The following are a series of articles published in the Nelson Star between August 2017 and February 2018. Each article touches on a single aspect of climate change, and how that aspect may impact people and ecosystems in the West Kootenays. The articles are intended to translate the complex science of climate change into stories that are meaningful to people living in the West Kootenays. Although they were written a few years ago, unfortunately the topics are still relevant today ï maybe even more so! Support of the Nelson Star is gratefully acknowledged for assisting in the dissemination of information about climate change to the general public. For further information visit: www.kootenayresilience.org

Climate Change and Wildfires – August 9, 2017

This is the first in a series of columns addressing various issues surrounding Climate Disruption in the West Kootenays. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.

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Many people are wondering if and how this summer of catastrophic wildfires relates to climate change.

Hereôs what science has to say.

Mike Flannigan, a wildfire specialist from Alberta, points to the four main factors that affect wildfires: forest fuels, human activity, ignition sources and weather.

Forest fuels are mainly determined by the type of forest we have and its history. Human activities, such as fire fighting and harvesting, affect the amount and distribution of fuels and humans also supply ignition (such as abandoned campfires).

Climate primarily drives weather patterns (temperature and precipitation) and the major source of ignition: lightning.

Historical climate data clearly demonstrates that July and August temperatures in the West Kootenay have risen by 1 to 3 degrees Celsius over the past few decades. This includes both average temperatures, and maximum temperatures that tend to drive extreme fire behavior. Precipitation in those months has either remained roughly constant or decreased slightly.

Climate projections indicate that average and maximum summer temperatures are likely to rise an additional 1 to 3 degrees by the 2050s. Projections of summer precipitation changes are more uncertain. Some climate models indicate little change, while others project significant decreases. There is agreement that spring snowmelt will occur earlier, making for longer summers.

Climate models also project changes in the distribution of precipitation. In the past, weôve generally experienced periodic gentle rains, with occasional intense storm events. The future may look more like this summerôs heatwaves and drought, punctuated with more frequent high intensity storms.

In our area, intense summer storms are often accompanied by lightning. Some storm modeling is suggesting a modest increase in the frequency of lightning as well.

Consistent with the increase in temperatures, studies of historical wildfire occurrence in the western US and Canada have shown two things. One is that the average area burned per year has increased. And, second, the fire season itself is longer.

One University of Idaho wildfire study for the western US concluded that since the 1980s, the increased fuel drying due to increasing temperatures has contributed to a doubling of the area burned over what would have occurred without climate change.

Another study in the western US showed the fire season has increased in length by over 50 percent since the 1970s. Large fires are occurring earlier in the year, but also burn for longer periods once they get started. The current BC fires are an example of the same trend.

What does that all that mean for us?

Projected climate trends for the West Kootenay indicate that forest fuels are getting drier, and that trend will continue. Other indirect impacts of climate change may also contribute to an increase in wildfire impacts. Trees dying due to drought, windstorms, and increased insect and disease attacks all create more dry fuel for fires.

Virtually all published studies on the occurrence of wildfires for Canada and the US project a continuing increase in the number of fires and in the average area burned for the coming decades.

For example, a recent study was completed for the BC Government by local scientists. It projected that the average annual area burned in the West Kootenay may increase from about 1500 hectares per year (the average for the latter half of the last century) to approximately 9,000 hectares per year by the mid-2020s. In comparison, approximately 5,000 hectares have burned so far this year in the West Kootenay.

These trends are not limited to western North America. This past winter Chile, Australia and New Zealand had catastrophic wildfires. This summer there is not only ongoing devastating wildfires in BC, but also in France, Portugal, Israel and Italy.

Here in the West Kootenay we haven't experienced the dramatic increase in area burned that other places have ï yet. However, we have experienced the lengthening of the fire season, as well as the increased days of high and extreme fire hazard.

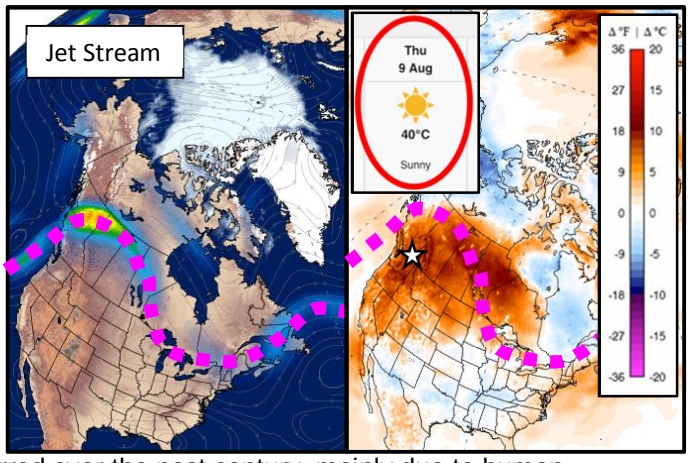
The West Kootenay has been very lucky the last few years because we've received precipitation at crucial times. But the statistics indicate our luck will not hold forever.

Can we do anything?

There are three main things we can do right now. We can reduce our emissions of greenhouse gases to slow the advance of climate change; we need to convince our governments to act decisively now. We can support the interface fuel treatment programs initiated by the RDCK and the City of Nelson to reduce forest fuel loads around our communities. And we can fire-smart our own properties to make it easier to defend them from wildfires.

Global Warming? Climate Change? or Something Else? - September 10, 2017

This is the second in a series of columns addressing various issues surrounding Climate Disruption in the West Kootenays. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.



The argument about whether the earth is warming needs to end. The record is unequivocal. Since the late 1800s, the average annual surface temperature has risen more than one degree Celsius. Sixteen of the 17 warmest years in the last 136 years have occurred since 2000.

"Global warming" is a useful term for describing one aspect of the changes that occurred over the past century, mainly due to human emissions of greenhouse gases. But it doesn't tell the whole story. Since other aspects of climate are also changing, the term "climate change" may be more useful.

As the temperature of the atmosphere increases, so does its capacity to hold water. The result is that precipitation is generally increasing in places and seasons that are normally wet, but also decreasing in seasons and locations that are drier.

In the West Kootenays, temperatures are projected to increase in all seasons. But precipitation is projected to decrease in the summer, and increase in the other seasons, particularly in the winter. This may mean more snow at the higher elevations (good news for backcountry skiers). But the main result will be increased winter rains at mid and lower elevations due to higher winter temperatures.

These are general trends, and not every year will steadily represent them. Other cyclical patterns affect year-to-year variation in weather, such as El Niño. These cycles influence whether any given year is above or below the average long-term trend. But they do not negate the long-term trend.

As well, not all parts of the globe have warmed at the same rate. The Arctic Council (comprised of eight circumpolar countries including Canada) reported this year that the Arctic is warming at about twice the rate of North America (NA) as a whole.

This is important because temperature differences between the Arctic and the temperate regions drive the polar jet stream, the undulating high altitude winds that move weather systems west to east across NA. Historically the jet stream has been a wavy pattern that moves at a moderate pace across mid- and southern Canada and the northern US.

However, the jet stream has weakened as the difference between the Arctic and temperate zones has decreased. The flow of weather systems has become erratic, sometimes stalling for days, and the wave patterns have started to increase in amplitude, dipping further north and south.

When they dip further south, cold Arctic air moves south. The colder winters in Eastern Canada the past few years have coincided with the jet stream dipping far south into the northeastern US.

It also works the opposite way, with warmer air from the south moving further north. In the spring of 2013, that pattern allowed warm moist air from the Gulf of Mexico to reach Calgary. When the associated low pressure system stalled, intense precipitation continued for days. One of the most costly ónaturalô disasters in Canadian history resulted.

That series of storms eventually continued west resulting in severe flooding in the East and West Kootenays. Kaslo received more than 100 mm of precipitation in 48 hours, while Campbell, Schroeder, Fry and Hamill Creeks experienced severe flood damage.

In 2016 a slow-moving pattern in the jet stream facilitated the transfer of warm dry air from the US all the way to Ft. McMurray, resulting in extreme wildfire activity and another of Canadaôs most costly ónaturalô disasters.

This summer, when Arctic temperatures set new records, the jet stream was severely weakened. A large high pressure system stalled over BC and the Pacific northwest. This resulted in our hot dry summer and record-breaking fire season. That same high pressure system helped to hold Hurricane Harvey over Houston, resulting in record-breaking precipitation there. Fortunately, the jet stream is just now starting to increase in strength, finally breaking that pattern.

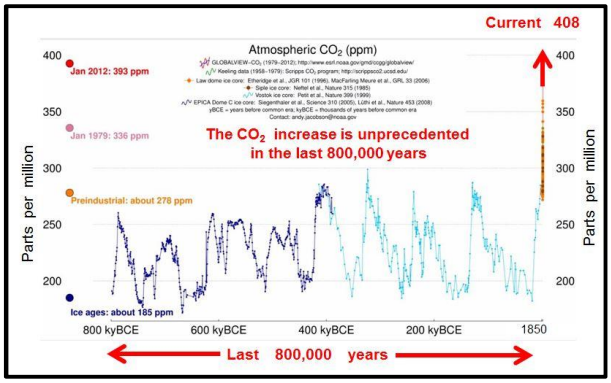
The increase in these éextreme eventsôhas caused many people to use the term éclimate disruption.ô Global warming and climate change are reasonable expressions for gradual changes in average climatic conditions. But the changing averages arenôt most important. Itôs the increase in frequency and/or magnitude of extreme weather events that generally has the greatest impacts, such as this summerôs drought and the current hurricanes.

The increase in extreme weather events is consistent with what climate models are projecting for the future. Economists, including the former Bank of Canada governor Mark Carney, are clear ï there is an urgent need for government, business and investors to adjust to greenhouse gas emission reductions, or face the severe and costly consequences of ever-increasing climate disruption events.

We need to convince ourselves and our politicians that climate change is happening now, and that itôs wiser to move away from fossil fuels in the short-term, not sometime in the future.

Greenhouse Gases – What's all the fuss? – October 10, 2017

This is the third in a series of columns addressing various issues surrounding Climate Disruption in the West Kootenay. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.



It's a wonderful experience to walk into a greenhouse, especially in the winter. The moist warm air and the fragrant plant life it supports, like getting off a plane in Hawaii. So why are we so worried about greenhouse gases?

Greenhouse gases, or GHGs, are substances that allow solar radiation to penetrate our atmosphere, while simultaneously restricting the flow of other radiation back out. The result is a net gain of heat within the atmosphere. Winds and ocean currents distribute this heat across the surface of the earth and deep into oceans. The most significant GHG is carbon dioxide (CO2), but a few other gases act in a similar manner.

If you took high school chemistry, you may recall the biological "carbon cycle" in which plants take CO2 out of the atmosphere through photosynthesis, animals breath in oxygen and exhale CO2, and decomposition eventually releases more CO2 back to the atmosphere.

As well, carbon from plants is washed into the oceans, buried and eventually turns into coal, oil or natural gas (fossil fuels), while sea shells are turned into carbonaceous rocks. Through this geologic carbon cycle, carbon is removed from the active carbon that circulates in the atmosphere and the biological cycle.

Humans have been disrupting these cycles over the past 10,000 years. At first it was through the development of agriculture, clearing land and draining wetlands. This created minor tweaks to the biological cycle. With the advent of the industrial age, we began to also impact the geologic cycle. By burning fossil fuels we began to take carbon that had been stored in geologic strata for millions of years and release it back to the atmosphere as CO2 emissions.

We also create concrete from carbonaceous rocks and release more CO2. Land clearing has greatly expanded, and places where forests used to uptake and store carbon are now occupied by cattle that emit methane, another GHG. Cow burps!

How can anyone know how much CO2 was in the atmosphere before we started messing with the cycles? Based on analysis of bubbles in ice sheets in Antarctica, over the past 800,000 years levels of CO2 in the atmosphere varied between about 200 and 300 parts per million (ppm). Our GHG emissions have already raised that number to over 400 ppm, and it continues to rise every year. So far this has already increased average global temperature by more than one degree Celsius.

So who's responsible for all these emissions? Canada contributes less than two percent of global emissions, the US about 15 percent, and China about 30 percent. However when you look at emissions per person, the numbers are quite different. Each Canadian is responsible for about 21 tonnes each year, Americans about 20 and the Chinese about 8.5.

Within the Canadian Columbia Basin, about three-quarters of our emissions come from industrial activities. Mining and smelting by Teck Resources accounts for the vast majority. Over half of community emissions result from burning gasoline and diesel for transport, while heating our homes and buildings

with propane and natural gas makes up most of the rest. Our decomposing landfills also contribute substantial amounts.

One aspect that's often ignored is the contribution of exports to global GHG emissions. When purchasers in other countries burn East Kootenay coal, on an annual basis it contributes over 30 times the non-coal emissions produced in the Columbia Basin.

The inevitable conclusion is that if we want to meaningfully reduce Columbia Basin GHG emissions, locally and globally, we must start moving toward a new economic future. Digging up and exporting fossil fuels has no future in a world that wants to avoid catastrophic climate disruption. We need to reassess our transportation infrastructure and our household uses to reduce dependence on fossil fuels. Our abundance of hydroelectric power and sources of bio-energy certainly give us viable alternatives. Solar is also beginning to make a significant contribution.

The recent Paris Accord is often touted as evidence that we are making significant progress in solving the climate crisis. Although the commitments under the accord are politically impressive, they are not nearly enough to keep global temperature increases below two degrees Celsius. The general scientific consensus is that we need to be at zero emissions by 2050 if we are to have hope of avoiding a major catastrophe.

The argument is often made that since Canada is less than two percent of global emissions we are not that important, or that we shouldn't act too soon as it might hurt our competitive advantage. An analogy that comes to mind is a group of people in a lifeboat. The lifeboat has a serious leak, and everyone has something for bailing, a bucket or a tea cup. No single bailer can stop the boat from sinking. What happens if everyone waits for someone else to start bailing?

We all need to act now.

Will our Forests Survive? – November 15, 2017

This is the fourth in a series of columns addressing various issues surrounding Climate Disruption in the West Kootenays. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.

Forests are one of the things that make the West Kootenay (WK) such a wonderful place to live, whether it be the majestic old growth cedars, the lichen-laden Engelmann spruce-subalpine fir stands or the brilliant golden larches in the fall. For anyone who spends even a few minutes outside of their house, be it at Gyro Park or the back country, the Interior Temperate Rainforests are the essence of the WK.

In a recent project for the BC Ministry of Forests. a team of local scientists explored what climate disruption will mean for WK forest ecosystems. As with most things around ecology, the answer was not simple.

Using the results of available climate projections and modeling by researchers at the U. of Alberta, the team examined what WK forests might look like in the 2080s. They chose this long timeframe because trees planted today will likely not be harvested for 100 years, and therefore they have to be suitable for good growth many decades into the future.

The models didn't actually predict what future vegetation would be, but rather identified what vegetation is currently associated with projected climates. The models did this by searching all over Western North America for climates similar to those projected for the future in the WK.

Due to variation in climate models, there is some uncertainty about what our future climate may look like. Some of that uncertainty stems from not knowing whether we will reduce our GHG emissions or, if so, by how much.

The team therefore chose to look in detail at three unique scenarios of the more than 40 available. They purposely chose three recommended by climate scientists to explore the range of possibilities. Although the results of no single scenario is likely correct, the answer was probably somewhere between the three outcomes.

The results of the three scenarios differed in some factors but there was significant agreement in others. They all agreed that temperatures would increase in the future, particularly in the summer, but differed by how much. They also all agreed that annual precipitation would also increase, but that summer precipitation would either decrease or remain roughly unchanged. In short, they all agreed the summer growing season will become more arid.

One key agreement among the scenarios concerned changes projected for the valley bottoms where we mostly live. All the scenarios agreed that the increasing aridity would result in a shift from climates that support closed forests to climates more conducive to open Ponderosa pine stands or grasslands. Imagine Castlegar resembling Boise, Idaho, or Kaslo looking like Grand Forks. The difference between the three models was how far north the grassland climates extended, or how soon the change occurred.

Another point of agreement was that the high elevation forests of majestic spruce and subalpine fir will no longer find the climate suitable. What the models didn't agree on was what they would be replaced with. The projected "bioclimates" of the future ranged from climates similar to today's WK low elevation forests, today's Alaskan coastal forests, or forests similar to low elevation forests in the East Kootenays. This uncertainty will prove very difficult for foresters trying to decide which trees to plant following logging.

Another question explored by the research team was how our forests will make the change from today's ecosystems to tomorrow's. The optimistic view would be that they would slowly transition over time. Unfortunately what is more likely is an abrupt change following a catastrophic disturbance, such as wildfire, windstorm, killing frost, landslide or pest infestation.

The lack of cold winters contributed to the recent mountain pine beetle epidemic. The ongoing mortality of birch in the WK is the result of interplay between warm springs, late frosts, leaf miners, and attacks by the bronze birch borer. Recent droughts resulted in the death of tree seedlings on shallow soils and the increased incidence of Douglas-fir beetle. What kind of forests will develop following last summer's wildfires?

Unfortunately the climate is changing too rapidly for many species to adjust their ranges. Many plant species can only expand their ranges by a few meters or kilometers per decade, and some of the predicted changes will require species to move hundreds of kilometers in a few decades. What may result following these disturbances are ecosystems full of opportunistic weeds, rather than species that supply us with the ecosystem services we have come to expect.

To avoid the worst of these projections, we have to reduce our GHG emissions immediately. Simultaneously we also have to build resiliency into our forest ecosystems for the changes that are already locked in. In contrast to what the forest industry is calling for, conservation measures have to be strengthened, not weakened. Current forest management practices have to change.

Water: Enough, too much, or too little? – December 15, 2017

This is the fifth in a series of columns addressing various issues surrounding Climate Disruption in the West Kootenay. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.

Water touches almost all aspects of our lives. We drink it for sustenance and it waters our forests and our food crops. Water provides rivers and lakes for fish and other aquatic life, wetlands for diverse wildlife, power for electricity and, yes, even a place to dump our waste. We swim in it when itôs liquid and ski on it when itôs frozen. We also fear water when it misbehaves ï whether due to storms, flooding, drought, landslides or snow avalanches. Water is the basis for our economy and life in general.

Yet we often take it for granted. And especially by continuing to burn fossil fuels, we are threatening many of waterôs benefits and increasing the frequency and magnitude of water-related calamities. Climate change is projected to have profound impacts on all aspects of the water cycle.

Most climate models project significant changes to seasonal precipitation patterns for the West Kootenay. Total annual precipitation will likely increase slightly, but that increase will not be evenly distributed. Summers will likely be drier and winters wetter. Rather than coming as gentle rains that nurture the garden, precipitation will likely fall more often as high intensity storms, with longer dry periods between precipitation events.

Lower elevations will begin to get more rain and less snow in the winterï potentially dropping from about 50 percent snow to 15 percent by the end of the century. This will create higher winter streamflows. While snow will still be dominant at higher elevations, avalanches may be less predictable and the snowpack will melt earlier in the spring creating earlier freshets.

As a result of that, and decreasing summer precipitation, summer/fall streamflows will drop. The water available for domestic use and irrigation will decrease, at the same time as higher summer temperatures increase the need for irrigation and cooling. Kokanee spawning may be threatened in some stream reaches that dry up in the fall. Small ponds, wetlands and shallow springs may run dry in drought years, affecting humans as well as amphibians and other wildlife.

Water in streams that are not fed by glaciers or groundwater will increase in temperature. As Kokanee Glacier and others disappear, streams fed by them will also begin to warm and decrease in flow. Retention of riparian forests will become even more critical for supplying shade to keep streams cool. Algae blooms may become more common in ponds and shallow bays where water temperatures reach critical levels.

Some streams will become unsuitable for cold-water dependent fish like bull trout. Invasive species like pike and bass may be favoured over native trout and salmonid species. As First Nations lobby for the return of salmon to the upper Columbia River, climate change is already having severe impacts on salmon returns in the lower Columbia. Some salmon returns in the US have already had more than 90 percent losses due to lethal stream temperatures. Climate projections show much of the lower Columbia may be unsuitable for salmon by the end of the century.

Climate disruption of the water cycle is beginning to have real local effects. Increased frequency and intensity of extreme precipitation events are already triggering more flooding, erosion and landslides. The 2012 Johnsonôs Landing landslide was triggered by two extreme climate events ï extreme monthly precipitation and rapid snowmelt. Rainfall saturated the soil from above and rapid snowmelt fed springs

that further saturated the slide area from below. The result was a deadly landslide that killed four local residents.

In 2013 a rain-on-snow event flooded Calgary and created the most expensive ñnaturalò disaster in Canadian history. It then continued moving west into the Kootenays creating further havoc. Raging debris floods destroyed numerous bridges in the East Kootenay. With over a monthôs precipitation in two days at the north end of Kootenay Lake, residents lost their home at the mouth of Hamill Creek, a campground was destroyed on the Fry Creek fan, the highway was flooded at Schroeder Creek, and homes were narrowly spared at Campbell Creek. Shifting streamflow patterns create increased uncertainty for planners. Choice of culvert sizes for roads, restrictions for construction on floodplains and seasonal projections of hydro-electric production can no longer be based solely on historical data. Some of these impacts may also be amplified by other disturbances such as fire or logging.

The greenhouse gas emissions we have already put in the atmosphere guarantee that the types of impacts described here will be with us for at least a few decades. However, we still have an opportunity to contain the increase of these impacts if we stop burning fossil fuels now. But time is quickly running out.

On a positive note, a warmer Kootenay Lake will probably make swimming more enjoyable!

Climate Disruption Could Ruin Your Holiday – February 21, 2018

This is the sixth in a series of columns addressing issues surrounding Climate Disruption in the West Kootenay. Greg Utzig is a local Conservation Ecologist who has been working on climate change issues for two decades.

While taking a holiday to south Pacific islands sounds idyllic, itôs hard to escape the impacts of climate disruption no matter where you go these days. Communities, economies, ecosystems and even whole countries are at risk ï and we are all interconnected.

As we arrived in New Zealand (NZ) in mid-January, they were experiencing a severe drought and an unprecedented and extended heat wave with temperatures approaching 40^{o}C in the southeastern part of the country. Wildfires were breaking out and conflicts between urban dwellers and rural irrigation users were beginning to surface. It has just been determined that this January was the warmest ever recorded in NZ.

To the south and west of NZ, ocean temperatures were 3-5^{o}C above normal. Apparently ocean currents had shifted and subtropical waters were not mixing with Antarctic waters as they normally do. For us, the swimming was great ï for the penguins, it was not so good.

As we moved on to the western shores of the south island, it looked like the weather would finally bring some relief. However rather than just a bit of rain, the weather system was a tropical storm, the tail end of cyclone Fehi. The storm brought high winds and torrential rains ï described by some as the worst storm in 165 years. The resulting damage inland and on the sea coast was substantial: roads washed out, landslides, storm surge flooding, downed trees and dozens of people trapped in their cars overnight. Costs to repair infrastructure will be challenging for the small communities.

We know itôs very difficult to tie any particular weather event to climate change. However it is a scientific fact that increased ocean temperatures increase the strength of tropical storms. Itôs also a fact that as the atmosphere heats up precipitation is much more likely to fall as intense storms, rather than gentle rains ï exactly what occurred.

From NZ we headed further out into the Pacific to the Cook Islands anticipating snorkeling among the coral reefs surrounding the islands. We chose the Cooks after reading a recent report that warned that nearly all the World Heritage coral reefs had been significantly damaged by bleaching in the last three years of unprecedented warm ocean temperatures.

During our time in the Cooks, that region was under the influence of another cyclone, Gita. This storm reached Category 5 intensity (the highest level) and created extensive damage to the nearby islands of Tonga, including leveling their parliament building. It subsequently hit NZ as a damaging tropical storm creating further havoc.

In the Cooks we experienced the heaviest rain I have ever seen ï the swimming pool rose noticeably in a few minutes. Large waves and high winds caused huge breakers to throw chunks of coral on to the coastal highway

Standing on the beach it was obvious that if sea level rises, coral reefs die and storms continue to intensify, as predicted, shoreline erosion will destroy much of the islandsô coastal infrastructure in a few decades. The loss of coral reefs will severely impact the Islandsôtwo economic mainstays: tourism and the production of black pearls. Warm ocean waters are already creating survival issues for the oysters. Many of the smaller islands in the Cooks are atolls, rising only a few metres above sea level, and are likely to be uninhabitable by the end of the century. Other South Pacific nations are buying land in other countries with higher ground, so their citizens have somewhere to go when the sea levels become critical. Whole cultures that have existed for centuries will be lost entirely.

To bring this back to the Kootenays, we here in Canada live a lifestyle that makes us one of the top per capita producers of greenhouse gases on earth. We have a moral responsibility and the means to do our part to stop the global catastrophe that is unfolding. Instead, we continue to produce natural gas and coal because it might be good for the economy, or we buy a gas-powered car because itôs slightly cheaper than an electric. Or in the case of myself, go on a long distance flight that doubles my GHG output for the year. If not for ourselves, then at least for the sake of South Pacific islanders, we must change our ways ï NOW ï before it is too late!