KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Appendix I – Project Reports

Agriculture and food security in Area D/Kaslo

‘Agriculture and food security’
A report produced for Dr. Paul Sneed in GIS 331 by Dylan Hackenbrook, David Springer, Shannon Swayze, Selkirk College. April 19 2010.

‘Climate change and food security’
Prepared by Jennifer Ellis, Coordinator Adapting to Climate Change Project, City of Rossland. May 13 2010.

Water provision in Area D/Kaslo

‘Climate data for Area D/Kaslo’
Update from Hans Shreier, University of British Columbia. 23 July 2010.

‘Kaslo Climate Change Adaptation – Water Issues Relation to Supply and Demand Issues (Draft Report)’
Hans Schreier (UBC), Martin Carver (Aqua Environmental), Arelia Werner (PCIC)

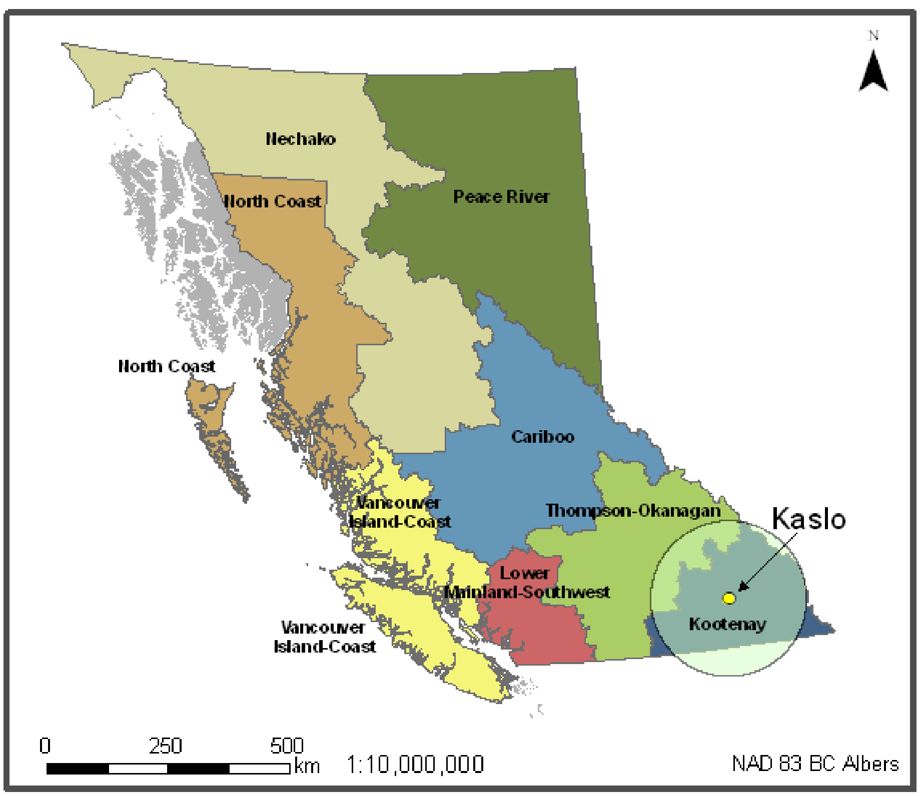
‘Comparison of Kaslo watersheds’
A report produced for Dr. Paul Sneed by Chris Gray, Katie Ward, Melissa MacLeod, Selkirk College, 15 April 2010

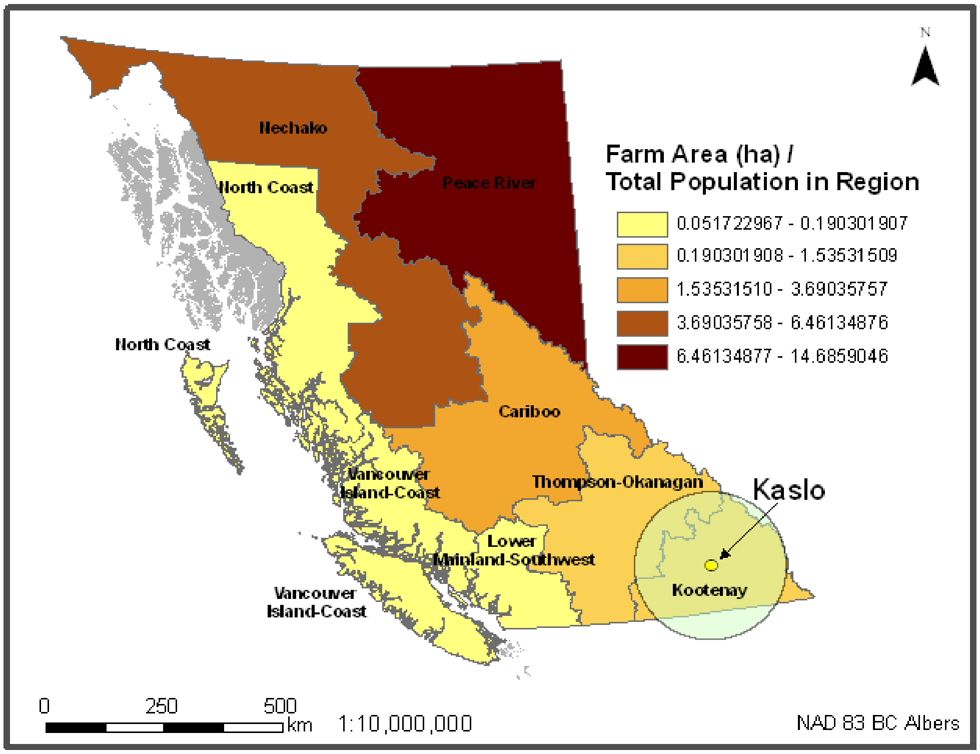
Agriculture and Food Security: Introduction

Food security has been a subject of increasing concern given the threat of peak oil and climate change. Food security refers to the availability of food and one's access to it. Many cities are increasing their efforts to be more food secure, and reduce their carbon footprint on the earth. The city of Kaslo and area D in British Columbia has been particularly concerned with increasing local agricultural production and being more self-reliant. Geographic Information Systems (GIS) is one tool that is useful for analyzing and visualizing the agricultural potential of areas. Using spatial analysis techniques, potential viable agricultural area can be calculated. Remote sensing can also be used for classifying different land types. This project attempt to analyze the current situation of food security in Kaslo using GIS techniques.

Agricultural Regions in BC

There are 8 different agricultural regions in British Columbia. Area D and Kaslo are in the Kootenay agricultural region. The Kootenay region has a less than average amount of farm area available per person compared to the other regions in BC. Also the total production value per person in the Kootenay region is less than average compared to other regions. On average there is about 0.5 to 1.5 hectares of farm land available per person in the Kootenay region. Although there is likely enough land for the Kootenay region to be food secure, there are many other factors that could influence self-reliance.





Kaslo and Area D Food Security

The Village of Kaslo falls within Electoral Area D of the Regional District of Central Kootenay (RDCK). It is the largest electoral area in the RDCK but has the smallest population at approximately 1525 people (Statistics Canada 2006). Of those 1525, approximately 1072 live within the Village of Kaslo. According to the Statistics Canada 2006 data, Agriculture and Resource based industries are the largest industries in the RDCK Electoral Area D.

Currently, numerous different kinds of food crops and animals are raised in the North Kootenay Lake area. Based on documents obtained from Aimee Watson at the North Kootenay Lake Community Services Society, the majority of food produced in Area D falls into the following categories:

- Organic Vegetables
    - Lettuce, cabbage, tomatoes, squash
- Root Crops
    - Onions, garlic, carrots
- Meat
    - Chickens & Eggs
    - Beef
    - Venison
    - Pork

Very little commercial grain and fruit is being produced in the local area. However, these are crop types that local have expressed interest in and may attempt to grow in the future.

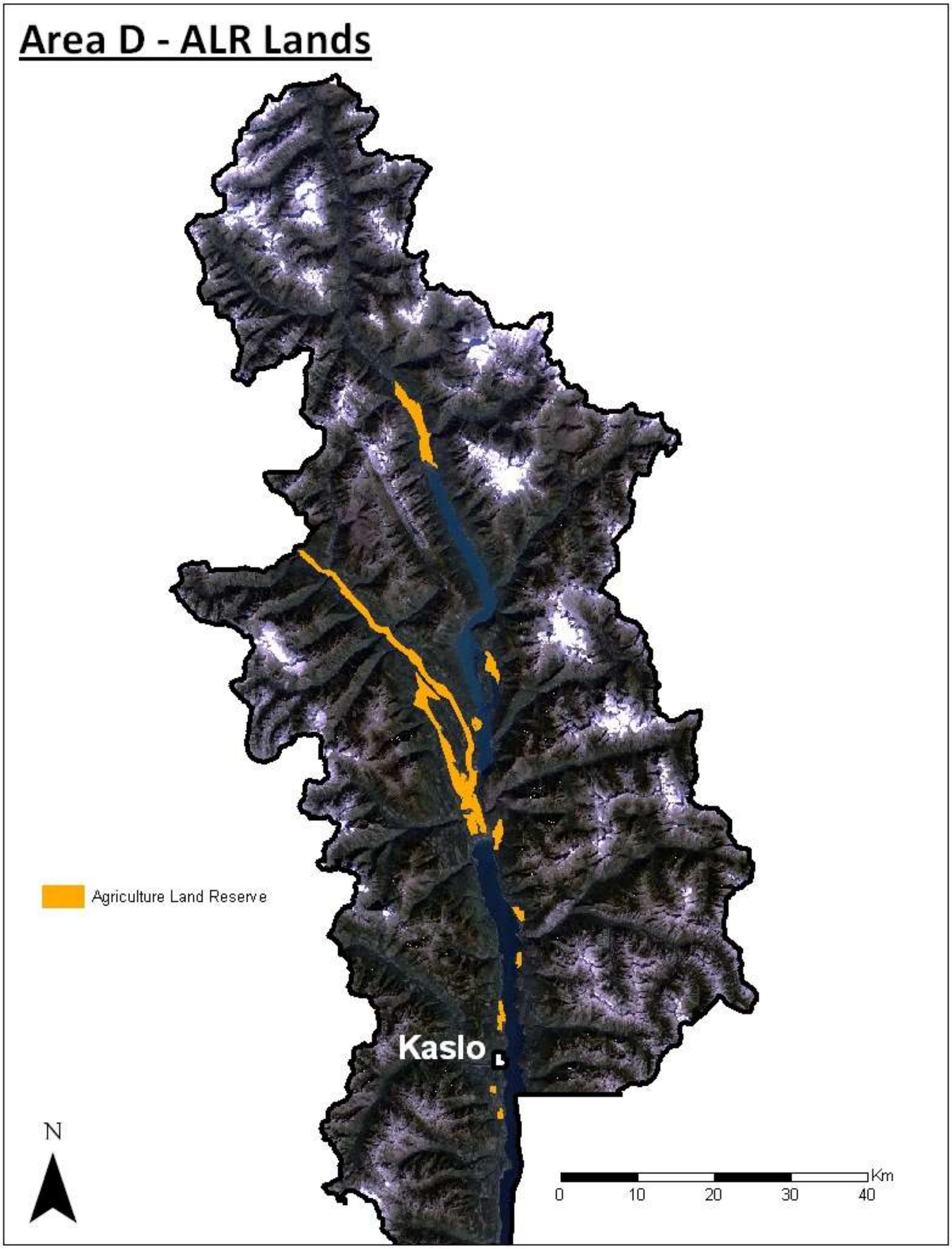
Agricultural Food production in Area D, and throughout the Kootenays, is facing numerous challenges. While attending the *Climate Change Impacts on Local Food Security & Agriculture Conference* in Castlegar, BC on March 18th, 2010, many issues were brought up for discussion. The most common and biggest issues raised by local stakeholders included:

1. Vegetables
    - Difficult to compete with industrial prices
        - High Cost of producing organic, high quality veggies
2. Meat
    - 2006 Government Legislation required all meat to be slaughtered at Government Regulated Facilities
        - Closest Facility in Salmon Arm, BC (8 hours)
        - Killed the livelihood of Kootenay Meat Farmers and availability of local meat
3. Lack of Storage Facilities

Despite the challenges listed above, many local initiatives to improve security have been undertaken by the Village of Kaslo. For over 9 years, Kaslo has maintained a community garden program that allows residents of the village to purchase plots of land to grow their own food. The project is currently operated through the The Community Garden Society of Kaslo and plots can be purchased for as little as $10 per year. As well, Kaslo has a local area fruit tree rescue project, where volunteers may harvest and redistribute fruit from excess fruit trees and abandoned orchards. In 2005, the fruit tree project harvested approximately 19,000 lbs. of excess fruit in Area D (Sanders 2006). Lastly, Kaslo has an active Community Supported Agriculture Program (CSA) for 50-60 families (Sanders 2006). This program enables community members to buy a share in local farms and in return, receive a weekly distribution of seasonal vegetables.

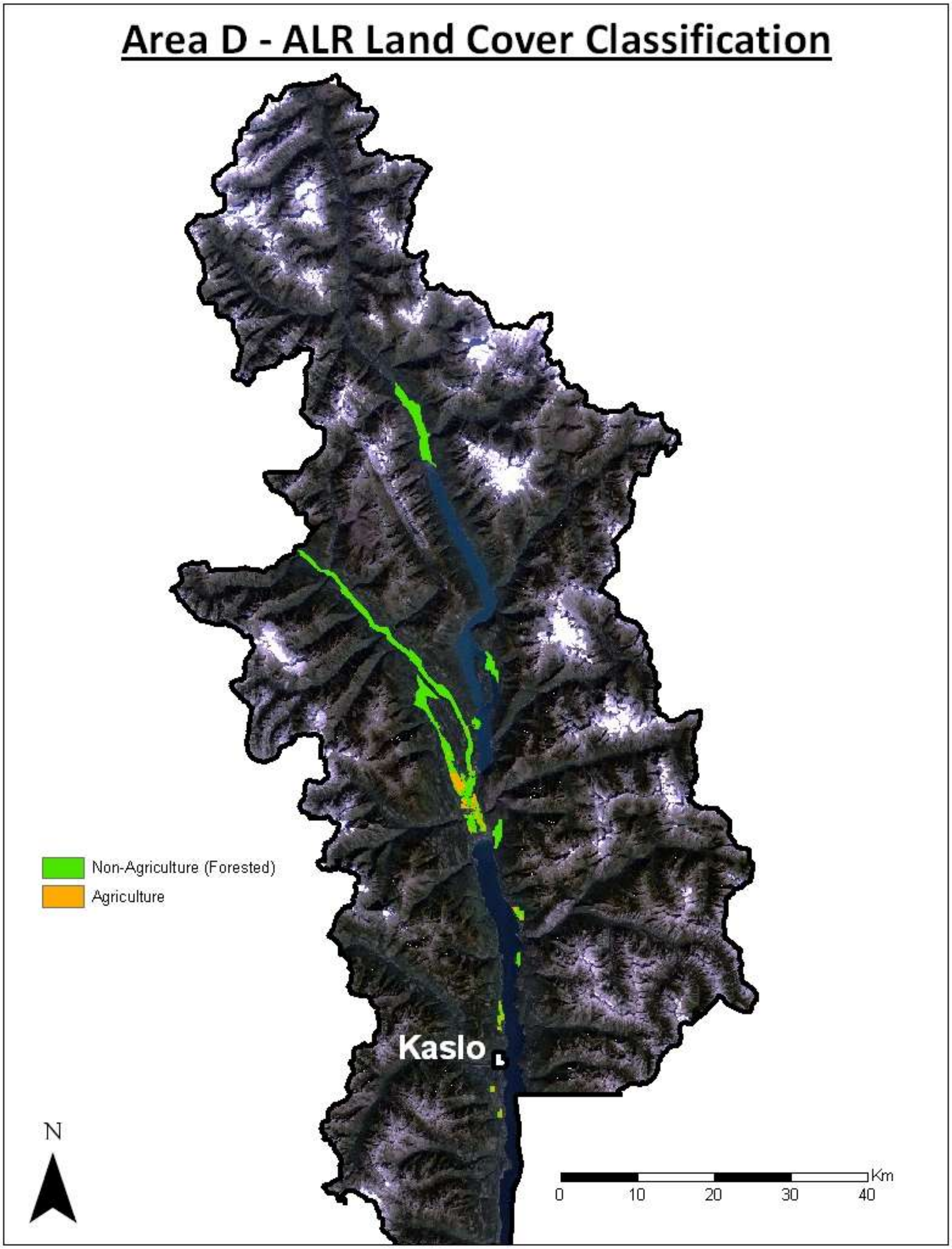
ALR in Area D

From our GIS analysis, the agricultural land reserve in Area D is approximately 7,515 hectares. As seen in the following map, the majority of ALR lands in Area D are located at the North Shore of Kootenay Lake and the Lardeau River Valley. This is most likely due to the rich soils found in these basins and the inaccessibility of the majority of land in Area D. In general, a large majority of land in Area D is crown wilderness that is either managed under provincial park status or too steep for agricultural production.


Area D - ALR Lands
Agriculture Land Reserve
Kaslo
N
0
10
20
30
40
Km

Even though, 7,515 hectares of ALR are present in the ALR, we can use GIS and Remote Sensing techniques to evaluate current utilization of the ALR for agricultural purposes. When the Area D ALR polygon is overlaid on top of satellite imagery, we find that the majority of ALR lands are forested and not necessarily being used for agricultural purposes. The following images show a portion of ALR lands in Area D overlaid upon LANDSAT 7 satellite imagery from 2009.

The image on the right above shows an Unsupervised Classification of cover types within the ALR polygon using PCI Geomatica Remote Sensing Software. The steep, forested areas are classified differently than the more open, lighter fields based on the digital number values within the pixels. This classification technique was applied across the entire ALR lands in Area D. The results show that the majority of ALR in Area D is forested and not utilized for agricultural purposes. In total, the classification technique found 885 hectares of agricultural lands in Area D, and 6,630 hectares of Non-Agriculture (forested) land within the ALR. The results can be seen in the map below, where green represents forested land within the ALR and orange the land that appears to be used for agricultural purposes.


Area D - ALR Land Cover Classification
Non-Agriculture (Forested)
Agriculture
Kaslo
N
0
10
20
30
40
Km

According to a study by the British Columbia Agriculture in the Classroom federation , the average North American diet requires 0.524 hectares of productive farm land to be sustained annually (Grow BC 2008). Therefore, with a population of 1500 people, Kaslo and Area D would have more than enough farm land to be “food secure” because only 786 hectares of land would be required. However, it is the general feeling of Kaslo residents that they are currently not food secure and are facing challenges in the future, in the forms of climate change and peak oil. The above classification could be used as an example of the under utilization of farm land in Area D in an effort to provide food security to its residents.

Creating Spatial Data

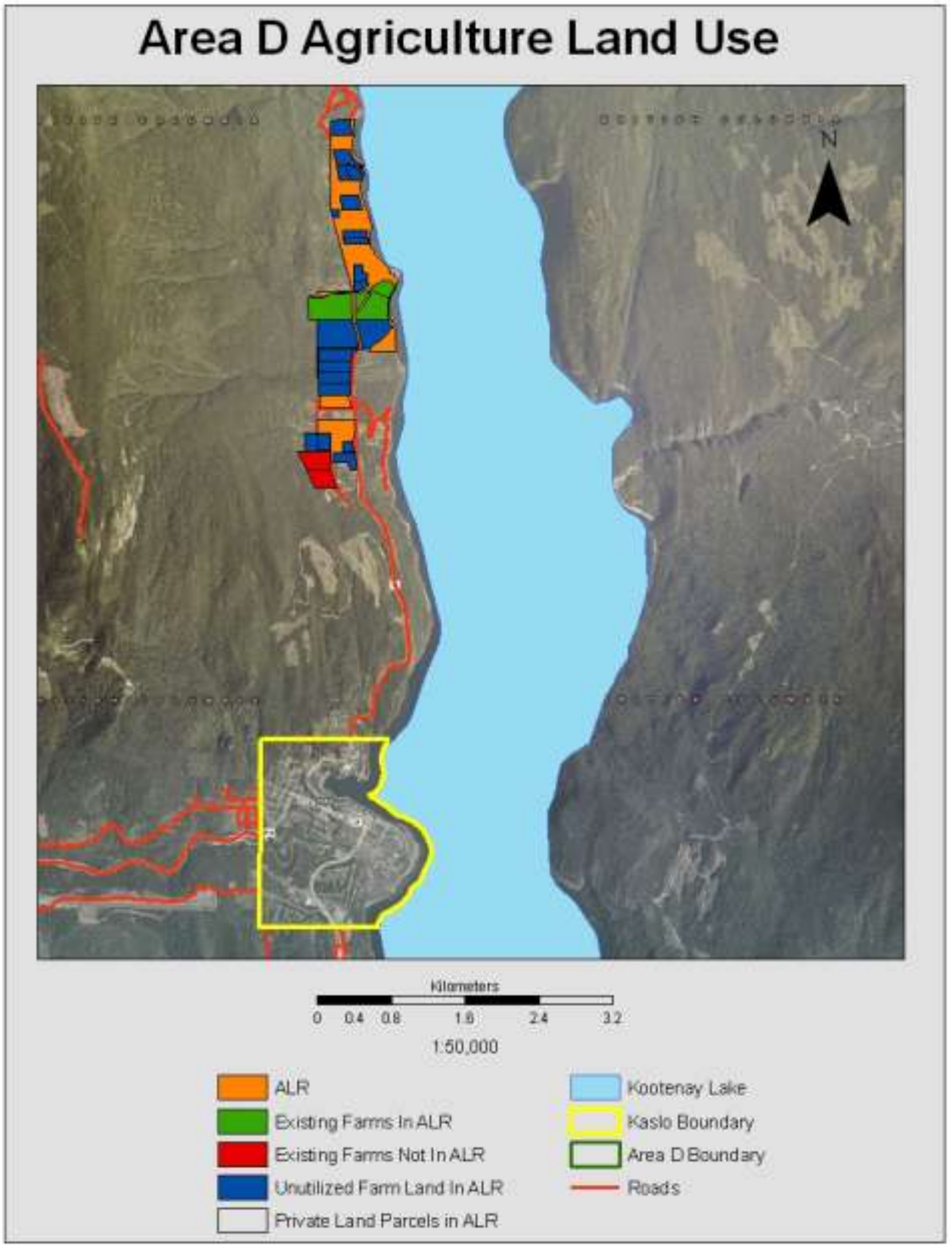
With the exception of the existing basic base layer shapefiles from the U Drive, the only existing spatial data for agricultural land use in Area D of the Kootenays was a shapefile called “Cad_ActUse” containing information areas of private land that was currently being taxed as agricultural land, which was obtained from Tom Dool from the RDCK. In an attempt to create some quantitative spatial data that could be visualized, I created pin points in Google Earth of all the land parcels containing suitable land for agriculture to try and This was done by importing some base layer shapefiles from the U Drive for the Area D boundary, Kaslo Boundary, ALR, and Private Land, then zooming in over the Area D boundary and visually picking out desired land, and then grouping the points into 2 different categories. In total there were three classes of agricultural land use, including the existing data from the records called “Mixed” in the “Actuse_des” field of the “Cad_ActUse” shapefile.

The first class created from the Cad_ActUse file received from Tom was called “Existing Farms In ALR” (symbolized in green on the maps). The second class was called “Unutilized Farm Land In ALR” (symbolized with blue on the maps). For this class I chose parcels of land within the ALR that appeared to already contain pastures of large gardens. I called the third class “Existing Farm Not In ALR” (symbolized on the maps with blue), and created the same way as the second class, except these areas were not within the ALR boundary.

Once all the pin points were placed, I used DNR Garmin to covert the KML files to shape files. Next, I added the shapefiles to Arc Map, but they were still in point form, which was not useful to perform calculations to obtain numerical data for the area of each polygon. I solved this problem by selecting each polygon that had a point and created a layer out of the selected features. The layer was then imported back into Google Earth as shapefiles. This process was followed for each of the three classes I created.

The final products created from this data were a sample map created in Arc Map, as well as a Google Earth KML file and flythrough of Area D.

RESULTS



Existing Farms ALR (Green) = 49 Ha

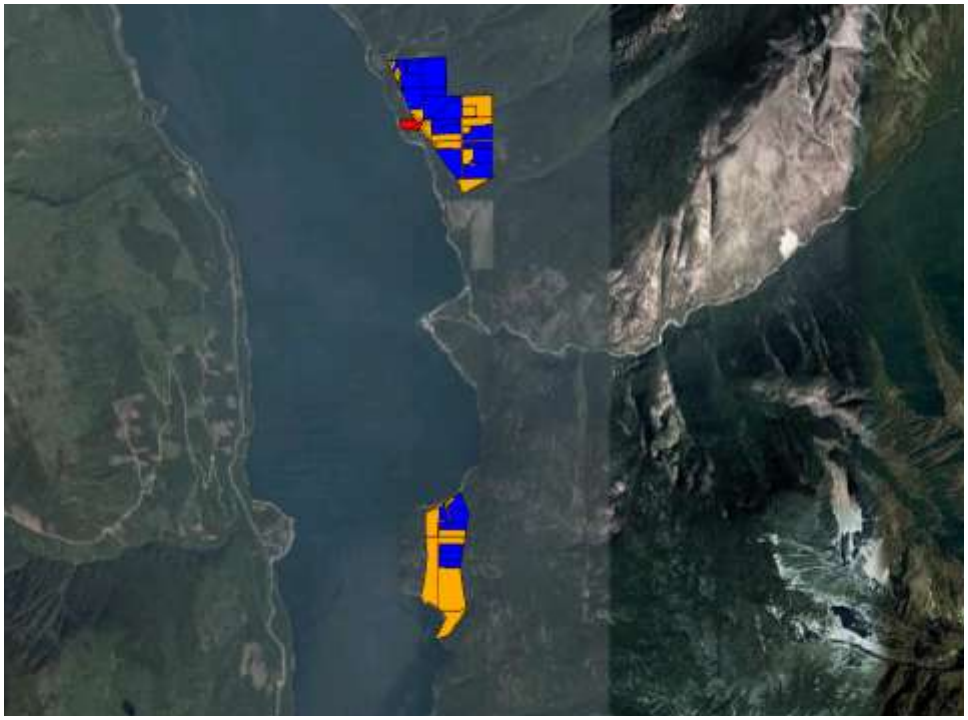
Existing Farms Not ALR (Red) = 21 Ha

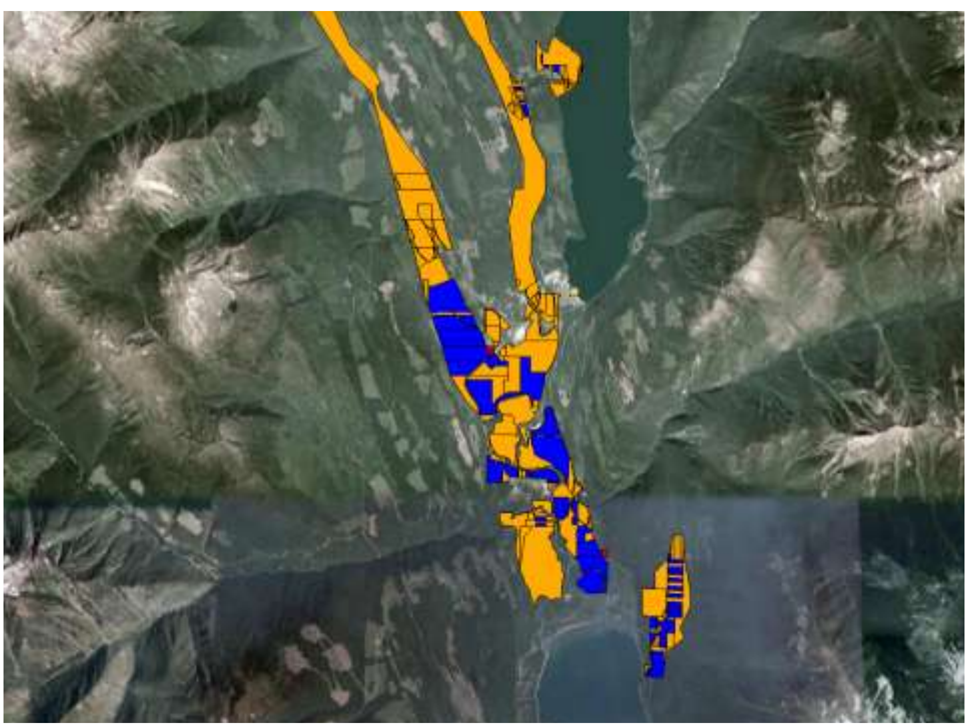
Unutilized Farms in ALR (Blue) = 996 Ha

Shapefiles imported into Google Earth, saved as KML files (used to create flythrough)


Kaslo


Kaslo



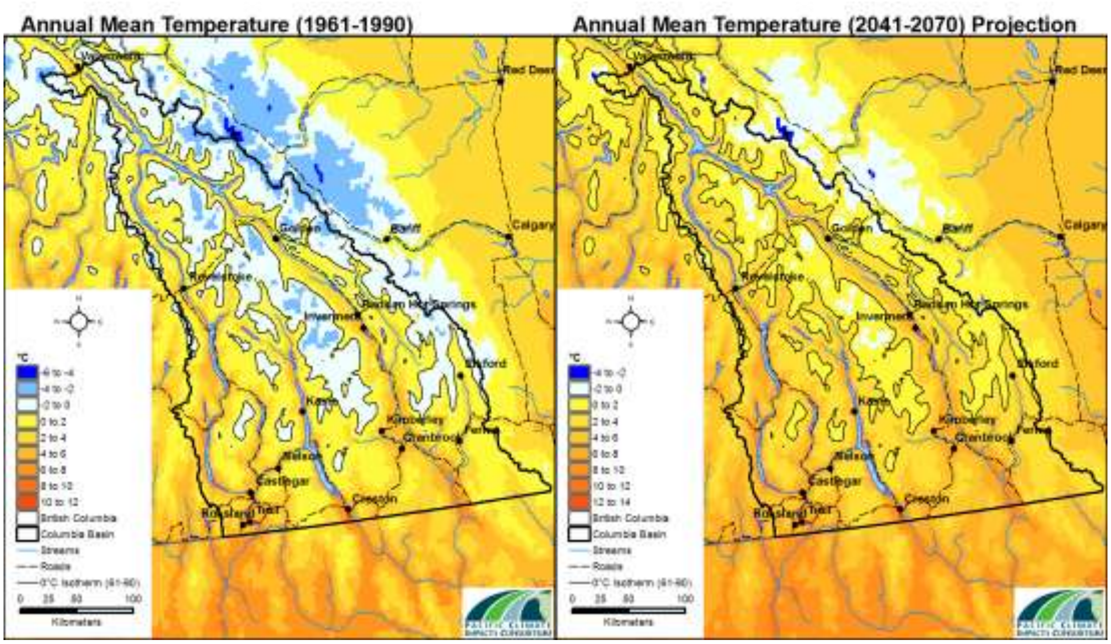


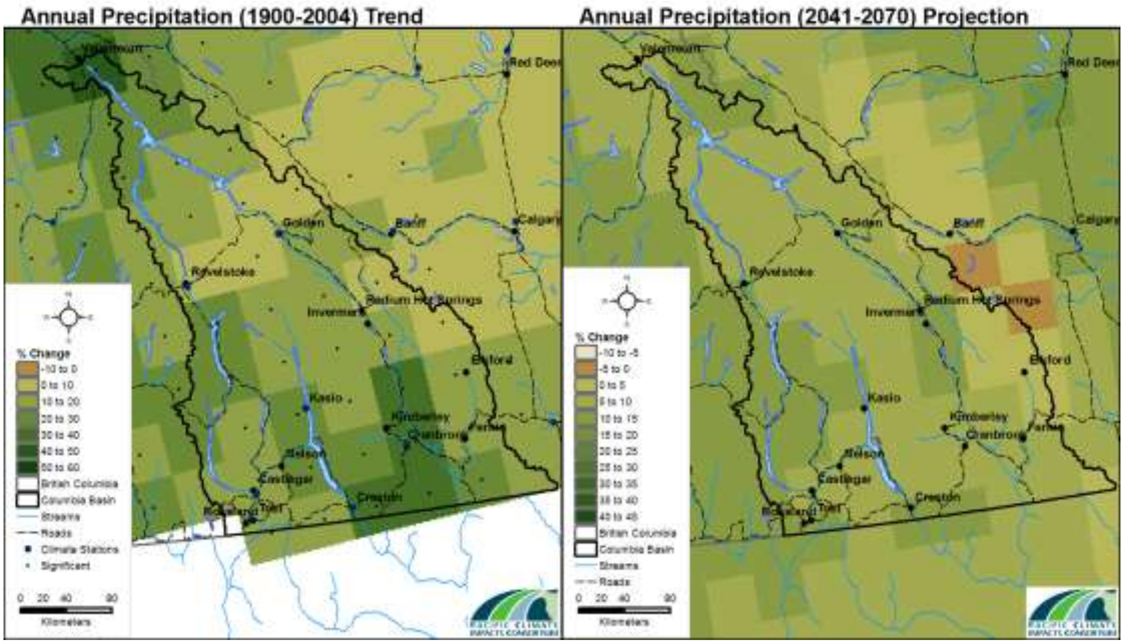
Future Scenarios

There are many factors that could potentially affect the issue of food security in the future. Climate change and peak oil are the two main topics of concern for the future. Climate change could increase temperatures, shift precipitation levels, and cause more extreme weather effects. Peak oil could decrease transportation, decrease food variability, and increase demand on local production.

The main concerns with climate change are increasing temperatures, precipitation shifts, and extreme whether affects. Droughts from higher temperatures could cause increasing demands on irrigation. A positive result from higher temperatures could be an increased growing season. Precipitation shifts could increase the amount of pests or increase the amount of fires which could cause soil erosion. Finally, extreme weather effects could increase crop damage.

The concern with peak oil is that transportation would decrease drastically. This would result in a large decrease in the amount of food imported into regions. Local regions would have to rely more on local production, and less on importing goods. Food variability would also decrease. It might not be possible to get different fruits or vegetables that grow in a particular remote climate.





Conclusions

Area D, and the Kootenay Region in general, should have enough farm land area per person to be food secure. However, the GIS and Remote Sensing analysis in this study on the ALR in Area D seem to reveal an under utilization for farm land and the entire ALR in general. A simple 2 class remote sensing land cover classification on Area D ALR shows that the vast majority is forested land. As well, the current ownership and tax layer show that very little of the ALR is actually being used for commercial farming/food production. Moving forward, it will be very difficult to make conclusions regarding food security in the RDCK without more spatial, and non-spatial, data. A complete Agricultural Land Use Inventory for the region may help address this issue. Furthermore, very little information is publically available on local farm production and food export in Area D. If this information was available, perhaps food resources could be properly redistributed to the advantage of Kaslo and Area D residents.

References

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Retirved from: http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/prof/92-591/details/page.cfm?Lang=E&Geo1=CSD&Code1=5903039&Geo2=PR&Code2=59&Data=Count&SearchText=Central%20Kootenay%20D&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=&GeoCode=5903039

Report produced for Dr. Paul Sneed in GIS 331 at Selkirk College by Dylan Hackenbrook, David Springer, Shannon Swayze on April 19, 2010.

Climate Change and Food Security

Backgrounder for

Communities Adapting to Climate Change
Phase II Communities
Rossland, Castlegar and Kaslo Area D

DRAFT
May 13, 2010

Prepared by Jennifer Ellis
Coordinator Adapting to Climate Change Project
City of Rossland

Table of Contents

1.0 Goal of Backgrounder

The goal of this backgrounder is to provide an initial review of the literature with respect to food security as it relates to climate change in the Rossland, Castlegar and Kaslo regions. It is intended to outline what we currently know with regard to food security, identify questions that require further research and provide a basis for each of the three Phase II communities undertaking the Columbia Basin Trust's Communities Adapting to Climate Change to complete local or regional vulnerability assessments with regard to food security.

This backgrounder is structured to follow a logical progression of questions: What do we mean by food security? How might climate change affect food systems in the region, taking into consideration that the majority of the food consumed within the region comes from outside the region? And finally what is our local, regional and/or provincial capacity for self-sufficiency in food systems?

The majority of food consumed in our region is sourced from around the world, with the average distance traveled for a single ingredient food item being 1500 miles and that for a multiple ingredient item being 2200 miles (Brynne, 2009). As a result, food security is a climate change adaptation issue area that must be considered on a global level.

For the purposes of this backgrounder, the region under discussion will be considered to include all of the municipalities between Grand Forks on the West and Creston on the East, ranging from the US border on the South to Nakusp and the Slocan Valley in the North. These boundaries are arbitrary at the moment and it is suggested that a clearer definition of the region from a food security perspective that takes into consideration realistic potential future food distribution routes and boundaries be developed.

This is intended to be a draft living document prepared to assist the Phase II Adapting to Climate Change Communities undertake vulnerability assessments with regard to food security. In many cases with respect to regional food security, there are more unknowns than knowns. This report reflects that state of knowledge. Information requests have been sent out as part of the preparation of this backgrounder. As new information becomes available and comments are received, this document will be updated.

2.0 Definition of Food Security

Food security is challenging to define and means different things to different people. Defining food security is bound up in what one considers to be human food needs. Human food needs can vary broadly depending on whether one is defining it based on a subsistence vegetarian diet or a traditional meat and grain based North American diet. The choice one makes with respect to what kind of diet is to be the basis for defining food security will have enormous implications for the degree to which a region can be considered food secure, and the types of measures and agricultural land base required for a region to be food secure.

Changing food consumption and preparation patterns may be all that is necessary to ensure food security in some circumstances (FAO, 2008).

Food security also relates not only to the food being available for consumption in a certain region, but also that it is available at prices that people can afford, which is affected both by the price of the food itself but also the level of employment income and unemployment in the region under consideration.

In a report for the Vancouver Food Policy Council, (Serecon Management Consulting et al., 2009), food security is defined as follows:

Food security is achieved when the structure and capacity of the food system is resilient and adaptive and can meet the food related human, cultural, economic, social and environmental needs of the individual and community.

The most commonly used and accepted definition of food security developed by the United Nations Food and Agricultural Organization (FAO) is:

"Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).

For a more local definition, the Kootenay Food Strategy Society defines food security on a community level. Note the greater emphasis on environmentally sound and socially just food production:

"A community enjoys food security when all people, at all times, have access to nutritious, safe, personally acceptable and culturally appropriate foods, produced in ways that are environmentally sound and socially just" (KFSS, nd).

The Food and Agricultural Organization (FAO) considers four dimensions to food security:

- *food availability* – the physical availability of the food in the region due to the overall ability of the agricultural system to meet demand;
- *food accessibility* – the economic accessibility of the food in the region for families based on their income or rights;
- *food stability* – the absence of seasonal shortfalls i.e. in the months before the next harvest or other temporary or permanent disruption in access to food;
- *food utilization* – the safety and nutrition of the food and the ability of the body to use the food (Schmidhuber and Tubiello, 2007; Bals et al., 2008; FAO, 2008).

As a result, the FAO sometimes adds to its definition of food security:

"To achieve food security, all four of its components must be adequate. These are availability, stability, accessibility and utilization." (Bals et al., 2008:43).

The concept of food security was initially developed to be analyzed on a global level based on the comparison of how much food can be produced globally versus global demand (Bals et al., 2008). It has since been extended to allow for consideration of food security on a national, regional, household and individual level and to focus also on accessibility of food, rather than just availability of food. Food security often relates just as much, if not more, to the ability of individuals to access food through monetary or non-monetary means, rather than the physical availability of food (Schmidhuber and Tubiello, 2007; FAO, 2008). It is often a socio-economic issue rather than an agro-climatic one.

It is critical to emphasize that food security differs from the viability of local agriculture as a result of climate change from an economic or social perspective. A region can be food secure through secure access to food from other regions in the complete absence of local agriculture. Thus climate change impacts that could negatively impact local agriculture might not affect a region's food security. However, one could argue that access to food from other regions will never be 100 percent secure and thus regional food sources are a critical element of regional food security. In addition, individual food production may be a fundamental element of household food security in some households. As a result, this paper will attempt to move from a global assessment of food security to a more regional and local one.

3.0 A Food Systems Lens

This paper will examine food security through a *food systems* lens. The FAO (2008) describes food systems as a holistic set of interacting processes including:

- food production,
- food processing and packaging,
- food distribution and retailing, and
- food consumption.

This section will explore how climate change will affect our food systems on a local, regional and global level both directly and indirectly.

Unlike many of the impacts of climate change, such as water and ecosystems, which can be more localized, it is critical to assess food security implications on a global, regional and local scale. The majority of our food comes from outside of our region. Thus the question of how that global and provincial food systems will be affected by climate change is a critical element of assessing regional food security. As the FAO (2008:xi) observes, "Climate change will affect food security through its impacts on all components of global, national and local food systems."

Food systems are highly complex and globalized. Any change affecting one or more aspects of the food production and distribution system could have significant ripple effects resulting if not in reduced food availability, increases in market prices. The FAO stresses that to evaluate the potential impacts of climate change on food security it is not enough to assess the impacts on domestic production. Factors such as the impacts of climate change on overall global food surpluses and the ability of countries and individuals to purchase those surpluses must also be considered.

4.0 Impacts of Climate Change on Food Systems

4.1 Overview

4.1.1 Direct and Indirect Impacts

Climate change will likely affect food systems:

- *directly* through its impacts on biophysical factors such as plant and animal growth and the physical infrastructure associated with food processing and distribution; and
- *indirectly* through its effects on human capital, and economic and sociopolitical structures (Schmidhuber and Tubiello, 2007).

This section will provide outline some of the potential direct and indirect impacts of climate change on food systems. Because there is more information available on the direct potential effects of climate change on food systems, that will be the focus of this section. However the indirect effects are highly interrelated and ultimately may be the primary threat to global and regional food systems.

Climate change will bring both impacts and opportunities with respect to global food systems. Food *production*, especially agriculture and fisheries, will be one of the key aspects of our food system affected by climate change. This is important because food production is how the food we consume is generated, but also because food production employs 36 percent of the world's population (FAO, 2008). Thus if people are no longer able to make a living producing food, their ability to have the capital to access food may also be affected thereby creating an indirect effect of climate change on food security. While the potential impacts of climate change on food production may be the most immediately obvious, the food processing, distribution and utilization aspects of our food system will also likely be directly impacted by climate change and are of equal importance.

4.1.2 Timing of Impacts

Some of the impacts of climate change on food systems will be felt more immediately and indeed are already being experienced in some part of the world, such as the impacts of extreme weather events, less predictable rainfall patterns and rising sea levels (FAO, 2008). Other climate change impacts will be longer term and potentially more gradual, such as changes in temperatures and precipitation (FAO, 2008). In addition, some climate change impacts will result in short term shortfalls and volatility, while others will result in longer term more likely permanent changes in overall global production capacity (Bals et al., 2008). Certain already vulnerable crops, people and food systems, particularly small-scale farmers living off of rain-fed crops in tropical areas, will likely be affected first, but over time, the distribution of vulnerability and risk will likely shift (FAO, 2008).

4.1.3 Certainty of Impacts

There is a significant amount of uncertainty associated with forecasts of how climate change might affect food security (Bals et al., 2008). This uncertainty increases exponentially when making forecasts on a regional and local level. This is because of uncertainty with regard to how climate change will manifest on a regional and local level, but also due to uncertainty with regard to feedback loops and chaotic changes in the natural ecosystems upon which we depend for our food (Bals et al., 2008). Downscaling global climate models to local and regional levels continues to be challenging and highly uncertain. Even global models of climate change, particularly when they incorporate socioeconomic projections to develop emissions scenarios, are uncertain. As a result, most of the analysis with respect to food security presented in this paper is based on models that are at best highly uncertain (Schmidhuber and Tubiello, 2007). Thus, the potential impacts outlined below, and the final conclusions, are best guesses on a global scale, particularly with respect to the indirect impacts.

4.2 Direct Biophysical Impacts of Climate Change

Food systems will likely be directly affected by many aspects of climate change including increased CO2 concentration in the atmosphere, increased temperatures, reduced precipitation, new diseases and pests, more extreme events and rises in sea level.

4.2.1 Increased CO2 Concentrations in the Atmosphere

Increased CO2 concentrations in the atmosphere are a key element of climate change that could affect food security. Atmospheric CO2 concentrations are estimated to be approximately 379 ppm today and are projected to potentially rise to 550 ppm by 2100 under the IPCC Scenario B1 (the lowest future emissions scenario) and greater than 800 ppm in Scenario A1 (the business as usual scenario) (Schmidhuber and Tubiello, 2007).

Crops

Increases in carbon dioxide concentrations in the atmosphere cause plant stomata to narrow reducing water losses and decreasing water requirements associated with agriculture. In addition, increased CO2 concentrations could stimulate photosynthesis resulting in a fertilizing effect on many crops increasing biomass accumulation and final crop yields. It was initially thought that this would contribute significantly to increased crop yields (WBGU, 2007). However the effects of CO2 concentrations are influenced by many factors including the species, growth stage, competition, pests, fertilization and water availability (Schmidhuber and Tubiello, 2007; Bals et al., 2008). As result the degree of crop yield increase is highly uncertain. While greenhouse based experiments were positive, open field tests have found that closure of the plant stomata reduces photosynthesis increases (WGBU, 2007). Some types of crops, such as wheat, rice and soybeans could increase yields by up to 10 to 20 percent if atmospheric CO2 concentrations reach 550 ppm, but the projected increase for other crops is less than 10 percent (Schmidhuber and Tubiello, 2007; Bals et al., 2008) and little to none for millet and maize (WBGU, 2007). In addition, the nutritional quality of the crops produced in elevated CO2 conditions may not be any higher than that produced in current CO2 conditions, despite higher yields (Schmidhuber and Tubiello, 2007).

Fisheries

Increased CO2 concentrations in the atmosphere could cause an increase in ocean acidification which could severely impact the viability a wide range of coral reefs, planktonic and other benthic marine organisms that make their shells or skeletons from aragonite (Bals et al., 2008). This could have significant implications for marine food chains and the overall productivity of the oceans. Reefs are critical to marine fisheries production as they are breeding grounds for many species as well as habitat for juveniles.

4.2.2 Increased Temperatures

Increases in mean, maximum and minimum temperatures are forecast for most regions of the world as a result of climate change. These temperature increases will have impacts on plant and animal growth.

Crops

It is expected that in mid to high latitude (temperate) areas of the world, higher temperatures of up to 1 to 3° C could result in greater crop productivity, longer growing seasons, more growing degree days, and an expansion in the areas suitable for agriculture (Schneider et al., 2007; Bals et al., 2008; FAO 2008). The extent of these increases in crop yields is still uncertain, but more recent analyses are suggesting that they may be lower than initially expected (Bals et al., 2008). It is also expected that temperature increases will create the opportunity for different kinds of crops in temperate areas (FAO, 2008).

Low latitude (tropical) areas, where water availability is lower, are at risk of decreased crop yields at even 1 to 2° C of warming (Schneider et al., 2007; FAO 2008) as increases in temperature increase evapotranspiration and lower soil moisture levels (Bals et al., 2008). These processes will cause some cultivated areas to become unsuitable for cropping and some grasslands to become unsuitable for pasture (Bals et al., 2008). The extent of these declines in yields is still unknown, but some analyses suggest they could be severe (Bals et al., 2008).

It is expected increases in yields in temperate areas will offset decreases in yields in tropical areas and that as a result, that crop yields may increase globally with temperatures of up to 1 to 3° C (Schneider et al., 2007; FAO, 2008). However, larger temperature increases could have much more adverse effects. Most plants have a limit to the temperature increases they can tolerate. Grains for example can tolerate increases in temperature of about 1.5 to 3° C in tropical regions and 4.5 to 5° C in temperate regions (Bals et al., 2008).

Warmer days and nights could also affect plants in unexpected ways – i.e. temperatures rising to near the maximum earlier in the day. Even if the daily high is not significantly above historical levels, most plants close their leaf stomata and become dormant at only 2-3 degrees above their "working" temperature. If plants go dormant earlier in the day, time incrementally lost from the growing season. Other plants, such as nuts and fruits, require chill hours, or a number of hours below a certain temperature in the winter to undergo a required period of dormancy (CNRA, 2009).

Beyond 3° C of warming, crop yields in all regions of the world including temperate regions are projected to decline (Schneider et al., 2007). Temperature rises of 4° C are likely to have major negative impacts on global agriculture (WBGU, 2007).

In BC, because it is a temperate area of the world, climate change temperatures increases are expected to have little impact on crops in most regions of BC (Serecon Management Consulting, 2009).

Fisheries

Fisheries industries are likely to be significantly affected as climate change affects freshwater and marine ecosystems for fish (Schneider et al., 2007). It is projected that the temperatures of many lakes and rivers and marine ecosystems will rise (Bals et al., 2008). This will impact the composition, productivity and nature of these ecosystems, and therefore could have an impact on the types, abundance and seasonal availability fish and sea life as a food source (Bals et al., 2008; FAO, 2008; ESCAP, 2009). The impact of rising temperatures on fisheries is very difficult to predict, but there are many potential causes for concern (ESCAP, 2009).

In some cases, some species could experience a range, growth rate and population expansion due to higher temperatures, access to new areas of ocean due to the decrease in ice cover (Bals et al., 2008). However fish also have ranges of thermal tolerance and temperature increases in the wrong season could impact fish populations (Bals et al., 2008). Rising temperatures could affect breeding habitats and predator prey relationships in unpredictable ways (ESCAP, 2009).

Rising temperatures in lakes and rivers could also result in water quality problems, such as algal blooms, which would have impacts on fisheries, and aquaculture (Bals et al., 2008).

Temperature changes could also affect large ocean circulation systems and the vertical stability of the water column impacting nutrient availability for fish (Bals et al., 2008). Changes in the stability of the water column has already resulted in a decrease in marine and lake productivity in some areas (Bals et al., 2008).

Livestock

Higher temperatures will have implications for the quality and extent of rangeland for animals (Schneider et al., 2007). Livestock is sensitive to thermal stress even at limited temperature increases (Bals et al., 2008; CNRA, 2009). Higher temperatures can cause increased mortality and decreased productivity in livestock (CNRA, 2009). While the productivity of rangeland is expected to increase in temperate areas, it could decrease in arid or semiarid regions (Bals et al, 2008). At the same time, shorter and milder winters could result in increased livestock production at a lower cost by lower heating requirements for animals, reduced winter feeding, easier winter grazing, and less winter kill.

Wild Plants and Animals

Higher temperatures will also likely lead to ecosystem movements towards the poles in the case of some of the world's ecosystems. This is already being observed. Since not all plants and animals will be equally successful at migrating, the dominance of certain species will change. This expected to result in species extinctions, reductions in biodiversity and ecosystem change (Bals et al., 2008), which could have implications for populations that depend on forest ecosystems for their food security.

Food Infrastructure

Higher temperatures could have both positive and negative implications for food distribution. New arctic shipping routes could be opened up and transportation disruptions due to winter conditions could be reduced. At the same, time transportation disruptions due to increased wildfires, which will be discussed further in the extreme events section, and the overheating of vehicles could have negative implications for food security.

4.2.3 Changes in Precipitation

It is expected that as a result of climate change, wet areas in the world, particularly temperate regions, could become wetter and dry areas in the tropics could become drier (FAO, 2008). In addition, the timing of precipitation will likely shift resulting in earlier spring runoffs and dryer summers in some areas of the world. The intensity of rainstorms could increase and precipitation could become more variable and unpredictable in its timing.

Crops and Livestock

Since 80 percent of total global agricultural land is rain fed, changes in precipitation patterns could have a very significant effect on global food security (Bals et al., 2008). Temperature increases combined with reduced precipitation in some parts of the world will likely result in the loss of arable land in some areas, particularly tropical parts of the world, due to decreased soil moisture, increased aridity, increased salinity and groundwater depletion (Bals et al., 2008). Reduced overall water supply will limit opportunities to maintain or extend these cultivated and pasture areas through the use of irrigation. Soil erosion due to decreased soil moisture and increased extreme wind and water events is considered to be a major risk (WBGU, 2007). Grassland productivity in semi-arid and arid regions in tropical and sub-tropical parts of the world could decline by 40 to 90 percent by 2020 (WFP et al., 2009).

Reduced availability of good quality water overall, or at certain times of the year, for crops and livestock will likely negatively affect food supplies in many parts of the world (FAO, 2008). Water shortages could lead to water rationing and higher water costs, which could negatively affect agriculture (Serecon Management Consulting, 2009).

Moreover, even if overall precipitation for a particular region is not decreased, the tendency for this precipitation to be concentrated into more intense rain events, and for more winter precipitation to fall as rain, thereby changing the timing of peak stream and river flows could have negative implications for agriculture that will be challenging to predict. If peak river flows occur before the water is needed for agriculture, different strategies will have to be employed to capture that water. If rain does not come at the right time, or occurs more intensely for fewer days, crops will be affected, and the types of crops that can be successfully grown may change (Bals et al., 2008). In South Asia and parts of Africa, the timing of monsoon related rainfall events is key for the success of local agriculture. If this timing is affected by climate change, crop productivity or survival could be affected. More intense rain events could adversely affect the quality of surface and ground water, damage crops or lead to soil erosion (Bals et al., 2008).

Fisheries

Aquaculture could be negatively affected by the reduction in water availability for inland fish production (Bals et al., 2008), which could have a significant effect on food security in certain parts of the world that depend on fish protein (FAO, 2008).

4.2.4 Pests and Diseases

Most studies on global agriculture and climate change have not yet analyzed the spread of pests and diseases in detail (Schneider et al., 2007). Nevertheless it is generally acknowledged that the incidence and distribution of pests and diseases will change as a result of climate change (Bals et al., 2008; FAO, 2008). Pests and diseases can be considered a spin off effect of the main climate related changes associated with climate change including increases in temperature and changes in precipitation.

Crops and Livestock

Higher temperatures are likely to lead to increased earlier spring insect activity, insect outbreaks and the proliferation of some species (Bals et al., 2008). Higher winter temperatures will increase the ability of some pest populations to survive the winter (Schmidhuber and Tubiello, 2007), and the northern migration of some pest species (CNRA, 2009). Weather extremes could also promote pest and disease outbreaks. Invasive plants could also become more problematic in agriculture (WBGU, 2007).

The increase in animal and crop diseases is considered to be one of the key likely climate change impacts on agriculture in BC (Serecon Management Consulting, 2009). The significant decline in animal and plant diversity in our food, due to genetic modification and selective breeding (Serecon Management Consulting, 2009) makes us more vulnerable to diseases and pests. The expansion of the mountain pine beetle in BC in part as a result of warming trends is an example of how pest activity can be increased by climate change.

Fisheries

Temperature increases in lakes and oceans can also result in the spread of pathogens (Bals et al., 2008). For example warmer oceans may contribute to the increased incidence of human shellfish and reef-fish poisoning (ciguatera) and the expansion of the disease towards the poles (Schmidhuber and Tubiello, 2007).

Food Safety and Human Diseases

The expansion of food safety and human diseases, such as salmonella and malaria, also affects food security because it can impact the food utilization component of food security. If because of disease, humans cannot utilize the food available, hunger can be compounded and eventually result in a decline of labour to produce the food compounding food security issues (Schmidhuber and Tubiello, 2007). Increases in temperature as a result of climate change are expected to increase the incidence of salmonella poisoning and diarrhoeal disease (Schmidhuber and Tubiello, 2007). Extreme rainfall events and flooding can increase the risks of water-borne diseases such as cholera, which are considered relevant to food security in the sense that they affect population's capacity for food utilization (Schmidhuber and Tubiello, 2007).

4.2.5 More Extreme Events

Extreme climate change events such as storms, cyclones, hailstorms, drought, flooding, heat waves could have unpredictable impacts on food systems (Schmidhuber and Tubiello, 2007). These events are already increasing with an average of 500 weather related disasters per year compared with 120 in the 1980s with a six times increase in the number of floods (FAO, 2008) and are predicted to continue to increase significantly as a result of climate change (Bals et al., 2008). Extreme events are not new phenomena in agriculture, particularly in certain parts of the world, but they are expected to increase in frequency and the areas subject to extreme events are likely to expand (Schmidhuber and Tubiello, 2007). Most studies on global agriculture have not yet considered the impacts of changes in extreme events (Schneider et al., 2007) and yet the possible implications are significant.

Crops and Livestock
Drought in Australia in 2006 already resulted in a decrease in grain yields from 25 million tones to less than 10 million tones (Bals et al., 2008). Heat waves could cause crop failure and/or reduced yields and livestock death due to heat stress (Bals et al., 2008). Heat waves in Europe in 2003 reduced crop yields by 25 to 36 percent (Bals et al., 2008). Wildfires and flooding could wipe out entire crops. Even short term heat waves could have significant effects on certain crops if they occur at specific developmental stages for the crop, such as flowering (Bals et al., 2008). The impacts of droughts and floods could be most severe in semiarid and subhumid areas, in which populations are already subject to chronic instability in food production (Schmidhuber and Tubiello, 2007).

In addition to wiping out already planted crops, causing short-term shortfalls and affecting the stability of food security, extreme events can also have longer-term implications for global food security. For example, flooding can reduce the overall fertility of cropland by washing away fertile soil and soil organisms causing long term declines in crop yields. (Bals et al., 2008). Wind and storms could damage coral reefs, which are critical for fish production, and forest ecosystems (Bals et al., 2008).

Winter floods and summer droughts are considered to be a climate change impact that will affect BC agriculture in some regions, although the Fraser Valley is expected to be more or less unaffected (Serecon Management Consulting, 2009).

Food Infrastructure
In addition, as the frequency and intensity of weather events increases, there is an increased risk of temporary disruptions or longer-term damage to food production and distribution infrastructure from storms, flooding or wildfire (ESCAP, 2009). The damage to food distribution infrastructure, such as roads, bridges or ports in particular, could have impacts on food security (FAO, 2008). The longer our food chains, the greater the risks associated with transportation disruptions (FAO, 2008). Unlike Canada, some countries, such as Switzerland, have a six-month food stockpile for their citizens (Brynne, 2009). Given that most Canadian households no longer stock up food for the winter and most North American grocery stores only have three days food in stock (Brynne, 2009), transportation disruptions of longer than three days could have serious implications in some communities.

Damage to other non-food related infrastructure from extreme events, such as power and water supply infrastructure, could also have implications for food systems.

4.2.6 Rising Sea Levels

In the 20th century, sea level has already risen by 15 to 20 cm due in part to melting glaciers and polar ice, as well as rising temperatures in the oceans (thermal expansion) (WBGU, 2007). There is significant uncertainty with regard to how much sea level could rise, but current projections suggest a sea level rise of about half a metre by 2100 can be expected and that it could possibly be significantly higher (WBGU, 2007).

Crops and Fisheries
Although rising sea levels will not affect this region directly, it could affect other food producing regions in the world and therefore overall global food supplies through the loss and salinization of arable land, as well as the salinization of irrigation water (FAO, 2008; ESCAP, 2009). Contamination of arable land through greater exposure to wastewater is also

a possibility (ESCAP, 2009).

Highly productive estuaries and freshwater fisheries systems could also be lost or damaged and sources of freshwater for agriculture could be reduced due to salt-water intrusion (Bals et al., 2008).

Food Infrastructure

Sea level rises could also have significant negative implications for port infrastructure, which is critical for global food distribution.

4.2.7 More Seasonal Weather Variability

It is highly likely that there will be greater variability in seasonal weather patterns as a result of climate change (Bals et al., 2008). This variability could have significant implications for food security.

Crops

Increases in seasonal weather variability will result in changes in the start and end of the growing season and less predictability for growers (FAO, 2008). Already the timing of most spring events, such as leaf unfolding and egg-laying, has shifted to be earlier in the season (Bals et al., 2008). While this could be positive in some locations and in some years by extending the growing season, it could also have negative effects, such as greater risk of tree fruit crop loss due to late and unexpected frosts, or a disconnect from when there is sufficient rainfall to support agriculture (Bals et al., 2008).

The predictability of rainfall patterns will also decline, presenting challenges for farmers to know what crops to plant and whether there will be sufficient rainfall. This is critical as 60 percent of the global harvest is produced on rain fed land (Bals et al., 2008).

4.2.8 Overall Outlook

Initial projections of the impacts of climate change on food security by the Food and Agricultural Organization (FAO) and other organizations suggest that on a biophysical level climate change is *not* expected to decrease global food security over the next century (Schmidhuber and Tubiello, 2007; Bals et al., 2008).

According to the mainstream literature, food availability is not projected to decrease on a global level to 2080 and is expected to be sufficient to meet the needs of the growing global population, due to increases in overall crop yields due to the CO2 fertilization effect, and due to increases in agricultural production in some regions of the world, due to increased temperatures and precipitation to offset decreases in regions of the world. Even if the expected CO2 fertilization effect, which will boost crop productivity, is discounted, food availability over the next century is projected to be sufficient to meet the needs of the global population (Schmidhuber and Tubiello, 2007). The total land and prime land areas in the world available for agriculture are expected to remain unchanged as a result of climate change at current levels of 2,600 million and 2,000 million hectares respectively (Schmidhuber and Tubiello, 2007). Some researchers suggest that only half of the world's agricultural land is currently being farmed, suggesting that there is considerable extra capacity (WBGU, 2007). This figure should be confirmed.

Nevertheless there will be critical shifts in the capacity if different countries and regions to produce food. It is expected that as a result of climate change, overall agricultural food production and crop yields will increase in high latitude temperate areas, decrease in the low latitudes and be mixed in the mid-latitudes. The declines in some low latitude areas could be significant with agricultural productivity in Central and South Asia projected to decline by 5 to 30 percent by 2050 (ESCAP, 2009). Potential cropland at higher latitudes in developed countries will increase by 160 million ha and potential cropland at lower latitudes in developing countries will decrease by 110 million ha (Schmidhuber and Tubiello, 2007). Moreover, the quality of land in developing countries will decline by an even greater amount with a loss of 135 million ha of prime land offset by an increase of about 20 million ha of moderately suitable land (Schmidhuber and Tubiello, 2007). The greatest losses of cropland are likely to be in Africa, while the greatest expansion of cropland are likely to be in Russia and Central Asia (Schmidhuber and Tubiello, 2007).

As a result, as with most climate change impacts, the impacts on food security are expected to fall disproportionately on *developing countries*, not only because their agriculture and livestock production may be most affected by changes in climate, but also because their economies, including the percentage of people employed, depend to a greater extent on primary food production, and they are the least able to purchase higher priced imported foods (Bals et al., 2008). Thus the negative impacts of climate change on food security will be most felt where food insecurity is already high and the reliance of developing countries on food imports will increase. In particular sub-Saharan Africa is considered to be the most likely to be the most food insecure region in the world as a result of climate change, both because of the direct impacts of climate change on food production will fall disproportionately on Africa, but also due to the indirect effects of income loss from agriculture (Schmidhuber and Tubiello, 2007). Capacity to adapt is a critical element of food security and developing nations often have less adaptation capacity than developed countries.

Developed countries may not be immune to food security impacts associated with climate change, particularly the short-term effects of extreme events, but they will likely experience them to a much lesser extent than developing countries. The overall percentage of undernourished people in the world is projected to decline in the next century, due primarily to projections of socioeconomic growth, rises in real income and stabilization of population growth (Schmidhuber and Tubiello, 2007). Climate change *is* projected to have a negative impact on food security – that is, the number of undernourished people is projected be greater than it would be in a non-climate change scenario, but its likely effects are considered to be small, and offset by the socioeconomic and population growth developments that will reduce the overall percentage of people that are undernourished in the world (Schmidhuber and Tubiello, 2007).

<u>Thus it is projected that on a biophysical level, the ultimate impact of climate change on food security will likely be that global food markets will provide sufficient food for those with purchasing power, while those without an adequate income who cannot produce enough of their own food will become food insecure (Bals et al., 2008).</u>

It is critical to note, however, that this relatively optimistic outlook does not account for the indirect impacts of climate change on food security (Section 4.3), and critical cautionary notes regarding non-linearity, extreme events and tipping points (Section 4.4), which will be discussed in the next two sections. This optimistic outlook also does not take into account the implications of non-climate change events and factors for food security, which will also be considered in Section 5.

4.3 Indirect Impacts of Climate Change

Climate change will have implications for human capital and economic and sociopolitical structures. These implications could in turn have indirect effects on our food systems that exceed the direct biophysical impacts. These indirect effects of climate change on our food systems, such as greater migration, poverty, civil unrest and resource-based conflicts have significant potential to negatively impact food security on global, national and regional levels (FAO, 2008).

Unlike the direct biophysical effects of climate change on food systems, which have significant implications for the availability of food, the indirect impacts of climate change also have significant potential to impact the accessibility of food. Accessibility refers to the ability of individuals, communities and countries to purchase sufficient quantities and qualities of food (Schmidhuber and Tubiello, 2007). A key element of improving global food security over the last thirty years has been an improvement in the accessibility of food through increases in the real incomes in many developing countries (Schmidhuber and Tubiello, 2007). Climate change impacts that affect the ability of households, regions and countries to access food from a socioeconomic perspective will have significant implications for food security.

The potential for civil unrest and conflict as well as general income level effects arising from climate change have not been very well addressed in the climate change food security literature. The food security and climate change literature tends to be dominated by fairly scientific analyses of the physical impacts of climate changes on food production. In addition, many analyses of climate change impacts are sectoral, focusing on specific ecosystems or events, and considering only the implications of climate change, rather than considering cumulative effects or examining the potential responses of populations to multiple concurrent threats.

The analyses that do consider social implications rely on the IPCC SRES (Special Report on Emissions Scenarios) development paths, which do not forecast significant breakdown of economic and sociopolitical structures. All of the IPCC SRES (Special Report on Emissions Scenarios) development paths envision a world of economic growth and rising real incomes in most parts of most developing countries (Schmidhuber and Tubiello, 2007). Modeling based on these scenarios suggests that food prices will rise moderately in part due to climate change and its direct impacts on food production and distribution, but also due to other exogenous factors. Nevertheless, real incomes are projected to keep pace, and while some regions are expected to continue to have food security issues and undernourished populations, the overall percentage of undernourished people in the world is projected to decline from current percentage levels (Schmidhuber and Tubiello, 2007).

However, human economic, social and political systems are highly complex and the potential climate change impacts to spin off into larger socio-political or socio-economic breakdown need to be considered with respect to regional food security (WBGU, 2007; Dyer, 2009). Countries at war, undergoing mass migrations due to sea level rise, or severely impoverished may not be able to produce food for export even if the climate conditions are conducive to growing food.

The German Advisory Council on Global Change (WBGU) has undertaken a comprehensive survey of the potential conflict constellations associated with climate change and stresses that climate change will overstretch many societies' adaptive capacities unless serious action is taken (WBGU, 2007). In particular, they stress the potential conflict constellations around the degradation of freshwater resources, a potential decline in global food production, increases in storm and flood disasters and environmentally induced migration (WBGU, 2007).

Moreover, extreme events such as war or mass migration are not necessary to cause declines in food security. There is little disagreement that climate change will likely have the most significant impacts on the poorest nations and populations of the world both biophysically and socio-economically (Stern, 2006; ESCAP, 2009). These nations and populations are already the most vulnerable and have the least adaptive capacity. While Stern (2006) suggested that most nations would experience GDP losses, GDP losses in some smaller African countries could be as high as 30 percent (WBGU, 2007). Moreover although the total global amount of viable agricultural land may be increased or remain the same as a result of climate change, the expected regional shifts in the locations of those lands could have more significant impacts than expected. The loss of agricultural lands in some areas will mean economic ruin for the farmers who own those lands. Those economically ruined farmers are unlikely to shift their operations elsewhere, particularly if the new viable agricultural land lies across borders or continents. The true viability of the new biophysically viable agricultural lands depends on having farmers to farm it, which is a less than certain proposition.

While developed countries in Europe and North American may initially experience only minimal impacts on food security arising from the direct impacts of climate change on agriculture and fisheries, the indirect effects of larger structural changes to agriculture markets, global conflict and migration could affect developed countries (WBGU, 2007). This is an area that requires further study and consideration.

4.4 Non-Linear Effects, Extreme Events and Tipping Points

While the general outlook in the literature for food systems on a global level is optimistic, these analyses are based on examining changes that are in general highly predictable and gradual and continuous (WBGU, 2007). The cumulative effects of all of the changes expected from climate change or increases in global mean temperatures exceeding 3° C may be more than the system can handle.

It is quite possible that climate change may proceed in unexpected non-linear ways, with surprising tipping points and thresholds that have large implications for global and regional food security (Bals et al., 2008). When critical thresholds, or tipping points are crossed runaway changes can be triggered that are impossible to bring under control (WBGU, 2007). Non-linear processes have occurred in earth's history – ice shields have abruptly melted and ocean streams have stalled (Bals et al., 2008). Sometimes small disruptions in systems are sufficient to generate fundamental changes.

While agricultural systems are often monocultures, they are still complex ecosystems and with the costs of inputs that simplify these ecosystems, such as fertilizers and energy rising, and therefore potentially becoming less utilized, they may become even more complex. Marine and freshwater fisheries are highly complex ecosystems. Ocean circulation and weather systems are equally complex. The WBGU (2007) suggests that non-linear phenomena such as weakening of the North Atlantic current, changes in atmospheric circulation that results in monsoon transformation, which account for 90 percent of annual precipitation in some regions, and instability of continental ice sheets leading to sea level rise of several metres are possible and would have far reaching consequences for global food security.

Moreover it was repeatedly emphasized in the literature that projections for food systems is optimistic, unless warming trends exceed 3° C. All of the models that provide a relatively optimistic overall outlook for food security generally assume mean climate change of 3° C or less, and do *not* consider the possibility of major abrupt climate or socioeconomic change, or a *significant* increase in the number of extreme events (Schmidhuber and Tubiello, 2007). Given that the potential impact of extreme events is being increasingly recognized as possibly the most serious climate change related issue for food security, potentially offsetting the potentially positive effects of moderate increases in temperature (Bals et al., 2008), this is a very significant shortcoming.

In addition, the models that provide the optimistic outlooks for food security outlined above are based on SRES models assuming future socioeconomic growth, and FAO models regarding future food production through extensive expansive of irrigation, that are highly uncertain. In addition the models that analyze overall food production in a climate change scenario have many important exclusions, such as the implications of food safety and food borne diseases, the implications of sea level rise and extreme events (Schmidhuber and Tubiello, 2007). The potential for these impacts are mentioned as qualitative considerations, as they are in the analysis above, but are not explicitly incorporated into the models of future food availability and accessibility (Schmidhuber and Tubiello, 2007).

5.0 Non-Climate Change Events/Factors

In addition to climate change, to properly assess a region's food security it is critical to consider some of the non-climate events and changes that are affecting and will affect food production and distribution over the next few decades. While it is beyond the scope of this backgrounder to examine these events and factors in detail, they require some mention as it is possible and likely that some of these events and factors will exacerbate or be exacerbated by climate change impacts and contribute to the overall regional vulnerability of our food systems. Given some of these trends, it is possible that even in a non-climate change scenario that global food production might be insufficient to meet food needs in the next few decades.

Some of these key factors include:

5.1.1 Increased Input Costs

Increasing energy and input costs (decline in supply, decrease in hydroelectric production capacity, regulated carbon economy) and increasing energy demand in all parts of the world could have a significant effect on global agriculture (Bals et al., 2008). Food production, processing and distribution are all highly energy intensive. It is estimated that producing one calorie of food requires 10 calories of fossil fuels, leading some researchers to suggest that we are literally eating fossil fuels (Pfiefer, 2006). Many of our gains in food production in the last century have been based largely on increases in the use of fossil fuel inputs, especially fossil-fuel based fertilizer (Pfiefer, 2006). If fossil fuel prices increase over the next several decades, which they are projected to as a result of declines in global oil production due to peak oil, so too will the costs of food production, processing and distribution (Pfiefer, 2006), and if fossil fuels reach a point whereby they are significantly less available, overall global food production could decline significantly.

Food distribution systems, which rely heavily on fossil fuel dependent modes of transport, such as trucks and planes, will also be dramatically affected if energy prices increase and will result in higher food prices and potentially reduced food security.

The costs of other agricultural inputs are also increasing including fertilizer and pesticide costs, in part because of increasing energy costs but also because of depletion and therefore increasing prices of certain other inputs. Water costs may also increase in the future as a result of increasing water demand due to lifestyle changes and urbanization in many countries (Bals et al., 2008).

5.1.2 Population Increase

The global population is projected to continue to increase (from 6.5 billion people to 9 billion people in 2050) and the population of many countries and regions of the world including British Columbia is expected to increase. Food insecurity already exists on a global level for many populations (FAO, 2008) with 850 million people, mostly in developing countries, chronically hungry or malnourished (Bals et al., 2008). At the moment this is primarily an access issue. Sufficient food is available but these people do not have adequate income to access it (Bals et al., 2008). The global food security situation has improved dramatically over the last thirty years, largely due to improvements in food accessibility with lower food prices and significant income growth in developing countries (Schmidhuber and Tubiello, 2007). Nevertheless, with increased global population, even if food production and distribution are unaffected by climate change, greater demand will require increases in food production to meet food security needs (Bals et al., 2008). This is projected to occur and it is forecast that the number and/or percentage of undernourished people in the world will decline by 2080 even considering the effects of climate change (Schmidhuber and Tubiello, 2007).

5.1.3 Dietary Shifts

Changes to a more meat, dairy and cereal centered diet in many countries, such as China and India has and will continue to increase requirements for cropland globally (Bals et al., 2008). Meat consumption has doubled globally in the last 25 years (Bals et al., 2008). If this trend continues and a meat, dairy and cereal centered diet are adopted globally, global production of some crops may have to double to meet demand (Bals et al., 2008).

5.1.4 Loss of Arable Land

Arable land is being lost and degraded around the world (possibly as much as 0.5 percent annually) due to a number of factors (Bals et al., 2008). Urbanization of farmland in both developed and developing countries including Canada is a key trend leading to not only loss of farmland but also the contamination of adjacent farmland (Bals et al., 2008; Serecon Management Consulting, 2009). This trend is predicted to continue in developed countries shifting greater reliance for food production on developing countries (WBGU, 2007). There is also a trend towards the increased use of agricultural production land for biofuels crops. This trend will be driven partly by increases in oil prices, but also by the desire to reduce GHG emissions in the transport sector (Bals et al., 2008). Diversion of cropland to non-food crops will likely reduce global food production. Analyses of the implications of biofuels for food security have been both positive and negative (Schmidhuber and Tubiello, 2007).

This is already a critical problem in British Columbia whereby the Fraser Valley is one of our most agricultural productive areas, but is subject to significant pressures from urbanization (Vancouver Sun, 2007).

5.1.5 Shifts in Agriculture

Many shifts in the way agriculture is organized and undertaken serve to make it a more vulnerable system to potential climate change disruptions. For example, the oncentration of a significant portion of global food production and distribution in hands of a small number of multi-nationals (Brynne, 2009), the decline in farm incomes (farmers receive only a tiny portion of the revenues from consumer spending on food) making farming a relatively unattractive profession and therefore the subsequent decline in global and regional farming skills and knowledge (Brynne, 2009).

On a global level, long-term food production projections from the FAO are optimistic, despite all of these non-climate change factors (WBGU, 2007). For example, the annual growth rate for world cereal production is projected to increase from 1 percent to 1.4 percent by 2015, eventually falling to 1.2 percent over the long-term (WBGU, 2007). However, these projections and conclusions are not completely supported by ongoing trends. Food demand is currently outstripping production and as a result reserves for some major crops have been declining (Bals et al., 2008). Food prices, particularly for cereals, have already been increasing around the world and may continue to do so (Bals et al., 2008). This could be offset slightly by higher food prices driving more investment in agriculture (Bals et al., 2008).

6.0 Capacity for Regional Food Self-Sufficiency

This section examines food security from a regional and provincial perspective to address the question:

If climate and non-climate changes significantly disrupt the global food systems that serve our region, can we produce all of our food needs within in the region (Grand Forks to Creston) or within the province?

Experts do not currently believe that BC or the Columbia Basin can produce all of its required food on a year round basis (MAL, 2006; Brynne, 2009; Serecon Management Consulting, 2009). Moura Quayle, former Dean of the University of British Columbia Faculty of Land and Food Systems, has said with regard to BC:

"it's unlikely we'll ever get all our food from local sources, but more small-scale agriculture would provide a balance to the current agricultural model, and a mixed food supply system may give us more choices in the future" (Somerton, 2008:2).

However it has been stated that conclusion is based on the current composition of BC's population and the limited capacity of some components of the agricultural system.

It is believed that 100 years ago, the Kootenay region was a net exporter of food (Future of Food, 2007). Moreover even mountainous communities, such as Rossland, were believed to be relatively food self-sufficient at the turn of the century.

This section will review the basis for conclusions regarding self-sufficiency and raise some questions regarding the extent to which self-sufficiency can be achieved. It will examine potential for regional or provincial food self-sufficiency from a biophysical growing capacity, social growing capacity and a processing and distribution capacity perspective.

6.1 Biophysical Capacity for Food Production

This section will review the regional biophysical capacity for food production with respect to the availability of land and water for growing, current food production levels, the potential implications of climate change on regional food production and options for shifting diets.

6.1.1 Land and Water for Growing

Canada's productive land mass is estimated to be 6 percent (Brynne, 2009). In BC only 5 percent of the land base is suitable for growing crops (Curran, 2007). Prime farmland (Classes 1 – 3 of the Canada Land Inventory), also called 'dependable' agricultural land, comprises less than 1 percent of the land base (948,600 ha) and is primarily concentrated near urban areas in the Lower Mainland and Okanagan (Hofmann, 2001; Curran, 2007). To put this into context 25 percent of Saskatchewan is suitable for growing crops (Hofmann, 2001).

There are 63,924 hectares of Agricultural Land Reserve (ALR) land in the Central Kootenay and 53,443 hectares of ALR land in Kootenay Boundary (Penfold, 2009). The total area of farms in 2006 was 27,338 hectares (67,554 acres) in the Central Kootenay, representing 48 percent of ALR land and 53,260 hectares of farms (131,260) in the Kootenay Boundary, representing 103 percent of ALR land (Penfold, 2009). Approximately one third of the ALR in the region is lower quality agricultural classifications (i.e. lower than class 1-3) land and therefore limited in its productive capacity (Brynne, 2009).

The BC Ministry of Agriculture and Lands (MAL) indicates that given the production technology available in BC today, 0.524 hectares (1.3 acres) of farmland are required to produce healthy food sufficient for one person annually (MAL, 2006). The guidelines utilized for healthy food were those set out in the Canada's Food Guide to Healthy Eating (MAL, 2006).

According to the Ministry to produce a healthy diet for all British Columbians, farmers would need 2.15 million ha of farmland, of which 10 percent (215,000 ha) would need to be irrigated, for economic fruit, vegetable and dairy production (MAL, 2006). Currently there are about 189,000 ha of farmland in BC with access to irrigation, 88,000 of which is currently irrigated for dairy, fruit and vegetable production (MAL, 2006). However given projected population growth, by the year 2025 farmers would need to have 2.78 million ha in production of which 281,000 would need access to irrigation (MAL, 2006).

Extending this analysis to the Central Kootenay and Kootenay Boundary Regional Districts (the Regional Districts whose boundaries most closely coincide with the "region" under discussion in this paper, one finds that *at the 2006 combined population* of the two Regional Districts of 86,625 people (Central Kootenay – 55,883 ha, Kootenay Boundary 30,742 ha) (Penfold, 2009) that 45,392 ha of farmland would be required to support the existing population, of which 4540 ha would have to be irrigated.

This total amount is far less than the existing ALR land of 117,367 ha within the region, and in farms in the region 80,598 ha, but far exceeds the amount of land currently in crops in the region (under 18,027 ha) (Penfold, 2009). This is a back of the envelope calculation that does not take into consideration what percentage of the ALR or farmland is arable, the kinds of crops that can be produced on the arable land, and how much is irrigated or has the potential to be irrigated in the region. BC government agrologists have stated that water will be an extremely limiting factor for any agricultural production outside the Fraser Valley (Vancouver Sun, 2007). Theoretically, at the right price, and the water is available, much of the land would be capable of being irrigated, if the market forces were such that if the production of certain crops became more profitable. More information is required regarding the amount of class 1-3 land in the region. It is also not clear whether the Ministry of Agriculture calculation of 0.524 ha of land per person per year is an average for the province, or if it primarily for the Lower Mainland, based on Lower Mainland growing seasons, which will be longer than those in this region.

6.1.2 Current Food Production

British Columbia farmers currently produce 48 percent of the food that is consumed in BC (MAL, 2006; Brynne, 2009). If healthy diet considerations are incorporated, BC produces only 34 percent of the food its citizens would need (MAL, 2006). In the Columbia Basin, local production is considered to be an even smaller percentage of the food consumed (Brynne, 2009). Moreover, given projected population increases on a provincial level, unless provincial production is increased the percentage of food consumed in BC that is produced on a provincial level will drop.

In some areas BC is fairly self-sufficient, including the production of chicken, eggs and dairy, and there is significant provincial sufficiency in the production of vegetables, beef, fish and fruit (Serecon Management Consulting, 2009). However in some areas it is not self-sufficient at all, such as in the production of grains (14 percent self sufficient) and oils (10 percent self sufficient) (MAL, 2006).

Within the Columbia Basin, all agricultural production is small-scale (Brynne, 2009). Because of their size, these operations do not at the moment have the capacity for investments in things such as mechanization that would increase their production and reduce their costs (Brynne, 2009). Regional farmers face many barriers including low returns on their products, and huge challenges getting their products into major grocery chains (Brynne, 2009). The total land *in crops* in the Central Kootenay and Kootenay Boundary Regional Districts is significantly lower than the total farm land –11,434 hectares for Central Kootenay and 6,593 hectares for Kootenay Boundary and that Tame Hay/Fodder and Alfalfa represent over 50 percent of cropland in production in both Regional Districts (over 75 percent in Kootenay Boundary) (Penfold, 2009). Roughly half of the region's farmland lies fallow on a regular basis (Brynne, 2009).

Table 1 outlines the crops that the Kootenay Organic Growers Society currently lists as available seasonally in the region:

Table 1: Crops grown in Kootenays

• apples	• celery	• lettuce	• radish
• apricots	• chard	• melons	• raspberries
• arugula	• cherries	• mizuna	• rutabaga
• asparagus	• collards	• mushrooms	• salad greens
• beans	• corn	• onions	• spinach
• beets	• cucumbers	• parsnips	• sprouts
• blueberries	• dandelion	• squash	• strawberries
• bok choy	• eggplant	• peaches	• sunchokes
• broccoli	• garlic	• pears	• tomatoes
• burdock root	• grapes	• peas	• zucchini
• cabbage	• herbs	• peppers	•
• carrots	• kale	• potatoes	•
• cauliflower	• leeks	• plums	•

(KOGS, nd)

To this list, the Kootenay Local Agricultural Society would add mustard and artichokes. Note also that in many cases multiple varieties of the crop can be grown. Clearly this list provides little context with regard to how much of each of these crops can be grown or precisely where. Inventories of what can be grown in the region and a more detailed analysis of the region's carrying capacity need to be done. Grains are not listed in Table one and regional capacity for grain production could be a limiting factor in regional food self-sufficiency. Grains are grown in Grand Forks and Creston and efforts are being made to foster an expansion in grain production through the Local Grain Revolution in which residents purchase shares in grain crops in advance of planting to provide farmers with stability and assurance of markets.

Both Regional Districts are expected to produce Regional Agriculture Plans in the next year to provide some of this information. In addition, as part of their Adapting to Climate Change project, Area D (Kaslo) is conducting a North Kootenay Lake Foodshed survey of farmers to determine what farmers grow and how much of it they grow.

Nevertheless, some food items upon which most households depend (i.e. salt) are only available in certain locations may not be available within our region. These items would have to be purchased with cash (FAO, 2008). Similarly many fruits that we currently consume in BC cannot be grown economically in BC, such as avocadoes, citrus fruit, and bananas (MAL, 2006).

6.1.3 Local Impacts of Climate Change and Non-Climate Change Factors

Production in this region will also be affected by all of the biophysical impacts of climate change outlined in Section 4.0 of this backgrounder, with the exception of sea-level rise. While the region is in a temperate zone and therefore many of the impacts of climate change may be positive, including increased crop yields due to higher temperatures, greater rainfall and CO2 fertilization, some impacts will also likely be negative, such as those associated with extreme events and pests and diseases. The indirect effects of climate change on political, economic and social systems are extremely challenging to predict but could have significant impacts.

The non-climate change factors will also have significant implications for local food production. Increases in energy prices will likely be one of the largest factors affecting the amount of food that could be grown in the region.

6.1.4 Offsetting Issues and Dietary Shifts

There are factors however that would allow for food self-sufficiency at lower production levels. For example, it is estimated that 50 percent of the food produced is wasted (Serecon Management Consulting, 2009). Greater efficiency in food management and waste reduction could allow for food security at a lower production rate.

There are also significant opportunities with regard to shifting our diets. There is the potential to shift away from a meat-centered diet, shift to the consumption of potatoes instead of grains, and shift to a more game based diet. Changes in diet would significantly alter the amount and type of agricultural land required to support a population. The lower the consumption of meat, the more effectively agricultural land and cereal production can be utilized to ensure food security (WBGU, 2007). There is a five-fold difference in the acreage requirements between the diets incorporating the least amount of fat and meat (but still some meat, to make use of forage land that cannot be utilized for crops) (0.2 ha/0.5 acres per person per year) and those with the least amount of fat and greatest amount of meat (0.77 ha/1.9 acres per person per year) (Peters et al., 2008). The 0.2 ha per year estimate is less than the 0.524 estimate from the Ministry of Agriculture and Lands and a back of the envelope calculation based on the regions current population levels would result in agricultural land requirements in the region of 17,325 ha to support our population.

6.2 Social Capacity

The biophysical capacity to grow crops and raise livestock is not the only consideration in determining the potential for regional food self-sufficiency. The social capacity to grow food is also a critical component of food self-sufficiency. If individuals or farmers do not have access to land, skills to grow food or the appropriate incentives to grow food, achieving regional food self-sufficiency may be challenging.

6.2.1 Number of Farmers and Food Producers

There has been a considerable de-skilling of the population, both nationally and regionally around food production in the last century (Brynne, 2009).

Currently, given global food markets and the large amounts of food that are available at very low prices, achieving reasonable economic returns through local food production is very challenging. Average farm sales were below $60,000 in both Central Kootenay and Kootenay Boundary Regional Districts (Penfold, 2009). The average net return for farms in the region is extremely low ($5,422 in Central Kootenay and $1,680 in Kootenay Boundary) (Penfold, 2009). At those net returns, there is simply no incentive now for farmers to expand their crops or new farmers to enter the market. Thus the number of people engaged in farming in the population has declined dramatically over the last century. In 2006, there were 29,870 farm operators in BC, comprising 0.7 percent of the population (Statistics Canada, nd). To be classified as a farm operator, the farmer has to be producing an agricultural product for sale. Moreover, over half of those farm operators in BC have off-farm jobs or businesses (Statistics Canada, nd). In the region, there were 1445 farm operators (855 in Central Kootenay and 590 in Kootenay Boundary) (Penfold, 2009).

It is very challenging to get numbers on the number of backyard farmers or gardeners producing food in the region or the quantity of food they produce. Detailed surveys would have to be undertaken in each of the region areas. At the height of the US Victory Garden program in the US, only 40 percent of US vegetable needs were produced in backyard gardens (Brynne, 2009) raising concerns that in less favourable climate such as Canada, we could not produce sufficient food to be regionally self-sufficient. It is not clear, however whether this shortfall was because there was insufficient land planted, insufficient skill or interest in food production by backyard farmers (and therefore could be overcome with sufficient commercial producers), or an inability to grow the range of crops required due to climatic or arable land challenges.

If climate change were to make agriculture more profitable in the region there is the potential that there would be sufficient interest by existing and new farm operators to promote regional self-sufficiency. However, the years of low farm returns, and general decline in farming and backyard gardening skills will also mitigate against increased food self-sufficiency. If climate change related impacts on global food security occurred in a gradual fashion, these skills could technically be reacquired. However if global changes were sudden and unexpected it could be challenging to reestablish these skills in a timely manner.

6.2.2 Skill Preservation and Revival

There has been a significant revival in interest in local food production as a result of concerns regarding peak oil, climate change and the overall environmental impacts of global agriculture. This has resulted in the establishment of a multitude of local groups such as the

Kootenay Food Strategy Society, the Kootenay Local Agricultural Society, the Kootenay Organic Growers Society, and Rossland REAL food specifically geared to promoting local food production and preserving and enhancing local food production skills. Initiatives, such as the Castlegar and Rossland Community Gardens, the Kootenay Grain Community Supported Agriculture, the Kootenay Mountain Grown label, as well as the Kaslo Food Charter are also intended to foster regional food security through local growing.

6.2.3 Cost of Food Production

To achieve regional food security, region residents must also be able to afford to purchase the food produced in the region. This might be problematic if climate change has significant regional economic impacts and if local production requires an increase in prices. Thus food must not only be produced locally, but it must be produced economically. However, Canadians currently spend less than 10 percent of their disposable income on food (Brynne, 2009). Thus there is a certain degree of latitude in the extent to which prices could rise. Nevertheless, this is an area that requires significant further study.

6.3 Processing and Distribution Capacity

The question of whether the food produced could be processed and distributed within the region must also be addressed.

6.3.1 Fruit, Vegetable and Grain Processing

The region currently has no freezing or canning facilities. Grain milling can be done on a small scale in Creston, Nelson and Grand Forks (Pride of the Valley milling), but also can be undertaken through home milling. Packaging is done on a small scale by local farmers such as those selling under the Kootenay Mountain Grown label. This is an area that requires further research to determine food processing capacity on a regional and provincial level.

6.3.2 Animal Product Processing

Local meat processing and egg sales are seriously constrained by government regulation. Under BC legislation passed in 2004, all meat for human consumption must come from a provincially or federally licensed slaughter facility, or abattoir (Stueck, 2010). Many small abattoirs closed their operations due to the costs associated with getting licenced. As a result, there is no licensed facility to kill or butcher animals for commercial sale within the region. Locally raised animals have to be trucked to a butchering facility and then trucked back in order to be commercially sold. Efforts to establish a local abattoir have thus far been unsuccessful due to the inability to find an appropriate location. A Kootenay Mobile Poultry Abattoir, that processes as many as 500 chickens a day, based out of Cranbrook, was established in 2009, and a second unit is under consideration due to demand (Stueck, 2010).

Local eggs also cannot be sold (except at the farmer’s place of residence or in a farmer’s market) unless they are graded and marked in accordance with the Canada Agricultural Products Act (Zwicker, 2010). There are two licensed egg-grading stations in the area in Creston and in Rock Creek (Zwicker, 2010).

6.3.3 Distribution Channels

Current distribution channels are also problematic. Many of the food items sold in multi-national grocery store chains, such as Safeway, even if grown locally, are often transported to a central warehouse, which can be in a different province, and then back to the grocery store, adding many unnecessary kilometers to their travel (Brynne, 2009). These transportation channels, and the policies of the grocers, or the ownership of the grocery stores, would have to be reoriented to have regional food self-sufficiency. While independent grocers in the region, such as the Kootenay Country Store Co-operative and Ferarro Foods, are often highly supportive of local producers and will allow direct transport of foods from the producer to the grocery store, these independent grocers are becoming increasingly uncommon (Brynne, 2009).

The majority of local transport is currently by truck. If oil costs rise, this could become too costly. Climate change events, such as floods or snowstorms could also result in serious disruption in food distribution for local food products distributed by truck, just as they could for global food products. Through initiatives such the Local Grain Revolution, alternative methods of food distribution, in this case by sailboat, are being explored. However these efforts will need to be increased significantly to achieve regional food security.

7.0 Summary Points

Food Security Definitions

- On a regional level, food security has been defined by the Kootenay Food Strategy Society as follows:

"A community enjoys food security when all people, at all times, have access to nutritious, safe, personally acceptable and culturally appropriate foods, produced in ways that are environmentally sound and socially just" (KFSS, nd).

- There are four dimensions to food security – food availability, food accessibility, food stability and food utilization. To achieve food security all for dimensions must be in place.

- Food security must be considered through a food systems lens, which considers food production, food processing and packaging, food distribution and retailing and food consumption.

Impacts of Climate Change on Food Security

- Climate change will impact food systems both directly through it biophysical impacts on plant and animal growth, and indirectly through its effects on human capital, economic and political structures.

- The timing of climate change impacts will vary, with some impacts being experienced now, others occurring more gradually, and yet others being sudden and unexpected.

- Global models assessing the impacts of climate change in general and the impacts of climate change on food systems are subject to a high degree of uncertainty.

- The biophysical impacts of climate change on food security are expected to be both positive and negative. For example:
  - CO2 fertilization will likely lead to slight increases in crop productivity but declines in ocean productivity due to acidification
  - Higher temperatures will likely result in longer growing seasons and increased crop productivity in high latitude regions and crop losses and declines in productivity in mid and low latitude regions
  - Temperature changes will have unpredictable effects in lakes and oceans
  - Declines in precipitation will likely have significant impacts in reducing arable land and increasing aridity in mid and low latitude regions
  - Pest and disease distributions will likely change and could expand in some regions
  - Extreme events, such as flooding, storms and drought, could cause crop failure and cut off food transportation lines
  - Rising sea levels will eliminate and salinize arable land in some coastal regions

- On a global scale, the direct biophysical impacts of climate change on food systems are not expected to reduce overall global agricultural production as long as temperature increases do not exceed 3° C.

- The biophysical impacts of climate change on food systems will cause regional shifts in agricultural production with the higher latitude temperate regions of the world experiencing increases in agricultural production, and the lower latitude tropical regions of the world experiencing degreases in agricultural production.

- Global food security is not expected to be impacted significantly by climate change on a biophysical level, however developing nations are expected to have to start importing more of their food.

- Current analyses of climate change and food security do not sufficiently account for indirect impacts of climate change on socioeconomic and geopolitical structures, or for non-linear effects. These indirect and non-linear effects could lead to unpredictable and serious impacts on global food security.

- All of the models that provide a relatively optimistic overall outlook for food security generally assume mean climate change of 3° C or less, and do *not* consider the possibility of major abrupt climate or socioeconomic change, or a *significant* increase in the number of extreme events.

- Although they are beyond the scope of this backgrounder, many non-climate change events and factors including increased input costs, global population increases and loss of arable land will have implications for global and regional food security and need to be considered in any regional vulnerability assessment for food security.

Potential for Regional Food Self-Sufficiency

- Experts have suggested that BC could not be self-sufficient in food production. However it is believed that the Kootenay region was a net food exporter 100 years ago.

- In BC only 5 percent of the land base is suitable for growing crops. There are 117,367 ha of ALR land within the Regional Districts of Central Kootenay and Kootenay Boundary, and 80,598 ha in farms. A third of the ALR land in the region is considered of lower and limited quality for crop production.

- The BC Ministry of Agriculture and Lands (MAL) indicates that given the production technology available in BC today, 0.524 hectares (1.3 acres) of farmland are required to produce healthy food sufficient for one person annually. Estimates based on a less meat-centered diet suggest that 0.2 hectares of land per person annually is required.

- Using the Ministry of Agriculture and Lands formula and the 2006 population of the Central Kootenay and Kootenay Boundary Regional Districts, 45,392 ha of farmland would be required to support the existing population, of which 4540 ha would have to be irrigated. This is less than the current amount of ALR land in the region.

- BC currently produces 48 percent of its food and is fairly self-sufficient in the production of chickens, eggs, dairy, vegetables, fish and fruit. Regional food production is believed to be lower than 48 percent. The total area in crops in the region is 18,027 ha, many of which are hay/fodder and alfalfa crops.

- A wide variety of vegetable, fruit and grain crops can be grown in the region. Detailed production inventories, including the total amounts produced, and total amounts that could be produced are required to accurately assess the potential for regional food self-sufficiency.

- There has been considerable de-skilling of the regional population with respect to food production due to the low economic returns from farming and the loss of interest in backyard gardening. A considerable number of regional organizations are now working on revitalizing food production skills and promoting local food production.

- The regional capacity for food processing and distribution requires further assessment and faces many barriers due to provincial legislation and licensing requirements as well as the purchasing policies of many major grocery store chains.

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Addendum
23 July 2010
Hans Shreier
Latest Update on the Climate Data for Kaslo:

I have finally received all the climate data for Kaslo for 2007-2009 from Environment Canada. The reason why this information is of interest is because we have water consumption data for 2007-2009 and the questions that are of interest are:
1. Were these 3 years unusually wet or dry?
2. Were these 3 summers unusually hot?
3. Are the water consumption data representative of more or less average conditions?

From other research in the Okanagan we found that there is a 40% difference in water consumption between wet (1997) and dry years (2003). These differences are quite substantial and need to be considered in risk assessments.

The updated precipitation information is provided in Figures 1 and 2 and the summary results shown in Table 1 reveal that 2007-2009 were not unusual years in terms of overall precipitation (snow and rain), and were very close to the 60 year mean.. The only difference was observed in 2009 when the snow accumulation was 32% below the 60 year mean.

In terms of July-August precipitation it is evident in Figure 3 that since 2000 the summer precipitation has been somewhat below the long term mean, suggesting that drier summers are becoming more frequent (6 of the last 10 years were below the average long term record). However, this includes the drought years of the 1930's. If we consider the average July-August rainfall since 1950, then 8 of the last 10 years were below to mean precipitation for these two months.

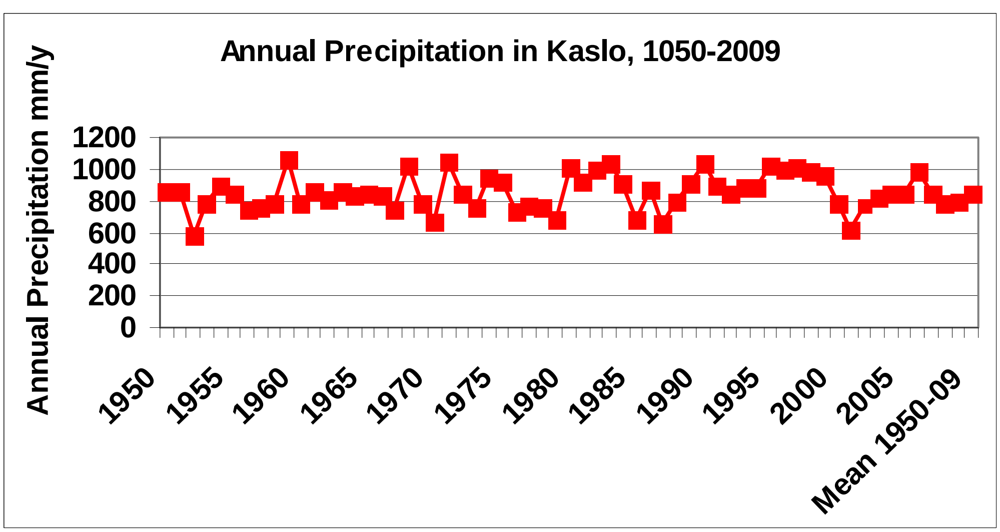

Figure 1. Total Annual Precipitation in Kaslo 1950-2009

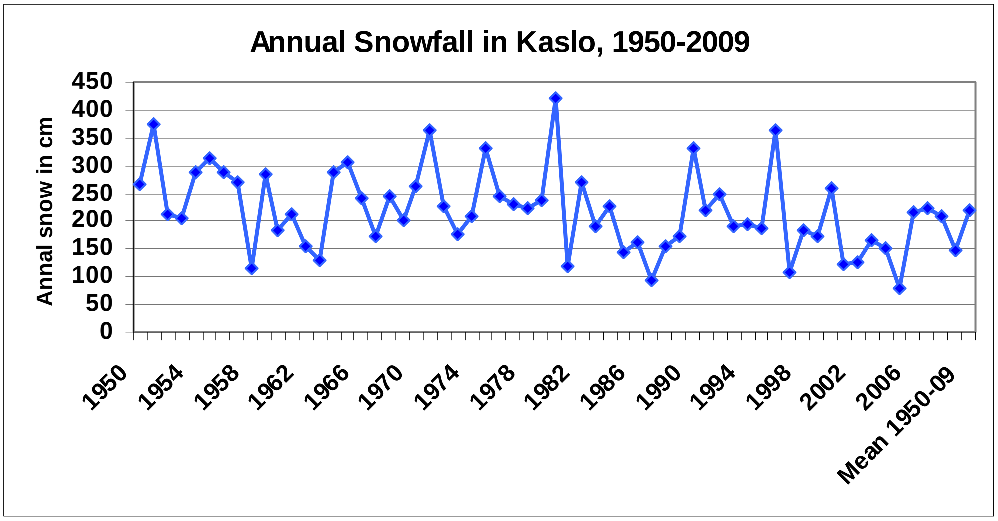

Figure 2. Total annual snowfall in Kaslo 1950-2009 (cm/y)

Table 1. Difference between 2007-2009 precipitation in comparison to the 60 year mean

Kaslo Climate Station Data	Total Precipitation (mm/y) % difference from the 60 year mean	Snow accumulation (cm/y) % difference from the 60 year mean
2007	- 1%	+ 2%
2008	- 8%	- 4%
2009	- 6%	- 32%

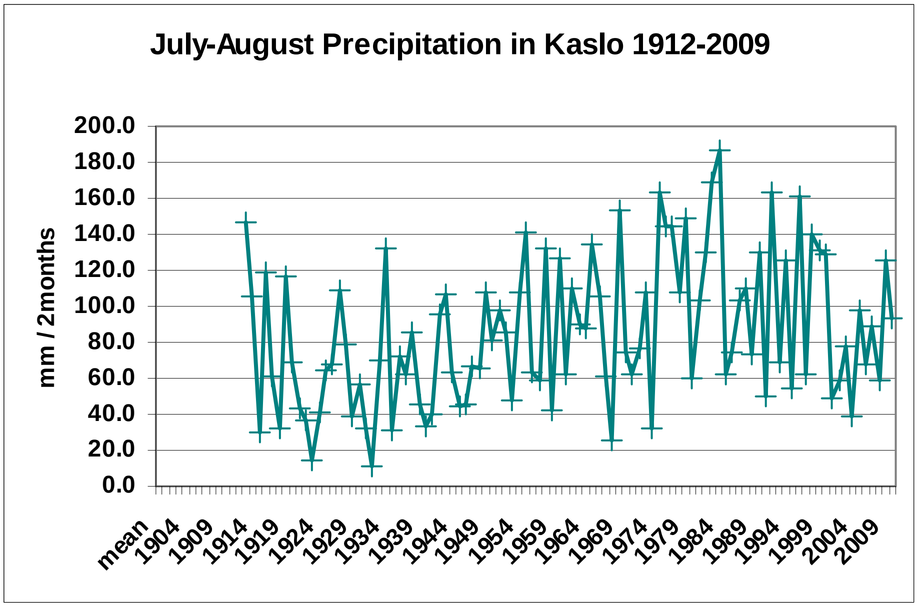

Figure 3. July-August precipitation in Kaslo 1904-2009 (in mm)

In terms of mean maximum temperatures for June, July and August for 2007-2009 none of the month were above the long term mean except for July 2009 which showed a mean maximum, approximately about 3 degrees above norm.

Conclusions:

The water consumption data for 2007-2009 represents consumption for fairly normal years of precipitation and temperatures. It is expected that water consumption during dry years are likely to be significantly higher.

Given the projections for warmer temperatures and longer summer dry period from the climate change scenarios and given the high water consumption data for 2007-2009 are for normal years, it is clear that the water demand will increase significantly during drier years unless we consider massive water conservation and improve or search for other water sources.

Kaslo Climate Change Adaptation – Water Issues Relation to Supply and Demand Issues (Draft Report)

Hans Schreier (UBC), Martin Carver (Aqua Environmental), Arelia Werner (PCIC)

This report covers the following issues: a) Summary of anticipated changes in climate, b) Trends evident from the historic climate record, c) Climate modeling results and d) Water demand in relation to Supplies.

1. Summary of anticipated changes in climate for the Columbia Basin

As indicated by the Provincial and PCIC summary paper Kaslo community faces the following climate and water issues

1.1. Warmer temperatures: This is particularly evident by the experience of higher nigh temperatures in late winter and higher summer temperatures

1.2. Uncertain Rainfall : Different models show contradictory results in how rainfall is changing and it appears that it is very difficult to predict how rainfall is changing particularly in these mountain environments

1.3. Snow accumulation changes: Because of warmer winters it is expected that there will be less snow at lower elevation and the snow is expected to melt earlier in the season

1.4. Runoff impacts: Given the above factors it is expected that peak run-off will occur earlier in the season, peak flow is likely becoming more variable and late summer stream flow will be lower as a result of higher temperatures, more evaporation, and extended summer season.

2. Trends from the historic climate record of Kaslo

A good long climate record is available for Kaslo (Station 1143900 Environment Canada) covering the 1910-2006 period. From an analysis of the data the following observations can be made:

2.1. Increased Temperatures: All winter month showed an increase in mean monthly maximum temperatures with the greatest increases occurring in January-February (Figure 1). In the summer there is a slight increase in mean maximum temperature in August but a more pronounced increase in September (Figure 2)

2.2. Precipitation: There is no apparent trend in the total annual precipitation (rain and snow). The precipitation is highly variable but has not changes significantly since 1950 (Figure 3). However, the snow accumulation has declined particularly since the 1970's (possibly as a result of the PDO shift) (Figure 4), and the rainfall (excluding snow) has increased significantly over the past 60 years (Figure 5). The increase in rainfall compensated for the decrease in snow, resulting in a relatively unchanged annual total over time. The total precipitation (rain & snow has decreased February but showed the greatest increase in March (Figure 6) The reduction in snow is greatest in January and February but is most pronounced in February (Figure 7 & 8). This suggests that less snow falls due to warmer temperatures and the rainfall is increasing significantly in early spring (March & April) and this is likely leading to higher and earlier season peak flow in rivers. Dry season rainfall shows greater variability in July and a significant reduction in August particularly since the mid 1970 (Figures 9-10). This suggests that summer base flows will likely decrease because earlier peak flow, higher summer temperatures, more evaporation and less rainfall in August.

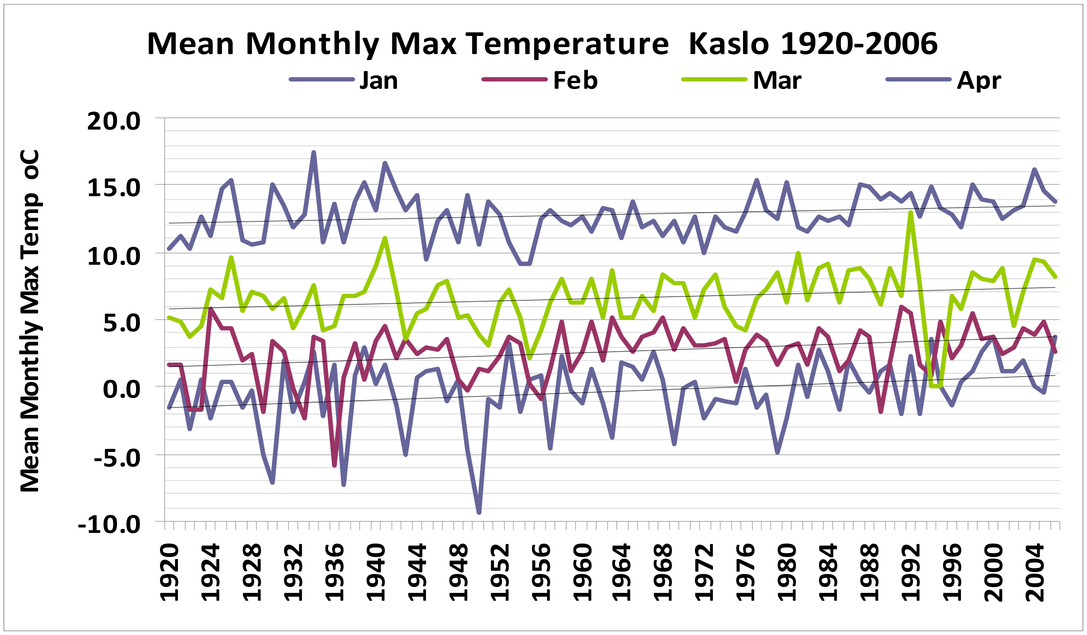

Figure 1 Mean monthly maximum temperature in late winter in Kaslo (1920-2006)

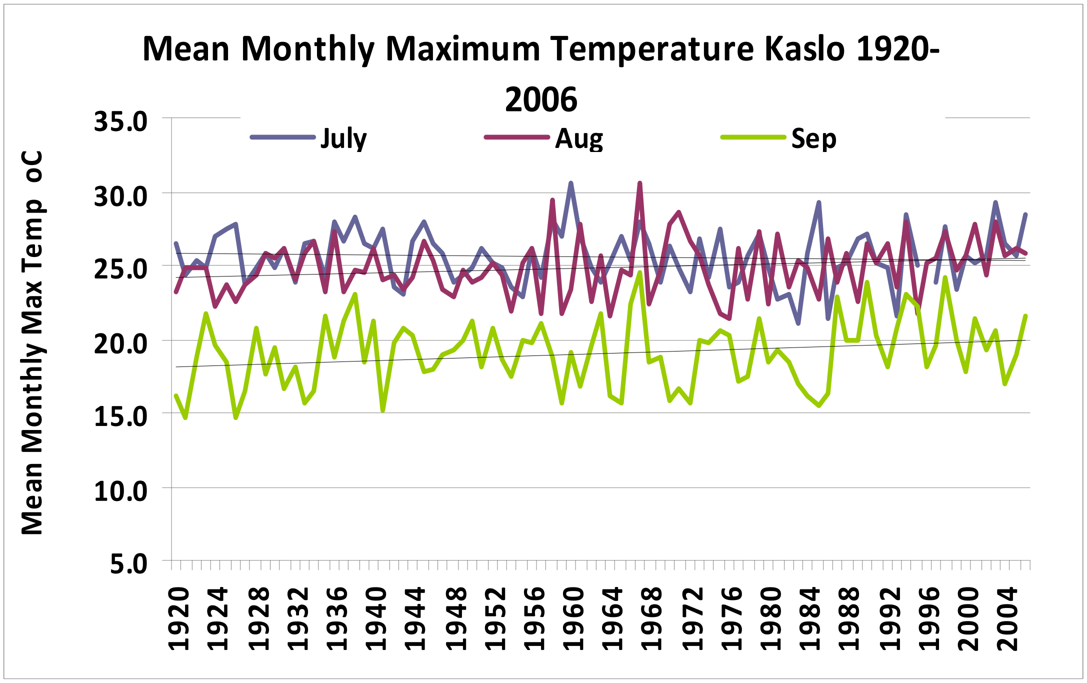

Figure 2 Mean monthly maximum temperatures in the summer in Kaslo (1920-2006)

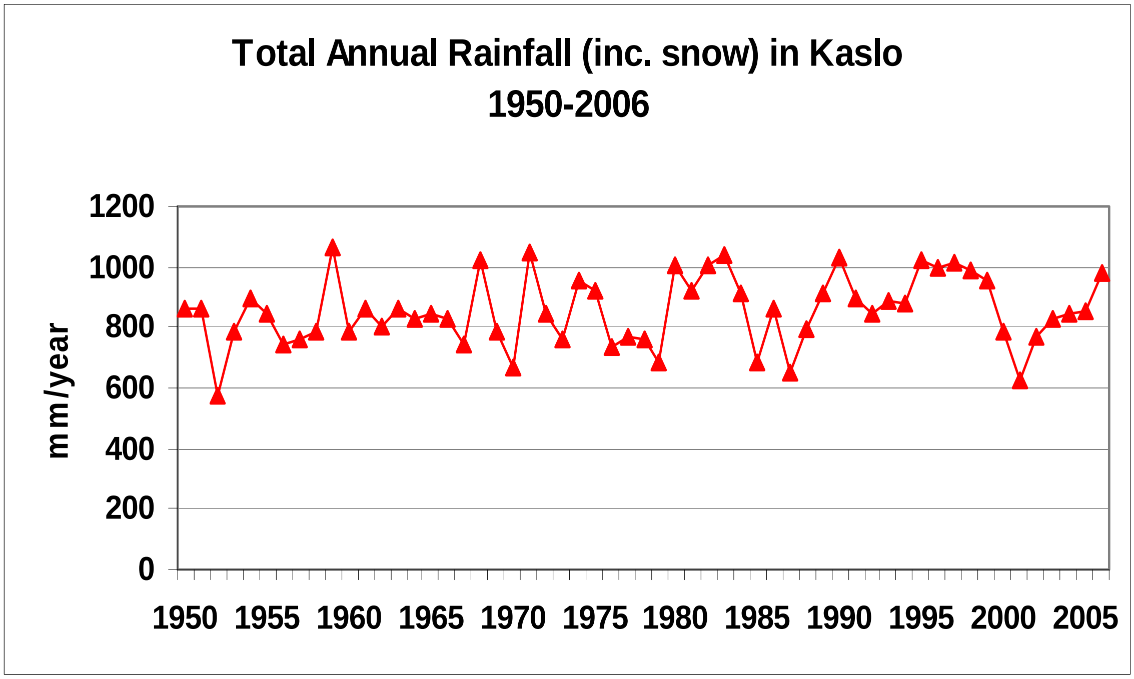

Figure 3. Total annual precipitation in Kaslo - 1950-2006 (rain and snow)

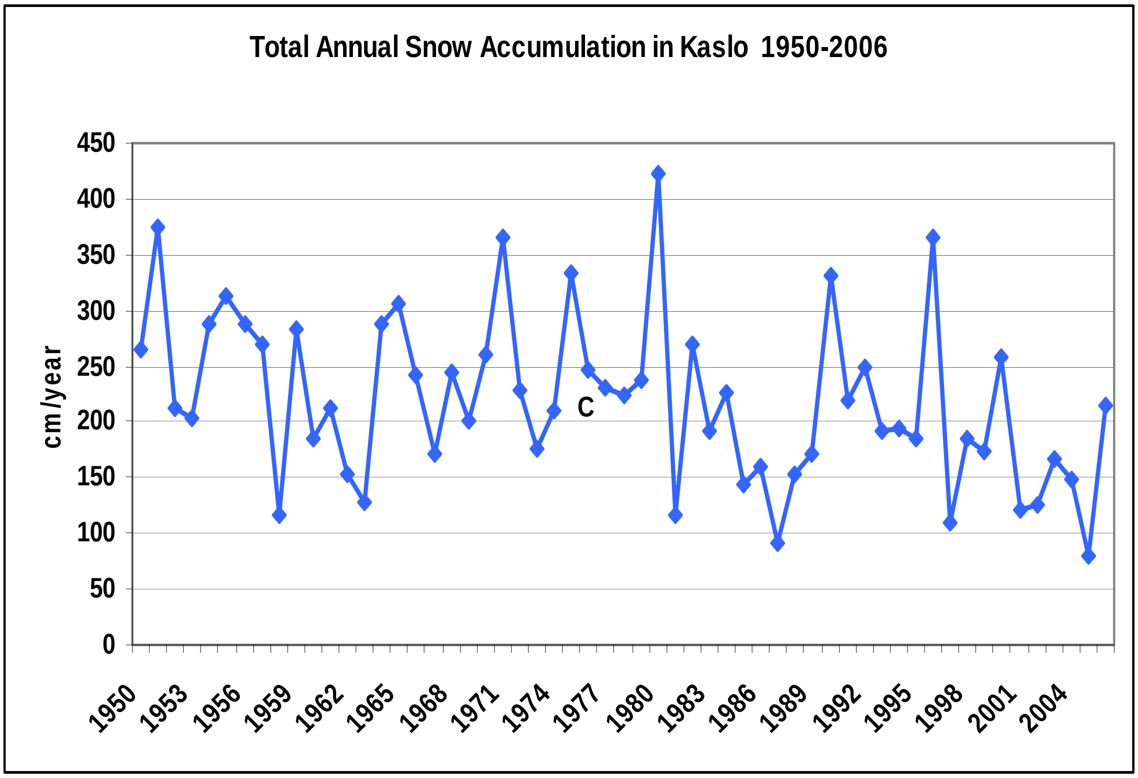

Figure 4. Total annual snow accumulation in Kaslo – 1950-2006

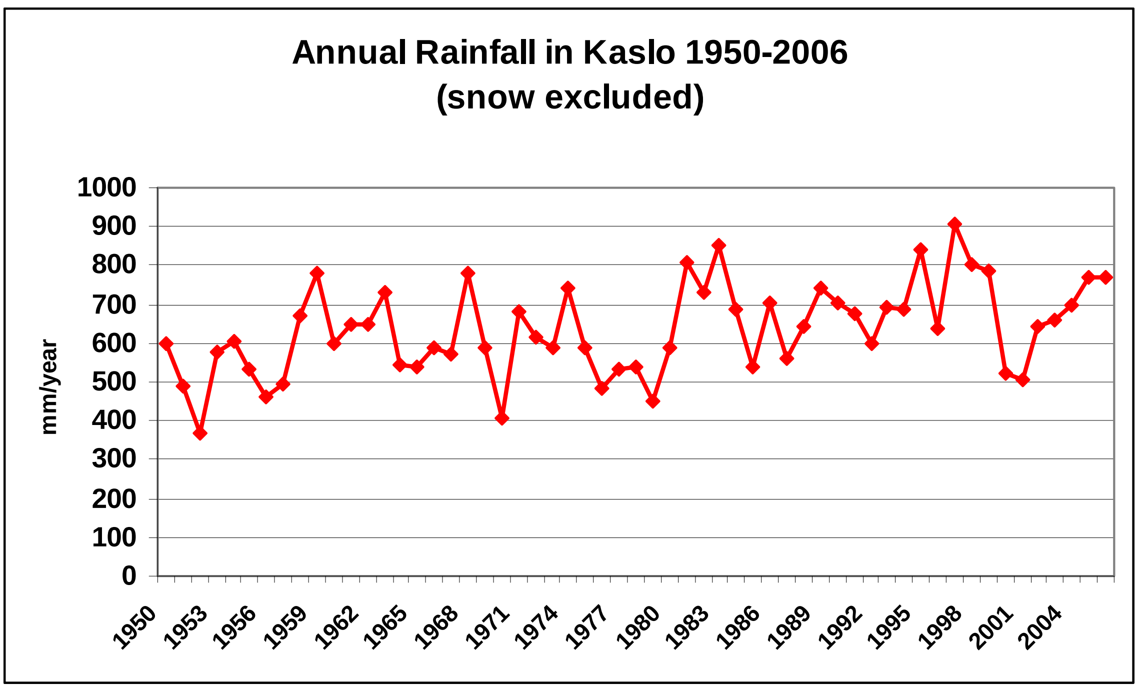

Figure 5. Total Annual rainfall in Kaslo -1950-2006 (rain only)

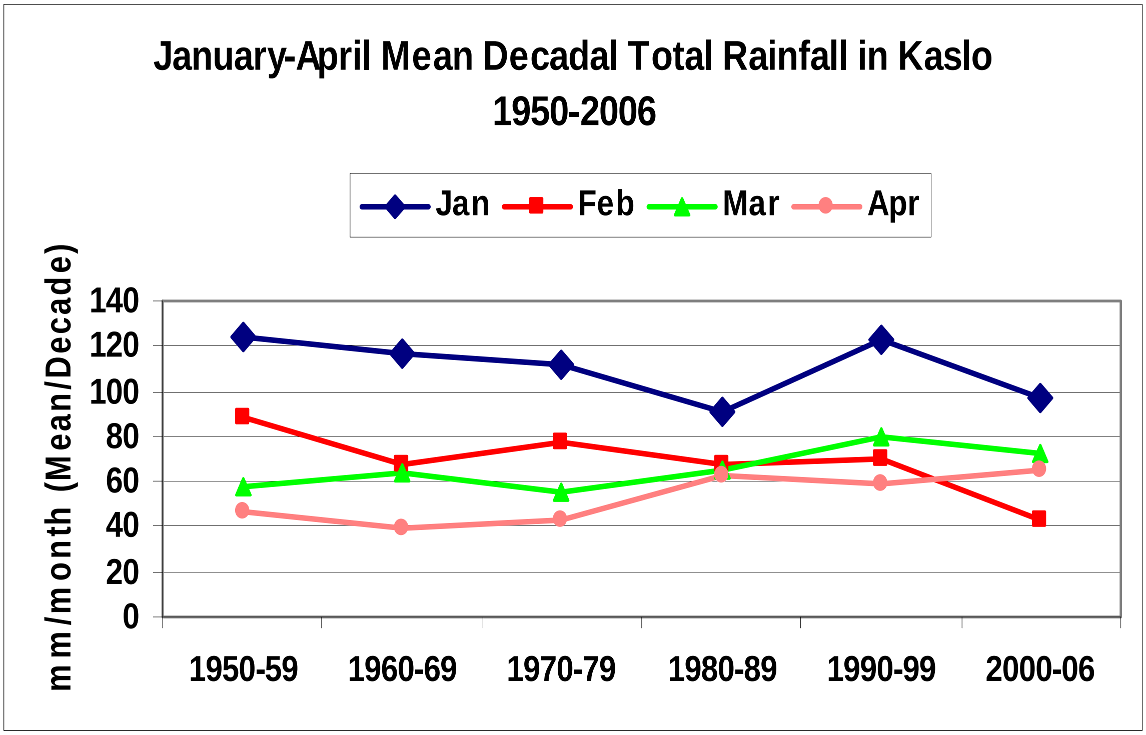

Figure 6... Mean decadal total precipitation changes January-April 1950's-2000's.

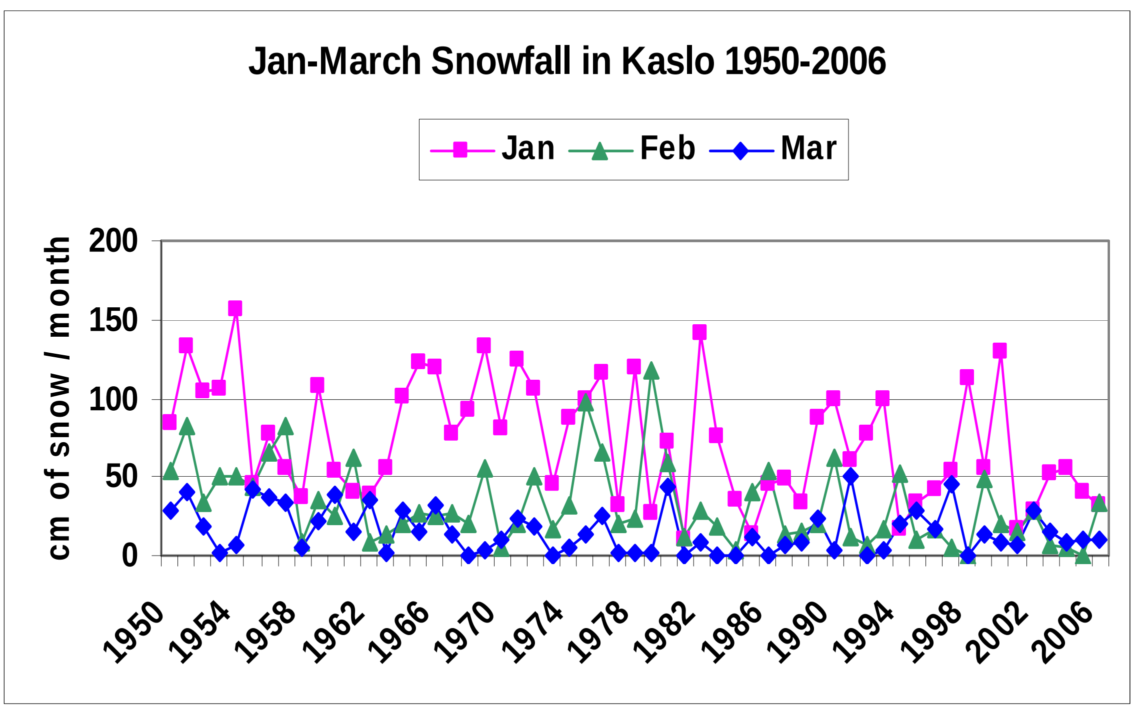

Figure 7. January –February snow accumulation in Kaslo -1950-2006

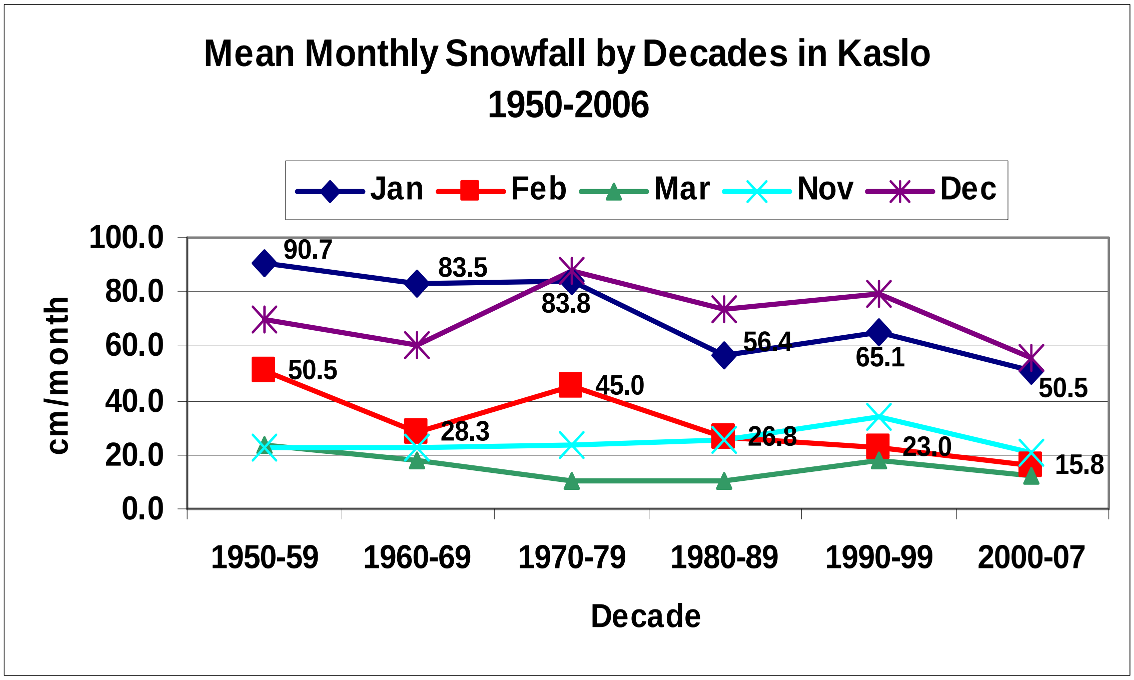

Figure 8. Mean decadal changes in snow accumulation in Kaslo with greatest declines in January and February from the 1950's to 2000's.

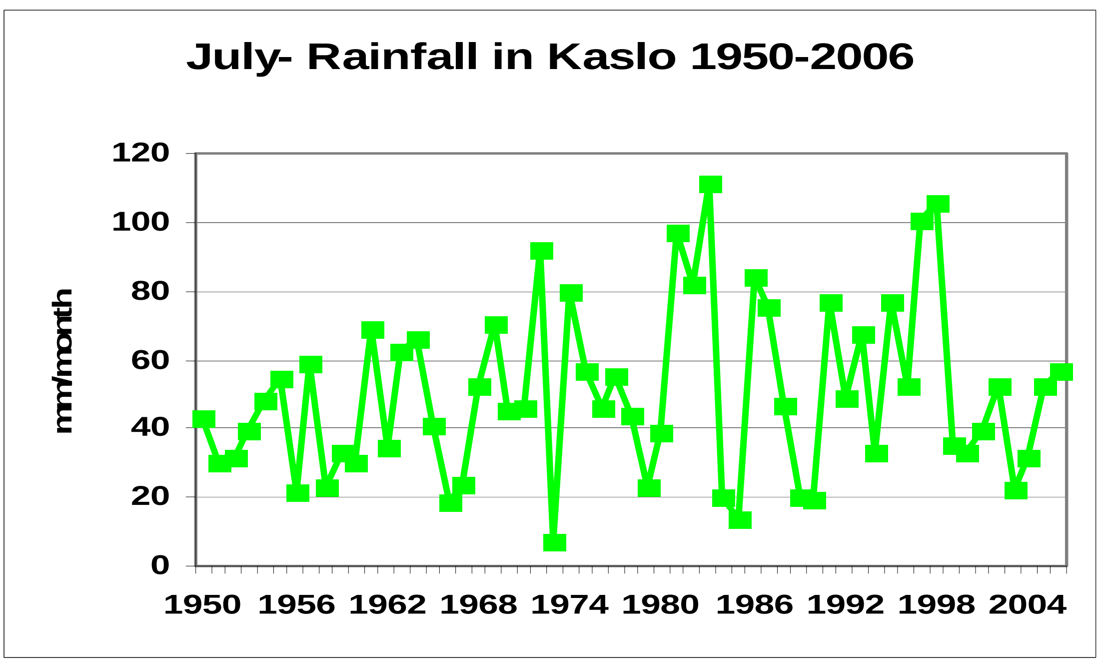

Figure 9. Rainfall variability in July in Kaslo -1950-2006, showing greater variability and low amounts since 1998

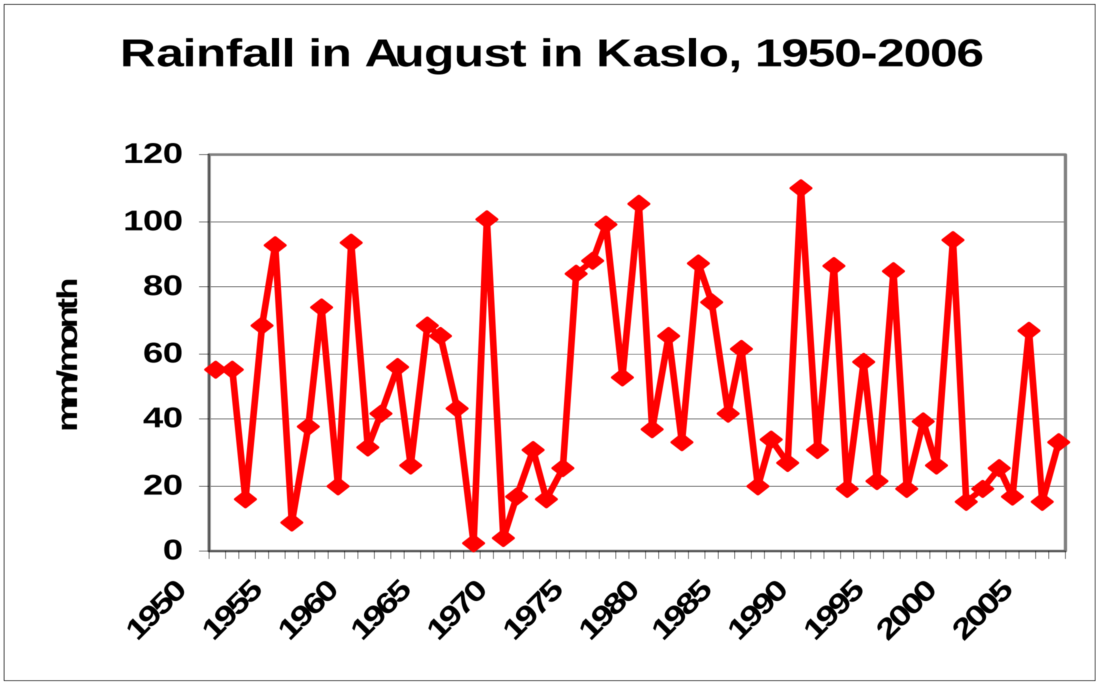

Figure 10. Rainfall variability in August in Kaslo – 1950-2006, showing high variability and an overall; declining trends since the mid 1970's.

3. Projected Changes in Streamflow

Seven Global Climate Models (GCMs) were selected for analysis because they compared well to historical climate averages and trends for the Pacific Northwest Region (Mote and Salathe, 2010). These coarse-scale (~350 km a side) models were corrected for bias and adjusted spatially to represent temperature and precipitation changes at the ~32 km^2 grid scale (Salathe, 2007). These temperature and precipitation data were then used to run a gridded hydrologic model (VIC), which represents the processes of the natural system, such as snowpack accumulation and melt. Customarily, this model is applied to basins larger than ~500 km^2 and calibrated to their observed records. For this project, output produced by the Climate Impacts Group (CIG) at the University of Washington from the hydrologic model simulations was extracted and processed to represent the relatively small basins near Kaslo (i.e. Redfish Creek: 26 km^2; Kemp Creek: 12 km^2) as a first approximation of how streamflow might change out to 2100.

Two emission scenarios were downscaled, the A1B scenario, which assumes a relatively high CO2 emission rates and the B1 scenario that uses a more conservative future emissions level. For the purpose of this study, considering that the A1B scenario is closer to the current rate of emissions, only this scenario was considered. As a first step, the mean projected streamflow from the 7 GCMs was determined for the Kemp Creek watershed. A transient record was created by driving the VIC model with transient climate data produced using the Bias Correction Spatial Downscaling (BCSD) approach outlined above. Monthly VIC model results were download from the CIG ftp site and transformed into a projection of Kemp Creek discharge by multiplying by the proportional area of the Kemp Creek watershed within appropriate grid tiles to provide monthly streamflow from 1950-2100. For the purpose of this study, only the period of 1950-2070 was analyzed.

The modeled projection of monthly stream discharge for Kemp Creek suggests that the overall runoff is increasing on a decadal scale from a low in the 1990's to a high in the 2040's (Figure 11a).

Comparing monthly average streamflow for 2041-2070 to 1961-1990 (Figure 11b), there is a projected increase in runoff from October-May of up to 300% in March and a decrease from June-September of up to 50% in the 2050s (2041-2070).

The projected monthly discharge is provided for the peak flow (Figure 12) and summer dry period (Figure 13).

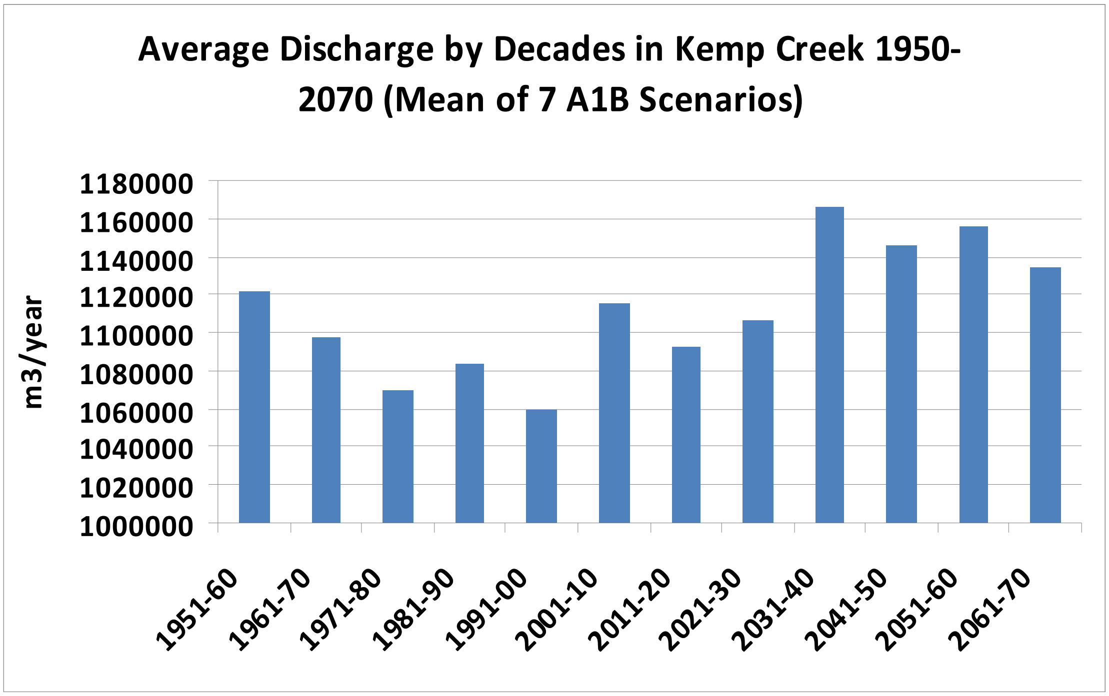

Figure 11. Average annual discharge by decades in Kemp Creek 1950-2070 showing an increase in runoff over time.

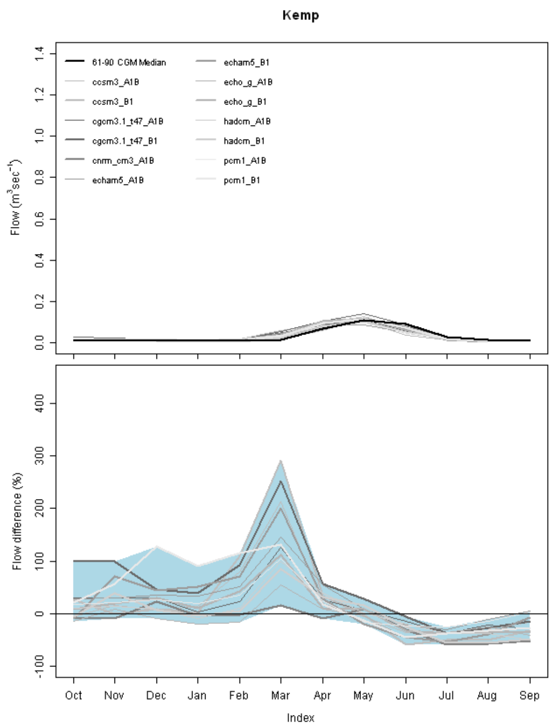

Figure 11b. Average monthly discharge for Kemp Creek 1961-1990 and for all 7 GCMs and 2 emissions scenarios (B1 and A1B) for 2041-2070.

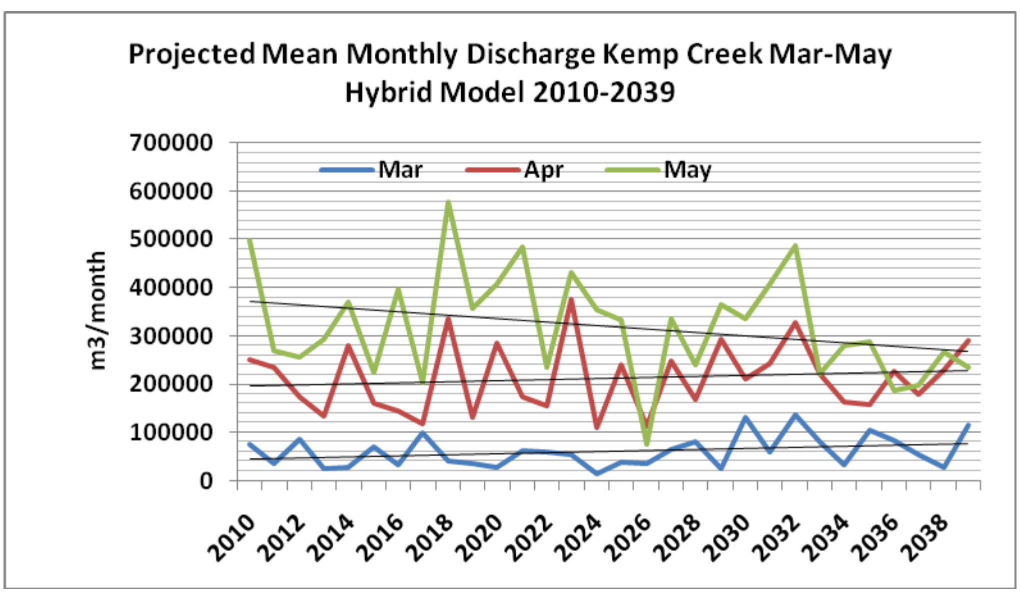

Figure 12. Projected mean monthly discharge rates during peak discharge period in Kemp Creek from 2010-2039

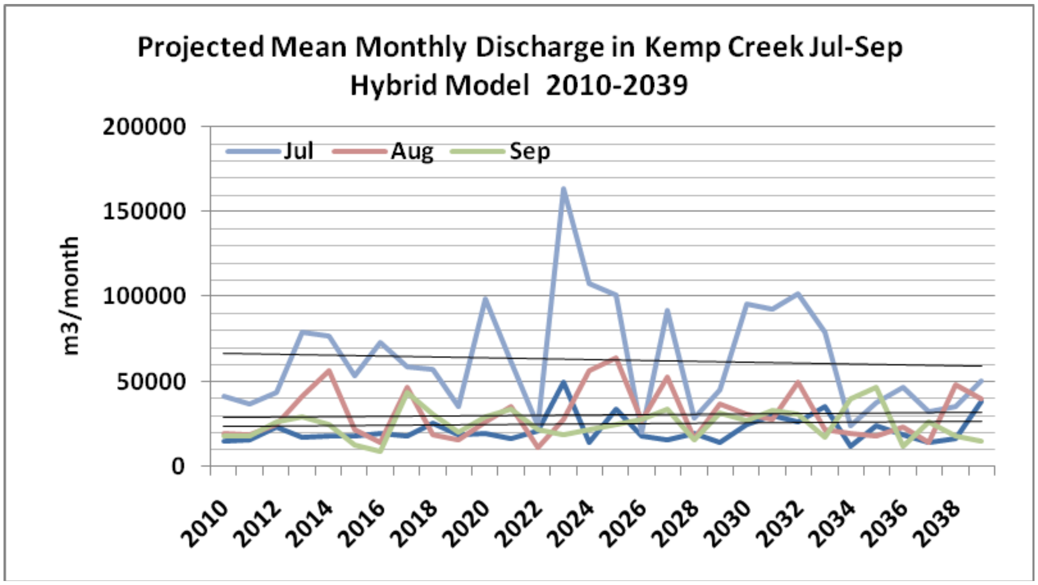

Figure 13. Projected mean monthly discharge in summer dry period in Kemp Creek from 2010-2039

The resulting trends show a slight increase in discharge in March and April and a substantial decrease in May. There is a slight advancement of the peak to mid-April from the historical peak in May (Figure 11b) and the increase corroborates the projections of earlier snowmelt and increased rainfall described in the introduction to this report.

The results for the dry summer period show a decline in monthly discharge for each of the May-September period. The greatest decline occurs in July and the lowest values are projected for September.

Based on the month by month projections it is evident that the Kemp Creek stream flow is projected to increase over the November – April, and a decrease in May marginally in October.

A note of caution is needed her because there is little opportunity to calibrate the modeled results because only 7 month of measured flow data is available (Jan 1929-Dec 1920). From the Calibration in Redfish Creek it appears that the modeled data is significantly underestimating the actual flow. However, it is not possible to suggest that the same trend applies to the Kemp Creek. We will examine the Redfish Creek Data to determine if we can better calibrate the data because Redfish and Kemp Creek have pretty

much the same elevation distribution. Results will be available for the June meeting in Kaslo.

Water demands in relation to supplies
The water-use data for domestic and golf course use was collected by Martin Carver from the Kaslo treatment plant and covers the 2006-2009 period. These demand values were compared with the projected monthly supplies from Kemp Creek.

2.1. Water use in Kaslo: The amount of water released from the Kaslo treatment plant is provided in Table 1. Unfortunately only 3.5 years of domestic water-use data was available, and at the time of preparing this report, the rainfall data for Kaslo was not available for 2007-2009. As a result, it is not yet possible to determine if any of the 2007-2009 years were dry or wet years relative to the long term record. The 2006 year, for which the climate record is available, had above annual rainfall (982 mm/year versus the long-term mean (time period) = 855mm/year).

The water use records show that there has been great variability in water used seasonally and from year to year historically. The greatest domestic water use has been in July and August and the approximate daily water use on an annual basis is between 1077-1196 L/person/day (based on 1500 residents). However, summer use in July and August can reach over 2342 L/person per day. These calculations include the Golf course water use, which is provided in Table 3. Even if the golf course use is excluded the annual average was 1094 L/person/day during 2007-2009.

The golf course water use is highest in May and June ranging from 13-18% of domestic water use. This drops to about 6% during July and August when the residential water use is the highest.

Table 1. Monthly water supplied to Kaslo residents from the treatment plant 2006-2009

Month	Total Use During Each Month (litres/month)			
	2006	2007	2008	2009
Jan		37514223	36091874	40608671
Feb		32975187	30095249	30293974
Mar		34401390	32307180	41038310
Apr		39055632	32023889	40645510
May		50876426	47802967	48692544
Jun		60429515	63198762	65671039
Jul	108880359	104506146	96067647	82100288
Aug	102431043	91388387	77045644	77917924
Sep	68165000	63689510	51296581	62185346
Oct	52200629	47109465	43776027	47274353

Nov	40958299	41347930	39701501	43039744
Dec	41738933	51615290	41628867	54608276
Total		654909101	591036189	634075979

Table 2. Daily water consumption by month per person in Kaslo in 2006-2009

Month	Avg Use (litres/day/person)			
	2006	2007	2008	2009
Jan		807	776	873
Feb		785	692	721
Mar		740	695	883
Apr		868	712	903
May		1094	1028	1047
Jun		1343	1404	1459
Jul	2342	2247	2066	1766
Aug	2203	1965	1657	1676
Sep	1515	1415	1140	1382
Oct	1123	1013	941	1017
Nov	910	919	882	956
Dec	898	1110	895	1174
Average		1196	1077	1158

Table 3. Amount of water used for the golf course and % of monthly domestic supply

Month	Golf Course Daily Use (m3/day)			Golf Course Proportional Use(%of Village total)			Golf Course Monthly Use (m3/month)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
Mar									
Apr	125.5	175.9	52.3	9.6	16.5	3.9	3765	5277	1569
May	217.2	195.8	230.2	13.2	12.7	14.7	6733	6070	7136
Jun	265*	376.7	197.3	13.2*	17.9	9.0	7950*	11301	5919
Jul	265*	128	158.7	7.9*	4.1	6.0	8215*	3968	4920
Aug	265*	24.1		9.0*	1.0		8215*	747	
Sep		16.8			1.0			510	

*Based on Jun-Aug

							average use by golf course

2.2. Demand vs. Supply: Having obtained some information on water an attempt was made to compare the projected stream flow from the modeled scenarios.

For the critical month of July-September the demand largely exceeds the projected supply for all years between 2010 and 2039 by more than 200% in all years.
This suggests that the Kemp creek modeled projections a are clearly unreliable. Suggestions have been made to PCIC to see if they can come up with a more appropriate modeling result.

Given the uncertainty in the modeled data, and the very high domestic water use data the results suggests that water conservation is the most viable option. Unfortunately Environment Canada has not yet made available the temperature and rainfall data for 2007-2007 and as a result it is not possible to determine whether these 3 years of consumption data occurred during a year of above or below the norm for historical temperature and precipitation. It is expected that the demand will be higher in hot and dry years and none of these projections take into consideration population growth and land use changes and intensification.

5. Summary:

The historic climate record shows that total monthly maximum temperatures have increased in both late winter and late summer with the highest increases in January-February and September. The total annual precipitation (rain & snow) is showing no clear trend from 1950-2006. However, there has been a marked decrease precipitation in January and February and an increase in March and April. Snow accumulation, particularly at lower elevations, has declined between January and March with the largest declines in February. These shifts are likely resulting in earlier season peak flow. The summer rainfall shows high year to year variability with July and August rainfall declining since the mid 1970's. This means less base flow as a result of higher temperatures, more evaporation and less rainfall.

There is evidence that the projected annual discharge for Kemp Creek is increasing, but the more dominant change is projected for the seasonality or when the water arrives throughout the year based on modeled discharge. Streamflow is projected to increase most predominantly in Between November to April, with a decline over the May-September period. The reduction is most pronounced in July at a time when the water demand and environmental stress is usually the highest.

There are only 3.5 years of domestic water use data available and the highest demand usually occurs in the July-August period. The average annual consumption (water released from the treatment plant) suggests that the per capita water use is between 1000-11000 L/person/day (excluding water use for the golf course).
The highest water use for the golf course in May and June ranging from 13-18% of the domestic water used. This drops down to 6% of domestic water used in July and August when residential demand can reach to more than 2300 L/person/day.

Comparing water use in Kaslo with projected discharge in Kemp Creek is difficult because it is apparent that the modeled data provided by PCIC vastly underestimates the supply. PCIC is informed of this and we will respond once we get feedback.

Calibrating the modeled data with measured data was done in Redfish Creek and the results suggest that the models over-predict measured data during the peak flow period and under-predicts measured flow in June and July (report is forthcoming). It is not possible to determine if this also applies to the Kemp Creek modeled data but if this indeed the case then the water shortages will likely be higher.

This analysis suggests that the anticipated climate change described in the introduction as summarized from previous work can be verified, at least in part, by trends in the historic climate data and some of the modeled discharge data. The results suggest that earlier peak flow and lower summer low flow should be of concern. Considerable differences exist between the projections of the 7 GCMs and these projections should be considered with caution since they are derived from a modeled tailored for use on larger watersheds. The model was not calibrated to the Kemp Creek watershed directly, as there is no calibration data is available. Additionally, Kemp Creek is represented here with portions of only 3 grid cells from the VIC model. That being said, the projected changes align with projections from other studies and compare well to trends already occurring in nearby watersheds. Considering the consequences of the projected changes and agreement of models towards increased winter and reduced summer flows, the need to adapt to these changing conditions is evident. There are ample adaptation options particularly in terms of water conservation, which is likely the most expedient and cost effective measure to be taken in the short term.

References

Mote, P.W. and Salathe, E.P.J., 2009. Future climate in the Pacific Northwest, Chapter 1: The Washington Climate Change Impacts Assessment. JISAO Climate Impacts Group, University of Washington, Seattle, WA, USA. pgs. 21-43. http://cses.washington.edu/cig/res/ia/waccia.shtml

Saltahe, E.P. P.W. Mote and M.W. Wiley, 2007. Review of scenario selection and downscaling methods for the assessment of climate change impacts on hydrology in the United States pacific northwest. International Journal of Climatology, 27: 1611-1621.

Analysis of Present/Future Water Supply and Demand Issues
Preliminary Findings
***(*Hans Shreier, Martin Carver, Arelia Werner)**

Question: How will projected climatic changes affect water provision for Kaslo/Area D?
Why do we want to know this? If precipitation and melt patterns alter due to climate change, will demand outstrip supply in years to come under present consumption levels?
Quick answer: Initial findings indicate that water conservation measures need to be seriously considered to avoid costly water shortages.

<u>Water supply findings include:</u>

- Increased monthly maximum temperatures in both late winter and late summer
- Highest increases occur in January-February and September.
- No clear trend in total annual precipitation (rain & snow) from 1950-2006 (same amount but more rain and less snow).
- Marked decrease in precipitation in January and February and increase in March and April.
- Snow accumulation, particularly at lower elevations, has declined between January and March with the largest declines in February.
- The peak flow is occurring earlier in the season.
- July and August rainfall declining since the mid 1970s. This means less base flow as a result of higher temperatures, more evaporation and less rainfall.
- Evidence for increased annual discharge for Kemp Creek
- Increased streamflow between November to April
- Lower streamflow during May-September, particularly in July at a time when the water demand and environmental stress is usually the highest.

<u>Water demand findings include:</u>

- Only 3.5 years of domestic water use data available in Kaslo
- Highest demand usually occurs in the July-August period.
- Average annual consumption (water provided by the treatment plant) per person between 1000-1100 L/person/day (excluding water use for the golf course).
- Golf course consumption highest in May and June (13-18% of the domestic water used)
- Golf course consumption lower in July/August (6% of domestic water used)
- Total residential demand can reach more than 2300 L/person/day during hot summer days in July and August.

Conclusion

There is a need to adapt to changing conditions, eg through water conservation, especially in the short term.

- Further modeling and comparisons are recommended.
- Climate change can be partly verified by trends in the historic climate data and some of the modeled discharge data.
- Earlier peak flow and lower summer low flow are of concern.

GIS 331

Comparison of Kaslo Watersheds

Cris Gray, Katie Ward, Melissa MacLeod

5/21/2010

We have collected information and classified the physical characteristics based on slope, aspect, percent vegetation, percent area lakes, and geology. None of the watersheds encompass any glaciers. We do not have annual temperature, precipitation/snow data. Based on our findings, the three Kaslo watersheds are different from Redfish Creek. We recommend further data collection in the local watersheds to allow for a more meaningful comparison.

INTRODUCTION

Earth's climate is changing; these changes are predicted to have a large impact on global communities. Climate change impacts threaten to alter snow pack characteristics, stream peak flow, water quality, and water availability. Snow fall rates are predicted to decrease over time and snow pack melt rates to increase causing greater peak flows arriving earlier in the year. These changes in the hydrologic cycle are likely to increase periods of low flow in streams producing potential drought conditions.

The Kaslo water basin is an important freshwater resource for the area, providing water for irrigation, domestic, commercial, and hydropower uses. As water use increases with growing populations and climate change affects the amount of water supply available is decreasing, limiting the amount of water available for the Kaslo community as well as for fish and wildlife.

The village of Kaslo has received funding from the Columbia Basin Trust (CBT) for its Communities Adapting to Climate Change initiative. The purpose of the initiative is to help communities address issues they feel are locally important in relation to climate change and develop strategies. Kaslo identified water supply and food security as important issues.

Our group at Selkirk College has undertaken the task to describe and compare physical characteristics of three of the major watersheds in the Kaslo area. Kemp Creek, Bjerkness Creek and Fletcher Creek watersheds will be compared to Redfish Creek watershed, where extensive data has been collected since 1932. These watersheds are snowmelt dominated with no input from glaciers. A model is being designed by a hydrologist from Pacific Climate Impacts Consortium (PCIC) to assess stream flow from snowmelt dominated watersheds (based on Redfish data). The purpose of this characterization is to provide information to aid in the assessment of how climate change will impact the quantity and quality of year round water resources available to the Kaslo Region.

STUDY AREA

Three of the study watersheds; Kemp Creek, Bjerkness Creek and Fletcher Creek are near the village of Kaslo and provide water resources for the village and surrounding communities. Redfish creek watershed is about 30 km SW of Kaslo (Figure 1)

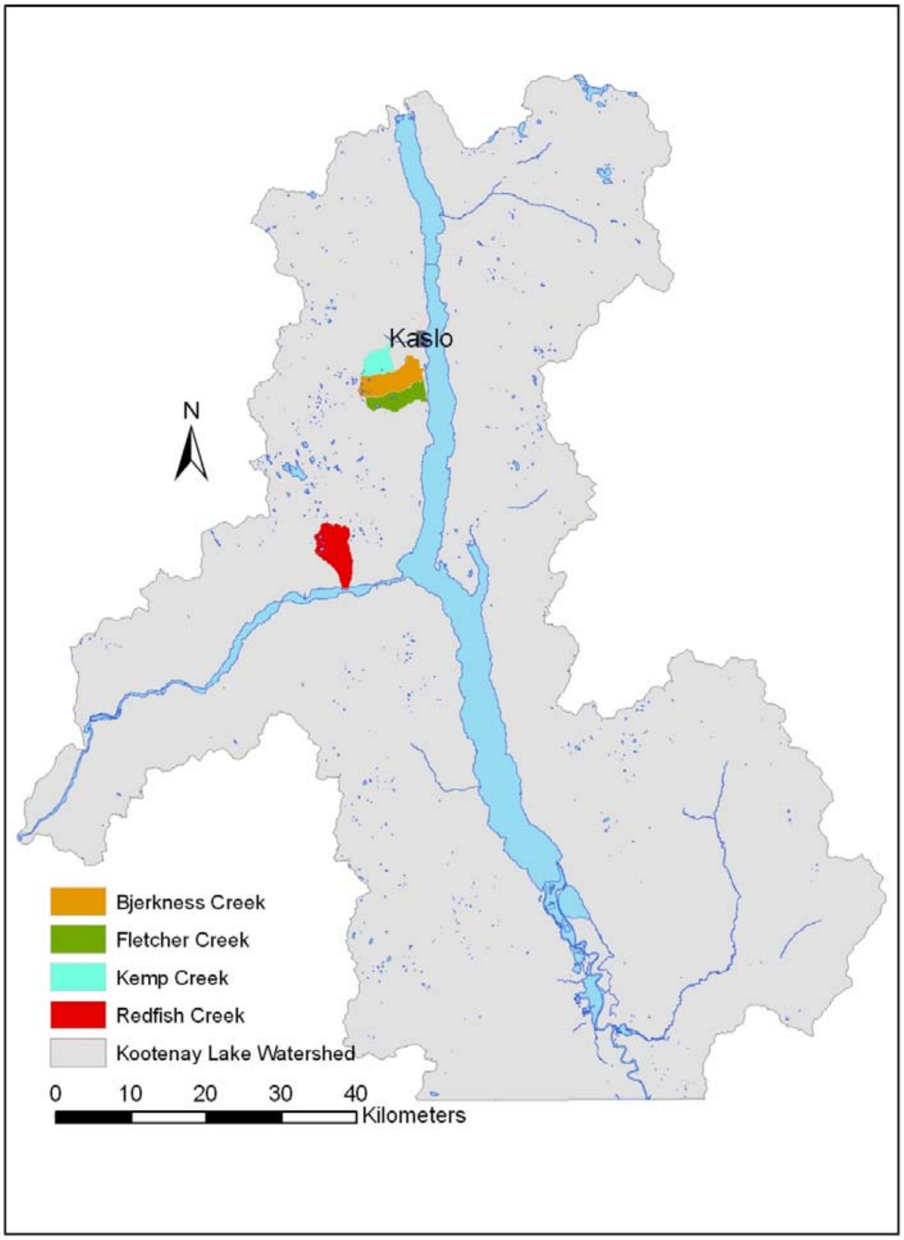

Figure 1. General study area of the watersheds of interest within Kootenay Lake watershed.

Characteristics of Study Streams

Redfish Creek

Redfish Creek is a 4th order stream that flows southward into the west arm of Kootenay Lake. It has an area of 2729.1 ha with an elevation ranging between 530 and 2362 m. The watershed spans two major biogeoclimatic zones, ICH (interior cedar hemlock) up to 1200 m and ESSF (Engleman spruce and sub-alpine fir) between 1200 and 2000 m. About 6% of the watershed area is estimated alpine (Jordan & Fanjoy 1999). The watershed is teardrop shaped with the mainstream channel running down the middle of the watershed. Redfish Creek is steep and confined along most of its length.

Kemp Creek

Kemp Creek is a fourth-order stream that flows northeastward into the Kaslo River. The watershed basin has an area of 1271.3 ha ranging in elevation from 659 to 2429 m. The creek is fed by tributaries that cascade down its steep valley walls into its two main branches (Sundberg 2000). The area we determined for Kemp creek seems to be considerably higher than that from other sources, which all reference 1997 IWAP (BC 1997)(11.81 km^2).

The alpine upper section of the Kemp Creek watershed has steep, glacier-carved valley walls with avalanche-scarred slopes. Above the village water intake, the creek flows through a steep, V-shaped valley with unstable walls (Wells 1995). Kemp Creek is a community watershed providing water to the waterworks local authority of Kaslo, which then distributes it to residents of Kaslo for domestic purposes.

Fletcher Creek

Fletcher Creek basin has an area of 1785.3 ha and ranges in elevation from 620 m to 2520 m at the
northwest margin of the drainage. A number of small tributary streams in the upper portion of the basin
feed Upper Fletcher Lake at an elevation of 1967 m.

Bjerkness Creek

The longest of the study streams, Bjerkness Creek is a third-order system that originates in a cluster of alpine lakes on Trafalgar Mountain (elev. 2554 m). The main Bjerkness Creek has an area of 2706.6 ha and ranges in elevation from 548 to 2566 m at the west margin of the drainage. Several small streams drain into Bjerkness Lake at 1910 m elevation (Masse 2001). Bjerkness Creek is a community watershed providing water to the community of Mirror Lake for domestic and irrigation purposes.

METHODS

Watershed Spatial Data

The sub basins of interest; Redfish, Kemp, Bjerkness, and Kemp were clipped from the BC corporate watershed Base project (BC CWB)watershed shapefile feature class using the clip tool in ArcGIS 9.3 ArcMap application. Watershed boundaries were identified from the BC CWB project datasets. Associated spatial data layers of interest including TRIM 1:20000 streams, lakes, contours, and a digital elevation model (DEM) raster of resolution 25m x 25m were clipped to each of the four watersheds. All shapefiles were transformed to geodatabase feature classes and stored in a feature dataset for each watershed.

A model was created in ArcInfo to classify the DEM into slope, aspect and elevation slice rasters. This was edited for each of the watersheds. Model environments were set to the spatial extents of the utm_82F DEM with a cell size of 25. Parameters were set for model inputs and outputs. Each watershed required model parameters modification due to their spatial differences. Raster outputs were not put into the geodatabase, they were placed into watershed specific file folders.

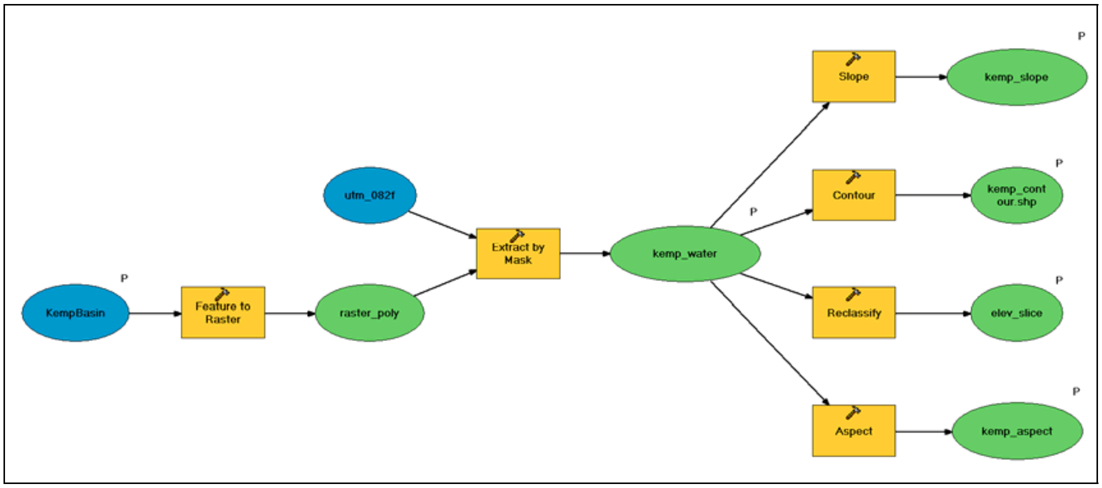

Figure 2. Model created in model builder for raster creation from a DEM.

A basin shapefile for the desired watershed was added as an input to the model and processed with the feature to raster tool to create a raster of the watershed. This raster was then used to select watershed area from the DEM with the extract by mask tool. This produced a DEM raster of the selected watershed area. From each watershed DEM :

- A slope raster was created with the slope tool
- Contours were created (output shapefile) with 100m intervals
- Reclassification was performed on the raster to divide it into elevation slices at 100m intervals as well as 6 equal intervals of 400m
- An aspect raster was created with the aspect tool

Each output raster created was a 32-bit floating point data type which could not produce an attribute table. To extract pixel values from aspect and slope rasters, we used the sample tool and extracted discrete values based on the 6 elevation slice rasters. This created a table that was exported to a dbf table and opened into excel. Data was manipulated to give us the sampled aspect and slope values for each elevation slice for each watershed. This data is located in folder GISData\STATS\AllSlopeAspect.xlsx

Watershed Analysis and Statistics

Area (ha) of each watershed was determined from the clipped DEM rasters using the 3D Analyst area and volume statistics tool in ArcMap. This tool calculated the 2D and 3D surface area for each watershed.

Random rasters were created for each watershed using the Create Random Raster Tool in ArcMap to select random sampling points in order to statistically analyze the watersheds. The random raster was then reclassified to produce random sampling points that characterized approximately 10% of each of the watershed areas. This sub-sampling technique was done by calculating the total amount of pixels in each watershed area and selecting approximately 10% of these random pixels. Figure 3A and B present the random raster produced for Kemp Creek watershed and the 10% random points generated for statistical analysis. Table 1 below presents the random point's selection process. The Actual number of pixels selected for sub-sampling was determined using the random raster attribute table and selecting the record with pixel counts closest to 10% of the total.

Table 1: Production process to extract random sampling points.

Watershed	Total # of Pixels in Watershed Area	10% of the Pixels	Actual # of Pixels Selected as Random Points
Fletcher	28564	2856	3358
Kemp	20340	2034	2361
Bjerkness	43305	4331	5031
Redfish	43665	4367	4996

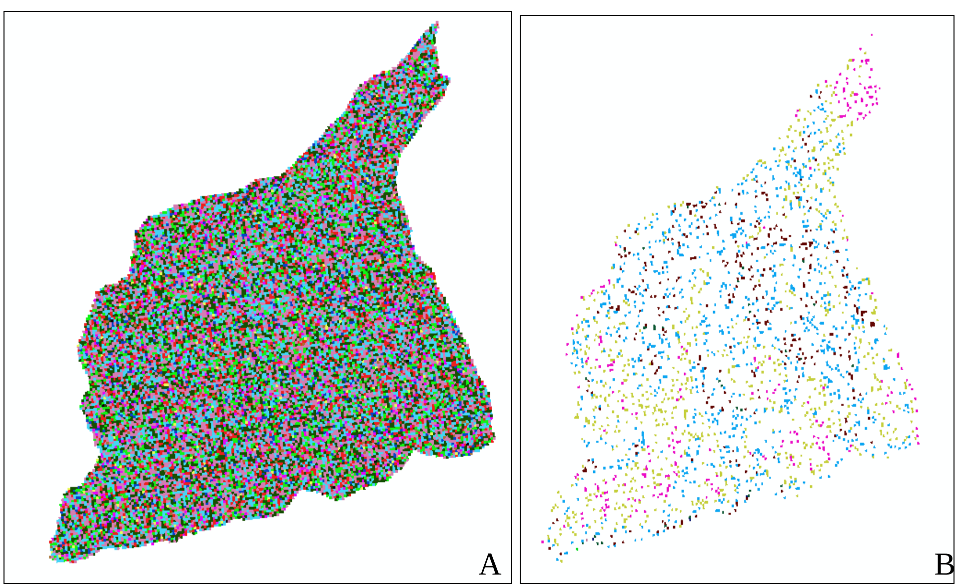

Figure 3A: The random raster created for the Kemp Watershed.
Figure 3B: 10% of the random raster selected as random sampling points for the watershed.

Maps of elevation slices for each watershed and graphs depicting percent area of watershed for each elevation slice were produced. River length elevation profiles for the main stream stem in each watershed were also produced. Elevation values for the streams were extracted from each clipped DEM using the 3D Analyst feature to 3D conversion tool.

RESULTS

Physical characteristics of the watersheds are summarized in table 2. Statistical analysis was performed on Aspect and Slope only.

Table 2. Watershed Characteristics

Measure	Redfish Creek	Kemp Creek	Fletcher Creek	Bjerkness Creek
Watershed code	340-186300	340-215300-16300	340-214600	340-215000
Aspect	S	NE	E	E
Length (km)	8.69	6.46	9.28	10.23
Watershed Area (ha)	2729.1	1271.3	1785.3	2706.6
Min Elevation(m)	532	659	532	548
Max Elevation (m)	2362	2429	2520	2566
Elevation change (m)	1830	1770	2018	1988
Stream magnitude	10	5	2	11
H60 (m)	1700 (H65)	1860	1700	1700
Shape	Teardrop	Teardrop	Elliptical	Elliptical
% lakes	0.75	1.23	0.70	0.84

Biogeoclimatic Subzones

The study watersheds traverse four different biogeoclimatic subzones (Wells 1999). Figure 4 shows a graphical representation of the BEC zones over the study watersheds. The Interior Cedar-Hemlock (ICH) zone is a highly diverse zone with the highest number of tree species of any zone in the province. The ICH zone is typified by western red cedar and western hemlock. Elevations below 1,200 m occur in the Dry Warm ICH Subzone (ICHdw) which commonly occupies valley bottoms in the region. The ICHdw region is present in all of the study watersheds. Soils typical of this region are Brunisols which are more common in this drier subzone (Marcoux 2004). The Moist Warm ICH subzone (ICHmw2) extends from 1,200 m to 1,550 above the ICHdw in this study area. Podzolic soils are common in the wetter ICHmw2 zone.

The upper part of the Redfish watershed is occupied by the Engelmann Spruce – Subalpine fir zone (ESSF). This is a high elevation subalpine habitat. The Selkirk Wet Cold ESSF Subzone (ESSF-wc4) occurs in elevations greater than 1,650 m and can receive precipitation exceeding 1,000 mm annually. All four watersheds occupy the ESSF-wc4 zone. Podzolic soil with a thick organic layer is common in the ESSF zone. Late season snow melt that is critical for refilling of reservoirs is provided by the ESSF zone and other high elevation zones.

The highest elevations within this study area are in the Alpine Tundra (AT) undifferentiated and Parkland or Wet Cold Parkland Engelmann Spruce-Subalpine fir subzone (ESSFwcp) above 1,950 m (Braumandl 1992). The

Alpine Tundra zone is not present in the boundaries of the Redfish drainage basin, but does occur in the 3 Kaslo area watersheds. Soils in the AT zone are largely undeveloped regosols or weakly developed brunisols as this zone is typically the last zone of glacial retreat.

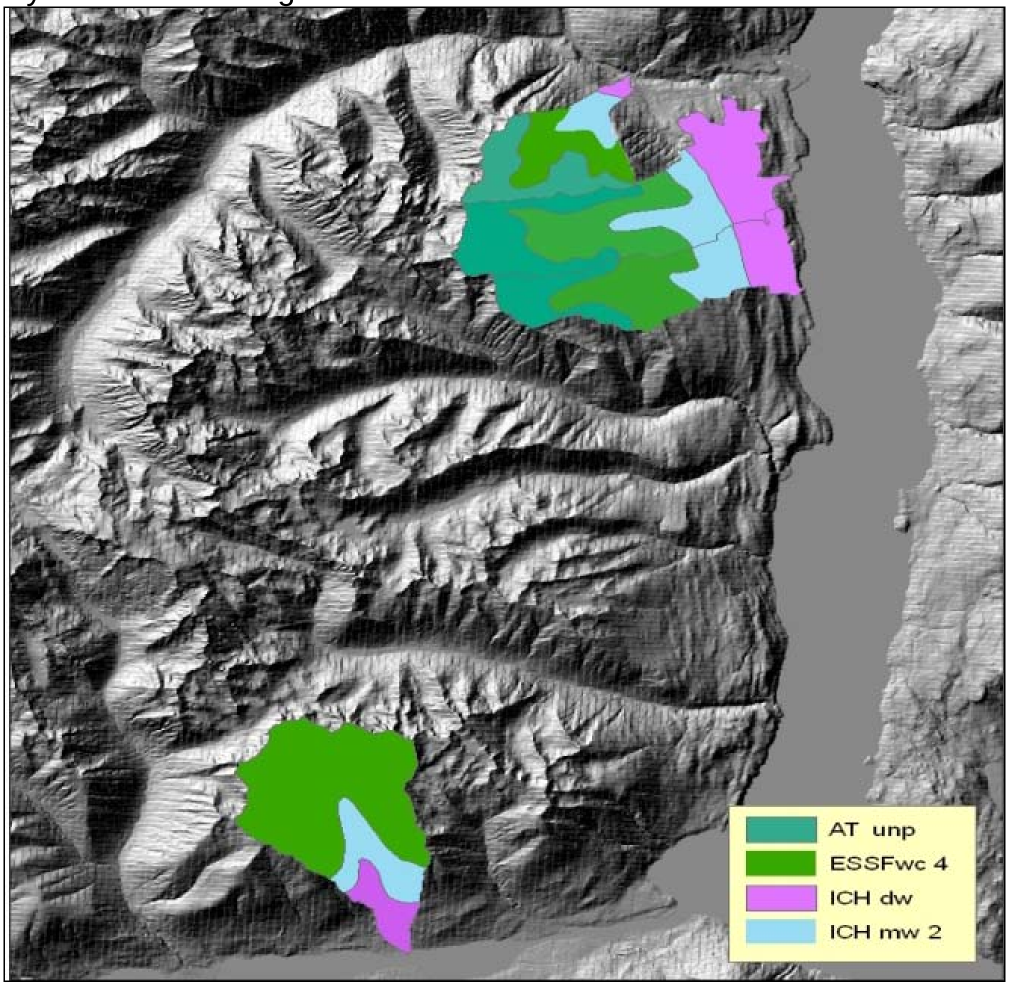

Figure 4. Biogeoclimatic zone classification for study area watersheds

Geology

The study area is largely underlain by coarse granodioritic intrusive bedrock of the Nelson intrusion (Jordan & Fanjoy 1999). The Redfish watershed is made up entirely of a uniform distribution of intrusive granodiorite rock, whereas the three Kaslo watersheds are underlain by 5 different geology types. The bedrock of the Kaslo watersheds includes the Triassic Slocan group which consists of limestone, slate, siltstone and argillite; this bedrock also includes deposits of volcanic basalts and sedimentary rocks (Figure 5). The Triassic Slocan group covers the largest area of the three Kaslo basins.

Soil textures within the study area are mostly of silty loam texture, and soil is typically well to moderately well drained, with some seepage areas. (Jordan 2007)

A large amount of research has been done on sediment patterns in streams within the Redfish Creek watershed (Jordan & Fanjoy 1999). The largest source of sediments within Redfish is from logging and associated roads (Jordan 2001).There is also moderate sedimentation within Kemp Creek watershed due to a large fire that occurred in 2007 (Jordan 2007).

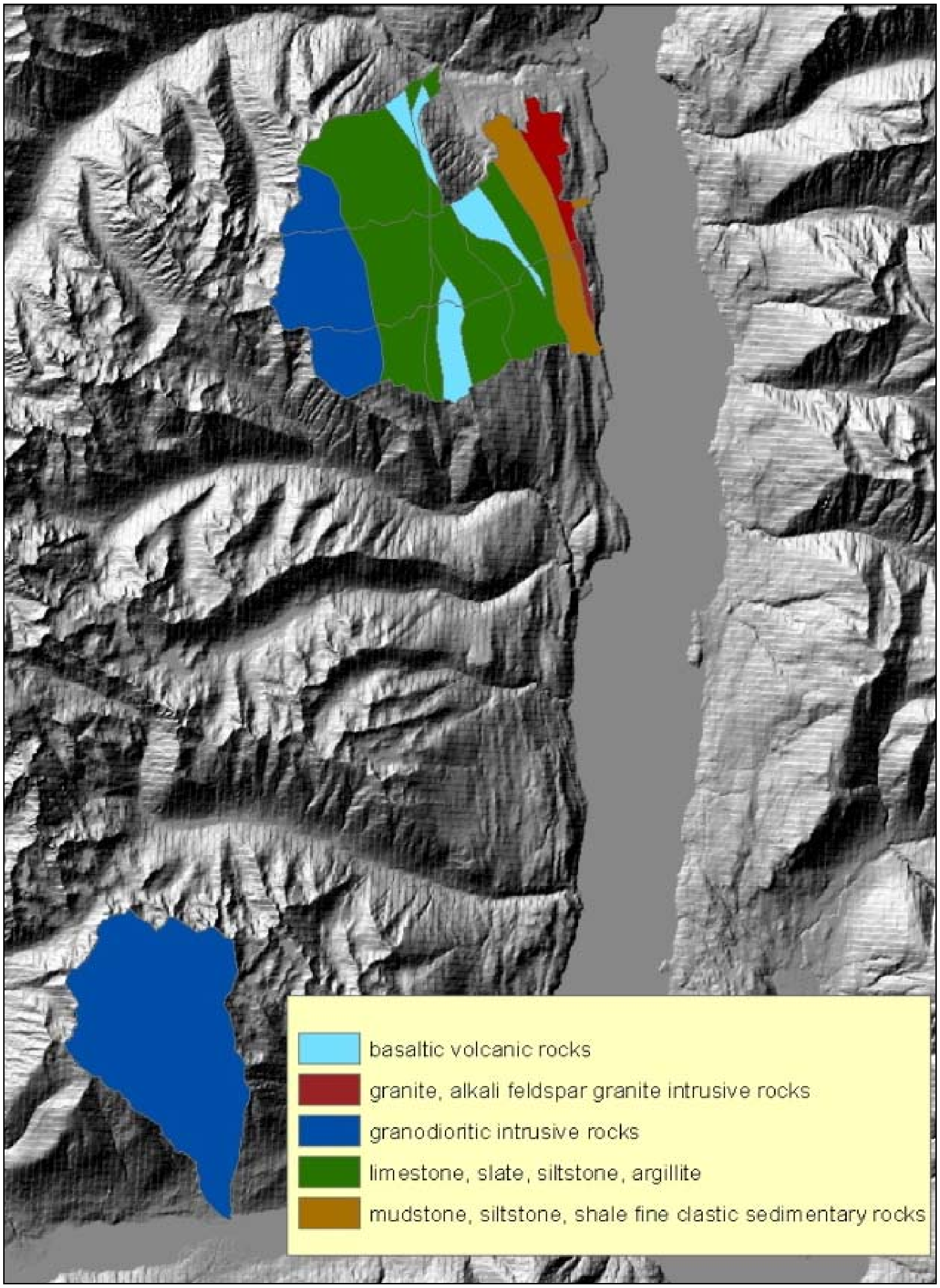

Figure 5. Rock type classification of the study watersheds.

Water Licenses

Water license information for 2009 is displayed below in table 3. The licenced water values were converted to a common unit of gallons per day. No information could be obtained for the actual water used or water available. Licenses are granted for the amount of water use allowed but no data has been collected for actual use. Figure 6 shows the comparison of different uses for each watershed.

Table 3. Summary of Water License data (did not graph “Conserve” category as we were unable to determine what this was.)

Water source	Waterworks Local Authority	Domestic	Irrigation	Lawn & Garden/Watering	Residential Power	Conserve (use of water)	Stock water	Enterprise
	GD(Gallons/day)	GD	GD	GD	GD	GD	GD	GD
Kemp	2098260							
Bjerkness		37500	180306.6	12324.3			200866.4	1000
Fletcher	60000	12500	61822.2		161481.6			
Redfish		20875	14114.2		313992	4485600		

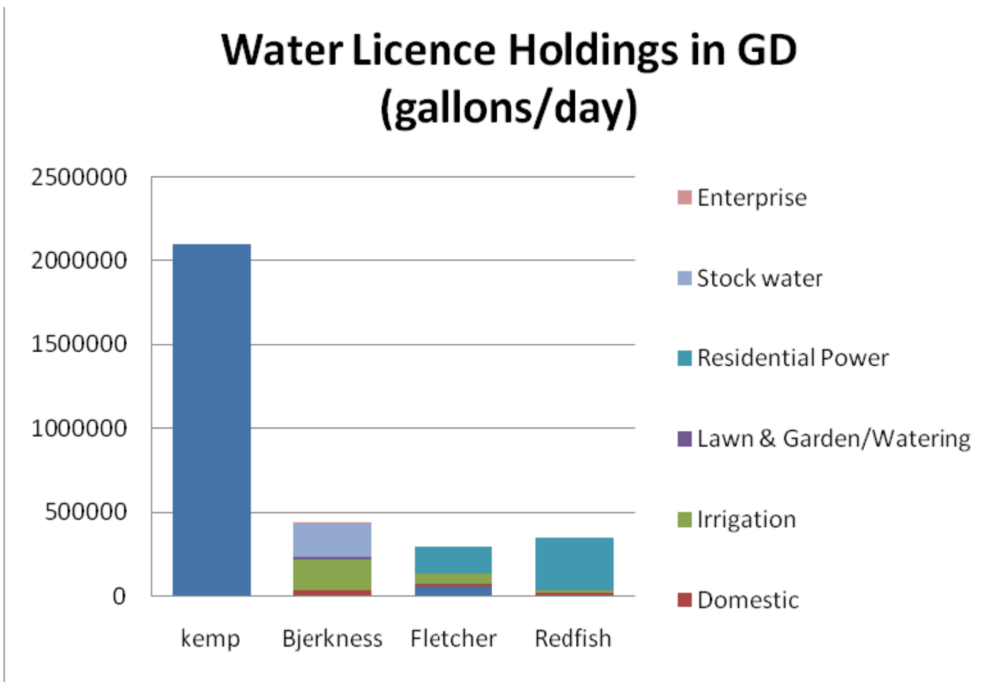

Figure 6. Graphic representation of water use for each watershed in the study.

STATISTICAL ANALYSIS

Initial exploration of the dataset for aspect and slope suggested that there is not a significant difference between elevation slice values. We decided to exclude elevation slice blocking from our analysis.

Eastness

The analysis of variance (ANOVA) test was performed on eastness values between watersheds and produced a resultant p-value of < 0.05. This p-value indicates that there is a significant difference in east values between watersheds.

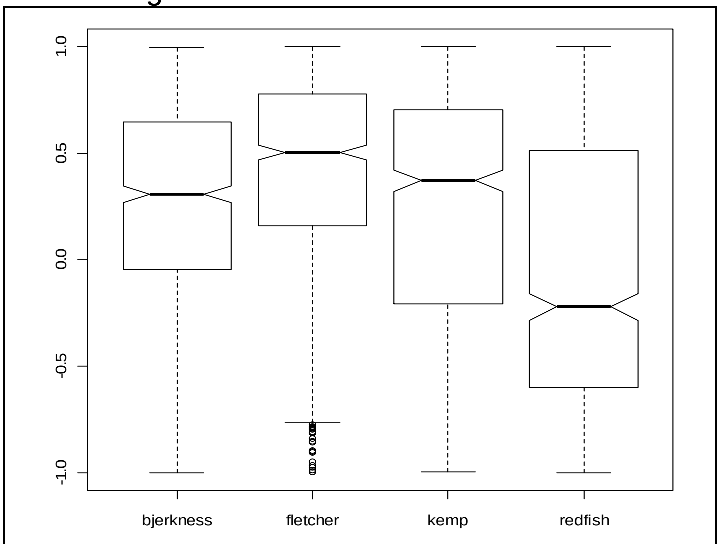

Figure 7 .Boxplot representations of watershed for east[3] aspect values.

The box plots in figure 7 indicate that Bjerkness and Kemp basins may not be significantly different from each other. Further analysis using the Tukey test confirmed the assumption that Bjerkness and Kemp are not significantly different from each other while all other combinations of watershed comparisons are significantly different.

Northness

Northness values for each watershed were compared statistically using the ANOVA test. This test produced a p-value of < 0.05 which indicates that there is a significant difference in northness values between watersheds.

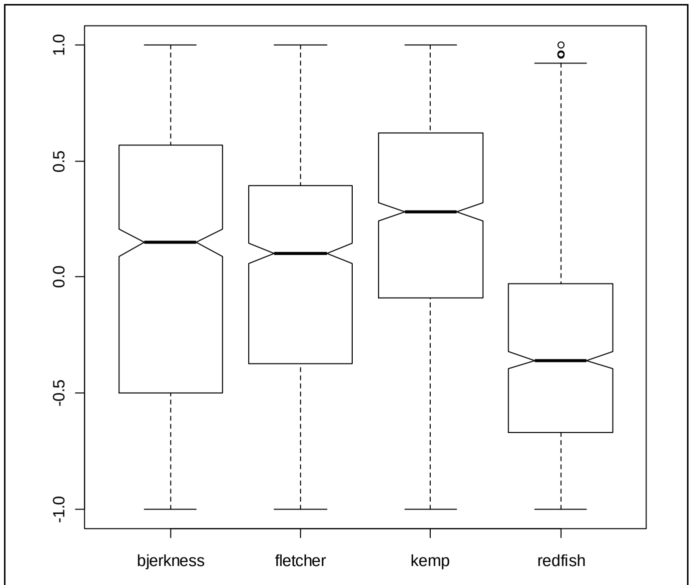

Figure 8. Box plots by watershed for north[3] aspect values.

Box plots were used to visualize the northness differences between watersheds (figure 8). The overlapping values of the Fletcher and Bjerkness 95% confidence intervals indicate that these two watersheds may not be significantly different. The Tukey test was used to test which of the watersheds are significantly different. The Tukey test confirmed that Fletcher and Bjerkness do not have significantly different north values (p-value > 0.05).

Slope

Initial exploration of the slope data indicated that the data is not normally distributed. To normalize the slope data a square root transformation was applied the values and resulted in a normal distribution. The ANOVA test was run and produced a p-value of < 0.05 which indicates a significant difference between slope values in all watersheds. Box plots were used to visualize this analysis (Figure 9). The overlapping 95% values in figure 9 indicate that Redfish and Fletcher watersheds are not significantly different. The Tukey test supported this conclusion made from the box plots. Results indicate that for all other watershed comparisons there is a significant difference between slope values.

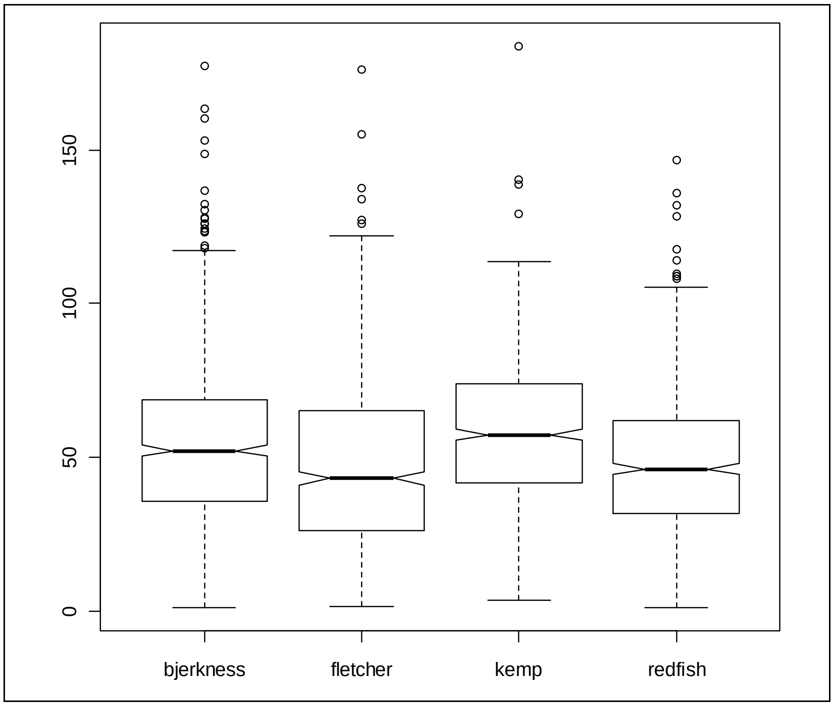

Figure 9. Box plots by watershed for sqrt(slope) values.

DISCUSSION

The primary goal of this study was to determine if the three Kaslo watersheds: Kemp, Fletcher, and Bjerkness Creeks are similar enough to Redfish Creek watershed to use a model based on data from Redfish Creek. The statistical and physical analysis results of the watersheds show that the four watersheds are significantly different.

Slope and Aspect were the only variables looked at statistically as they are important to the dynamics of water flow in the system. Slope of the landscape has a large influence on the rate and direction of water flow; this is a valid parameter to compare these watersheds. Aspect strongly influences the rate of snow melt as well as evaporation of water throughout the watershed area.

Redfish Creek watershed has a southerly aspect whereas the three Kaslo watersheds have a north-easterly aspect. Aspect is important in determining the hydrological characteristics of a watershed. Watersheds with a northerly aspect are likely to have greater water storage in snowpack and will experience a slower snow melt rate during the spring compared to watersheds with a southerly aspect.

The Kemp Creek watershed has an overall greater slope value than the other three watersheds. This result may indicate that the Kemp Creek Basin will experience a greater drainage rate. A greater drainage rate in Kemp Creek is significant as this basin has the greatest amount of water licenced to be withdrawn from it. Kemp Creek basin also has the potential to be greatly impacted by climate change as it is the smallest watershed, with possibly the greatest drainage rate, and provides the most water to consumers within our study.

The three Kaslo watersheds are not only different from Redfish but different from each other. Further data collection in the area is recommended prior to any major decisions being made. We recommend that data on precipitation, snowpack and temperature be collected at each of the watersheds to determine how much water is available in the system at a given time. A number of license holders draw water from these watersheds but there is great uncertainty as to how much is actually removed from the system. Quantification of water consumption rates needs to be determined in order to make any predictions about future water availability.

RECOMMENDATIONS

Based on our findings, the following recommendations would enable a more complete comparison:

- set up local weather stations – precipitation, temperature, snowpack
- collect information on stream flow (water availability) and water usage (metering)
- combine data from multiple watersheds and average to make model
- further analysis to consider Redfish data to be used to represent Kaslo watersheds

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DATA SOURCES
Raster Data sets

produced from DEM UTM 082F raster, 25mx25m spatial resolution.
Original source file path in SGRC data sets:
O:\GIS_Data\topo\dem\20k\082f\grid\utm_082f
Spatial Reference: NAD83 UTM Zone 11N

- Aspect Raster
- Slope Raster
- Elevation Slices
- Randomized raster for statistical analysis: Randomized Block Analysis

Feature Classes
Feature classes were produced from shapefiles and coverages using a feature class to feature class transformation tool. The original data files are from:

- Streams data : TRIMii streams shapefile tiiwtr arc.shp:
  Kootenay Regional Coverage of TRIMii Water Features. Extracted from TRIMii library on Provincial Server. Datum: NAD 83. Resolution: 1:20 000.
- Lakes data :TRIM water features coverage feature class, twtra_r4:
  Kootenay Regional Coverage of TRIM 1, 2001. Datum: NAD 83. Resolution: 1:20 000.
- Watershed boundary data: Produced from TRIM Water Atlas 1: 20 000 Heights of Land using Barrodale Height-of-Land generation software from the BC Corporate Watershed Base Project. Original shapefile: CWB_NAMWTR.shp. contains watershed boundaries and names. Datum: NAD83
  Corporate Watershed Base Project (2006). Refractions Research Inc. Victoria, BC.
- Geology data: TRIM Raster/tif/utm11/082f/bc_082f005_xc2m_utm11.zip downloaded from GeoBC http://geobc.gov.bc.ca

Kaslo Climate Change Adaptation – Water Issues Relation to Supply and Demand Issues (Draft Report)

Hans Schreier (UBC), Martin Carver (Aqua Environmental), Arelia Werner (PCIC)

This report covers the following issues: a) Summary of anticipated changes in climate, b) Trends evident from the historic climate record, c) Climate modeling results and d) Water demand in relation to Supplies.

1. Summary of anticipated changes in climate for the Columbia Basin

As indicated by the Provincial and PCIC summary paper Kaslo community faces the following climate and water issues

1.1. Warmer temperatures: This is particularly evident by the experience of higher nigh temperatures in late winter and higher summer temperatures
1.2. Uncertain Rainfall : Different models show contradictory results in how rainfall is changing and it appears that it is very difficult to predict how rainfall is changing particularly in these mountain environments
1.3. Snow accumulation changes: Because of warmer winters it is expected that there will be less snow at lower elevation and the snow is expected to melt earlier in the season
1.4. Runoff impacts: Given the above factors it is expected that peak run-off will occur earlier in the season, peak flow is likely becoming more variable and late summer stream flow will be lower as a result of higher temperatures, more evaporation, and extended summer season.

2. Trends from the historic climate record of Kaslo

A good long climate record is available for Kaslo (Station 1143900 Environment Canada) covering the 1910-2006 period. From an analysis of the data the following observations can be made:

2.1. Increased Temperatures: All winter month showed an increase in mean monthly maximum temperatures with the greatest increases occurring in January-February (Figure 1). In the summer there is a slight increase in mean maximum temperature in August but a more pronounced increase in September (Figure 2)

2.2. Precipitation: There is no apparent trend in the total annual precipitation (rain and snow). The precipitation is highly variable but has not changes significantly since 1950 (Figure 3). However, the snow accumulation has declined particularly since the 1970's (possibly as a result of the PDO shift) (Figure 4), and the rainfall (excluding snow) has increased significantly over the past 60 years (Figure 5). The increase in rainfall compensated for the decrease in snow, resulting in a relatively unchanged annual total over time. The total precipitation (rain & snow has decreased February but showed the greatest increase in March (Figure 6) The reduction in snow is greatest in January and February but is most pronounced in February (Figure 7 & 8). This suggests that less snow falls due to warmer temperatures and the rainfall is increasing significantly in early spring (March & April) and this is likely leading to higher and earlier season peak flow in rivers. Dry season rainfall shows greater variability in July and a significant reduction in August particularly since the mid 1970 (Figures 9-10). This suggests that summer base flows will likely decrease because earlier peak flow, higher summer temperatures, more evaporation and less rainfall in August.

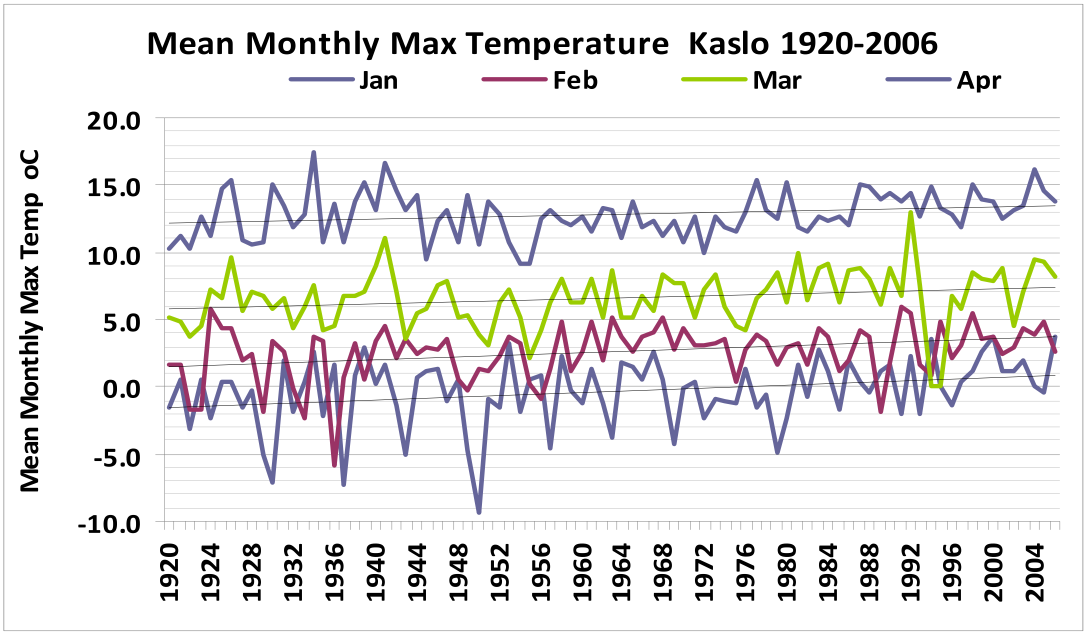

Figure 1 Mean monthly maximum temperature in late winter in Kaslo (1920-2006)

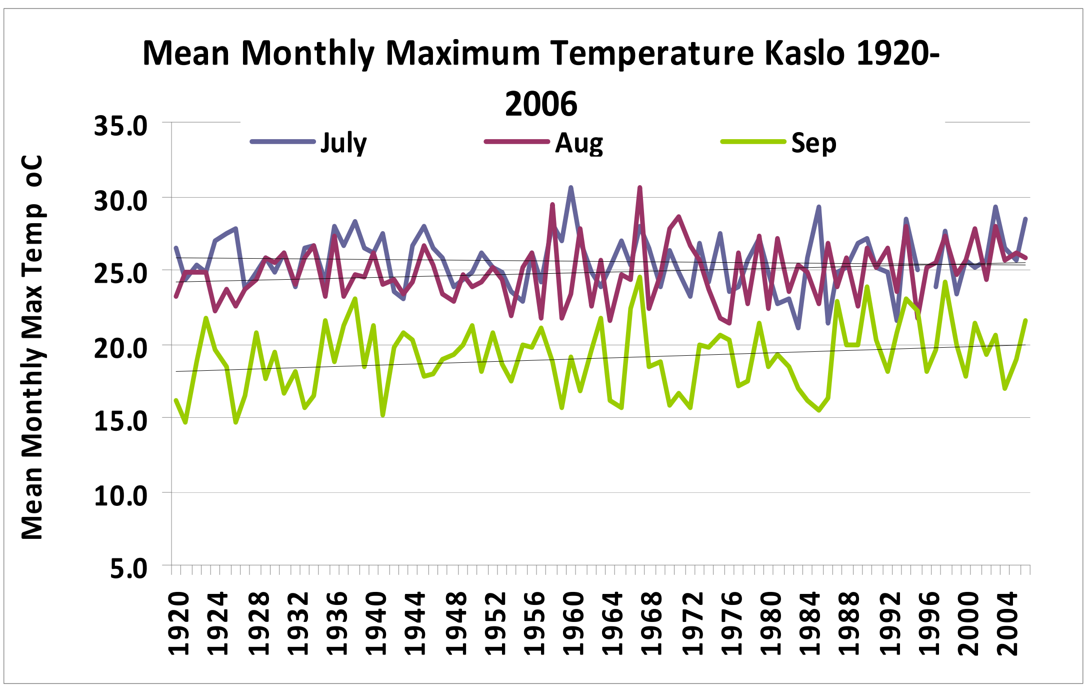

Figure 2 Mean monthly maximum temperatures in the summer in Kaslo (1920-2006)

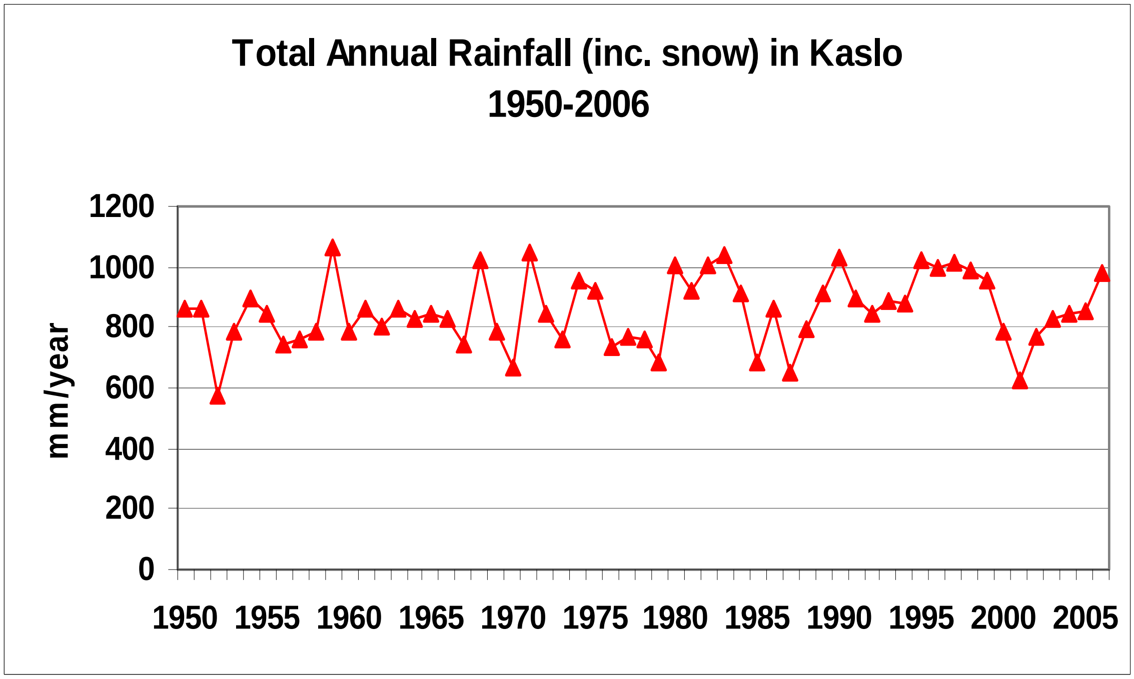

Figure 3. Total annual precipitation in Kaslo - 1950-2006 (rain and snow)

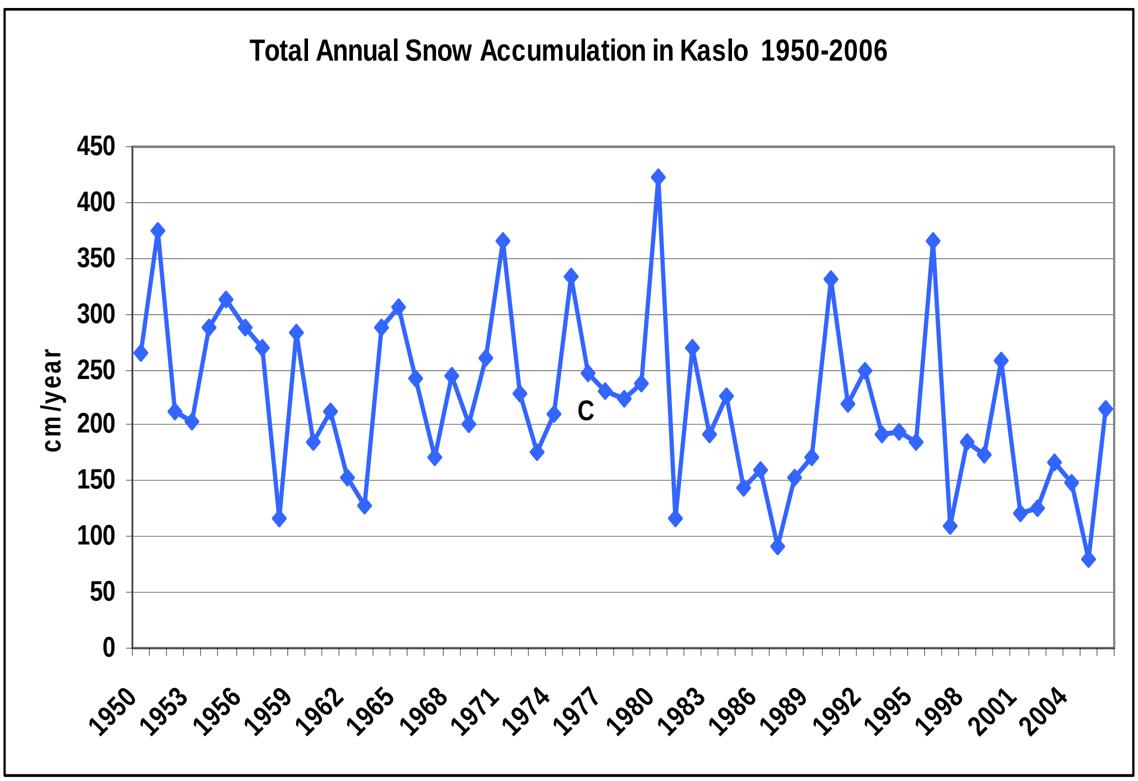

Figure 4. Total annual snow accumulation in Kaslo – 1950-2006

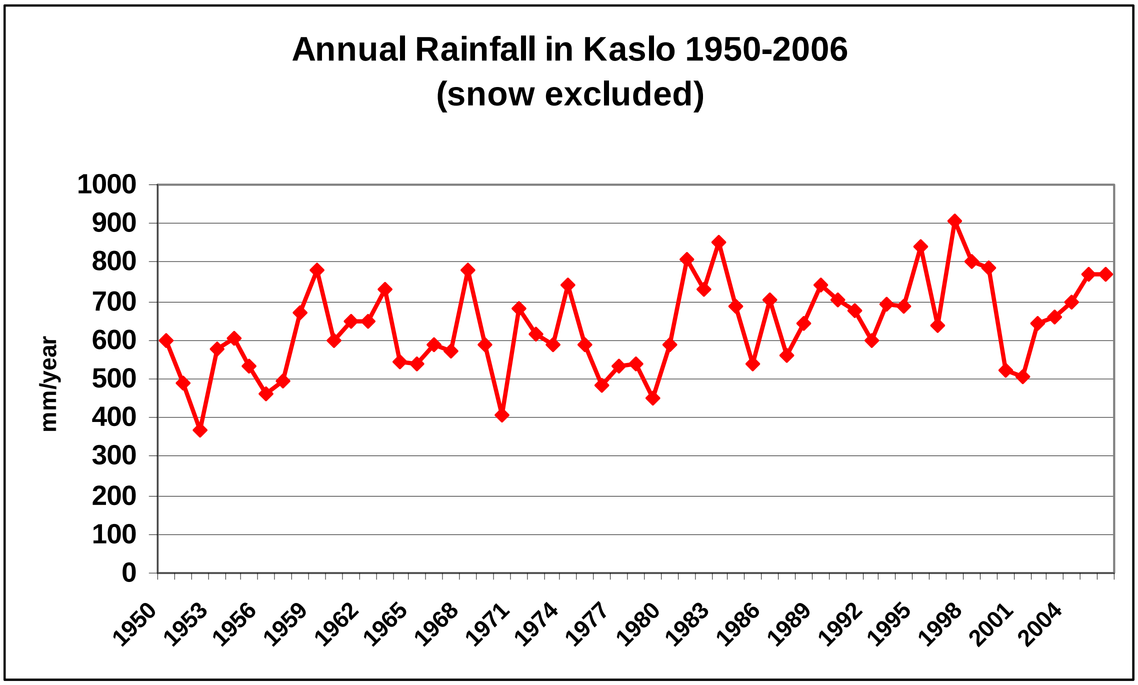

Figure 5. Total Annual rainfall in Kaslo -1950-2006 (rain only)

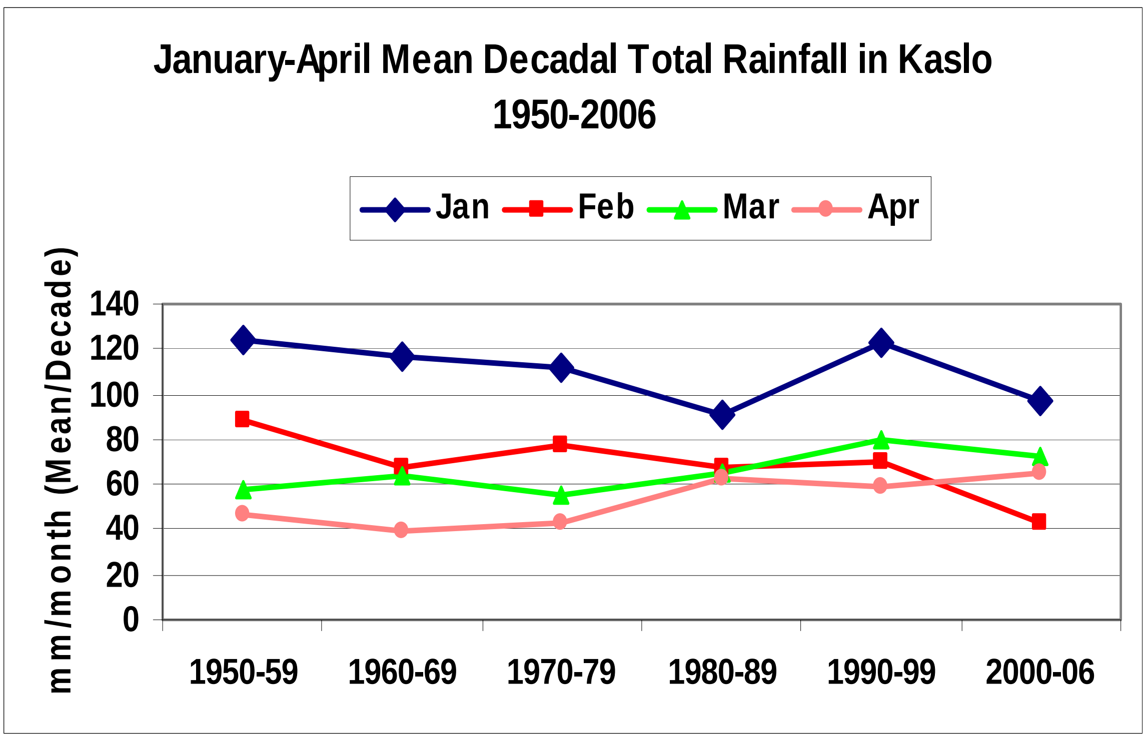

Figure 6... Mean decadal total precipitation changes January-April 1950's-2000's.

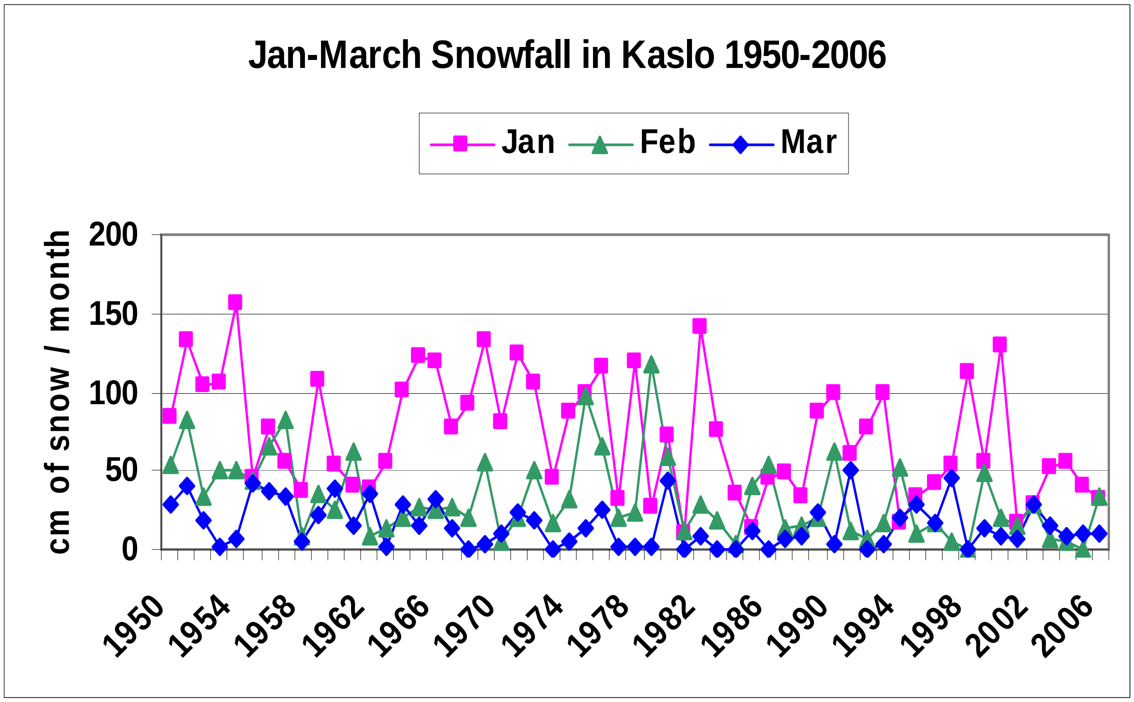

Figure 7. January –February snow accumulation in Kaslo -1950-2006

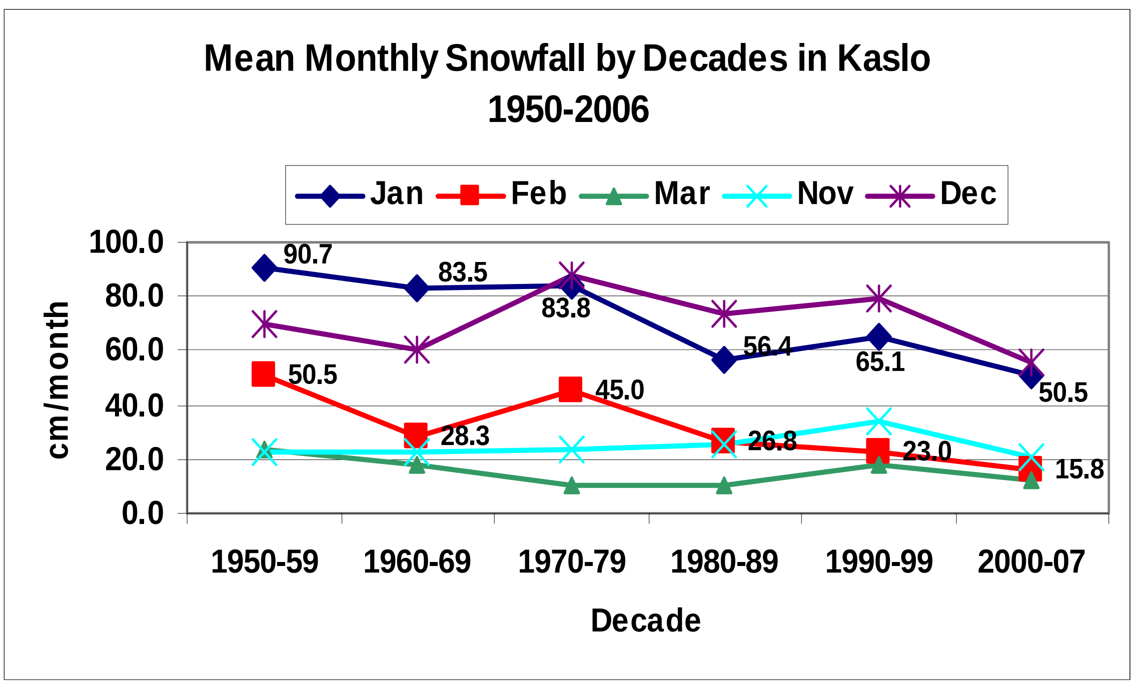

Figure 8. Mean decadal changes in snow accumulation in Kaslo with greatest declines in January and February from the 1950's to 2000's.

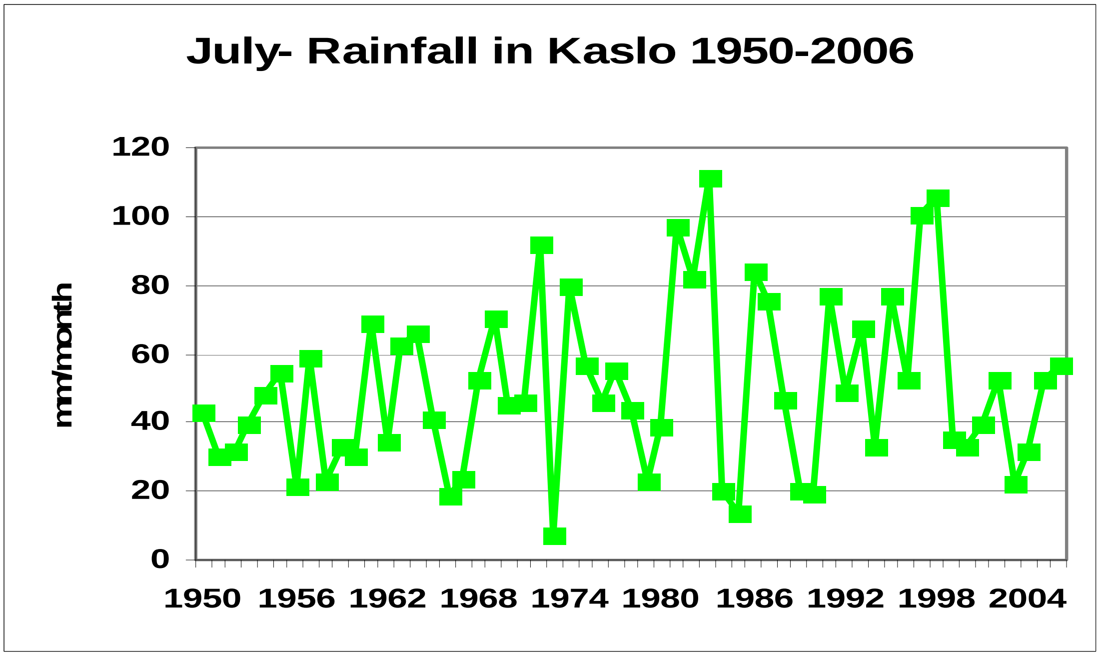

Figure 9. Rainfall variability in July in Kaslo -1950-2006, showing greater variability and low amounts since 1998

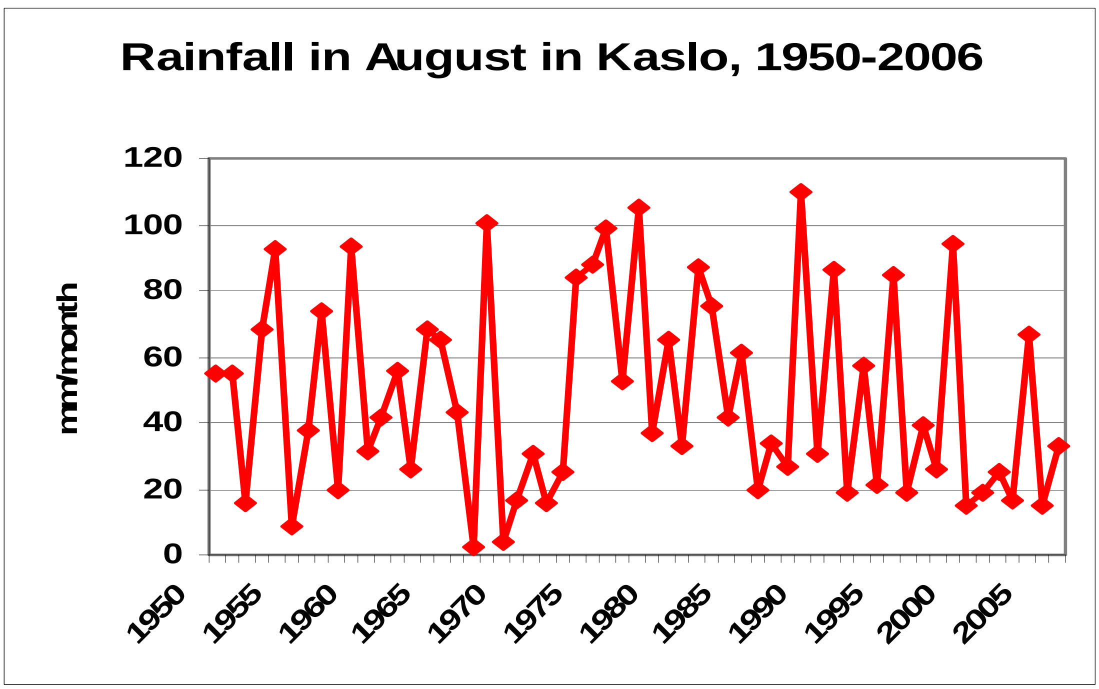

Figure 10. Rainfall variability in August in Kaslo – 1950-2006, showing high variability and an overall; declining trends since the mid 1970's.

3. Projected Changes in Streamflow

Seven Global Climate Models (GCMs) were selected for analysis because they compared well to historical climate averages and trends for the Pacific Northwest Region (Mote and Salathe, 2010). These coarse-scale (~350 km a side) models were corrected for bias and adjusted spatially to represent temperature and precipitation changes at the ~32 km^2 grid scale (Salathe, 2007). These temperature and precipitation data were then used to run a gridded hydrologic model (VIC), which represents the processes of the natural system, such as snowpack accumulation and melt. Customarily, this model is applied to basins larger than ~500 km^2 and calibrated to their observed records. For this project, output produced by the Climate Impacts Group (CIG) at the University of Washington from the hydrologic model simulations was extracted and processed to represent the relatively small basins near Kaslo (i.e. Redfish Creek: 26 km^2; Kemp Creek: 12 km^2) as a first approximation of how streamflow might change out to 2100.

Two emission scenarios were downscaled, the A1B scenario, which assumes a relatively high CO2 emission rates and the B1 scenario that uses a more conservative future emissions level. For the purpose of this study, considering that the A1B scenario is closer to the current rate of emissions, only this scenario was considered. As a first step, the mean projected streamflow from the 7 GCMs was determined for the Kemp Creek watershed. A transient record was created by driving the VIC model with transient climate data produced using the Bias Correction Spatial Downscaling (BCSD) approach outlined above. Monthly VIC model results were download from the CIG ftp site and transformed into a projection of Kemp Creek discharge by multiplying by the proportional area of the Kemp Creek watershed within appropriate grid tiles to provide monthly streamflow from 1950-2100. For the purpose of this study, only the period of 1950-2070 was analyzed.

The modeled projection of monthly stream discharge for Kemp Creek suggests that the overall runoff is increasing on a decadal scale from a low in the 1990's to a high in the 2040's (Figure 11a).

Comparing monthly average streamflow for 2041-2070 to 1961-1990 (Figure 11b), there is a projected increase in runoff from October-May of up to 300% in March and a decrease from June-September of up to 50% in the 2050s (2041-2070).

The projected monthly discharge is provided for the peak flow (Figure 12) and summer dry period (Figure 13).

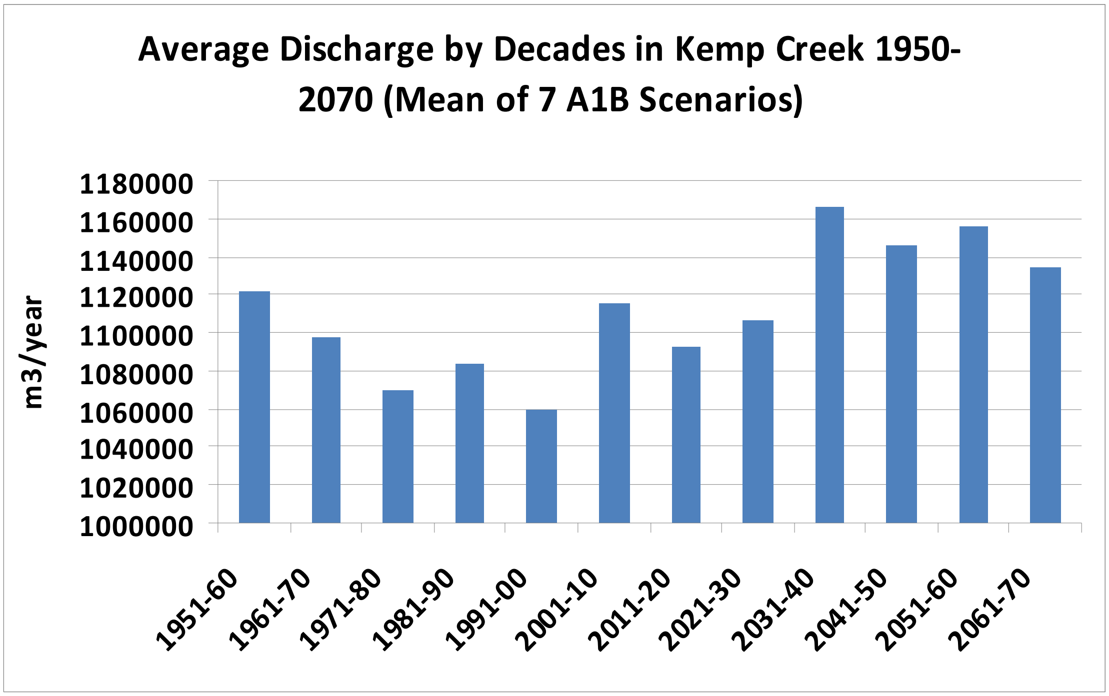

Figure 11. Average annual discharge by decades in Kemp Creek 1950-2070 showing an increase in runoff over time.

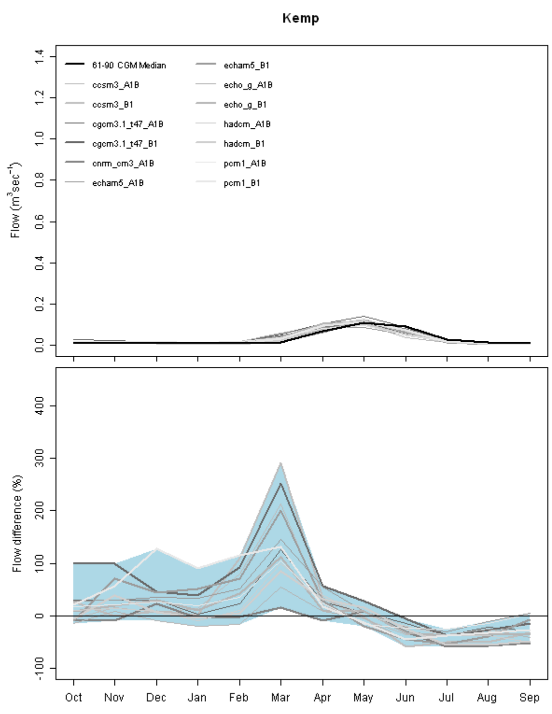

Figure 11b. Average monthly discharge for Kemp Creek 1961-1990 and for all 7 GCMs and 2 emissions scenarios (B1 and A1B) for 2041-2070.

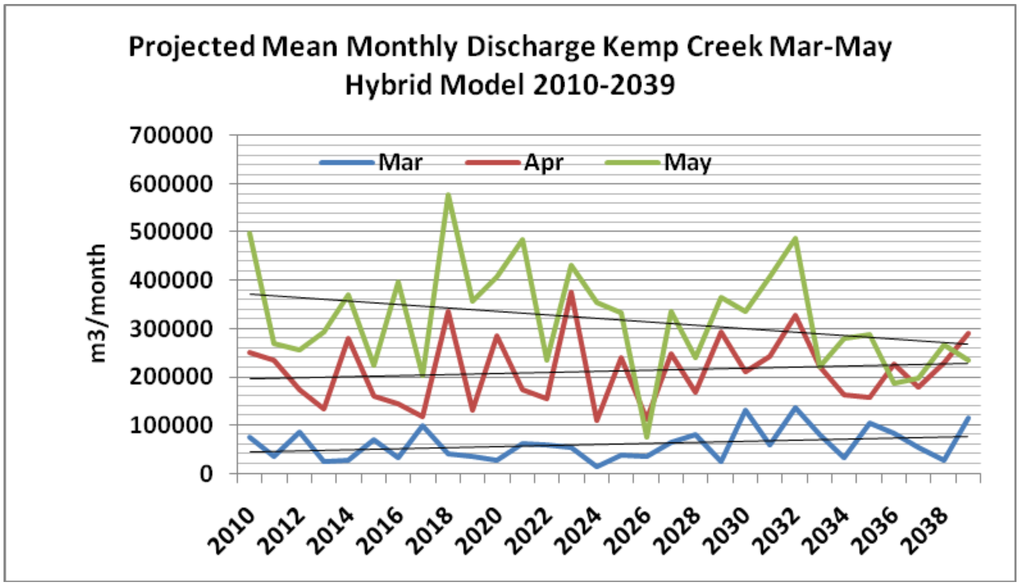

Figure 12. Projected mean monthly discharge rates during peak discharge period in Kemp Creek from 2010-2039

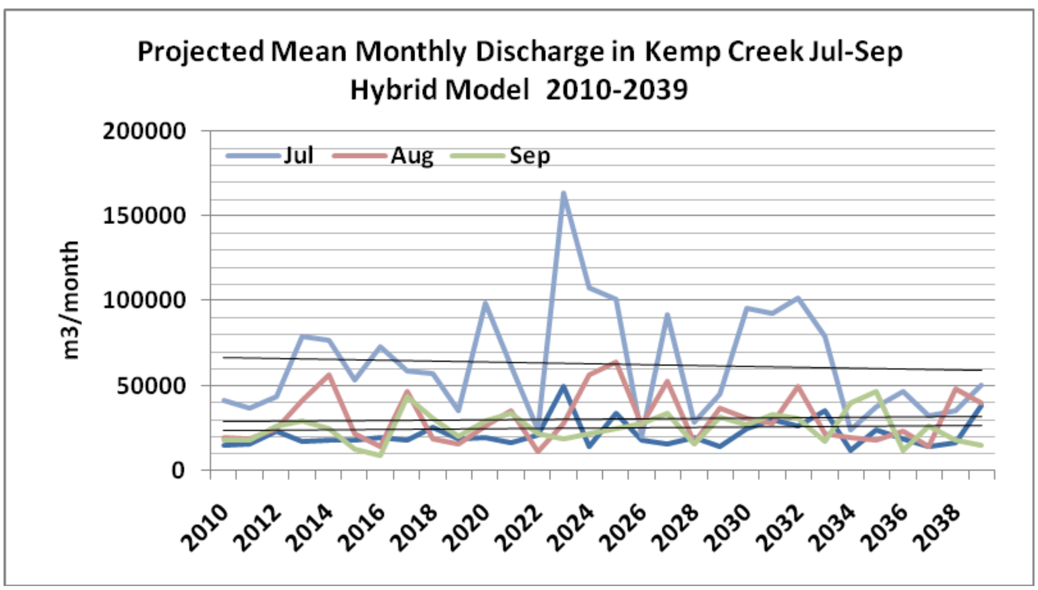

Figure 13. Projected mean monthly discharge in summer dry period in Kemp Creek from 2010-2039

The resulting trends show a slight increase in discharge in March and April and a substantial decrease in May. There is a slight advancement of the peak to mid-April from the historical peak in May (Figure 11b) and the increase corroborates the projections of earlier snowmelt and increased rainfall described in the introduction to this report.

The results for the dry summer period show a decline in monthly discharge for each of the May-September period. The greatest decline occurs in July and the lowest values are projected for September.

Based on the month by month projections it is evident that the Kemp Creek stream flow is projected to increase over the November – April, and a decease in Maymarginally in October.

A note of caution is needed her because there is little opportunity to calibrate the modeled results because only 7 month of measured flow data is available (Jan 1929-Dec 1920). From the Calibration in Redfish Creek it appears that the modeled data is significantly underestimating the actual flow. However, it is not possible to suggest that the same trend applies to the Kemp Creek. We will examine the Redfish Creek Data to determine if we can better calibrate the data because Redfish and Kamp Creek have pretty much the same elevation distribution. Results will be available for the June meeting in Kaslo.

Water demands in relation to supplies

The water-use data for domestic and golf course use was collected by Martin Carver from the Kaslo treatment plant and covers the 2006-2009 period. These demand values were compared with the projected monthly supplies from Kemp Creek.

2.1.Water use in Kaslo: The amount of water released from the Kaslo treatment plant is provided in Table 1. Unfortunately only 3.5 years of domestic water-use data was available, and at the time of preparing this report, the rainfall data for Kaslo was not available for 2007-2009. As a result, it is not yet possible to determine if any of the 2007-2009 years were dry or wet years relative to the long term record. The 2006 year, for which the climate record is available, had above annual rainfall (982 mm/year versus the long-term mean (time period) = 855mm/year).

The water use records show that there has been great variability in water used seasonally and from year to year historically. The greatest domestic water use has been in July and August and the approximate daily water use on an annual basis is between 1077-1196 L/person/day (based on 1500 residents). However, summer use in July and August can reach over 2342 L/person per day. These calculations include the Golf course water use, which is provided in Table 3. Even if the golf course use is excluded the annual average was 1094 L/person/day during 2007-2009.

The golf course water use is highest in May and June ranging from 13-18% of domestic water use. This drops to about 6% during July and August when the residential water use is the highest.

Table 1. Monthly water supplied to Kaslo residents from the treatment plant 2006-2009

Month	Total Use During Each Month (litres/month)			
	2006	2007	2008	2009
Jan		37514223	36091874	40608671
Feb		32975187	30095249	30293974
Mar		34401390	32307180	41038310
Apr		39055632	32023889	40645510
May		50876426	47802967	48692544
Jun		60429515	63198762	65671039
Jul	108880359	104506146	96067647	82100288
Aug	102431043	91388387	77045644	77917924
Sep	68165000	63689510	51296581	62185346
Oct	52200629	47109465	43776027	47274353
Nov	40958299	41347930	39701501	43039744
Dec	41738933	51615290	41628867	54608276
Total		654909101	591036189	634075979

Table 2. Daily water consumption by month per person in Kaslo in 2006-2009

Month	Avg Use (litres/day/person)			
	2006	2007	2008	2009
Jan		807	776	873
Feb		785	692	721
Mar		740	695	883
Apr		868	712	903
May		1094	1028	1047
Jun		1343	1404	1459
Jul	2342	2247	2066	1766
Aug	2203	1965	1657	1676
Sep	1515	1415	1140	1382
Oct	1123	1013	941	1017
Nov	910	919	882	956
Dec	898	1110	895	1174
Average		1196	1077	1158

Table 3. Amount of water used for the golf course and % of monthly domestic supply

Month	Golf Course Daily Use (m3/day)			Golf Course Proportional Use(%of Village total)			Golf Course Monthly Use (m3/month)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
Mar									
Apr	125.5	175.9	52.3	9.6	16.5	3.9	3765	5277	1569
May	217.2	195.8	230.2	13.2	12.7	14.7	6733	6070	7136
Jun	265*	376.7	197.3	13.2*	17.9	9.0	7950*	11301	5919
Jul	265*	128	158.7	7.9*	4.1	6.0	8215*	3968	4920
Aug	265*	24.1		9.0*	1.0		8215*	747	
Sep		16.8			1.0			510	

*Based on Jun-Aug average use by golf course

2.2. Demand vs. Supply: Having obtained some information on water an attempt was made to compare the projected stream flow from the modeled scenarios.

For the critical month of July-September the demand largely exceeds the projected supply for all years between 2010 and 2039 by more than 200% in all years. This suggests that the Kemp creek modeled projections a are clearly unreliable. Suggestions have been made to PCIC to see if they can come up with a more appropriate modeling result.

Given the uncertainty in the modeled data, and the very high domestic water use data the results suggests that water conservation is the most viable option. Unfortunately Environment Canada has not yet made available the temperature and rainfall data for 2007-2007 and as a result it is not possible to determine whether these 3 years of consumption data occurred during a year of above or below the norm for historical temperature and precipitation. It is expected that the demand will be higher in hot and dry years and none of these projections take into consideration population growth and land use changes and intensification.

5. Summary:

The historic climate record shows that total monthly maximum temperatures have increased in both late winter and late summer with the highest increases in January-February and September. The total annual precipitation (rain & snow) is showing no clear trend from 1950-2006. However, there has been a marked decrease precipitation in January and February and an increase in March and April. Snow accumulation, particularly at lower elevations, has declined between January and March with the largest declines in February. This shifts are likely resulting in earlier season peak flow. The summer rainfall shows high year to year variability with July and August rainfall declining since the mid 1970's. This means less base flow as a result of higher temperatures, more evaporation and less rainfall.

There is evidence that the projected annual discharge for Kemp Creek is increasing, but the more dominant change is projected for the seasonality or when the water arrives throughout the year based on modeled discharge. Streamflow is projected to increase most predominantly in Between November to April, with a decline over the May-September period. The reduction is most pronounced in July at a time when the water demand and environmental stress is usually the highest.

There are only 3.5 years of domestic water use data available and the highest demand usually occurs in the July-August period. The average annual consumption (water released from the treatment plant) suggests that the per capita water use is between 1000-11000 L/person/day (excluding water use for the golf course).

The highest water use for the golf course in May and June ranging from 13-18% of the domestic water used. This drops down to 6% of domestic water used in July and August when residential demand can reach to more than 2300 L/person/day.

Comparing water use in Kaslo with projected discharge in Kemp Creek is difficult because it is apparent that the modeled data provided by PCIC vastly underestimates the supply. PCIC is informed of this and we will respond once we get feedback.

Calibrating the modeled data with measured data was done in Redfish Creek and the results suggest that the models over-predict measured data during the peak flow period and under-predicts measured flow in June and July (report is forthcoming). It is not possible to determine if this also applies to the Kemp Creek modeled data but if this indeed the case then the water shortages will likely be higher.

This analysis suggests that the anticipated climate change described in the introduction as summarized from previous work can be verified, at least in part, by trends in the historic climate data and some of the modeled discharge data. The results suggest that earlier peak flow and lower summer low flow should be of concern. Considerable differences exist between the projections of the 7 GCMs and these projections should be considered with caution since they are derived from a modeled tailored for use on larger watersheds. The model was not calibrated to the Kemp Creek watershed directly, as there is no calibration data is available. Additionally, Kemp Creek is represented here with portions of only 3 grid cells from the VIC model. That being said, the projected changes align with projections from other studies and compare well to trends already occurring in nearby watersheds. Considering the consequences of the projected changes and agreement of models towards increased winter and reduced summer flows, the need to adapt to these changing conditions is evident. There are ample adaptation options particularly in terms of water conservation, which is likely the most expedient and cost effective measure to be taken in the short term.

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Mote, P.W. and Salathe, E.P.J., 2009. Future climate in the Pacific Northwest, Chapter 1: The Washington Climate Change Impacts Assessment. JISAO Climate Impacts Group, University of Washington, Seattle, WA, USA. pgs. 21-43. http://cses.washington.edu/cig/res/ia/waccia.shtml

Saltahe, E.P. P.W. Mote and M.W. Wiley, 2007. Review of scenario selection and downscaling methods for the assessment of climate change impacts on hydrology in the United States pacific northwest. International Journal of Climatology, 27: 1611-1621.

GIS 331

Comparison of Kaslo Watersheds

Cris Gray, Katie Ward, Melissa MacLeod

5/21/2010

We have collected information and classified the physical characteristics based on slope, aspect, percent vegetation, percent area lakes, and geology. None of the watersheds encompass any glaciers. We do not have annual temperature, precipitation/snow data. Based on our findings, the three Kaslo watersheds are different from Redfish Creek. We recommend further data collection in the local watersheds to allow for a more meaningful comparison.

INTRODUCTION

Earth's climate is changing; these changes are predicted to have a large impact on global communities. Climate change impacts threaten to alter snow pack characteristics, stream peak flow, water quality, and water availability. Snow fall rates are predicted to decrease over time and snow pack melt rates to increase causing greater peak flows arriving earlier in the year. These changes in the hydrologic cycle are likely to increase periods of low flow in streams producing potential drought conditions.

The Kaslo water basin is an important freshwater resource for the area, providing water for irrigation, domestic, commercial, and hydropower uses. As water use increases with growing populations and climate change affects the amount of water supply available is decreasing, limiting the amount of water available for the Kaslo community as well as for fish and wildlife.

The village of Kaslo has received funding from the Columbia Basin Trust (CBT) for its Communities Adapting to Climate Change initiative. The purpose of the initiative is to help communities address issues they feel are locally important in relation to climate change and develop strategies. Kaslo identified water supply and food security as important issues.

Our group at Selkirk College has undertaken the task to describe and compare physical characteristics of three of the major watersheds in the Kaslo area. Kemp Creek, Bjerkness Creek and Fletcher Creek watersheds will be compared to Redfish Creek watershed, where extensive data has been collected since 1932. These watersheds are snowmelt dominated with no input from glaciers. A model is being designed by a hydrologist from Pacific Climate Impacts Consortium (PCIC) to assess stream flow from snowmelt dominated watersheds (based on Redfish data). The purpose of this characterization is to provide information to aid in the assessment of how climate change will impact the quantity and quality of year round water resources available to the Kaslo Region.

STUDY AREA

Three of the study watersheds; Kemp Creek, Bjerkness Creek and Fletcher Creek are near the village of Kaslo and provide water resources for the village and surrounding communities. Redfish creek watershed is about 30 km SW of Kaslo (Figure 1)

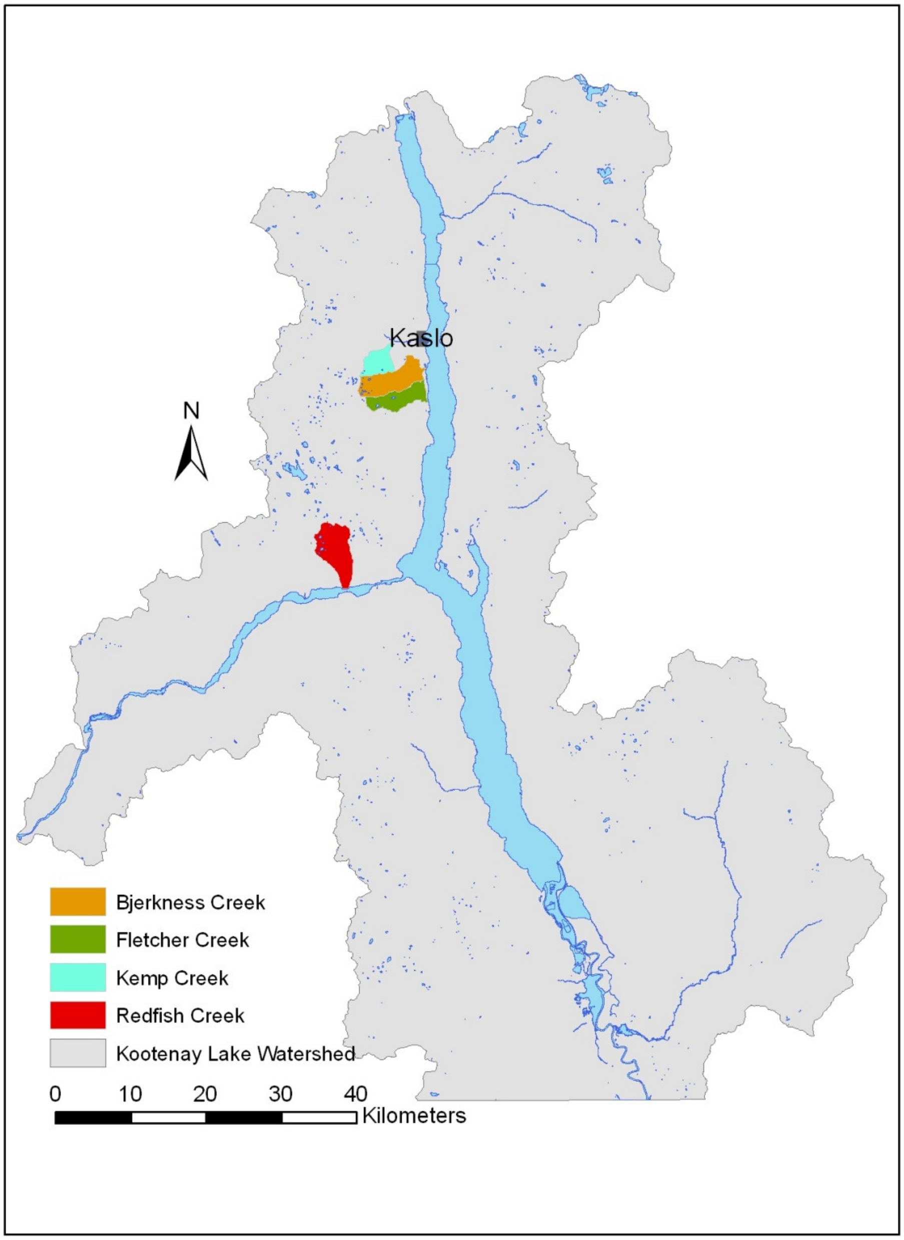

Figure 1. General study area of the watersheds of interest within Kootenay Lake watershed.

Characteristics of Study Streams

Redfish Creek

Redfish Creek is a 4^{th} order stream that flows southward into the west arm of Kootenay Lake. It has an area of 2729.1 ha with an elevation ranging between 530 and 2362 m. The watershed spans two major biogeoclimatic zones, ICH (interior cedar hemlock) up to 1200 m and ESSF (Engleman spruce and sub-alpine fir) between 1200 and 2000 m. About 6% of the watershed area is estimated alpine (Jordan & Fanjoy 1999). The watershed is teardrop shaped with the mainstream channel running down the middle of the watershed. Redfish Creek is steep and confined along most of its length.

Kemp Creek

Kemp Creek is a fourth-order stream that flows northeastward into the Kaslo River. The watershed basin has an area of 1271.3 ha ranging in elevation from 659 to 2429 m. The creek is fed by tributaries that cascade down its steep valley walls into its two main branches (Sundberg 2000). The area we determined for Kemp creek seems to be considerably higher than that from other sources, which all reference 1997 IWAP (BC 1997)(11.81 km^2).

The alpine upper section of the Kemp Creek watershed has steep, glacier-carved valley walls with avalanche-scarred slopes. Above the village water intake, the creek flows through a steep, V-shaped valley with unstable walls (Wells 1995). Kemp Creek is a community watershed providing water to the waterworks local authority of Kaslo, which then distributes it to residents of Kaslo for domestic purposes.

Fletcher Creek

Fletcher Creek basin has an area of 1785.3 ha and ranges in elevation from 620 m to 2520 m at the northwest margin of the drainage. A number of small tributary streams in the upper portion of the basin feed Upper Fletcher Lake at an elevation of 1967 m.

Bjerkness Creek

The longest of the study streams, Bjerkness Creek is a third-order system that originates in a cluster of alpine lakes on Trafalgar Mountain (elev. 2554 m). The main Bjerkness Creek has an area of 2706.6 ha and ranges in elevation from 548 to 2566 m at the west margin of the drainage. Several small streams drain into Bjerkness Lake at 1910 m elevation (Masse 2001). Bjerkness Creek is a community watershed providing water to the community of Mirror Lake for domestic and irrigation purposes.

METHODS

Watershed Spatial Data

The sub basins of interest; Redfish, Kemp, Bjerkness, and Kemp were clipped from the BC corporate watershed Base project (BC CWB)watershed shapefile feature class using the clip tool in ArcGIS 9.3 ArcMap application. Watershed boundaries were identified from the BC CWB project datasets. Associated spatial data layers of interest including TRIM 1:20000 streams, lakes, contours, and a digital elevation model (DEM) raster of resolution 25m x 25m were clipped to each of the four watersheds. All shapefiles were transformed to geodatabase feature classes and stored in a feature dataset for each watershed.

A model was created in ArcInfo to classify the DEM into slope, aspect and elevation slice rasters. This was edited for each of the watersheds. Model environments were set to the spatial extents of the utm_82F DEM with a cell size of 25. Parameters were set for model inputs and outputs. Each watershed required model parameters modification due to their spatial differences. Raster outputs were not put into the geodatabase, they were placed into watershed specific file folders.

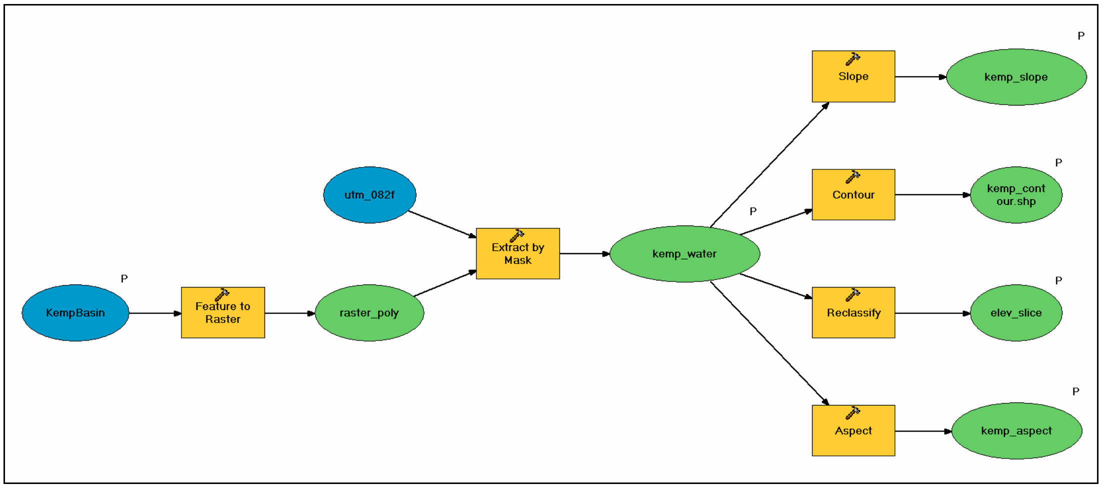

Figure 2. Model created in model builder for raster creation from a DEM.

A basin shapefile for the desired watershed was added as an input to the model and processed with the feature to raster tool to create a raster of the watershed. This raster was then used to select watershed area from the DEM with the extract by mask tool. This produced a DEM raster of the selected watershed area. From each watershed DEM :

- A slope raster was created with the slope tool
- Contours were created (output shapefile) with 100m intervals
- Reclassification was performed on the raster to divide it into elevation slices at 100m intervals as well as 6 equal intervals of 400m
- An aspect raster was created with the aspect tool

Each output raster created was a 32-bit floating point data type which could not produce an attribute table. To extract pixel values from aspect and slope rasters, we used the sample tool and extracted discrete values based on the 6 elevation slice rasters. This created a table that was exported to a dbf table and opened into excel. Data was manipulated to give us the sampled aspect and slope values for each elevation slice for each watershed. This data is located in folder GISData\STATS\AllSlopeAspect.xlsx

Watershed Analysis and Statistics

Area (ha) of each watershed was determined from the clipped DEM rasters using the 3D Analyst area and volume statistics tool in ArcMap. This tool calculated the 2D and 3D surface area for each watershed.

Random rasters were created for each watershed using the Create Random Raster Tool in ArcMap to select random sampling points in order to statistically analyze the watersheds. The random raster was then reclassified to produce random sampling points that characterized approximately 10% of each of the watershed areas. This sub-sampling technique was done by calculating the total amount of pixels in each watershed area and selecting approximately 10% of these random pixels. Figure 3A and B present the random raster produced for Kemp Creek watershed and the 10% random points generated for statistical analysis. Table 1 below presents the random point's selection process. The Actual number of pixels selected for sub-sampling was determined using the random raster attribute table and selecting the record with pixel counts closest to 10% of the total.

Table 1: Production process to extract random sampling points.

Watershed	Total # of Pixels in Watershed Area	10% of the Pixels	Actual # of Pixels Selected as Random Points
Fletcher	28564	2856	3358
Kemp	20340	2034	2361
Bjerkness	43305	4331	5031
Redfish	43665	4367	4996

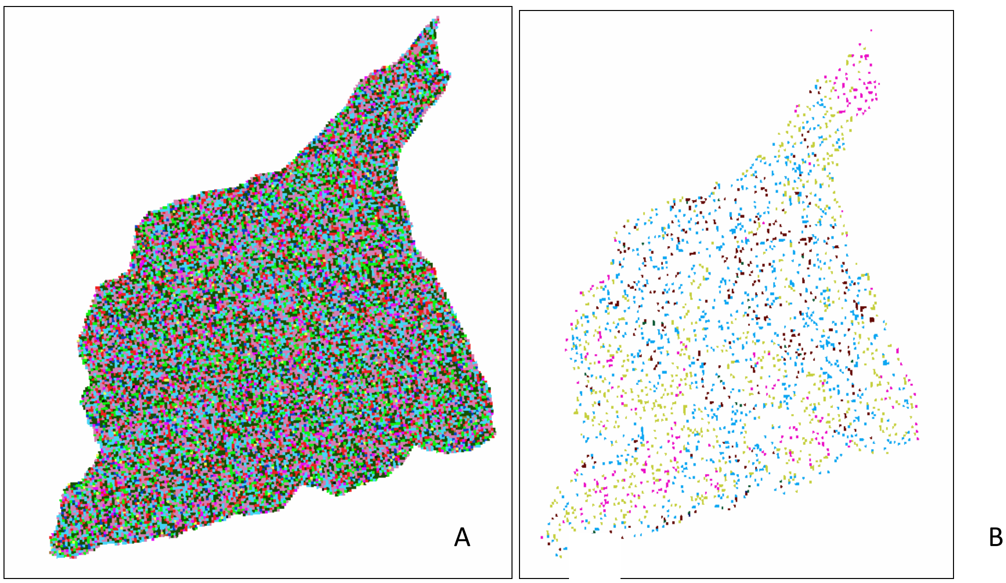

Figure 3A: The random raster created for the Kemp Watershed. Figure 3B: 10% of the random raster selected as random sampling points for the watershed.

Maps of elevation slices for each watershed and graphs depicting percent area of watershed for each elevation slice were produced. River length elevation profiles for the main stream stem in each watershed were also produced. Elevation values for the streams were extracted from each clipped DEM using the 3D Analyst feature to 3D conversion tool.

RESULTS

Physical characteristics of the watersheds are summarized in table 2. Statistical analysis was performed on Aspect and Slope only.

Table 2. Watershed Characteristics

Measure	Redfish Creek	Kemp Creek	Fletcher Creek	Bjerkness Creek
Watershed code	340-186300	340-215300-16300	340-214600	340-215000
Aspect	S	NE	E	E
Length (km)	8.69	6.46	9.28	10.23
Watershed Area (ha)	2729.1	1271.3	1785.3	2706.6
Min Elevation(m)	532	659	532	548
Max Elevation (m)	2362	2429	2520	2566
Elevation change (m)	1830	1770	2018	1988
Stream magnitude	10	5	2	11
H60 (m)	1700 (H65)	1860	1700	1700
Shape	Teardrop	Teardrop	Elliptical	Elliptical
% lakes	0.75	1.23	0.70	0.84

Biogeoclimatic Subzones

The study watersheds traverse four different biogeoclimatic subzones (Wells 1999). Figure 4 shows a graphical representation of the BEC zones over the study watersheds. The Interior Cedar-Hemlock (ICH) zone is a highly diverse zone with the highest number of tree species of any zone in the province. The ICH zone is typified by western red cedar and western hemlock. Elevations below 1,200 m occur in the Dry Warm ICH Subzone (ICHdw) which commonly occupies valley bottoms in the region. The ICHdw region is present in all of the study watersheds. Soils typical of this region are Brunisols which are more common in this drier subzone (Marcoux 2004). The Moist Warm ICH subzone (ICHmw2) extends from 1,200 m to 1,550 above the ICHdw in this study area. Podzolic soils are common in the wetter ICHmw2 zone.

The upper part of the Redfish watershed is occupied by the Engelmann Spruce – Subalpine fir zone (ESSF). This is a high elevation subalpine habitat. The Selkirk Wet Cold ESSF Subzone (ESSF-wc4) occurs in elevations greater than 1,650 m and can receive precipitation exceeding 1,000 mm annually. All four watersheds occupy the ESSF-wc4 zone. Podzolic soil with a thick organic layer is common in the ESSF zone. Late season snow melt that is critical for refilling of reservoirs is provided by the ESSF zone and other high elevation zones.

The highest elevations within this study area are in the Alpine Tundra (AT) undifferentiated and Parkland or Wet Cold Parkland Engelmann Spruce-Subalpine fir subzone (ESSFwcp) above 1,950 m (Braumandl 1992). The Alpine Tundra zone is not present in the boundaries of the Redfish drainage basin, but does occur in the 3 Kaslo area watersheds. Soils in the AT zone are largely undeveloped regosols or weakly developed brunisols as this zone is typically the last zone of glacial retreat.

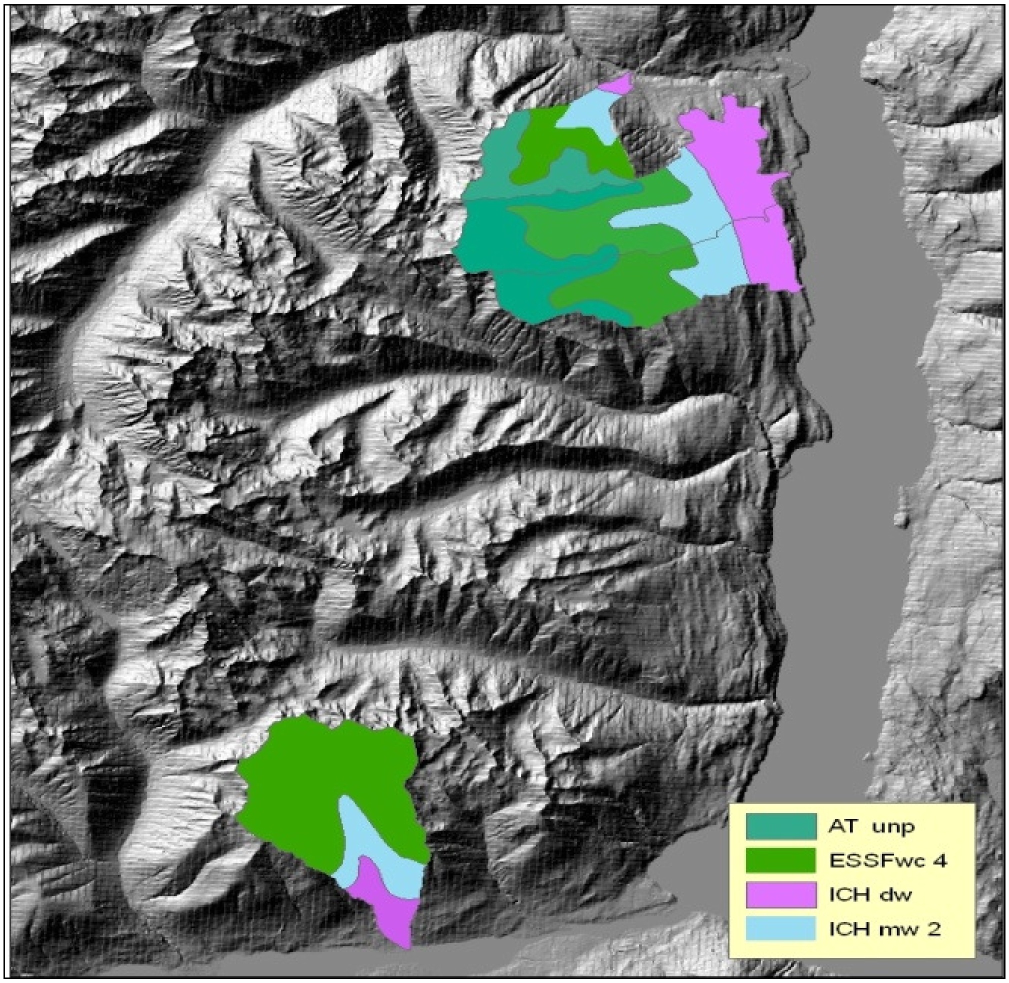

Figure 4. Biogeoclimatic zone classification for study area watersheds

Geology

The study area is largely underlain by coarse granodioritic intrusive bedrock of the Nelson intrusion (Jordan & Fanjoy 1999). The Redfish watershed is made up entirely of a uniform distribution of intrusive granodiorite rock, whereas the three Kaslo watersheds are underlain by 5 different geology types. The bedrock of the Kaslo watersheds includes the Triassic Slocan group which consists of limestone, slate, siltstone and argillite; this bedrock also includes deposits of volcanic basalts and sedimentary rocks (Figure 5). The Triassic Slocan group covers the largest area of the three Kaslo basins.

Soil textures within the study area are mostly of silty loam texture, and soil is typically well to moderately well drained, with some seepage areas. (Jordan 2007)

A large amount of research has been done on sediment patterns in streams within the Redfish Creek watershed (Jordan & Fanjoy 1999). The largest source of sediments within Redfish is from logging and associated roads (Jordan 2001).There is also moderate sedimentation within Kemp Creek watershed due to a large fire that occurred in 2007 (Jordan 2007).

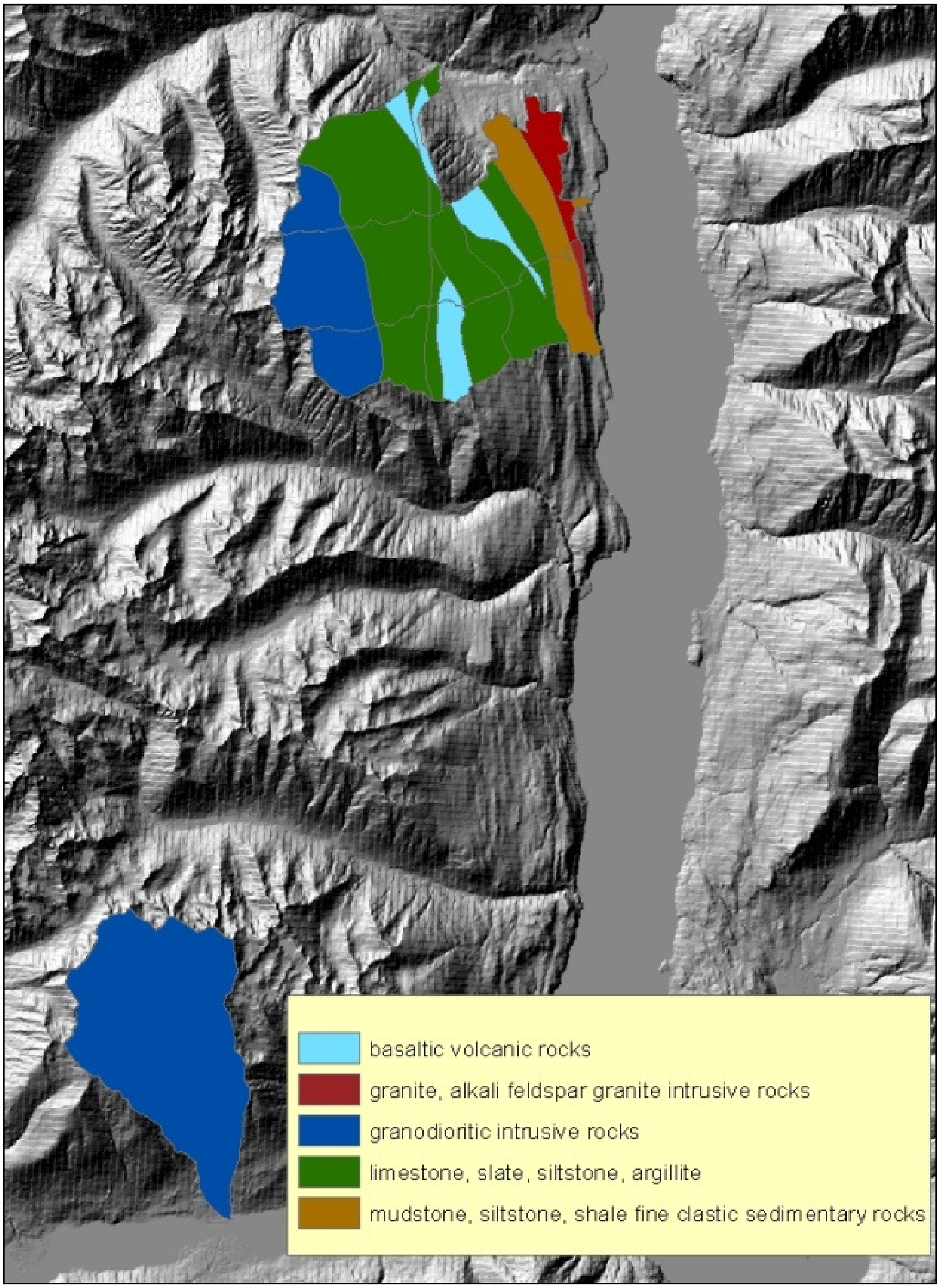

Figure 5. Rock type classification of the study watersheds.

Water Licenses

Water license information for 2009 is displayed below in table 3. The licenced water values were converted to a common unit of gallons per day. No information could be obtained for the actual water used or water available. Licenses are granted for the amount of water use allowed but no data has been collected for actual use. Figure 6 shows the comparison of different uses for each watershed.

Table 3. Summary of Water License data (did not graph "Conserve" category as we were unable to determine what this was.)

Water source	Waterworks Local Authority	Domestic	Irrigation	Lawn & Garden/Watering	Residential Power	Conserve (use of water)	Stock water	Enterprise
	GD(Gallons/day)	GD	GD	GD	GD	GD	GD	GD
Kemp	2098260							
Bjerkness		37500	180306.6	12324.3			200866.4	1000
Fletcher	60000	12500	61822.2		161481.6			
Redfish		20875	14114.2		313992	4485600		

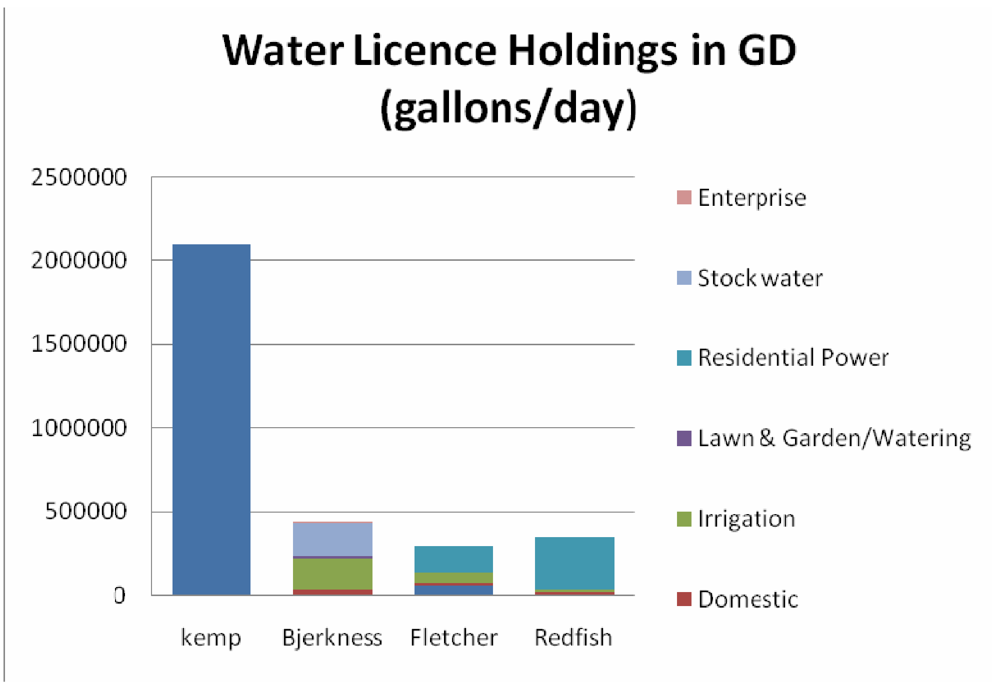

Figure 6. Graphic representation of water use for each watershed in the study.

STATISTICAL ANALYSIS

Initial exploration of the dataset for aspect and slope suggested that there is not a significant difference between elevation slice values. We decided to exclude elevation slice blocking from our analysis.

Eastness

The analysis of variance (ANOVA) test was performed on eastness values between watersheds and produced a resultant p-value of < 0.05. This p-value indicates that there is a significant difference in east values between watersheds.

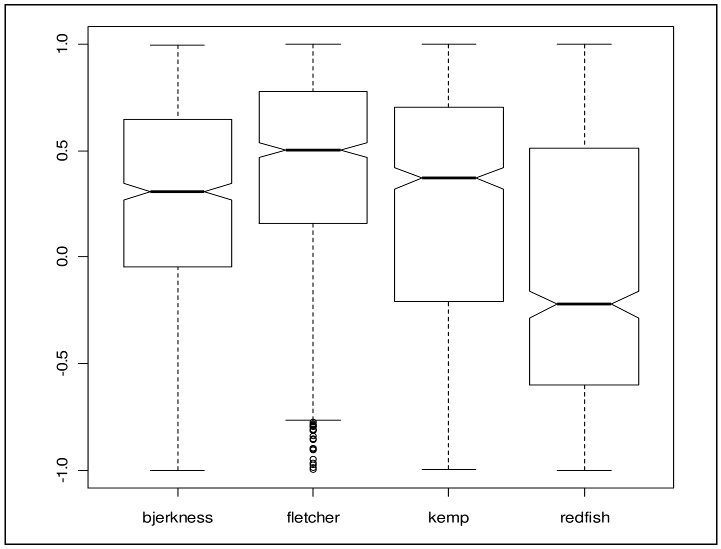

Figure 7 .Boxplot representations of watershed for east[3] aspect values.

The box plots in figure 7 indicate that Bjerkness and Kemp basins may not be significantly different from each other. Further analysis using the Tukey test confirmed the assumption that Bjerkness and Kemp are not significantly different from each other while all other combinations of watershed comparisons are significantly different.

Northness

Northness values for each watershed were compared statistically using the ANOVA test. This test produced a p-value of < 0.05 which indicates that there is a significant difference in northness values between watersheds.

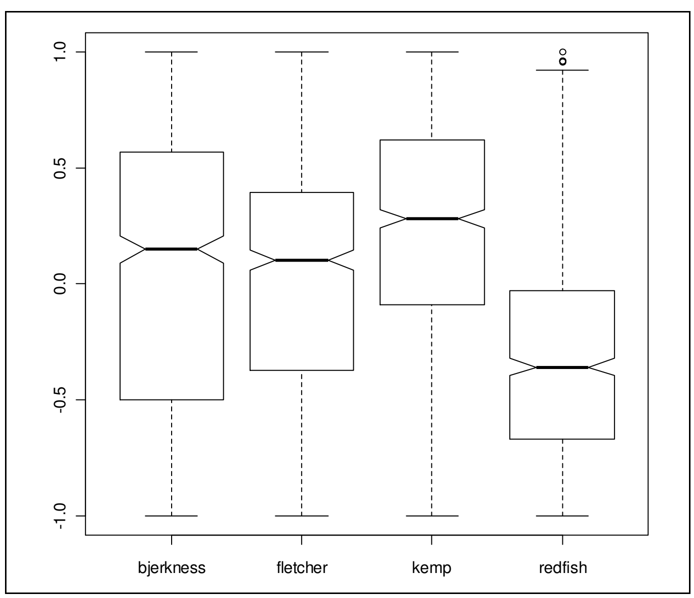

Figure 8. Box plots by watershed for north[3] aspect values.

Box plots were used to visualize the northness differences between watersheds (figure 8). The overlapping values of the Fletcher and Bjerkness 95% confidence intervals indicate that these two watersheds may not be significantly different. The Tukey test was used to test which of the watersheds are significantly different. The Tukey test confirmed that Fletcher and Bjerkness do not have significantly different north values (p-value > 0.05).

Slope

Initial exploration of the slope data indicated that the data is not normally distributed. To normalize the slope data a square root transformation was applied the values and resulted in a normal distribution. The ANOVA test was run and produced a p-value of < 0.05 which indicates a significant difference between slope values in all watersheds. Box plots were used to visualize this analysis (Figure 9). The overlapping 95% values in figure 9 indicate that Redfish and Fletcher watersheds are not significantly different. The Tukey test supported this conclusion made from the box plots. Results indicate that for all other watershed comparisons there is a significant difference between slope values.

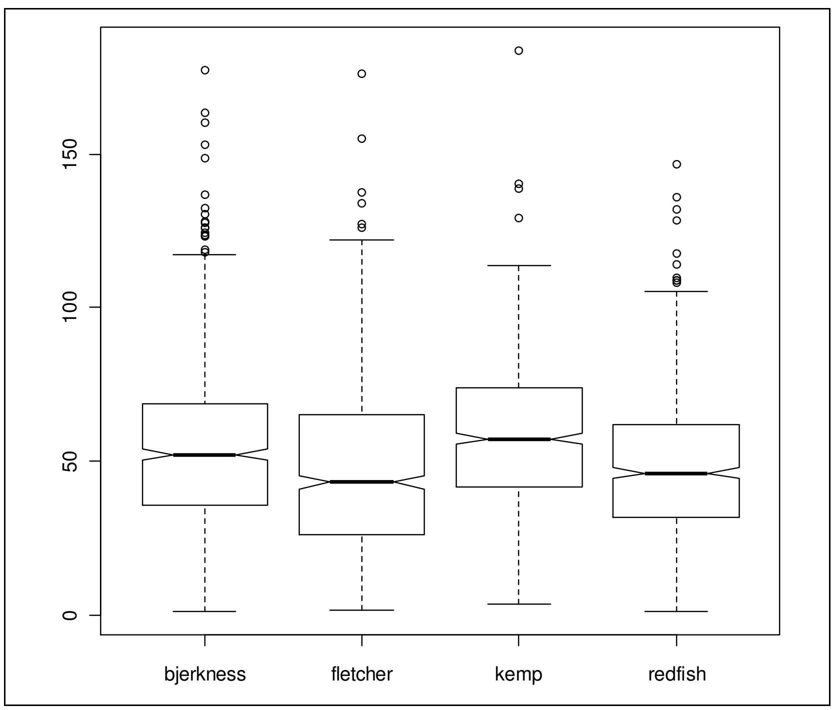

Figure 9. Box plots by watershed for sqrt(slope) values.

DISCUSSION

The primary goal of this study was to determine if the three Kaslo watersheds: Kemp, Fletcher, and Bjerkness Creeks are similar enough to Redfish Creek watershed to use a model based on data from Redfish Creek. The statistical and physical analysis results of the watersheds show that the four watersheds are significantly different.

Slope and Aspect were the only variables looked at statistically as they are important to the dynamics of water flow in the system. Slope of the landscape has a large influence on the rate and direction of water flow; this is a valid parameter to compare these watersheds. Aspect strongly influences the rate of snow melt as well as evaporation of water throughout the watershed area.

Redfish Creek watershed has a southerly aspect whereas the three Kaslo watersheds have a north-easterly aspect. Aspect is important in determining the hydrological characteristics of a watershed. Watersheds with a northerly aspect are likely to have greater water storage in snowpack and will experience a slower snow melt rate during the spring compared to watersheds with a southerly aspect.

The Kemp Creek watershed has an overall greater slope value than the other three watersheds. This result may indicate that the Kemp Creek Basin will experience a greater drainage rate. A greater drainage rate in Kemp Creek is significant as this basin has the greatest amount of water licenced to be withdrawn from it. Kemp Creek basin also has the potential to be greatly impacted by climate change as it is the smallest watershed, with possibly the greatest drainage rate, and provides the most water to consumers within our study.

The three Kaslo watersheds are not only different from Redfish but different from each other. Further data collection in the area is recommended prior to any major decisions being made. We recommend that data on precipitation, snowpack and temperature be collected at each of the watersheds to determine how much water is available in the system at a given time. A number of license holders draw water from these watersheds but there is great uncertainty as to how much is actually removed from the system. Quantification of water consumption rates needs to be determined in order to make any predictions about future water availability.

RECOMMENDATIONS

Based on our findings, the following recommendations would enable a more complete comparison:

- set up local weather stations – precipitation, temperature, snowpack
- collect information on stream flow (water availability) and water usage (metering)
- combine data from multiple watersheds and average to make model
- further analysis to consider Redfish data to be used to represent Kaslo watersheds

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Pg 323, 160.

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DATA SOURCES

Raster Data sets

produced from DEM UTM 082F raster, 25mx25m spatial resolution.

Original source file path in SGRC data sets: O:\GIS_Data\topo\dem\20k\082f\grid\utm_082f

Spatial Reference: NAD83 UTM Zone 11N

- Aspect Raster
- Slope Raster
- Elevation Slices
- Randomized raster for statistical analysis: Randomized Block Analysis

Feature Classes

Feature classes were produced from shapefiles and coverages using a feature class to feature class transformation tool. The original data files are from:

- Streams data : TRIMii streams shapefile tiiwtr arc.shp:
  Kootenay Regional Coverage of TRIMii Water Features. Extracted from TRIMii library on Provincial Server. Datum: NAD 83. Resolution: 1:20 000.
- Lakes data :TRIM water features coverage feature class, twtra_r4:
  Kootenay Regional Coverage of TRIM 1, 2001. Datum: NAD 83.
  Resolution: 1:20 000.
- Watershed boundary data: Produced from TRIM Water Atlas 1: 20 000 Heights of Land using Barrodale Height-of-Land generation software from the BC Corporate Watershed Base Project. Original shapefile: CWB_NAMWTR.shp. contains watershed boundaries and names. Datum: NAD83
  Corporate Watershed Base Project (2006). Refractions Research Inc. Victoria, BC.
- Geology data: TRIM Raster/tif/utm11/082f/bc_082f005_xc2m_utm11.zip
  downloaded from GeoBC http://geobc.gov.bc.ca

Appendix J - Web links

Regional District of Central Kootenay

Regional District of Central Kootenay
www.rdck.bc.ca

SustainAble Central Kootenay
www.rdck.bc.ca/publicinfo/climate_change/sustainable_central_kootenay.html

Fire smart program
www.rdck.bc.ca/publicinfo/community_wildfire_protection_plans/community_wildfire_protection_plans.html

Emergency preparedness plan
www.rdck.bc.ca/community/emergency/prepared_for_disaster

Carbon Neutral Kootenay
Work towards carbon neutrality by 2012.
www.rdck.bc.ca/publicinfo/climate_change/carbon_neutral_kootenay.html

Kaslo

Kaslo village
www.kaslo.ca

Kaslo Food Security Project
www.nklcss.org

Kaslo information including voluntary sector groups
www.kaslo.com

Kaslo & District Community Forest Society
www.kaslocommunityforest.org

Columbia Basin Trust

www.cbt.org

Water smart initiative
www.cbt.org/Initiatives/Water/?Quantity

Climate change adaptation resource kit
http://cbtadaptation.squarespace.com/

Others

Kootenay Organic Growers Society
www.kogs.bc.ca

Carbon Neutral Kootenay Project
www.communityenergy.bc.ca/community-energy-association-connecting-community-sustainability-and-energy/carbon-neutral-kootenays-project

Kootenay Local Agrictultural Society
www.klasociety.org

Power Smart
www.bchydro.com/powersmart/

Current monitoring Columbia Basin lake levels
www.env.gov.bc.ca/rfc/data/asp/realtime/asp_pages/asp_2d08p.html

Kootenay lake levels
www.fortisbc.com/customer_service/lake_levels.html

Water-Supply, Snow Survey and drought reports
www.env.gov.bc.ca/rfc/bulletins/

BC Soils survey, Area D
Lardeau: http://sis.agr.gc.ca/cansis/publications/bc/bc27/intro.html
Nelson: http://sis.agr.gc.ca/cansis/publications/bc/bc28/intro.html

Pacific Climate Impacts Consortium - Plan2Adapt
http://plan2adapt.ca/

Climate change adaptation strategies

Castlegar *'A sustainable Castlegar'*
http://castlegar.ca/sustainable

Rossland *'Vision to Action'*
www.visionstoaction.ca/

Elkford
www.cbtadaptation.squarespace.com/storage/Elkford_CCA_Final_Report-_FINAL-31.pdf

Kimberly
www.cbtadaptation.squarespace.com/storage/June17Final-LowRes.pdf

Managing the risks of climate change: a guide for arctic and northern communities
http://ccrm.cier.ca/

Provincial

The Provincial Government is committed to a 33% reduction in the Province's total greenhouse gas emissions by 2020.
www.livesmartbc.ca/attachments/climateaction_plan_web.pdf

Adaptation strategy statement
www.livesmartbc.ca/attachments/Adaptation_Strategy.pdf

Fire and Climate Change:
http://www.firelab.utoronto.ca/people/mdf/climatechange.html

Climate change and biodiversity:
http://www.forrex.org/JEM/ISS48/vol9_no2_art4.pdf

BC Firesmart Manual
http://www.pep.bc.ca/hazard_preparedness/FireSmart-BC4.pdf

Federal

The Government of Canada is committed to reducing Canada's total greenhouse gas emissions by 17 per cent from 2005 levels by 2020. This target is completely aligned with the U.S. target, and is subject to adjustment to remain consistent with the U.S. target.

Climate Change Impacts and Adaptation program
www.adaptation.nrcan.gc.ca/index_e.php, but no tools available for local communities. Page last updated 7 December 2009.

There are country-specific initiatives which are spearheading climate adaptation being lead by governments, academic institutions or, for example:
British Columbia Region Adaptation Collaboratives
www.adaptation.nrcan.gc.ca/collab/colcol_e.php

UK Climate Impacts Programme (UKCIP)
www.ukcip.org.uk

National Climate Change Adaptation Research Facility
www.nccarf.edu.au/conference2010

Green and Blue Space Adaptation for Urban Areas and Eco Towns (GRABS) - network of leading pan-European organisations involved in integrating climate change adaptation into regional planning and development.
www.grabs-eu.org

Adapting to CC in Australia
http://www.climatechange.gov.au/government/adapt.aspx

Appendix K - Land use planning, the Official Community Plan

Land use planning

Area D Official Community Plan contains many position statements, statements of intent and policy which support the Project Mission Statements. Supporting statements are reproduced below with the appropriate paragraph or policy numbering.
http://www.rdck.bc.ca/publications/bylaws/1996_Kootenay%20Lake%20Lardeau%20Valley%20OCP.pdf

Top 5 Community Values in Kootenay Lake North
1. Clean air and water
2. Scenic beauty
3. Wildlife and its habitat
4. Feeling of safety
5. Peace and quiet

(Source: 2009 Survey of Kootenay Lake and the Lardeau Valley residents and property owners)

5.0 AGRICULTURE
Background
Lands within the Agricultural Land Reserve can be found throughout the flats and benches of the Plan area, concentrated in many of the unincorporated communities north and in and around the Village of Kaslo. All communities north of Kaslo have historically been involved to some degree in commercial agriculture.
Lands designated as Agriculture in Schedule 'B' include areas within the Agricultural Land Reserve and additional lands with the identified potential for agricultural operation or activity. Agricultural operations and activities are also dependent on lands located outside of the Agriculture designation in Schedule 'B'.

Agriculture Objectives

1. To preserve agricultural land with continuing value for agriculture for current and future production, and to protect this land from uses which are inconsistent with agricultural use or are incompatible with existing agricultural uses in the area.

2. To minimize conflicts between agriculture and other land uses.

3. To encourage the agricultural sector's viability by pursuing supportive land use policies within and adjacent to farming areas and to ensure adequate water and land resources for agricultural purposes with recognition of the importance of local food production.

4. To examine any ALR boundary changes initiated by property owners, the RDCK, and the Province which reviews agricultural suitability in the Plan area.

5. To support a strategy for diversifying and enhancing farm income by creating opportunities for uses secondary to and related to agricultural use.

6. To encourage agricultural producers to consider environmental values during agricultural activity.

7. To encourage opportunities in agricultural skill building and education in Kootenay Lake and the Lardeau Valley in recognition of the area's agricultural heritage and to promote self-sufficiency and local food production.

The Regional Board policies:

1. Encourages that the principal use of lands designated as Agriculture in Schedule B shall be agricultural or residential.
2. Recognises the value of agriculture in the Plan area.
3. Ensures that all land use and subdivision of land within the ALR shall be in accordance with the provisions of the Agricultural Land Commission Act, associated regulations, orders and decisions of the Provincial Agricultural Land Commission.
4. Will work with the Province to ensure that new development adjacent to agricultural areas provides sufficient buffering in the form of setbacks, fencing and landscaping consistent with Provincial specifications.
5. Supports the preservation of environmental values, and where possible conserving these values, in conjunction with sustainable agricultural practices, Provincial Acts and Statutes, and associated amendments to the *Local Government Act*.
6. Will encourage food processing activities within the Plan area, and uses secondary to and complementary to agricultural production, such as market gardens, agri-tourism, farmers markets and farm gate sales.

7. Will support enhanced educational and training opportunities in agriculture in conjunction with local educational institutes, school districts and private initiatives.
8. Supports that lands under the Agricultural designation used for conservation purposes be encouraged to consider maintaining the agricultural value and/or use of such lands.
9. Will consider the impacts on local food production and self sufficiency when making land use decisions on lands within the Agricultural Land Reserve and/or designated Agriculture, including but not limited to:
   a. Soil capacity;
   b. Water resource
   c. Capability for agriculture

6.0 RESOURCE AREA

Background

For the purpose of this section, Resource Areas are described as large parcels of land and include both private and/or Crown land. Typical uses include forest land, grazing or range land, public recreation areas, tourism, watersheds, and resource extraction areas. Although it is recognized that local land use designations do not apply to the Crown, the designation is intended to provide regulations upon alienation, and to address Crown leases.

Resource Area Objectives

5. to encourage that the economic values associated with water resources within the Plan area provide benefit to the community. **(water)**

Resource Area Policies

The Regional Board:

2. For the purpose of subdivision of lands, supports larger minimum parcel sizes for ‘Resource Area’ designations, in recognition that these areas will remain rural with limited community services and infrastructure. **(agriculture)**

6. Will work with the Province to ensure that community watersheds and sources of domestic water supply are recognized and protected within the Plan area. **(water)**

7.0 RESIDENTIAL

General Residential Objectives

10. To take into consideration the service needs and resources required for new residential developments in recognition of limitations of water supply and sewage capabilities in localized areas within the Plan area. **(water)**

General Residential Policies

The Regional Board:

1. Will assess and evaluate proposed residential development based on the following criteria, irrespective of land-use designation:

c susceptibility to natural hazards including but not limited to flooding, slope instability or wildfire risk; **(hazard)**

2. Encourages future residential development to maintain adequate setbacks from Kootenay and Duncan Lakes and other riparian areas, to protect these important natural resources, reducing human impact and maintaining water quality and natural habitat. **(water)**

8.0 COMMERCIAL AND INDUSTRIAL

4. To support commercial agricultural opportunities in Kootenay Lake and the Lardeau Valley in appropriate locations. **(agriculture)**

11.0 SERVICING AND TRANSPORTATION

Servicing Objectives (water)

2. To ensure that new development proposals, including construction and subdivision of lands, do not put undue strain or pressure on existing domestic and irrigation water supply.

3. To ensure that water and sewer systems within the Plan area support good health and safety, and meet recognized standards of service.

4. To encourage that surface lake water sources for domestic and irrigation use within Kootenay Lake and the Lardeau Valley are identified and measures taken to ensure the long term quantity and quality of water supply are maintained or improved..

5. To support that new development be subject to the requirements of adequate water supply for both domestic and fire protection purposes.

6. To promote water resource conservation strategies and reduce water demand as much as possible through educative materials and voluntary incentives; particularly in areas where the water resource has already been over-subscribed.

7. To protect groundwater and surface water from degradation through improper disposal of water-borne waste.

Servicing Policies (water)

The Regional Board:

3. Requires that the acquisition of existing and new community water and sewer systems shall meet all policies of the Regional Board.

4. Encourages all users and government agencies having best management practices for the conservation of community watersheds in the Kootenay Lake and the Lardeau Valley area.
5. Applies the precautionary principle in ensuring that the density of land use is not increased in areas which are known to have concerns with supply of domestic drinking water.
8. Promotes the use of small scale residence, business and community generated power production and energy self-sufficiency and conservation.

12.0 NATURAL ENVIRONMENT

Natural Environment Objectives

1. To maintain high water quality of groundwater and surface water sources of domestic water supply. **(water)**
5. To encourage the creation of a watershed stewardship plan for the lakes, rivers and streams within Kootenay Lake and the Lardeau Valley **(water)**

Natural Environment Policies

The Regional Board:

1. Encourages the creation of a watershed stewardship plan for the lakes, rivers and streams within Kootenay Lake and the Lardeau Valley, including, but not limited to, an assessment of habitat values, provision of domestic and irrigation water, an assessment of risks, and opportunities for enhancement and conservation.

4. Supports the Provincial requirement that developers apply for and obtain appropriate permits and authorization for "Changes In and About a Stream" pursuant to Section 9 of the *Water Act.*

5. Encourages the retention of existing wildlife corridors and access to water. **(water)**

6. Encourages the Province to recognize environmentally sensitive areas, hazard areas, and areas upstream of alluvial fans, and uphold the strictest regulation for forest and mining or mineral development in these areas. **(hazard)**

10. Supports cooperation with Fisheries and Oceans Canada and the Province in the identification and management of sensitive habitat on Kootenay and Duncan Lakes and other riparian areas. **(water)**

17. Supports water conservation by residential, business and recreational users. **(water)**

Appendix L - Questionnaires

Farmers Questionnaire Summary
This questionnaire was passed to attendees of the North Kootenay Lake farmers meeting, as well as those in the Kaslo area and anyone else we could locate that may be involved in food production on a commercial scale within Area D.
As there are only 4 commercial farmers, described as selling to the retail market, in the North Kootenay Lake region, the facts about what is being produced and how much we are being fed by local farmers is a sad summary. However, if we were to include those who are growing their own food and feeding neighbors, we would see that we are rich with nutrients. The numbers of backyard gardeners has not been calculated, so the actual food production for Area D is still an unknown. For this summary, we have used the results from the above mentioned questionnaire and I must admit, it only paints a fraction of the reality.

<u>North Kootenay Lake Farmers Meeting</u>
20 attendees
10 questionnaires's returned
Of those 10:

- 4 were homesteaders
- 4 commercial farmers (2 selling farmgate, not retail as their product is not deemed "legal")
- 2 were potential farmers or working towards farming

Of the commercial farmers:

- 3 meat producers (beef, rabbit, chicken, goats- none are legal at this moment)
- 1 hay producer
- 1 grain producers
- 2 veggie growers
- 2 dairy (eggs, yoghurt, cheese)
- 4 organic, 0 certified

Not on the surveys, but observed in comments:

- 2 retired farmers
- 1 beekeeper retired due to loss of hives
- 1 retired due to loss of market, regional distributor went out of business

Limits to Farmers

- Land access
- Market potential

Kaslo and Area farmers meeting

- 1 attendee
- Former farmer, cheaper to eat the food then sell
- Still interested but need secure access to water and land
- Land tenure is secure for now, lease
- Water access is threatened by logging in watershed

Climate Change Summaries

All agreed on the following observations:

- Seasons are different every year
- Longer summers
- Hotter summers
- Less snow
- Less water
- Less mushrooms
- Less glaciers

One farmer not reflected in these notes is probably our biggest producer and not able to attend either meetings, so not reflected in the questionnaires. He produces a large amount of root veggies, selling to retail stores in Kaslo, Kootenay Coop, Nelson farmers market, Kaslo Bulk Buying club and direct. We don't have actual numbers on what he grows, but from estimates, about 10,000lb of veggies. His challenges are market prices undermining his true cost, storage and age. I believe he is hoping for some long term apprentices to take over, but not guaranteed.

1) Precipitation: Consider the rainfall and/or snowfall in your surroundings over the past two or more decades. Does it seem to you that we are experiencing more, less, or about the same amount of rain now than we once did? Is the seasonal pattern of rainfall changing?

Over past few decades, here in Kaslo and area, we are receiving a greater fluctuation of precipitation. Some years we can see a similar pattern of amounts of snowfall, but that snow fall is coming later in the fall and leaving earlier in the spring. Hard to measure the actual amount of rainfall, but there does seem to be less. It is the seasonal pattern of rainfall that is most noticeable, summers and fall have less, while the winters and springs can have more. Having said that, the trends can dramatically change from year to year and thus an obvious change in climate patterns or “Climate Change”!

2) Temperatures: Have you noticed any changes in temperatures over the last two or more decades summertime highs, wintertime lows, extended periods of hot or cold temperatures?

Temperature changes are dramatic, with both higher temperatures in the summer and winter and greater fluctuations of temperatures in the spring and fall. We have easily seen higher average temperatures over the past decade and extended periods of hot/dry summer weather.

3) Seasons: Have you observed any shifts in the lengths and dates of the seasons?

Longer summers and shorter winters!

4) Ponds/streams/waterways: Have you observed any changes in the depth of ponds, rivers, or streams between over the past two or more decades?

I have certainly heard from locals that some streams (based on aspect) have reduced flow and some actually drying up. Since I am a fisherman, I am noticing warmer water temperatures (due to extended hot summers)

5) Insects: Have you noticed any change in the number of insects where you live? Have you seen any new species that you've never seen in the past?

Noticed an increase in the amount of Wasps, although a reduction in the amount of bees.

6) Birds: Have you noticed any change in the number of birds where you live? Have you seen any new species that you've never seen in the past? Have you noticed different migration patterns?

I haven’t noticed a significant difference in the species of birds, just an overall reduction in the overall numbers. We use to have a significant number of ‘cedar waxwings’ overwintering and although we seem them just in lesser numbers.

Migration patterns are generally quite similar, although the migratory birds are staying longer and arriving earlier (again in lesser quantities).

7) Plants: Have you noticed any change in the number of plant composition where you live? Have you seen any new species that you've never seen in the past? Are different plants in different locations?

As I am involved in a localized "Invasive Plant" Program, I have certainly noticed a significant number of more invasive species of plant – out-competing the local plant species. Some of these plants are encouraged by 'unknowing' residents.

8) Animal Species: Have you noticed any change in the animal species where you live? Have you seen any new species that you've never seen in the past? Have you noticed different migration patterns or hibernation habits?

Really haven't noticed any new species of animals, but depending on availability of food, I've noticed an increase in bear, coyote and cougar incidents. Bear hibernation seems to be influenced somewhat, but I believe it is again dependant on the winter weather and availability of food.

9) Garden Plants: Have you noticed any change in the plants you are able to grow in your garden? Have there been any observable changes in the growing season?

Since I have changed my method of gardening (raised beds with a trickle water system) and with the longer summers, there has actually been an increase in food production. Due to the hotter summer temperatures, it is difficult to grow the plants that like cooler temperatures (like lettuce, beets & other 'greens')

10) Do you have any other climate change observations you would like to share?

Most noticeable are the increase in average climate temperatures and the fluctuations in 'climate change'. I have noticed more extreme weather patterns, more wind storms, dramatic thunder and lightning storms (with less precipitation)

11) How many years have you lived in the Kaslo/Area D region?

Have now lived in Kaslo for 17 years and the 'Kootenay's' for over 35 years!

12) Would you be willing to be contacted for further information regarding your observations? If so, please provide your name, email address and phone number below:

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

9) Garden Plants: Have you noticed any change in the plants you are able to grow in your garden? Have there been any observable changes in the growing season?

Earlier spring.

10) Do you have any other climate change observations you would like to share?

11) How many years have you lived in the Kaslo/Area D region?

Since 1972.

KASLO/ROCK AREA D PARTNERSHIP

Climate Change Adaptation & You

1) Precipitation: Consider the rainfall and/or snowfall in your surroundings over the past two or more decades. Does it seem to you that we are experiencing more, less, or about the same amount of rain now than we once did? Is the seasonal pattern of rainfall changing?

Snowfall has varied greatly from year to year. We had difficulty harvesting hay when it was ready to cut during the June months for many years due to June & early July rains.
The past 2 years have had fewer rain events during June & July.

2) Temperatures: Have you noticed any changes in temperatures over the last two or more decades summertime highs, wintertime lows, extended periods of hot or cold temperatures?

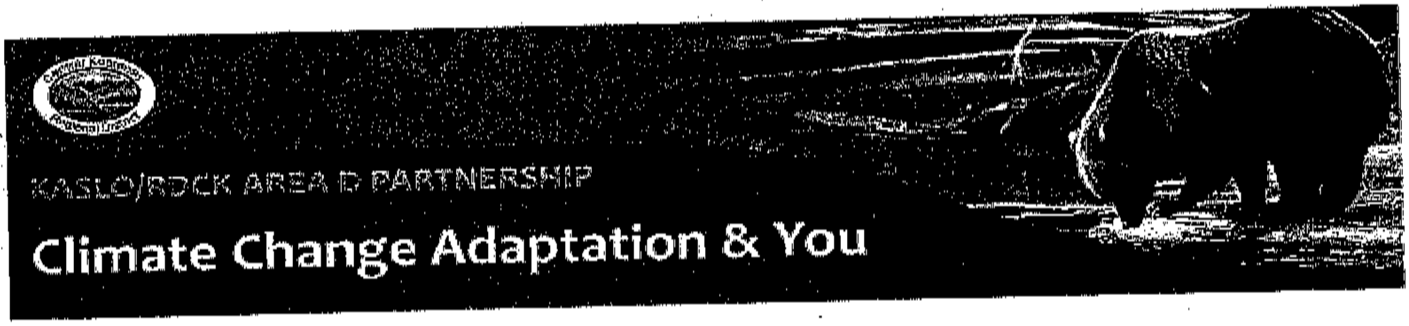
During the 1950s & 1960s, the winter temperaters were colder than in recent years.

3) Seasons: Have you observed any shifts in the lengths and dates of the seasons?

Longer summers.
Less rain in early summer months.

4) Ponds/streams/waterways: Have you observed any changes in the depth of ponds, rivers, or streams between over the past two or more decades?

No observations over long term. However, this past winter and spring have much lower flows in local rivers and streams. Some early spring ponds along some recreatio trails normally contain water at this time of the season, are absolutally dry this year.



5) Insects: Have you noticed any change in the number of insects where you live? Have you seen any new species that you've never seen in the past?

No.

6) Birds: Have you noticed any change in the number of birds where you live? Have you seen any new species that you've never seen in the past? Have you noticed different migration patterns?

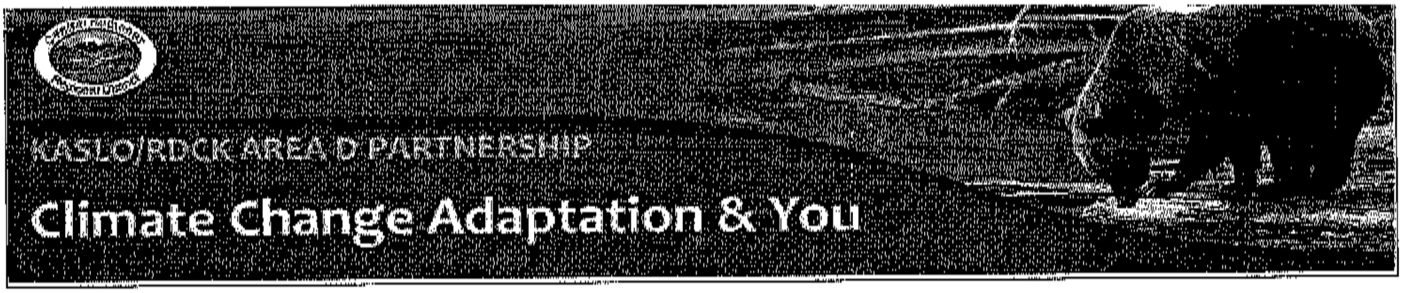
The last couple has seen fewer chickadees, grosbeaks, barn wrens, varied thrush and other small birds.

7) Plants: Have you noticed any change in the number of plant composition where you live? Have you seen any new species that you've never seen in the past? Are different plants in different locations?

Noticable spread of invasive plants i.e. knapweed and Scotch broom. Orange hawkweed and burdoc along remote trails and old roads. 3 years ago Kaslo Riding Club members pulled 7 garbage bags of Hoary alyssum from around th Kaslo Health Centre.

8) Animal Species: Have you noticed any change in the animal species where you live? Have you seen any new species that you've never seen in the past? Have you noticed different migration patterns or hibernation habits?

Elk have moved into the Kaslo areas, there were no elk in the area in the 1970s.



North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow? All my veggies - no grains - no mushrooms
very basic - nothing fancy

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product? Not nearly enough.

What season do you grow each product in? the seasons when they'll grow - All growing season.

How long have you been growing in this area? over 25 yrs.

How long have you been ~~farming~~? homesteading - since the 60s.

Environment homesteading

During your time ~~farming~~ in the North Kootenay region, what if any climatic changes have you observed? Every season every year is different

What impacts, if any, have they had? - Some years the seeds don't develope. Some years certain fruits are more bountiful. Some years new weeds appear.

Have you made any specific changes to adapt to these changes? Every years is a great experiment. Being an organic grower is one of the most creative lifestyles one can have. One is obliged to be a creative thinker.

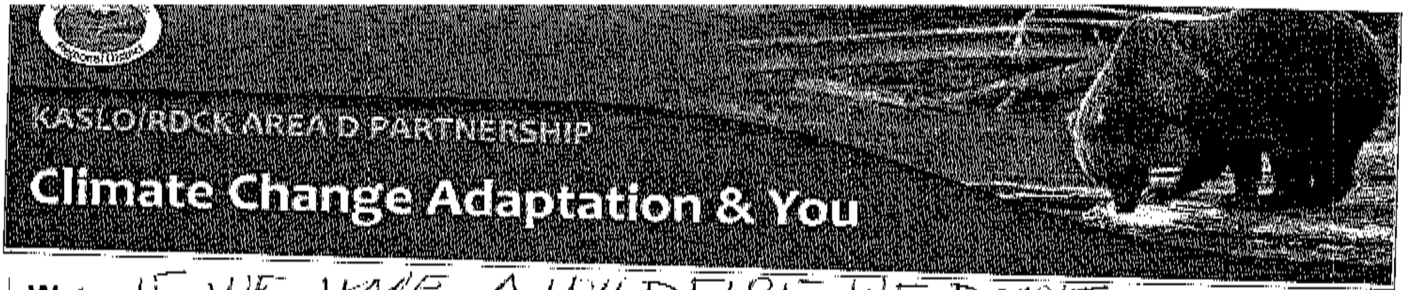
What is your estimated first frost date? whenever it comes

Estimated last frost date: ↓

Has this changed since you started farming in the North Kootenay Region? Every years i expect changes

Have your seasons lasted longer? Shorter? Some cold & rainy. Some hot & dry. Some Spring's are too wet & one needs to replant. Some Autumns certain plants do not mature. etc.

06/25/2010 07:10 8663716389 GREEN EXTREME PAGE 03/03



Water IF WE HAVE A WILDFIRE WE DON'T.

What are your water needs? Household of one + guests, one cat, + or - a dozen chickens.

What is your water source? Argenta Creek

Is your water source vulnerable? If so, how? - all are !

Market

Are you a commercial producer? NO

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

What would you do?

Are there limitations to expanding your agricultural practices?

Comments:

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
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Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

Tomato, squash, cucumber, peas, beans, radish, lettus.
swiss chard
onions, beets, carrots, parsnip, rubbard,

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

For family use.
Store carrots, parnips, beets and apples in the root house. (April 24) Still have plenty of the above vegetables for 2 or 3 months. Have lots of apples, but they are starting to deteriorate.

What season do you grow each product in?

Summer

How long have you been growing in this area?

1972

How long have you been farming? 1972 to 2007 and did plowing, disking, and harrowing for other farmers. Using horses. Have put up hay from

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

Getting warmer.

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date:

Estimated last frost date:

Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?

Longer.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs?

What is your water source? Have a shallow well. Shortage of water during late summer. (August, Sept, Oct) Have hauled water for the garden.

Is your water source vulnerable? If so, how?

Warming climate could reduce ground water and thereby adversely impact shallow well.

Market

Are you a commercial producer?

No

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

No

What would you do?

—

Are there limitations to expanding your agricultural practices?

Comments:

Recently installed a 1,000 gallon tank to collect water from house roof.

We were surprised at how quickly this tank filled with water.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

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Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

Home Produce.

COLUMBIA BASIN TRUST
a legacy for the people

This project is part of Columbia Basin Trust's Communities Adapting to Climate Change Initiative

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

What season do you grow each product in?

Spring to fall

How long have you been growing in this area?

3 yrs

How long have you been farming?

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

I haven't been here long enough to tell.

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date: Late October

Estimated last frost date: Late May

Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs?

My water needs are being met at the moment.

What is your water source?

Well

Is your water source vulnerable? If so, how?

I don't think so

Market

Are you a commercial producer? Not yet.

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

Yes.

What would you do?

Salad Crops, Root Crops, Fruit, Flowers.

Are there limitations to expanding your agricultural practices?

At the moment time & money

Comments:

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
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Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey
What do you grow?

Vegies. Grain.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

What season do you grow each product in?

In the growing season

How long have you been growing in this area?

10 years

How long have you been farming?

Since 1962

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

Longer Growing season. Dryer Summer

What impacts, if any, have they had?

Light irrigation

Have you made any specific changes to adapt to these changes?

As above

What is your estimated first frost date: ~~End of Oct.~~ End of October

Estimated last frost date: May 1.

Has this changed since you started farming in the North Kootenay Region? yes

Have your seasons lasted longer? ~~Shorter~~?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs? enough

What is your water source? ground water.

Is your water source vulnerable? If so, how?

Market

Are you a commercial producer? yes

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices? yes

What would you do? clearing 20-40 ac for grain.

Are there limitations to expanding your agricultural practices? yes: capital,

Comments:

"To predict is difficult, especially about the future"

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

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Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

ONLY A GARDEN SHARED WITH MEMBERS OF A LAND-SHARIN GROUP FOR OUR OWN NEEDS.

KASLO/ROCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

JUST OUR OWN NEEDS: SUMMER EATING, ROOT CELLAR & FREEZER STORAGE.

What season do you grow each product in?

How long have you been growing in this area?

SINCE 1973.

How long have you been ~~farming?~~ GARDENING SINCE 1973

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

ESPECIALLY: MORE DANGER OF FIRES IN HOTTER, DRIER SUMMERS.

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date:

Estimated last frost date:

Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs?

What is your water source?

Is your water source vulnerable? If so, how?

WATER FROM ARGENTA CREEK ~ VERY LOW AT PRESENT ~ CREEK WATER IS SHARED WITH A WATER-POWER ELECTRICITY CO-OP ~ CREEK IS ALSO VULNERABLE TO LANDSLIDE AND VULNERABLE TO LOGGING IN WATERSHED WHICH SHOULD NOT BE ALLOWED.

Market

Are you a commercial producer? NO

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

What would you do?

Are there limitations to expanding your agricultural practices?

Comments:

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
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Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow? - all veggies, except mushrooms, grains.
apples, pears, plums, cherries, berries
chickens, eggs (free range)
all for my own use

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product? sufficient for 2 people plus.

What season do you grow each product in? – spring, summer, fall
chickens – all year

How long have you been growing in this area? 20 years.

How long have you been farming? 25 yrs.

Environment
During your time farming in the North Kootenay region, what if any climatic changes have you observed? – hotter, burning sun,
less rain in summer
– warmer winters – 20 yrs ago –25°C for weeks, now –15° if we are lu[cky]

What impacts, if any, have they had? – no seed production of basil
– hoop house too hot for tomatoes + peppers

Have you made any specific changes to adapt to these changes? greenhouse for basil (I think it is ~~too hot~~ the heat ~~be~~ is less protected – (i.e. burns)

What is your estimated first killing frost date: – early Oct

Estimated last frost date: – April 30.

Has this changed since you started farming in the North Kootenay Region? – not noticea[bly]

Have your seasons lasted longer? Shorter?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs? abundant.
at present I have lots.

What is your water source? Gar Cr.

Is your water source vulnerable? If so, how? Yes - glacier fed.

Market

Are you a commercial producer? No.

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

What would you do?

Are there limitations to expanding your agricultural practices? age & help.

Comments:
land for growing seed is vital, not just for growing food.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey
What do you grow?

GARDEN (VEGGIES / FRUIT
+ Greenhouse
berries
apples
plums
Cherries

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

For my family (3 people)

What season do you grow each product in?

Spring -> fall

How long have you been growing in this area?

1984

How long have you been farming?

I'm not farming

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

every year is different ie: good/bad apple, cherry, squash etc year

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date: mid october?

Estimated last frost date: april?

Has this changed since you started farming in the North Kootenay Region? ?

Have your seasons lasted longer? Shorter?

more or less the same

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs? Clean, abundant

What is your water source? [illegible] Creek

Is your water source vulnerable? If so, how? When I watering pastures the water [illegible] and diminishes

Market

Are you a commercial producer? NO

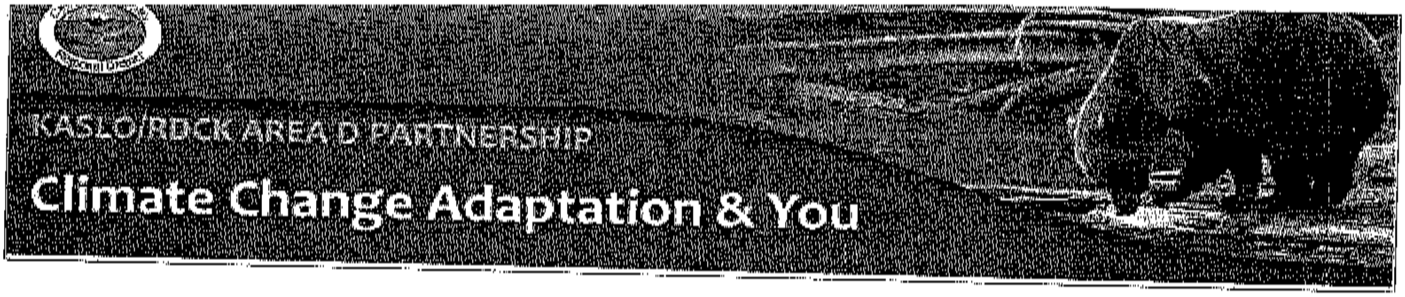
If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices? NO

What would you do? —

Are there limitations to expanding your agricultural practices?

Comments:



North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

Fruit, vegetables, flowers - too many to list. If you want me to list them I could but would need a bit more time.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

enough for family use.

What season do you grow each product in?

Spring, summer, fall

How long have you been growing in this area? 30 years !

5 years Johnsons landing 15 years Meadow Creek 11 years Kaslo

How long have you been ~~farming~~? gardening 40 years

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed? Difficult to tell. Natural yearly variations happen and so hard to know if anything is a trend or just a blip. It does seem that spring is longer as is fall.

What impacts, if any, have they had?

Not sure. Forest sure looks crappy.

Have you made any specific changes to adapt to these changes?

No

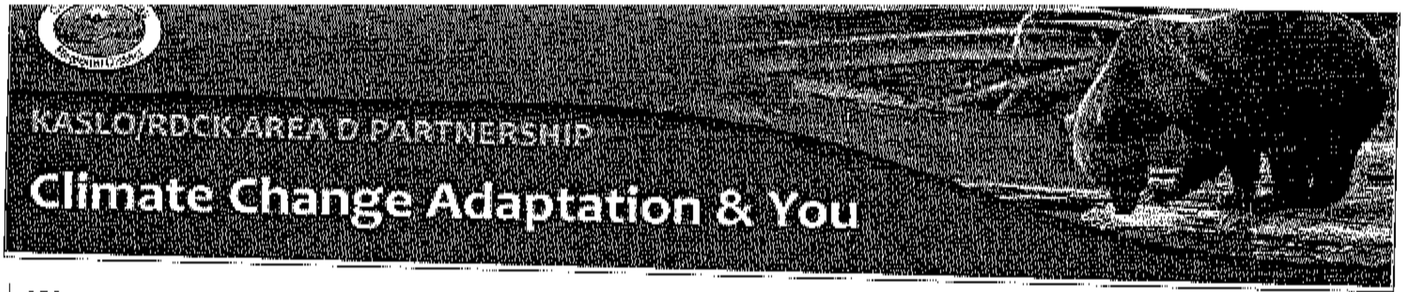
What is your estimated first frost date: Sept 30

Estimated last frost date: May 21

Has this changed since you started farming in the North Kootenay Region? I haven't changed what I work with. I am wondering though about changing.

Have your seasons lasted longer? Shorter?

Maybe longer but not sure.



Water

What are your water needs?

Depends on weather. During hot summer usually each area gets watered every 4 days or so. Sometimes every two days.

What is your water source?

Village

Is your water source vulnerable? If so, how?

Village watering restrictions are frustrating. This is my food. I am happy to let my lawn go dry but not my food.

Market

Are you a commercial producer? No

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

Plan to grow avocados.

What would you do?

Are there limitations to expanding your agricultural practices?

Comments:

I am far more worried about forrest fires due to what seems to be a drying trend than I am about my garden. I can adapt what I grow. But if the forest burns and burns my house that would be lousy.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

beef Producers
hay

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This project is part of Columbia Basin Trust's Communities Adapting to Climate Change Initiative

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

25 beef [illegible]
about 150 [illegible]

What season do you grow each product in?

beef all [illegible]
hay summer

How long have you been growing in this area?

since 1979

How long have you been farming?

since 1958 [illegible]

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

[illegible]

What impacts, if any, have they had?

[illegible]

Have you made any specific changes to adapt to these changes?

[illegible]

What is your estimated first frost date: [illegible]

Estimated last frost date: [illegible]

Has this changed since you started farming in the North Kootenay Region? no

Have your seasons lasted longer? Shorter?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs? less

What is your water source? [illegible]

Is your water source vulnerable? If so, how? flood.

Market

Are you a commercial producer? yes

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices? yes

What would you do? vegetables.

Are there limitations to expanding your agricultural practices? yes

Comments:

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey
What do you grow?

Chicken, Pigs. Goats, Rabbits

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

What season do you grow each product in?

all

How long have you been growing in this area?

4 years

How long have you been farming?

8 years

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed? lack of Rain, Smaller glaciers

creek levels are down

What impacts, if any, have they had?

more watering ~~$~~ lack of ~~[illegible]~~ pasture

Have you made any specific changes to adapt to these changes?

yes new water lines and changes to our gravity fed water.

What is your estimated first frost date:

end Sept - Oct

Estimated last frost date:

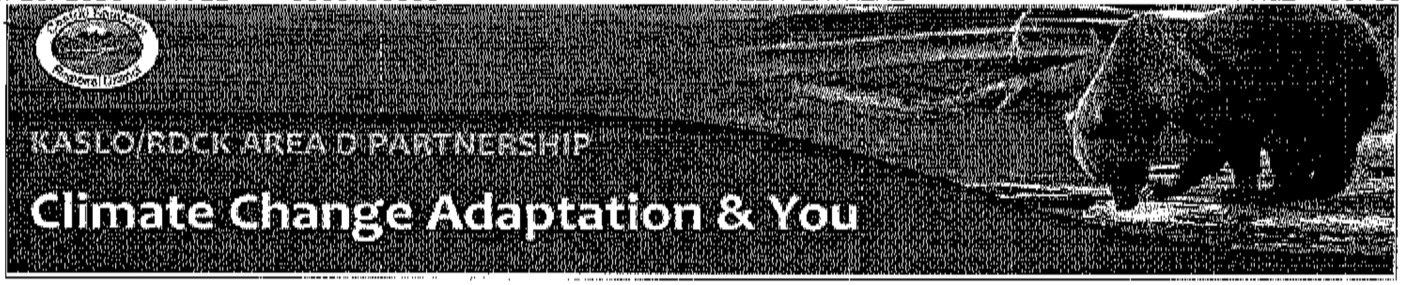
May

Has this changed since you started farming in the North Kootenay Region?

NO

Have your seasons lasted longer? Shorter?

longer



Water

What are your water needs?

Water live Stock

What is your water source?

Lardo River

Is your water source vulnerable? If so, how?

yes Small galchers

Market

Are you a commercial producer? all most

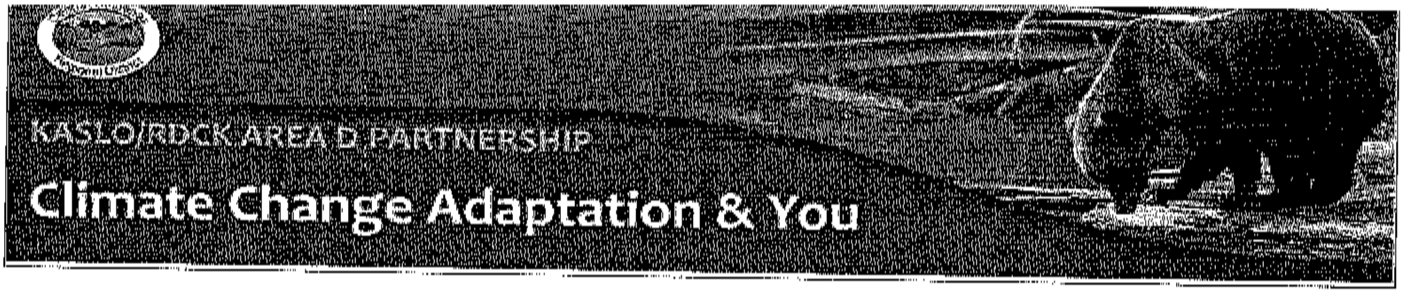
If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

What would you do?

Are there limitations to expanding your agricultural practices?

Comments:



North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey
What do you grow? just starting → veg & herbs

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

How much of each product?

/

What season do you grow each product in? Spring, Summer, Fall

How long have you been growing in this area?
Some last summer 2 months

How long have you been farming?

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed? Been here 1 Year

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date:

Estimated last frost date:

Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs?

What is your water source? Stream

Is your water source vulnerable? If so, how?

Market

Are you a commercial producer? [illegible]

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?

What would you do?

Are there limitations to expanding your agricultural practices? [illegible]

Comments: Any funding available for Geo Thermal, Solar more environmentally friendly operations. More [illegible]

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

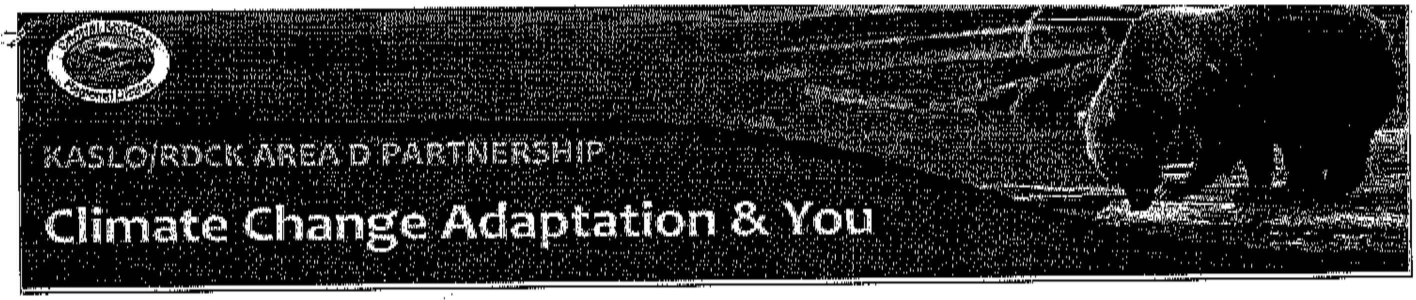
North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Foodshed Survey

What do you grow?

Vegetables
Grains
Berries
Herbs
Apples - other fruit
Seeds
eggs
dairy
meat
honey



How much of each product?

What season do you grow each product in?

food in the worm season
dairy / eggs year round.

How long have you been growing in this area?

12 years / 8 years

How long have you been farming?

20 years / 9 years

Environment

During your time farming in the North Kootenay region, what if any climatic changes have you observed?

Less snow - longer cool springs - less rain in the fal

What impacts, if any, have they had?

The main impact is the dry falls have vastly reduced wild mushroom growth.

Have you made any specific changes to adapt to these changes?

We now need to irrogate pastures earlier in spring, and increase irragation during summer months + so greater water consumption

What is your estimated first frost date:

Estimated last frost date:

We don't estimate, we pray for no surprises.

Has this changed since you started farming in the North Kootenay Region?

Frosts are totally unpredictable, weather is much les "stable".

Have your seasons lasted longer? Shorter?

Longer falls.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Water

What are your water needs?

About 20 acres.

What is your water source?

Mountain Creek.

Is your water source vulnerable? If so, how?

Don't know.

Market

Are you a commercial producer? Yes.

If so, what are your primary markets? (direct retail, farmers market, CSA?) not this year.

Would you expand your agricultural practices?

Yes, if the land were available

What would you do?

More of everything

Are there limitations to expanding your agricultural practices?

Labor,

Comments:

We need land to farm.

North Kootenay Lake Foodshed Questionnaire

Return completed form to:
Paper returns:
Climate Change Adaptation Project & You, Box 126, New Denver, V0G 1S0
Electronic returns:
areadadaptation@columbiawireless.ca

Contact Information
Name

Farm Name

Address (If you would prefer to not give your address, please provide your location or fire numbers)

Phone

Website/Email

Type of farming: (organic, biodynamic, etc..)
Non certified organic

Privacy
Would you like your contact information included in agricultural mapping?
YES

Can we contact you for local market opportunities? YES
Can we contact you for further information and updates regarding your agricultural endeavors in relation to climate change issues? YES

Foodshed Survey
What do you grow?
Full food garden
Orchard fruits
Bush berries
Sheep
Chickens
Tree nuts

How much of each product?
At this time only enough for residents of farm and family

What season do you grow each product in?
Spring, summer, fall – gardens/produce
Livestock/chickens – year round

How long have you been growing in this area?
8 years

How long have you been farming?
8 years

Environment
During your time farming in the North Kootenay region, what if any climatic changes have you observed?
Spring freshet (peak water) lower the last two years (2009/9). Over the 8 years I have been here there have been many variances from year to year and am just now beginning to record more accurately.

What impacts, if any, have they had?
Water rationing by August

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date:
Havent recorded over the 8 years

Estimated last frost date:
Have not recorded
Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?

Water
What are your water needs?
Constant and substantial for two households, livestock, gardens, orchard and pasture

What is your water source?
Surface and subsurface water seeps from Milford Lake catchment

Is your water source vulnerable? If so, how?
First summer after logging activity ended, water shifted in location so no water by mid summer
See below

Market
Are you a commercial producer?
Not at present

If so, what are your primary markets? (direct, retail, farmers market, CSA?)
Did sell direct

Would you expand your agricultural practices?
yes

What would you do?
Greenhouse, coldframes to extend growing season
grains

Are there limitations to expanding your agricultural practices?

Comments:
Kaslo and community forests society (KDCFS) built a road and logged on crown land around this farm in 2000. Our water intake was compromised as the road went through the water seep area. Now the KDCFS has plans to reactivate the road and extend it through the water seep area up higher (passing over the water seeps twice) and plans to harvest cedar trees from the riparian area. I have been advocating for water/watershed protection quite actively since 2007 but plans keep moving forward to log. I also think the riparian areas should be preserved for old growth forest, with an ecosystem based plan that also protects habitat.

The road also opens access to the public. There have been bags of garbage, an abandoned ATV, upside down chain saw oil container, felled live trees (presumably for firewood) all in the water source area.

If you have any recommendations for advocacy on behalf of this small watershed we would be most grateful. More information can be provided if needed. Thank you, Lorna Louise.

Contact Information
Name

Farm Name
Have a small family garden

Address (If you would prefer to not give your address, please provide your location or fire numbers)

Website/Email

Type of farming: (organic, biodynamic, etc..)
organic

Privacy
Would you like your contact information included in agricultural mapping?
Can we contact you for local market opportunities?
Can we contact you for further information and updates regarding your agricultural endeavors in relation to climate change issues? YES

Foodshed Survey
What do you grow?
Tomato, squash, cucumber, peas, beans, radish, lettuce, onions, beats, carrots, parsnip, rhubarb, swiss chard

How much of each product?
For family use. Store carrots, parsnips, beets and apples in the root house (April 24). Still have plenty of the above vegetables for 2 or 3 months. Have lots of apples, but thye are starting to deteriorate

What season do you grow each product in?
summer

How long have you been growing in this area?
1972

How long have you been farming?
Have put up hay from 1972 to 2007 and did ploughing, disking (??) and harrowing for other farmers. Using horses.

Environment
During your time farming in the North Kootenay region, what if any climatic changes have you observed?

Getting warmer

What impacts, if any, have they had?

Have you made any specific changes to adapt to these changes?

What is your estimated first frost date:

Estimated last frost date:

Has this changed since you started farming in the North Kootenay Region?

Have your seasons lasted longer? Shorter?
longer

Water
What are your water needs?
.

What is your water source?
Have a shallow well. Shortage of water during late summer (Aug, Sept, Oct). Have hauled water for the garden

Is your water source vulnerable? If so, how?
Warming climate could reduce ground water and thereby adversely impact shallow well.

Market
Are you a commercial producer?
No

If so, what are your primary markets? (direct, retail, farmers market, CSA?)

Would you expand your agricultural practices?
No

What would you do?
-

Are there limitations to expanding your agricultural practices?

Comments:
Recently installed a 1000 gallon tank to collect water from house roof. We were surprised at how quickly this tank filled with water.

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

Contact Information
Name

Farm Name

Address (If you would prefer to not give your address, please provide your location or fire numbers)

Website/Email

Type of farming: (organic, biodynamic, etc..)
Organic. Certified KMG

Privacy
Would you like your contact information included in agricultural mapping? YES
Can we contact you for local market opportunities? YES
Can we contact you for further information and updates regarding your agricultural endeavors in relation to climate change issues? YES

Foodshed Survey
What do you grow?
In the last 2 years I provided some restaurants and natural grocers with salad greens. This year my garden in in rotation and I wil not grow greens for a crop.
We are growing a crop of peas for a seed company and use 75% for our food. We have sheep, chickens, fruit trees and big gardens.

How much of each product?
571 lbs of greens in 2009
700 feet of peas for seed 2010

What season do you grow each product in?
Spring, summer, fal

How long have you been growing in this area?
5 years

How long have you been farming?

Al my life

Environment
During your time farming in the North Kootenay region, what if any climatic changes have you observed?

Every year has been different. Fall is longer, spring early in 2010. less water in our creek. Less snow in 2010.

What impacts, if any, have they had?

Lettuce now can seed in my garden
The season was not long enough before

Have you made any specific changes to adapt to these changes?
no

What is your estimated first frost date:
Oct 15th

Estimated last frost date:
May 15th

Has this changed since you started farming in the North Kootenay Region?
No

Have your seasons lasted longer? Shorter?
Fall seems to last longer, winter shorter in 2010 but long in 2009

Water
What are your water needs?
Vegetable gardens, pastures, livestock, human consumption, fruit trees

What is your water source?
Springs and creek

Is your water source vulnerable? If so, how?
YES!

The community forest is planning to log in or watershed, so I don't know if its worth it for me to invest in building a business, expanding our gardens. This farms water source is threatened and so is the future of this farm.

Market
Are you a commercial producer?
yes

If so, what are your primary markets? (direct, retail, farmers market, CSA?)
Retail 2010
Retail, farmers market 2009

Would you expand your agricultural practices?
yes

What would you do?
Grow more greens and more seed crops

Are there limitations to expanding your agricultural practices?
Yes, I don't own the land I farm on.

Appendix M - Briefing sheets

1. Introduction
2. Overview
3. Agriculture and food security
4. Water supply and demand
5. Water data
6. Watersheds

KASLO/RDCK AREA D PARTNERSHIP

Climate Change Adaptation & You

What is climate change adaptation?

Adapting to climate change refers to actions by individuals and organizations to avoid or take advantage of current and future climate changes and impacts.

Adaptation is about being prepared, being resilient and being ready as we can be for a future climate that is different from what we have seen in the past.

Examples of climate change impact and how it could affect Kaslo/Area D

Water Supplies - Lower stream flows in summer.
Q: What will lower flows mean for drinking water and how would we adapt to that?

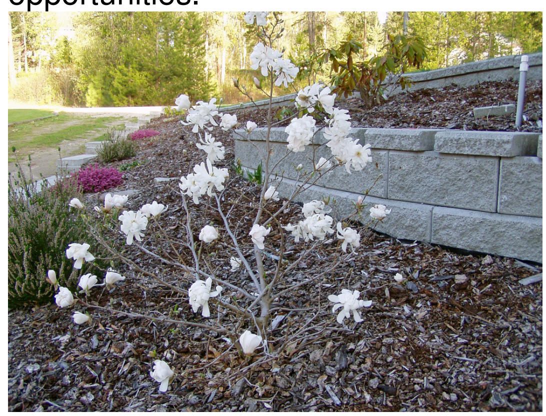
Ground transportation - Mud slides and floods could wash out bridges & roads.
Q: How could we prepare for that now & avoid washouts?

Agriculture - Higher temperatures alter irrigation needs
Q: What crops might be suitable in new growing season?

Learn more!
www.rdck.bc.ca/adaptation
Join the discussion group: send an email to
climateadaptation_kaslo_aread-subscribe@lists.groundwire.org
leave the subject line blank.
Contact: areadadaptation@columbiawireless.ca,
Project Coordinator 250 358 2721

What is Kaslo/Area D climate change adaptation project all about?

Our climate change adaptation project will help us see where we are likely to be most vulnerable (or at risk) to the local impacts of climate change, and if there are new opportunities. When we know that, we can decide what actions we can take to reduce risks and capture opportunities.



How will we decide what adaptation actions we might take?

* Increasing our understanding about climate change and expected local impacts
* Identifying priorities;
* Assessing vulnerability, risk & opportunities
* Developing adaptation strategies and actions
* Implementing & monitoring
* Engaging with local communities & businesses

Contact: Coordinator, Tim Sander areadadaptation@columbiawireless.ca (250) 358 2721

PROJECT OVERVIEW

Our climate change adaptation project will help us see where we are likely to be most vulnerable to the local impacts of climate change, and what opportunities might exist. When we know that, a strategy can be developed that will help us reduce vulnerabilities and capture opportunities..

Who is doing something?
The Village of Kaslo, RDCK/Area D and a Steering Committee of local people are working with scientists and technical experts to look at the changing climate and what this may mean for the area. We are one of the project communities for the Columbia Basin Trust's Communities Adapting to Climate Change Initiative.

What is being done?
Information is being collected for action recommendations, due to be agreed to in the summer of 2010. Future actions and monitoring will be central to the project.

What are the priorities?
The Steering Committee decided to concentrate on examining the impacts, vulnerabilities and opportunities for water availability and agriculture/food security.

Who is this for?
This will be used by the Regional District and Village Council to help local households, community groups and businesses prepare for and adapt to changing climate.

What is the timescale for this project?

November 2009	Steering committee formed
January 2010	Coordinator appointed Presentation to Steering Committee on preliminary climatic data projections
February	Expert visit to investigate potential priority issues and data gathering Steering Committee sets priorities: water availability, agriculture/food security
March	Agriculture/food security discussion for CBT project community reps Steering Committee introduced to impact mapping for the priority topics
April	Public engagement events on climate change impacts
May	Compilation of data, looking ahead
June	Vulnerability and opportunity assessments on priority topics
July	Action recommendations with public outreach Next steps

Steering Committee Members
Andy Shadrack, RDCK Area D Director
Bill Wells, Kaslo & District Community Forest Strategic Planning Team
Bob Dovey, Mirror Lake Water Users Vice-Chair, Area D Area Planning Commission
Greg Lay, Mayor Kaslo Village Council
John Alton, West Kootenay Eco-Society
John Addison, Kaslo Chamber of Commerce
Aimee Watson, Kaslo Food Security Project
Linda Brooks, Meadow Creek
Paul Sneed, Selkirk College
Rae Sawyer, Village of Kaslo
Rhonda Ruston, Shutty Bench Area D Area Planning Commission.
Gail Spitler, Johnsons Landing
Michelle Laurie, CBT Communities Adapting to Climate Change Initiative Coordinator
Ramona Mattix, Development Control Manager, Regional District of Central Kootenay

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a legacy for the people

The Climate Adaptation and You project is supported by the Columbia Basin Trust. To learn more about Columbia Basin Trust's Communities Adapting to Climate Change Initiative visit
www.cbt.org/climatechange.

Agriculture and food security in Kaslo/Area D

(Dylan Hackenbrook, David Springer, Shannon Swayze, Selkirk College 2010, edited by Aimee Watson)

Land allocation

- average North American diet requires 0.524 hectares of productive farm land to be sustained annually (Grow BC 2008) – this is obviously a very rough estimate but is one way of assessing what is need in the way of productive lands for a population
- Kaslo and Area D could be not be "food secure" because 1,362 hectares of land would be required
- 885 hectares of developed or cleared (agricultural) lands in Area D, and 6,630 hectares of forested, undeveloped (non-agriculture land) within the ALR
- under utilization for ALR and farm land, vast majority is forested land
- very little of the ALR is used for commercial farming/food production
- very little information is publicly available on farm production and food export

- Existing Farms in ALR = 49 Ha
- Existing Farms not in ALR = 21 Ha
- Unutilized Farms in ALR = 996 Ha

These numbers for "farm" land in ALR are higher because a different data set (RDCK cadastral and BC Assessment authority) was used than above where on provincial ALR data was used along with analysis of aerial photo imagery. However, in either case, there does not appear to be enough cleared or developed agricultural land in the ALR alone to feed the current population of Kaslo and Area D.

Food crops known to be grown commercially

- carrots, potatoes, leeks, cabbage, parsnip, corn, fava beans, tomatoes eggs
- No meat – nearest abattoir Creston
- Very little commercial grain and fruit produced

Problems faced with food growing:

Land access
Difficult to compete with industrial prices
High Cost of producing organic, high quality veggies
Lack of licensing administrative body for abattoirs
Lack of Storage Facilities

Food security initiatives

Re-launched Kaslo community garden program
Kaslo Food Charter
Food Security and our Official Community Plan
West Kootenay Food Directory
Founding of Community Garden Society of Kaslo
Community Kitchen Feasibility Study
Workshops: Canning, Cooking, Gardening, Seed Saving
Speaker Events: 8
Kaslo's Seedy Saturday
North Kootenay Lake Food Assessment
North Kootenay Lake Local Market Analysis
Director for Kootenay Local Agriculture Society
Director for Canadian Biotech Action Network

Ongoing Programs:

Lawns to Gardens- 3 gardens successfully installed!
Video Publication to showcase and educate about Lawns to Gardens
Community Garden
Demonstration Garden
Food for Families
Bulk Food Club
Food Hub working group
Food Policy working group
Farmer availability lists
Knowledge Pantry
Provincial Food Action E-Brief

Climate Change Adaptation Project & You! Food questionnaire summary
Aimee Watson

10 questionnaires's returned
Of those 10:
- 4 were homesteaders
- 4 commercial farmers (2 selling farmgate, not retail as their product are not deemed "legal")
- 2 were potential farmers or working towards farming

Of the commercial farmers:
- 3 meat producers (beef, rabbit, chicken, goats- none are legal at this moment)
- 1 hay producer
- 1 grain producers
- 2 veggie growers
- 2 dairy (eggs, yoghurt, cheese)
- 4 organic, 0 certified

Not on the surveys, but observed in comments:
- 2 retired farmers
- 1 beekeeper retired due to loss of hives
- 1 retired due to loss of market, regional distributor went out of business

Limits to Farmers
- Land access
- Market potential (global prices continuously undermine true costs and make the ability to sell for profit in the retail market impossible)

<u>Climate Change Summaries</u>
All agreed on the following observations:
- Seasons are different every year
- Longer summers
- Hotter summers
- Less snow
- Less water
- Less mushrooms
- Less glaciers

Analysis of Present/Future Water Supply and Demand Issues
Preliminary Findings
(Hans Shreier, Martin Carver, Arelia Werner)

Question: How will projected climatic changes affect water provision for Kaslo/Area D?
Why do we want to know this? If precipitation and melt patterns alter due to climate change, will demand outstrip supply in years to come under present consumption levels?
Quick answer: Initial findings indicate that water conservation measures need to be seriously considered to avoid costly water shortages.

<u>Water supply findings include:</u>

- Increased monthly maximum temperatures in both late winter and late summer
- Highest increases occur in January-February and September.
- No clear trend in total annual precipitation (rain & snow) from 1950-2006 (same amount but more rain and less snow).
- Marked decrease in precipitation in January and February and increase in March and April.
- Snow accumulation, particularly at lower elevations, has declined between January and March with the largest declines in February.
- The peak flow is occurring earlier in the season.
- July and August rainfall declining since the mid 1970s. This means less base flow as a result of higher temperatures, more evaporation and less rainfall.
- Evidence for increased annual discharge for Kemp Creek
- Increased streamflow between November to April
- Lower streamflow during May-September, particularly in July at a time when the water demand and environmental stress is usually the highest.

<u>Water demand findings include:</u>

- Only 3.5 years of domestic water use data available in Kaslo
- Highest demand usually occurs in the July-August period.
- Average annual consumption (water provided by the treatment plant) per person between 1000-1100 L/person/day (excluding water use for the golf course).
- Golf course consumption highest in May and June (13-18% of the domestic water used)
- Golf course consumption lower in July/August (6% of domestic water used)
- Total residential demand can reach more than 2300 L/person/day during hot summer days in July and August.

<u>Conclusion</u>

There is a need to adapt to changing conditions, eg through water conservation, especially in the short term.

- Further modeling and comparisons are recommended.
- Climate change can be partly verified by trends in the historic climate data and some of the modeled discharge data.
- Earlier peak flow and lower summer low flow are of concern.

Climate Impacts on Local Water Availability and Quality – STATUS REPORT

Purpose*:* Assess how climate change will impact the availability and quality of year round accessible water.

Resource people involved

CBT Technical Support:

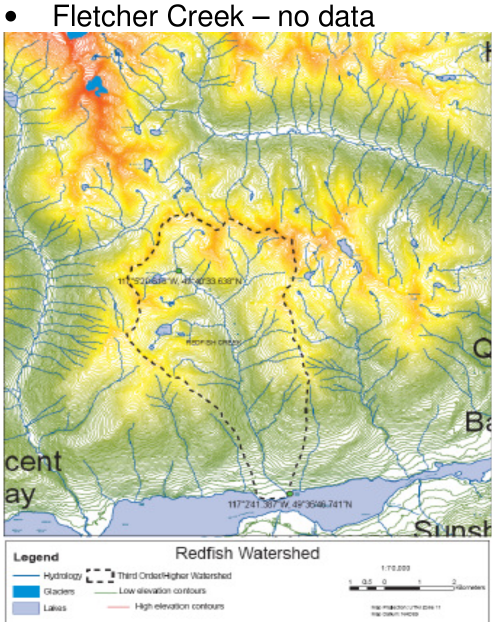
- Arelia Werner, Pacific Climate Impacts Consortium (PCIC)
- Hans Shreier, UBC
- Alan Hamlet, Climate Impacts Group (CIG), University of Washington
- Martin Carver, Hydrologist

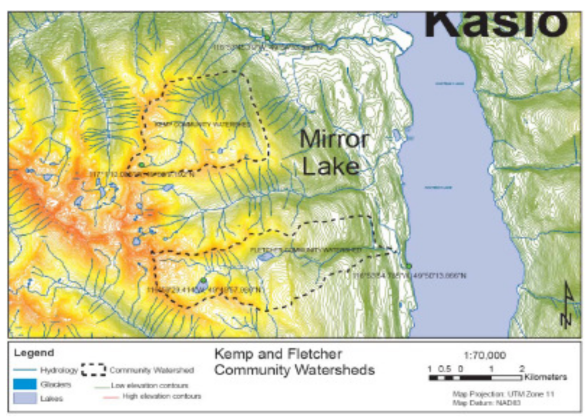
Kaslo/Area D Local Project Support:

- Paul Sneed, Selkirk, GeoSpatial Research Centre
- RDCK planning staff
- Bill Wells

Selected watersheds and data availability

- Redfish Creek (area 26.2 km2) – data for 1932 to 2010
- Kemp Creek (watershed for Village of Kaslo - area 11.9 km2) – data for 1929-1930
- Fletcher Creek – no data





These watersheds are snowmelt dominated, without any glaciers. Modeling work has been done on these watersheds by a hydrologist from PCIC. A model was used that is designed to assess stream flow from snowmelt dominated watersheds. It does not address glacier fed flows, or groundwater and storage.

What we now know about future stream flow with changing climate

- Peak flows are likely to arrive earlier and higher flows could occur over time

- Low flows are likely to start earlier and continue later into the fall, and flows could become lower over time
- Snow fall and snow pack are expected to decline. With less snow, and earlier melting, there will be longer dry periods.

What activities are planned?

- Hydrology and climate-change modelers will forecast:
  - tabulated monthly streamflow change as a percentage of existing flows and
  - apply a reservoir model to assess how inflows to water systems are expected to change in the future.
- RDCK and Martin Carver will acquire necessary reservoir model data, i.e. water licenses and observed data from public works staff and users.
- Selkirk College students will prepare maps to help compare the Redfish watershed to others streams on the western side of Kootenay Lake to discern how representative it is of other systems. Information collected will include:
  - % types of vegetation cover
  - % area lakes
  - % area glaciers
  - % area bare soils/rock
  - Average annual min and max temperature
  - Average annual rain, snow, precipitation
  - Geology
  - Elevation distribution
- Detailed modeling to provide projected snow melt per 100m rise in elevation to give a greater understanding of drainage and storage.
- Compare 6-8 creeks as per above characteristics, water demand data, water license data and potential groundwater sources: eg Laird Creek, Kaslo Creek, Bjerkness Creek, Lofstead Creek, McDonald Creek.

Timeline

March 19 Initial impact mapping of water availability with Steering Committee and technical supports

April 9 (to be confirmed) Public event to describe climate change project and science, impact mapping, description of modeling and expected outcomes

April 15 Maps for approximately 6 creeks with environmental characteristic comparison completed by Selkirk College and RDCK information gathering re: water licenses done

April 30 Observed demand data collected and synthesized by Martin Carver

May 15-30 Arelia Werner to extract available data from CIGs run of the Variable Infiltration Capacity (VIC) model and to compare with observed data, Hans Shreier to import appropriate results into Exel based water supply and demand model.

May Hans Shreier to collate and analyze information

May Project Coordinator to collect, synthesize and create background report on water availability for vulnerability/risk assessment and outreach

June 1/2 or 4 Potential vulnerability/risk assessment on water availability and adaption action listing

June 15 Water availability adaptation actions/strategies prioritized by Steering Committee with public input

Background information

- Nobody takes groundwater in Kaslo; systems are spring or stream fed

Water System (Treatment plant and pumphouse)

History

- Started in 1980's - 15-20 years old
- Village of Kaslo has owned for 3 years. Previous owner of the plant (for past 10 years) kept no records and nothing worked when Kaslo took over.

Watershed

- Draw out of Kemp Creek – and drawing every drop (not a fish bearing stream)
- There are no roads in the watershed
- Kemp Creek terrain is relatively stable
- Forest fire in ¼ of the watershed; trees are still standing.
- There are 3 springs available to get an extra 10% into the system.

System

- Downflow gravity fed system
- 1 million gallons/day = 4 million liters for 1,300 people
- Total of 200,000 gallon storage capacity for treated water = couple of hours water storage in the spring and a couple of days in winter
- 1.5 million gallons of untreated upriver water storage - possibility to bypass line, link with reservoir and put a boil water advisory in place.
- Treatment level is okay, depends on turbidity levels
- Automatic controls but manual is possible
- Just bought back-up generator and 2nd compressor back up
- Most of maintenance is done internally
- Pumphouse located beside the Kaslo River has rip rap protection

Users

- Commercial in town is on this system as well as the golf course and village parks

Water conservation

- Golf course is using treated water to irrigate greens.
- The Village waters parks.
- In summer, there are some voluntary sprinkler bans

Potential Vulnerabilities

- The system operates at a maximum for a couple of times a year.

- Liner for the reservoir has 20 year life span and Kaslo's is on year 22. Looking for funding. It is cleaned every year, 8 inches of sludge collects. Pumps are run when cleaning the reservoir. Reservoir sludge is going down with settling which is helpful. Would like sensors to detect levels as currently checking only every 2 days. This could reduce need for bigger reservoir.
- The potential of the pumphouse being damaged by flooding (high water and log jams) is a weak spot in the system.
- Landslide between pipe and pump station in 1999.
- Avalanche in 2009, no power for 2-3 days, back up generators for sewage and pump.
- Wash water goes into Kaslo Creek; can be seepage from ground around.
- Need to look at the Infiltration Gallery.
- Trained people - only 1.5 people now with knowledge

Options

- Kaslo River has turbidity issue, silts quickly.
- Concern is Whitewater Creek is 'creeping' and goes into Kaslo River.
- Back up pump in the river is possibility but not easy, due to turbidity issues.
- Discussion of lake treatment plant, perhaps for golf course.
- Other needs: better infiltration gallery on the river. Still need pumping but 200 vertifcal feet.
- Lower part of town is all gravel, upper has some clay, ½ gravel.

Sewage Treatment Plant

- Located on edge of Kootenay Lake.
- Capacity is 1 street in town, commercial, marina and condos; 60 new condos in development, 6-12 new homes this year.
- Most residential is on septic
- Need to do more - would like to add more streets
- Need liquid waste management plan as 1st step
- Has module structure so should be able to add.

Comparison of Kaslo watersheds

Question: Are the 3 Kaslo watersheds Kemp, Fletcher and Bjerkness Creeks similar to Redfish Creek?
Why would this be useful? There are extensive archived readily accessible data sets for Redfish Creek so it would be useful if it was found that the 3 water sheds were similar in water collection and supply ability.
Conclusion: Unfortunately, the statistical and physical analysis results of the watersheds show that the four creeks are different from each other.
Kemp and Redfish have a very similar elevation gradient with the majority of area above 1500m elevation (only 20% of the watershed area is below 1500m). However, the aspect is very different.
In contrast Bjerkness and Fletcher have similar elevation gradients but 20% of the watershed is below 1000m and 40% is below 1500m. This mean these two watersheds are more vulnerable to loss of snow accumulation in the future than Kemp and Redfish.
Slope influences rate and direction of water flow
Aspect influences the rate of snow melt as well as evaporation of water throughout the watershed area.

RECOMMENDATIONS

- set up local weather stations – precipitation, temperature, snowpack
- collect information on stream flow (water availability) and water usage (metering)
- combine data from multiple watersheds and average to make model
- further analysis to consider Redfish data to be used to represent Kaslo watersheds

Measure	Redfish Creek	Kemp Creek	Fletcher Creek	Bjerkness Creek
Watershed code	340-186300	340-215300-16300	340-214600	340-215000
Aspect	S	NE	E	E
Length (km)	8.69	6.46	9.28	10.23
Watershed Area (ha)	2729.1	1271.3	1785.3	2706.6
Min Elevation(m)	532	659	532	548
Max Elevation (m)	2362	2429	2520	2566
Elevation change (m)	1830	1770	2018	1988
Stream magnitude	10	5	2	11
H60 (m)	1700 (H65)	1860	1700	1700
Shape	Teardrop	Teardrop	Elliptical	Elliptical
% lakes	0.75	1.23	0.70	0.84

(Cris Gray, Katie Ward, Melissa MacLeod 2010)

Appendix N - Glossary

Glossary of terms

Adaptation
Actions in response to actual or projected climate change and impacts that lead to a reduction in risks or a realisation of benefits. A distinction can be made between a planned or anticipatory approach to adaptation (i.e. risk treatments) and an approach that relies on unplanned or reactive adjustments.

Adaptive capacity
The capacity of an organisation or system to moderate the risks of climate change, or to realise benefits, through changes in its characteristics or behaviour. Adaptive capacity can be an inherent property or it could have been developed as a result of previous policy, planning or design decisions of the organisation.

Climate
The composite of surface weather conditions such as temperature, rainfall, atmospheric pressure, humidity, sunshine and winds, averaged over a period of time ranging from months to thousands of years. The classical period for averaging, as defined by the World Meteorological Organisation, is 30 years.

Climate change
Any change in climate over time, whether due to natural variability or as a result of human activity.

Climate change mitigation
Response measures that reduce the emission of greenhouse gases into the atmosphere or enhance their sinks, aimed at reducing their atmospheric concentrations and therefore the probability of reaching a given level of climate change.

Climate scenario
A coherent, plausible but often simplified description of a possible future state of the climate. A climate scenario should not be viewed as a prediction of the future climate. Rather, it provides a means of understanding the potential impacts

of climate change, and identifying the potential risks and opportunities to an organisation created by an uncertain future climate. A ‘climate change scenario’ can be defined as the difference between a climate scenario and the current climate.

Climate projection
A projection of the response of the climate system to scenarios of greenhouse gas emissions or atmospheric concentrations of greenhouse gases. Climate projections are often based upon simulations of the climate system by computer based mathematical models. Climate projections depend on assumptions about emission rates and concentrations and response of the climate system to changes in these variables and can therefore be distinguished from climate predictions.

Climate variability
Variations or deviations from the mean state of the climate. The climate system has natural, internal variability but variability could be affected by external factors driving climate change such as changes in the atmospheric concentration of greenhouse gases.

Enhanced greenhouse effect
Increases in the atmospheric concentration of greenhouse gases such as carbon dioxide, methane and nitrous oxide due to human activities, leading to an increase in the amount of thermal radiation near the Earth’s surface. Most scientists agree that the enhanced greenhouse effect is leading to an increase in global average surface temperature (see global warming) and other changes in the atmospheric environment (see climate change). See also greenhouse effect.

Extreme event
Weather conditions that are rare for a particular place and/or time such as an intense storm or heat wave.

Global warming
An increase in the global average surface temperature due to natural or human caused factors.

Greenhouse effect
The process where gases in the lower atmosphere such as carbon dioxide and water vapour trap radiation released by the Earth’s surface after it has been warmed by solar energy. These gases then radiate heat back towards the ground, adding to the heat the ground receives from the Sun. The surface of the Earth would be about 33oC colder on average than it is without the natural greenhouse effect. See enhanced greenhouse effect.

Sensitivity
The degree to which a system is affected, either adversely or beneficially, by climate related variables including means, extremes and variability.

Vulnerability
The extent to which a system or organization can cope with the negative impacts of climate change, variability and extremes. It is a function of risk and adaptive capacity.

Risk management
Consequence
Outcome or impact of an event
1. There can be more than one consequence from one event.
2. Consequences can range from positive to negative.
3. Consequences can be expressed qualitatively or quantitatively.
4. Consequences are considered in relation to the achievement of objectives.

Control
An existing process, policy, device, practice or other action that acts to minimise negative risk or enhance positive opportunities. The word control may also be applied to a process designed to provide reasonable assurance regarding the achievement of objectives.

Event
Occurrence of a particular set of circumstances.
1. The event can be certain or uncertain.
2. The event can be a single occurrence or a series of occurrences.

Frequency
A measure of the number of occurrences per unit of time.

Hazard
A source of potential harm

Likelihood
Used as a general description of probability or frequency. Can be expressed qualitatively or quantitatively.

Monitor
To check, supervise, observe critically or measure the progress of an activity, action or system on a regular basis in order to identify change from the performance level required or expected

Probability
A measure of the chance of occurrence expressed as a number between zero and one.
1. ‘Frequency’ or ‘likelihood’ rather than ‘probability’ may be used in describing risk.

Risk
The chance of something happening that will have an impact on objectives.
1. A risk is often specified in terms of an event or circumstance and the consequences that may flow from it.
2. Risk is measured in terms of a combination of the consequences of an event and their likelihoods.
3. Risk may have a positive or negative impact.

Risk analysis
Systematic process to understand the nature of and to deduce the level of risk.
1. Provides the basis for risk evaluation and decisions about risk treatment.

Risk assessment
The overall process of risk identification, risk analysis and risk evaluation.

Risk evaluation
Process of comparing the level of risk against risk criteria. 1. Risk evaluation assists in decisions about risk treatment.

Risk identification
The process of determining what, where, when, why and how something could happen.

Risk management
The culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects.

Risk management process
The systematic application of management policies, procedures and practices to the tasks of communicating, establishing the context, identifying, analysing, evaluating, treating, monitoring and reviewing risk.

Risk treatment
Process of selection and implementation of measures to modify risk.
1. The term ‘risk treatment’ is sometimes used for the measures themselves, in addition to the process of generating the measures to deal with a risk.
2. Risk treatment measures can include avoiding, modifying, sharing or retaining risk.