought resistant and fire tolerant low elevation species' envelopes tend to expand and shift to the north and upslope. Changes in bioclimate envelopes for species currently occurring at upper elevations generally indicate a decrease in occurrence for those species.

The transitions of ecosystems that were compatible with past climate envelopes to those compatible with future climates will not necessarily be gradual, but are most likely to be episodic following major disturbances such as droughts, stand-replacement fires or major insect or disease outbreaks. The following sections provide some information on how changes in disturbance regimes may contribute to ecosystem shifts.

Fire Impacts

In the previous study in the West Kootenays, regression analysis was used to examine the historical interaction between annual area burned and climatic variables such as spring and summer maximum temperatures and summer precipitation. The resulting relationship was applied to projected changes in those variables from three climate scenarios to estimate potential future changes in annual area burned. The regression model developed for the northern subregion of the West Kootenays was applied to ecosystems similar to those that occur in this study area, and therefore its results are presented here as an example of how fire behaviour may change as climate

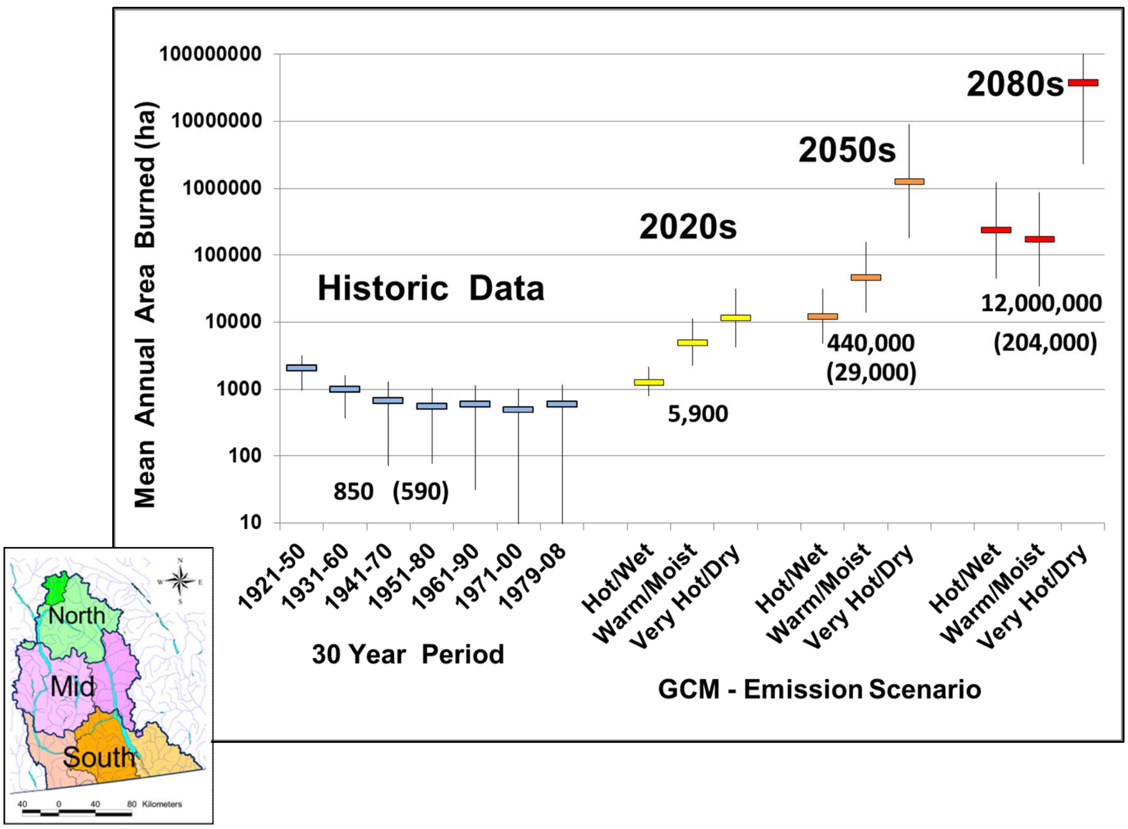

Figure 8. Historic 30-year means (blue boxes) and regression projections (yellow, orange and red boxes) of area burned (with 95% confidence intervals) for the northern West Kootenays. Values below the historic whisker plots are a mean of the 1921-2008 area burned, and in parentheses the mean of 1961-90 area burned. Values below the projection plots are means of the GCM/ emission scenarios for each time period (in parantheses the two moister scenarios). Note the log scale.

change proceeds (see inset map Figure 8). The historical pattern of area burned for the northern West Kootenay study area is shown in Figure 7. Analysis found that the majority of area burned occured episodically, and generally only in years with climatic anomalies. The regression results indicate steadily increasing area burned for all three climate scenarios, although there is substantial uncertainty regarding the magnitude of the increases. The minimum projected increase in average area burned for the 2050s (2041-2070) is 8 to 20 times greater than the area burned during the reference period (1961-90), with a potential increase of over a 1000 times (see Figure 8).

The diversity of topography and forest/fuel types in the study area will influence how changes in climate will affect future fire. With relatively little fire in the study area historically, and a high probability for drying and warming at lower elevations, fire magnitude and frequency are likely to increase. The importance of spring climatic variables found in the regression analysis for this area, is likely a reflection of the increased importance of warmer winter and spring tempertuares prompting earlier snowmelt, and its potential affect on the fire season. Early snowmelt can facilitate fires by increasing the length of the fire season and increasing fuel drying that leads to the build up of maximum drought codes. Although the modeling shows a very steep increase in estimated area burned, available fuel will likely become a limiting factor before the some of the area burned projections will be achieved.

There are many implications associated with the results found here – increased risk of fire will affect all values currently available from our forests – timber, water supplies, biodiversity and rural living to name a few. The implications for fire management are especially concerning. Recent modeling in Ontario has similarly projected an eightfold increase in area burned by the end of the 21st century – in part due to increased fire frequency potentially overwhelming fire suppression resources. There will be significant implications for forest management in general, including landscape scale wildfire fuel break planning, silvicultural systems, retention levels and species selection.

Insects and Pathogens

Climate change may affect forest health in many ways, some positive and some negative. Summer drought conditions can stress trees, thereby increasing susceptibility to a wider range of insects and diseases. Insects are primarily influenced by temperature, so increases in regional temperature will likely change the distribution, frequency and severity of population outbreaks. Timing of critical life stages of insects are also likely to change, resulting in both increases and decreases in insect levels In the Columbia Basin. Pathogen populations however are generally more influenced by precipitation, and so may respond differently than insect populations.

Evidence suggests that climate change may contribute to increased risk of outbreaks of Douglas-fir beetle, western balsam beetle, spruce beetle and western hemlock looper in mature stands. Spruce leader weevil, white pine blister rust, other stem rusts in lodgepole pine, foliar diseases of lodgepole pine and larch, and Armillaria root disease are routinely encountered in plantations, and some of these may increase with climate change. Although lodgepole pine is not a species presently used in the NW Columbia, climate envelope projections indicate it may be viable in the future. Unfortunately lodgepole pine plantations in particular appear to be at risk to a wide range of insects and diseases. As climate changes, regeneration will also be subject to attack by insects and diseases found in existing plantations, and new insects and diseases that have only occurred historically in low numbers may reach outbreak levels in future plantations. In addition, diseases that in the past have only caused growth loss may now contribute to tree mortality as observed with larch needle cast and dothistroma.

Hydrology and Aquatic Habitat

Increases in temperatures will cause a multitude of changes in annual hydrographs. Late fall and winter flows will likely increase due to an increase of precipitation falling as rain rather than snow, peak flows will occur earlier and potentially increase in magnitude, late summer low flows will likely decrease due to a loss of snow earlier in the season and reduced summer precipitation, and some stream temperatures will increase. Decreased snow storage and increases in evaporative demand may decrease groundwater recharge and water supply to some wetlands. Increases in the magnitude and frequency of extreme rainfall events, especially rain-on-snow will increase stream channel instability, potentially degrading aquatic habitat and putting crossing structures at risk. Loss of glaciers will change the flow regimes and water temperatures in watersheds where they occur. In some areas increases in seasonal precipitation may offset some of these impacts.