NORTHERN CLIMATE EXCHANGE, Yukon Research Centre



SUMMARY OF YUKON CLIMATE CHANGE SCIENCE

2003-2011

Northern Climate ExChange
YUKON RESEARCH CENTRE • Yukon College

NORTHERN CLIMATE EXCHANGE, YUKON RESEARCH CENTRE

Summary of Yukon Climate Change Science

2003-2011

Northern Climate ExChange

YUKON RESEARCH CENTRE • Yukon College

Printed in Whitehorse, Yukon, 2011 by Arctic Star Printing Inc., 204 Strickland St.

This publication may be obtained from:

Northern Climate ExChange
c/o Northern Research Institute, Yukon College
Whitehorse, YT
Y1A 5K8

Recommended citation:

Northern Climate ExChange, 2011. Summary of Yukon Climate Change Science 2003-2011. Northern Climate ExChange, Yukon Research Centre, Yukon College, 28 p.

Front cover photograph: Aerial photo of the Klutlan Glacier, St. Elias Mountains, Yukon. Photo courtesy of Jeff Bond, Yukon Geological Survey.

Foreword

This is a summary version of the Compendium of Yukon Climate Change Science; the full Compendium is available online at www.taiga.net/nce.

The Compendium is intended to provide an overview of recent (2003-2011) climate change work involving Yukon. It is comprised of various types of documents including scientific journal articles, government publications, workshop reports, and conference proceedings.

Information for the Compendium was gathered through:

- ASTIS Database
- Polar Data Catalogue
- Yukon Biodiversity Database
- Hydrocarbon Impacts (HI) database
- Wolf Creek Research Basin database
- Kluane Lake Research Station Bibliography
- NCE Infosources Database and NCE Library
- Northern Research Institute Fellowship Grants list
- Forest Management in a Changing Climate: Compendium of Information Sources
- Government of Canada and Government of Yukon websites
- INAC Present and Past Climate Change Adaptation Projects list
- Internet searches
- Internal knowledge

The Compendium is not an exhaustive list of climate change-related work in Yukon over the period 2003-2011. A greater emphasis was placed on studies dated between 2007 and 2011 and information that is available online.

This summary version is organized by research location. It has been separated into Yukon-Wide, North Yukon, Central Yukon, South Yukon, and Yukon River Basin sections. Pictures used in this document are for esthetic purposes only; the pictures are not intended to accurately represent the actual location or topic of study. Each entry is highlighted in a specific colour depending on topic as follows:

- General
- Fish, Wildlife, and Food Security
- Hydrology
- Permafrost
- Hazards
- Forestry

I would like to thank Lia Johnson, John Streicker, Bob Van Dijken, Rebecca World, Ryan Hennessey, Lacia Kinnear, Darcie Matthiessen, and Aynslie Ogden for their assistance. I am also grateful to all of the Yukon First Nations that responded to my request for information involving studies conducted in their respective traditional territories.

Aletta Leitch
Climate Change Assistant Analyst
Northern Climate ExChange
Yukon Research Centre, Yukon College
August 2011

Contents

Implications of Climate Change for Northern Canada: The Physical Environment

Research Location: *Yukon; Northwest Territories; Nunavut*

Local Relevance: Northern Hemisphere snow-cover extent has decreased in recent decades and continuing changes are expected to be most pronounced during fall and spring, affecting spring runoff. Of glaciers in northern Canada, the Yukon-Alaska glaciers have experienced the most melting, causing approximately 9% of the global sea-level rise observed over the past 50 years. It is estimated that recent melt of the Yukon-Alaska glaciers contributed two times more to sea-level rise than melt of the Greenland ice sheet. With respect to permafrost, Yukon is expected to experience the largest percentage increase in active layer depth over the coming 50 years. Northern Hemisphere lakes and rivers are displaying a trend toward earlier ice breakup and later freeze-up by about 6 days per century each.

Citation: Prowse, T.D., Furgal, C., Melling, H., Smith, S.L. 2009. "Implications of Climate Change for Northern Canada: The Physical Environment." *Ambio* 38(5): 266-271.

Climatic Conditions in Northern Canada: Past and Future

Research Location: *Yukon; Northwest Territories; Nunavut*

Local Relevance: During the period of 1948-2005, Yukon experienced an annual average warming of 2.2°C and a winter warming of 4.5°C, the greatest rate of temperature increase in Canada. The period 1950-1998 saw fewer extremely cold days and more extremely warm days, accompanied by more intense and more frequent precipitation events. Temperatures have warmed and precipitation has increased across Canada, and the rate of warming exceeds anything seen since the onset of the Holocene 10,000 years ago. Climate projections predict increasing temperatures (most pronounced during winter and fall) and generally agree that precipitation will increase. Rates of predicted warming increase further north, an effect that would act to equilibrate temperatures across the North and may affect north-flowing rivers.

Citation: Prowse, T.D., Furgal, C., Bonsal, B.R., Edwards, T.W.D. 2009. "Climatic Conditions in Northern Canada: Past and Future." *Ambio* 38(5): 257-265.

Traditional Food Attributes Must be Included in Studies of Food Security in the Canadian Arctic

Research Location: *Canadian Arctic*

Local Relevance: A survey involving women in 44 arctic communities, including Yukon First Nations communities, was conducted to delve into the role of traditional foods in arctic food security. Participants highlighted many physical, health, and cultural benefits of traditional foods. Research found that 38.2% of the participants noted recent changes in traditional food sources; the most common being physical changes to animals and fish, reduced animal and fish populations, and increasing difficulty accessing populations. In summary, this study shows that traditional foods are extremely important to indigenous women; therefore, availability of traditional foods is critical to food security.

Citation: Lambden, J., Receveur, O., Kuhnlein, H.V. 2007. "Traditional Food Attributes Must be Included in Studies of Food Security in the Canadian Arctic." *International Journal of Circumpolar Health* 66(4): 308-319.

Past and Future Forcing of Beaufort Sea Coastal Change

Research Location: *Beaufort Sea (Tuktoyaktuk and Pelly Island, NWT)*

Local Relevance: The researchers analyzed wind characteristics, sea level, sea-ice extent, and air temperature for the southern Beaufort Sea in order to better understand past climate change and predict future change. There has been a significant sea-level rise since 1962, accompanied by insignificant increases in air temperature and decreases in ice extent. Although there is likely to be a decrease in storm frequency overall, severe storms are predicted to increase in frequency. Based on a 1-5 scale (where 1 is very unlikely and 5 is very likely) deceased sea-ice extent, sea-level rise, and increased temperatures are very likely; and increased frequency of severe storms and increased wave energy are likely. More flooding and increased rates of coastal change are predicted.

Citation: Manson, G.K., Solomon, S.M. 2007. "Past and Future Forcing of Beaufort Sea Coastal Change." *Atmosphere-Ocean* 45(2): 107-122.

Climate Change Threatens Polar Bear Populations: A Stochastic Demographic Analysis

Research Location: *Beaufort Sea*

Local Relevance: A population model was developed to predict the future consequences of climate change on polar bears living in the southern Beaufort Sea area. From 2001-2003 to 2004-2005, the length of the ice-free season in this area increased by about 50%. The model output yielded an 80-94% chance that this polar bear population would become extinct by 2100 as a result of declining sea ice extent and thickness. Polar bears require sea ice to hunt prey and provide travel routes; decreased sea ice results in nutritional deficits, starvation, and increased risk of injury.

Citation: Hunter, C.M., Caswell, H., Runge, M.C., Regehr, E.V., Amstrup, S.C., Stirling, I. 2010. "Climate Change Threatens Polar Bear Populations: A Stochastic Demographic Analysis." *Ecology* 91(10): 2883-2897.

Permafrost and Climate Change at Herschel Island (Qikiqtaruq), Yukon Territory, Canada

Research Location: *Herschel Island, Yukon*

Local Relevance: The ground temperature profile measured on Herschel Island shows recent permafrost warming. A model of the ground temperature regime illustrates that the temperature at the top of the permafrost and at a depth of 20 metres has increased since the earliest period of measurement (1899-1905). This model also indicates that the depth of the active layer has increased since 1985.

Citation: Burn, C.R., Zhang, Y. 2009. "Permafrost and Climate Change at Herschel Island (Qikiqtaruq), Yukon Territory, Canada." *Journal of Geophysical Research* 114: F02001, doi:10.1029/2008JF001087.

Herschel Island *Qikiqtaruk* Territorial Park Management Plan

Research Location: *Herschel Island, Yukon*

Local Relevance: Climate change and the resulting effects on natural systems have been labeled as "major stressors" occurring at "accelerated" rates in Qikiqtaruk Territorial Park. Temperatures have risen, accompanied by increased winds, more summer storms, elevated water levels, and changes to ice. Associated with climate change are changes to natural processes, including altered vegetation, more erosion, and more-frequent landslides. It is noted that the park could assist in monitoring climate change by staffing the park weather station. Many of the goals outlined in the report address monitoring the changing climate.

Citation: Yukon. Dept. of Environment. *Herschel Island-Qikiqtaruk Territorial Park Management Plan.* Whitehorse: 2006.

Near-Record Precipitation Causes Rapid Drainage of Zelma Lake, Old Crow Flats, Northern Yukon Territory

Research Location: *Old Crow Flats, Yukon*

Local Relevance: It was determined from analyzing water isotope composition that the drainage of Zelma Lake, Old Crow Flats was likely the result of a period of record rainfall which caused rapid erosion of a land barrier separating the lake from the water network that removes water from the Flats. Zelma Lake drained in June 2007, after the largest May precipitation recorded since 1951 and above-average total precipitation from the previous two months. The lake experienced a volume loss of 80% and an area reduction of 43%.

Citation: Wolfe, B. B., Turner, K. W. 2008. "Near-Record Precipitation Causes Rapid Drainage of Zelma Lake, Old Crow Flats, Northern Yukon Territory." *Meridian*: 7-12.

Environmental Change and Traditional Use of the Old Crow Flats in Northern Canada: An IPY Opportunity to Meet the Challenges of the New Northern Research Paradigm

Research Location: *Old Crow, Yukon*


Photo Credit: Yukon Government

Local Relevance: Community members have noticed thawing permafrost, changes in wildlife abundance and vegetation, and shallower water levels in lakes and rivers. According to Old Crow's1930-2000 temperature records, all seasons (with the exception of fall) experienced a mean temperature increase. A tree-ring width chronology resulting from this IPY project illustrates that temperature increases during the last two to three decades were much more rapid than at any other time during the previous 300 years. This project provided community members with an opportunity to share their knowledge as well as to learn from skilled researchers. Locals were hired as field research assistants, one researcher engaged local youth in a Science Camp, and the research team regularly shared their findings and progress with the community.

Citation: Wolfe, B.B., Humphries, M.M., Pisaric, M.F.J., Balasubramaniam, A.M., Burn, C.R., Chan, L., Cooley, D., Froese, D.G., Graupe, S., Hall, R.I., Lantz, T., Porter, T.J., Roy-Leveillee, P., Turner, K.W., Wesche, S.D., William, M. 2011. "Environmental Change and Traditional Use of the Old Crow Flats in Northern Canada: An IPY Opportunity to Meet the Challenges of the New Northern Research Paradigm." *Arctic* 64(1): 127-135.

Hunting for Models: Grounded and Rational Choice Approaches to Analyzing Climate Effects on Subsistence Hunting in an Arctic Community

Research Location: *Old Crow, Yukon*

Local Relevance: Researchers used local knowledge and socially based models to predict the impacts of climate change on caribou subsistence hunting in Old Crow. Early winters with little snowfall reduce accessibility to hunting grounds and warmer summers increase meat spoilage. Modelling predicts that during years of later winter freeze-up (a consequence of climate change), less than 10% of Old Crow residents will hunt and the average household that does hunt will lose half a day's worth of time per season.

Citation: Berman, M., Kofinas, G. 2004. "Hunting for Models: Grounded and Rational Choice Approaches to Analyzing Climate Effects on Subsistence Hunting in an Arctic Community." *Ecological Economics* 49: 31-46.

Rationale for Implementing Conservation Measures to Protect the Porcupine Caribou Herd

Research Location: *range of the Porcupine Caribou herd*

Local Relevance: Part of the recent Porcupine caribou population decline may be related to warmer spring temperatures that cause freeze-thaw events during spring migration, resulting in poor conditions for migrating and feeding. It is also possible that the vast burning of the Eagle Plains area which destroyed essential lichen habitat was related to climate change. Overall, it is expected that climate change will be detrimental to the Porcupine caribou herd.

Photo Credit: Yukon Government

Citation: Yukon. Dept. of Environment. "Rationale for Implementing Conservation Measures to Protect the Porcupine Caribou Herd." Environment Yukon: 2009.

Photo Credit: Yukon Government

Potential Alteration by Climate Change of the Forest-Fire Regime in the Boreal Forest of Central Yukon Territory

Research Location: *Dawson and Mayo, Yukon*


Photo Credit: Yukon Government

Local Relevance: Overall, the most important variable in predicting fire severity in the Mayo and Dawson region is moisture. In addition, lightning-ignited fires and area burned are strongly correlated with temperature, and fire occurrence is negatively correlated with precipitation. Seven General Circulation Models were analysed for central Yukon: all simulated warmer summer temperatures; 4 of 7 predicted decreased moisture availability; and most called for an increase in precipitation. Using these scenarios, model results predict more forest fires and an increase in area burned as climate change continues. The highest predictions call for 60% more fires per year by 2010-2039 and a 20% increase in area burned by 2040-2069.

Citation: McCoy, V.M., Burn, C.R. 2005. "Potential Alteration by Climate Change of the Forest-Fire Regime in the Boreal Forest of Central Yukon Territory." *Arctic* 58(3): 276-285.

Community Flood Planning: An Assessment of Hazard and Response in the Dawson City Region, Yukon, Canada

Research Location: *Dawson, Yukon*

Local Relevance: In the Dawson area, there has been a trend of earlier spring river break-up dates since 1896, and it is predicted that warmer winter temperatures and greater seasonal temperature variability will manifest in more ice-jam floods. In 2002/2003 for example, abnormally warm December temperatures caused some of the ice on the Klondike River to break up and resulted in flooding of low-lying areas. This thesis includes an assessment of possible flood scenarios and which locations in Dawson would be flooded in each case. It is recommended that there be limited in-filling of the Dawson town site and the Klondike Valley area because these locations are at a high flood risk.

Citation: Beasley, E. 2010. "Community Flood Planning: An Assessment of Hazard and Response in the Dawson City Region, Yukon, Canada." MA diss., McGill University.

Geophysical and Borehole Investigations of Permafrost Conditions Associated with Compromised Infrastructure in Dawson and Ross River, Yukon

Research Location: *Dawson and Ross River, Yukon*


Photo Credit: Yukon Government

Local Relevance: A survey was conducted to investigate the state of permafrost at various sites in both Dawson and Ross River. In Dawson, the Palace Grand Theatre is at risk for damage due to permafrost degradation because it is underlain by ice-rich permafrost that is at a temperature just below freezing. Increasing depth of the active layer may cause damage to certain areas of St. Andrew's Church, while the Old Territorial Administration Building is not at risk.

Citation: Laxton, S. and Coates, J., 2011. Geophysical and Borehole Investigations of Permafrost Conditions Associated with Compromised Infrastructure in Dawson and Ross River, Yukon. *In*: Yukon Exploration and Geology 2010, K.E. MacFarlane, L.H. Weston and C. Relf (eds.), Yukon Geological Survey, p. 135-148.

Community-Based Fish and Wildlife Work Plan for the Na-Cho Nyäk Dun Traditional Territory 2008-2013

Research Location: *Na-Cho Nyäk Dun Traditional Territory*

Local Relevance: There is concern regarding the possible effects of climate change on trout habitat in smaller lakes—obtaining data from previous studies is proposed. Habitat changes such as lakes drying up and altered moose movements have been observed, and it is noted that habitat changes can be promoted by climate change or forest fires. It is also noted that moose are affected by snow depth and whether there is ice-crusting on top of the snow. The report calls for continued monitoring of plant and animal species to identify the potential impact of climate change.


Photo Credit: Yukon Government

Citation: Na-Cho Nyäk Dun Fish and Wildlife Planning Team. 2008. *Community based fish and wildlife management plan for the Na-Cho Nyäk Dun Traditional Territory*. Environment Yukon, Whitehorse, Yukon. 45 pages.

Climate Change in the Mayo Area: Observations of Long-Term Local Residents

Research Location: *Mayo, Yukon*

Local Relevance: It was noted that summer and winter temperatures have increased with fewer periods of extreme cold and there has been increased snow and rain in winter. There have been changes to the freeze-thaw cycle with earlier thaw of water bodies in spring and later freeze-up in fall. Permafrost conditions have also changed, resulting in damage to overlying houses and drainage of lakes into the ground. Vegetative changes noticed include larger trees and poorer crop yields from berry bushes. There has also been an increase in the number of forest fires, attributed to higher temperatures, less precipitation, and more lightning. These climatic changes have resulted in changes to fish and wildlife. The contribution of climate change to altered patterns of subsistence activities is hard to ascertain because social changes and participant aging has also affected the way people interact with the land.

Citation: 2005. "Climate Change in the Mayo Area: Observations of Long-Term Local Residents." Workshop Report, 9-10 Feb. 2005, Mayo, Yukon, 16 p.

Climate Change and Mining in Canada

Research Location: *Canada*

Local Relevance: The Minto mine released untreated water into the Yukon River (with more waste discharge than license standards) in both 2008 and 2009 because it was not prepared to deal with increased precipitation. Planning for future torrential rain events has been limited, as the mine requested permission to release untreated water again for 2009 and 2010. Permafrost thaw caused the tailing dumps of the abandoned Clinton Creek asbestos mine to fail, blocking the flow of Wolverine Creek and destroying aquatic life. Future implications of climate change on the mining industry are expected to be high for mines that are located in permafrost areas due to infrastructure damage.

Citation: Pearce, T.D., Ford, J.D., Prno, J., Duerden, F., Pittman, J., Beaumier, M., Berrang-Ford, L., Smit, B. 2011. "Climate Change and Mining in Canada." *Mitigation and Adaptation Strategies for Global Change* 16: 347-368.

Photo Credit: Yukon Government

Local Observations of Climate Change and Impacts on Traditional Food Security in Two Northern Aboriginal Communities

Research Location: *Beaver Creek, Yukon; Fort Providence, Northwest Territories*

Local Relevance: The participants of the White River First Nation at Beaver Creek have noticed changes in species distribution and migratory patterns: deer, lynx, and cougars have been seen around the community; different plants have been identified; birds are migrating north earlier in the spring and migrating south later in the fall; and there has been a large decrease in the population of the local caribou herd. Community members have noticed less precipitation accompanied by drier conditions and lower berry crop yields. The observed trend of less snow in the winter may lead to increased caribou predation by coyotes. Thunder storms are occurring in unusual months and there has been much less ice on water bodies around Beaver Creek. Predicting the weather has become more difficult, storms are endangering travelers, and warmer temperatures are making it more difficult to safely dry meat.

Citation: Guyot, M., Dickson, C., Paci, C., Furgal, C., Chan, H.M. 2006. "Local Observations of Climate Change and Impacts on Traditional Food Security in Two Northern Aboriginal Communities." *International Journal of Circumpolar Health* 65(5): 403-415.

Keeping Pace with Fast Climate Change: Can Arctic Life Count on Evolution?

Research Location: *Kluane Lake, Yukon*

Local Relevance: A population of red squirrels near Kluane Lake has shifted its birthing date earlier by about 18 days over the past 10 years in response to climate change. It was determined that while 62% of this shift was due to a direct response to changing climatic conditions, 13% of the shift was the result of evolutionary changes in species genetics. Evolution has occurred because squirrels that breed earlier in the year are more likely to have offspring that survive. This population has managed to keep pace with climate change in the Kluane region but researchers caution that other species may not be able to evolve as quickly as the red squirrel.

Citation: Berteaux, D., Réale, D., McAdam, A.G., Boutin, S. 2004. "Keeping Pace with Fast Climate Change: Can Arctic Life Count on Evolution?" *Integrative and Comparative Biology* 44: 140-151.

Mushroom Crops in Relation to Weather in the Southwestern Yukon

Research Location: *Kluane Lake, Yukon*

Local Relevance: It was determined that June rainfall of the current year and May rainfall of the previous year are both good predictors of mushroom crop production in southwest Yukon, whereas temperature showed no correlation. It is hypothesized that May rainfall of the previous year affects plant energy storage which in turn affects crop production the following year. Previous research has found that increased water availability promotes mushroom crop production; however, current and past research has found that a year of high production could not be followed by another productive year, regardless of rainfall.

Citation: Krebs, C.J., Carrier, P., Boutin, S., Boonstra, R., Hofer, E. 2008. "Mushroom crops in relation to weather in the southwestern Yukon." *Botany* 86: 1497-1502.

State of the Park Report—Kluane National Park and Reserve of Canada

Research Location: *Kluane National Park and Reserve, Yukon*

Local Relevance: From 1945 onward, climatic records indicate increased average temperature and precipitation, accompanied by decreased rain in summer; elders say winters are not as cold as they used to be. Icefields and glaciers have been melting rapidly in response to climate warming; elders are worried about the future of water systems in the area. Elders hear fewer birds and are worried about effects of the spruce beetle; beetle-killed trees increase the risk of ground fires, impede wildlife movement, and do not take up water from the soil. The arctic ground squirrel population has declined, possibly due to altered precipitation; however, mice and vole populations have increased, possible due to greater berry production as the forest canopy is opened by the spruce beetle. Kokanee salmon populations have decreased since 2002, perhaps due to water temperatures that are too high for optimal reproduction.

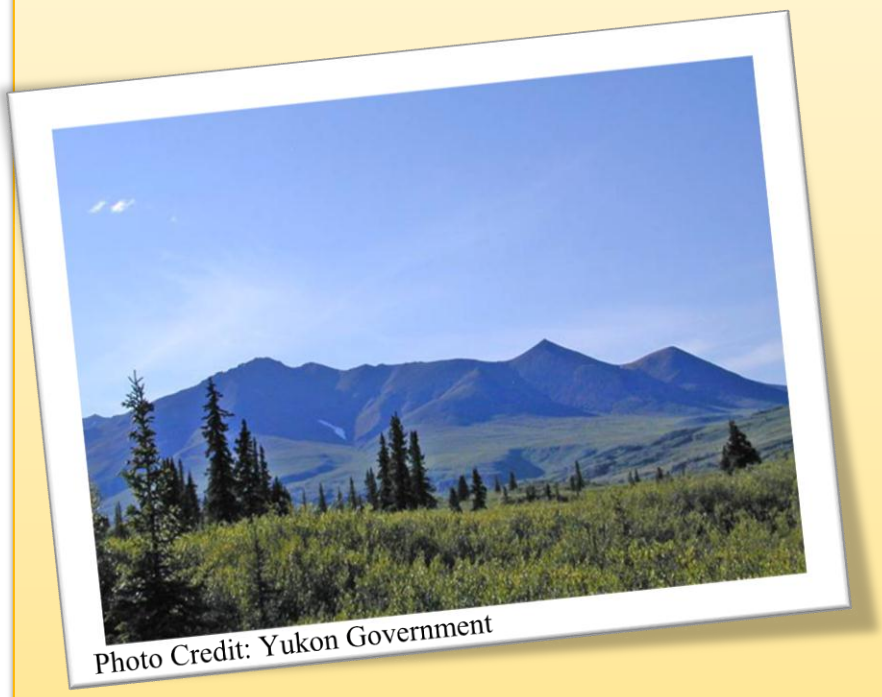
Photo Credit: Yukon Government

Citation: Henry, D., Landry, A., Elliot, T., Gorecki, L., Gates, M., and Chow, C., 2008. *State of the Park Report—Kluane National Park and Reserve of Canada*. Parks Canada, 72 p.

Spruce Beetle Outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: Relationship to Summer Temperatures and Regional Differences in Disturbance Regimes

Research Location: *Kluane National Park and Reserve, Yukon; Kenai Peninsula, Alaska*

Local Relevance: Tree-ring measurements showed evidence of the known 1940s spruce bark beetle outbreak and indicated that all four Kluane stands had experienced forest fires. Beetle outbreaks have occurred and been sustained due to periods of warmer summers—above-average temperatures beginning in 1989 in the Kluane region are associated with the 1990s outbreak and warm 1930s temperatures are related to the 1934 outbreak. Warm summers allow for greater beetle reproduction and cause trees to suffer drought stress; however, in Kluane it is suspected that drought stress is the more controlling factor.

Photo Credit: Yukon Government

Citation: Berg, E.E., Henry, J.D., Fastie, C.L., De Volder, A.D., Matsuoka, S.M. 2006. "Spruce Beetle Outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: Relationship to Summer Temperatures and Regional Differences in Disturbance Regimes." *Forest Ecology and Management* 227: 219-232.

Climate Change in Our Backyard

Research Location: *Champagne and Aishihik Traditional Territory*

Local Relevance: Information was gathered and shared by scientists and local community members in Haines Junction in order to gain a better understanding of climate change and plausible adaptive strategies. Locals noted many changes regarding fish, wildlife, weather, landscape features, and the boreal forest and they provided ideas for adaptation, many of which called for community involvement. Concerns included warm water affecting fish, snow-crusting making it difficult for big game species to access food, and rain and thaw in winter harming small mammals.

Citation: Champagne and Aishihik First Nations and Alsek Renewable Resource Council. 2006. "Climate Change in our Backyard." Conference Report, Haines Junction, Yukon, 34 p.

Adapting to Climate Change in the Southwest Yukon: Locally Identified Research and Monitoring Needs to Support Decision Making on Sustainable Forest Management

Research Location: *Champagne and Aishihik Traditional Territory*

Local Relevance: This paper analyses the results of a community workshop and a study involving forest practitioners, both aimed at determining research and monitoring needs for the forests of the Champagne and Aishihik Traditional Territory. The 2006 workshop was attended by more than 130 people, many of whom noted changes in weather (warmer temperatures, less snow), fish and wildlife, and altered forest species and ecosystems. Workshop participants expressed a desire for local people to be involved in monitoring of forests and wildlife. The 2007 study involved 30 forest practitioners that expressed the need for increased research and monitoring to identify promising forest management practices. The researchers believe that ongoing collaboration between local residents, governments, and academics will act to enhance the community's adaptive capacity.

Photo Credit: Yukon Government

Citation: Ogden, A.E., Innes, J.L. 2009. Adapting to Climate Change in the Southwest Yukon: Locally Identified Research and Monitoring Needs to Support Decision Making on Sustainable Forest Management. *Arctic* 62(2): 159-174.

Evidence of Recent Treeline Dynamics in Southwest Yukon from Aerial Photographs

Research Location: *Kluane Ranges, St. Elias Mountains, Yukon*

Local Relevance: Aerial photographs from 1989 were compared to those photographs from 1947-1948 to determine what changes had occurred along the treeline. The researchers primarily noted greater growth of individual trees, followed by greater tree density and upward advance. Increased tree growth commonly occurred as the only change or accompanied by increased density, while elevational advance generally occurred alongside the other two changes. The researchers believe these changes are the result of climate change and that the photographic evidence likely underestimates the extent of treeline dynamics during this time.

Citation: Danby, R.K., Hik, D.S. "Evidence of Recent Treeline Dynamics in Southwest Yukon from Aerial Photographs." *Arctic* 60(4): 411-420.

Interannual Variation in Timing of Parturition and Growth of Collared Pikas (*Ochotona collaris*) in the Southwest Yukon

Research Location: *Ruby Range, St. Elias Mountains, Yukon*

Local Relevance: The average breeding date of a population of pikas was shown to fluctuate based on climatic conditions, with breeding date being postponed as a result of increased snow cover and delayed snowmelt. Pikas may be able to use environmental cues to adjust breeding date in order for birthing to occur alongside vegetation growth. There was no evidence that breeding date affects pika survival, but it may affect early survival before young pikas emerge from the nest. Based on this evidence, pikas show an ability to adjust to changing climate conditions.

Citation: Franken, R.J., Hik, D.S. 2004. "Interannual Variation in Timing of Parturition and Growth of Collared Pikas (*Ochotona collaris*) in the Southwest Yukon." *Integrative and Comparative Biology* 44: 186-193.

Recent Glacier Mass Changes in the Gulf of Alaska Region from GRACE Mascon Solutions

Research Location: *Gulf of Alaska, Yukon and Alaska*

Local Relevance: Of all mountain glacier systems, the Gulf of Alaska glaciers are contributing the most to global sea-level rise. The St. Elias range experienced one of the most negative mass balances of the Gulf of Alaska glaciers over the period 2003-2007. An abnormally warm year occurred in 2004, and of the regions studied, the St. Elias region displayed the greatest summer mass loss during this time.

Photo Credit: Yukon Government

Citation: Luthcke, S.B., Arendt, A.A., Rowlands, D.D., McCarthy, J.J., Larsen, C.F. 2008. "Recent Glacier Mass Changes in the Gulf of Alaska Region from GRACE Mascon Solutions." *Journal of Glaciology* 54: 767-777.

Sustained Rapid Shrinkage of Yukon Glaciers since the 1957–1958 International Geophysical Year

Research Location: *St. Elias and Mackenzie Mountains, Yukon*

Local Relevance: It was determined that Yukon glaciers experienced a surface area decrease of 22% during the fifty-year period from 1956-1958 to 2006-2008. This period of melting was accompanied by increasing summer and winter temperatures, as well as decreasing winter precipitation. Less snow and warmer summers mean that glaciers accumulate less in winter and melt more in summer. This is aggravated by warmer winter temperatures which can cause winter melt and also results in a greater proportion of winter precipitation falling as rain. The estimated contribution of this glacial melt to sea-level rise was calculated, as was the proposed future contribution should the glaciers melt entirely.

Citation: Barrand, N.E., Sharp, M.J. 2010. "Sustained Rapid Shrinkage of Yukon Glaciers since the 1957–1958 International Geophysical Year." *Geophysical Research Letters* 37(7): L07501, doi:10.1029/2009GL042030.

Impacts of Drought on Forest Growth and Regeneration following Fire in Southwestern Yukon, Canada

Research Location: *southwest Yukon*

Local Relevance: Of the factors studied, precipitation had the greatest impact on the growth of mature spruce and aspen, where greater precipitation promotes growth. In addition, researchers observed that forest growth after fire was much slower than they would have expected. Therefore, it is predicted that if the climate becomes warmer and drier, there will be a reduction in forest cover in southwest Yukon due to both temperature-induced drought stress and poor growth following forest fires.

Citation: Hogg, E.H., Wein, R.W. 2005. "Impacts of Drought on Forest Growth and Regeneration following Fire in Southwestern Yukon, Canada." *Canadian Journal of Forest Research* 35: 2141-2150.

Detection of Changes in Glacial Run-off in Alpine Basins: Examples from North America, the Alps, central Asia and the Andes

Research Location: *Canada; Switzerland; Austria; central Asia; Peru; Chile*

Local Relevance: Glacierized river basins located in southwest Yukon and northwest British Columbia show an increase in runoff which is attributed to glacier thinning as a result of climate warming. However, basins in south and central British Columbia and southwest Alberta show a decrease in runoff. According to the researchers, this runoff decrease is because the southern glaciers have passed the threshold at which increased runoff from glacier thinning no longer compensates for decreased runoff due to glacier area loss. The authors hypothesize decreased runoff in glacierized basins will become increasingly common as glaciers approach a point of significant area loss.

Citation: Casassa, G., López, P., Pouyaud, B., Escobar, F. 2009. "Detection of Changes in Glacial Run-off in Alpine Basins: Examples from North America, the Alps, central Asia and the Andes." *Hydrological Processes* 23(1): 31-41.

Projected Impacts of Climate Warming on Production of Lake Trout (*Salvelinus namaycush*) in Southern Yukon Lakes

Research Location: *south Yukon*

Local Relevance: Data were used from 33 southern Yukon lakes to model the impacts of climate change on lake trout. Previous studies have indicated that lake trout prefer a water temperature of 8-12°C; as the climate warms the availability of water of this temperature in lakes may change. Although there were variations as to whether the quantity of water with the specific temperature range in a specific lake increased or decreased, overall warming scenarios correspond with decreased habitat for lake trout. This corresponds to a decrease in potential lake trout harvest from southern Yukon lakes. It is predicted that in the long term, preferred lake trout habitat will shift northward to colder lakes.

Citation: Mackenzie-Grieve, J.L., Post, J.R. 2006. "Projected Impacts of Climate Warming on Production of Lake Trout (*Salvelinus namaycush*) in Southern Yukon Lakes." *Canadian Journal of Fisheries and Aquatic Sciences* 63: 788-797.

Community Adaptation Project: Whitehorse Climate Change Adaptation Plan (Draft Plan)

Research Location: *Whitehorse, Yukon*

Local Relevance: Whitehorse is expected to experience a winter temperature increase of 3.3°C to 5.4°C, increased precipitation (especially in winter), and a growing season lengthened by 18-25 days by 2050. Impacts of climate change are expected to be the most pronounced regarding natural hazards (flooding, fires), infrastructure, food and energy security, and the environment. Opportunities resulting from climate change are also noted, including an opportunity for increased local agriculture and a heightened need for Whitehorse to be a hub for the north. High priority risks and adaptations are identified and a structure for implementing adaptation strategies is suggested.

Citation: Hennessey, R. and Streicker, J., 2011. *Community Adaptation Project: Whitehorse Climate Change Adaptation Plan.* Northern Climate ExChange, Yukon Research Centre, Yukon College, Whitehorse, YT.

Changes in Past Hydro-Climatology and Projected Future Change—for the City of Whitehorse (Summary Report)

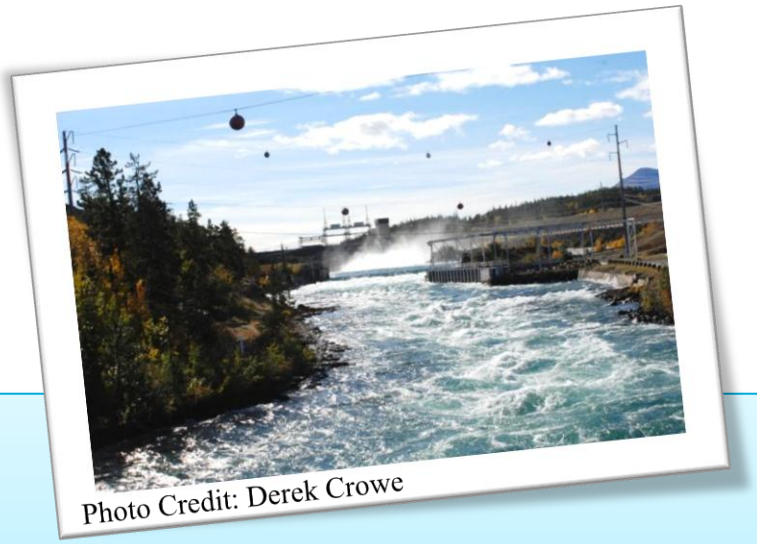
Photo Credit: Derek Crowe

Research Location: *Whitehorse, Yukon*

Local Relevance: From 1950-2003, temperatures in Whitehorse increased by 1.5°C to 2.5°C and precipitation increased by up to 30% in some regions (albeit mostly statistically insignificant). Climate models predict average temperature increases of 3°C to 6°C and precipitation increases between 10% and 45% by the 2050s. Streamflow trends were documented for many major rivers in Yukon. For the Yukon River, the current trend of increasing winter flows and decreasing summer flows is expected to continue. This may assist winter hydroelectric power production while having adverse impacts on some ecosystems.

Citation: Werner, A.T., and Murdock, T.Q. 2008. "Changes in Past Hydro-Climatology and Projected Future Change—for the City of Whitehorse." Pacific Climate Impacts Consortium, University of Victoria.

Historic Change in Permafrost Distribution in Northern British Columbia and Southern Yukon

Research Location: *Alaska Highway corridor, from Whitehorse, Yukon to Fort St. John, British Columbia*

Local Relevance: In 2007, the researchers investigated permafrost extent and distribution at sites along the Alaska Highway from Whitehorse to Fort St. John that had previously been studied in 1964. Of the original sites located, over half of the places where permafrost was present in 1964 no longer contained permafrost. In areas where permafrost was still intact, the active layer had deepened. It is suggested that this permafrost thaw is related to the 1.5-2.0°C rise in air temperature since the previous study as well as changes in precipitation.

Citation: Bryan, R., Hinzman, L.D., Busey, R.C., 2008 Historic Change in Permafrost Distribution in Northern British Columbia and Southern Yukon. *In*: Ninth International Conference on Permafrost, Extended Abstracts, D.L. Kane and K.M. Hinkel (eds.), Fairbanks, Alaska, June 29-July 3, 2008, p. 115-116.

Permafrost and Landslide Activity: Case Studies from Southwestern Yukon Territory

Research Location: *Alaska Highway corridor, southwest Yukon*

Local Relevance: Five permafrost-related landslides in the southwest Yukon provide precedents for future landslides that may result from climate change. The landslides in Marshall Creek Basin and on Haeckel Hill were the result of fire disturbance that increased the depth of the active layer; therefore, more forest fires as a result of climate change will lead to more of this type of ground failure. In addition, predicted increases in air temperature and snow depth would also increase active layer depth. The Silver Creek and Mount Sumanik landslides were the result of heavy rainfall, indicating that more heavy rainfall events associated with climate change may lead to this type of landslide. Increasing precipitation may also lead to river migration, causing ground slumping like that observed in the Takhini Valley.

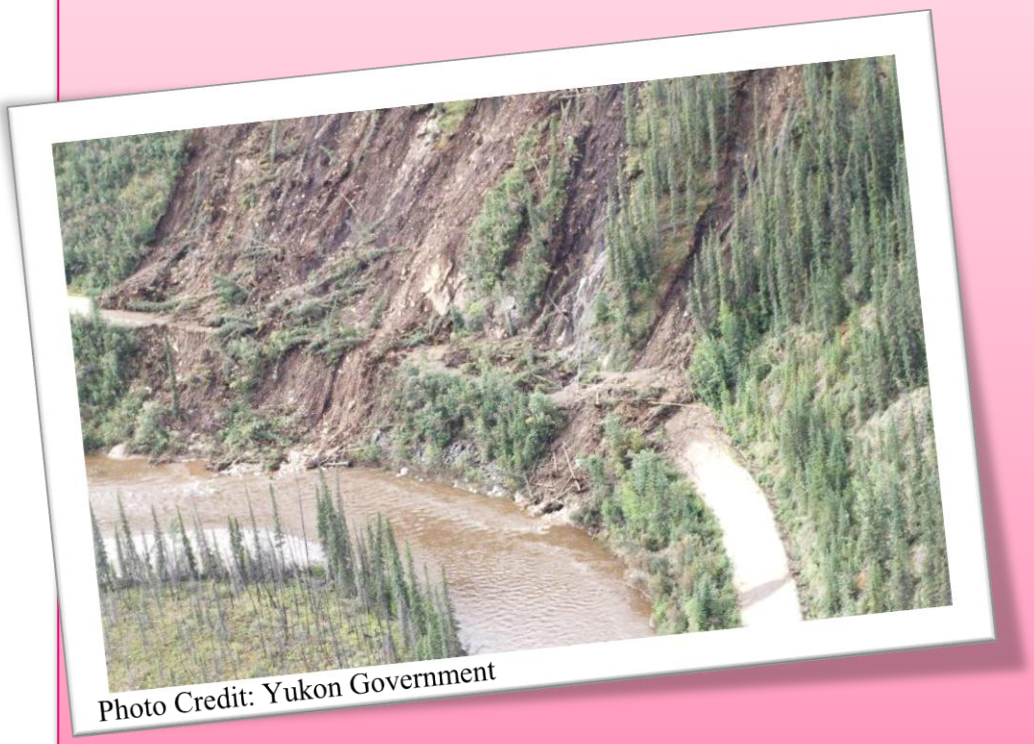

Photo Credit: Yukon Government

Citation: Huscroft, C.A., Lipovsky, P. and Bond, J.D., 2004. Permafrost and Landslide Activity: Case Studies from Southwestern Yukon Territory. *In*: Yukon Exploration and Geology 2003, D.S. Emond and L.L. Lewis (eds.), Yukon Geological Survey, p. 107-119.

Effect of *Ichthyophonus* on Survival and Reproduction in Yukon River Chinook Salmon

Research Location: *Yukon River; Tanana River; Chena River; Salcha River*

Local Relevance: From 1999 to 2002, Yukon River chinook salmon were studied for signs of the pathogen *Ichthyophonus*. There was a greater proportion of diseased fish during the second half of the run correlated with increasing water temperatures from the middle of June to mid-July. The greatest number of fish with multiple infected organs was observed during the years with highest water temperature (1999 and 2001) and the lowest number was observed during 2002, the year with the lowest water temperature. Evidence suggests that the pathogen is better able to spread and infect salmon in higher water temperatures (above 15°C).

Photo Credit: Yukon Government

Citation: Kocan, R., and Hershberger, P. 2004. "Effect of *Ichthyophonus* on Survival and Reproduction in Yukon River Chinook Salmon." University of Washington, Project # URE-13-01 & 02.

Hydrologic Effects of Climate Change in the Yukon River Basin

Research Location: *Yukon River Basin (at Pilot Station, Alaska)*

Local Relevance: A climate model was used to predict the effects of increased temperature and precipitation on Yukon River Basin (YRB) runoff. Runoff is expected to increase throughout the 21st century, mostly as a result of increased precipitation. Increased winter precipitation will result in increased snowpack available for spring melt, and increased summer precipitation will add to river flows. The model predicts the majority of increased runoff to occur from May through July, as a result of an increase in the ratio of rain to snow as well as increased snowmelt. Increased temperature is expected to delay snow accumulation and promote earlier snowmelt, which will affect the timing of spring runoff.

Citation: Hay, L.E., McCabe, G.J. 2010. "Hydrologic Effects of Climate Change in the Yukon River Basin." *Climatic Change* 100: 509-523.

Impact of Doubled CO_2 on the Interaction between the Global and Regional Water Cycles in Four Study Regions

Research Location: *Yukon, Ob, St. Lawrence, and Colorado River Basins*

Local Relevance: Compared to the control scenario (355 ppm CO_2), doubling CO_2 results in a temperature increase of 5°C in winter and 2°C in summer in the Yukon River Basin region. In the doubled CO_2 scenario, winter snowfall starts later, evapotranspiration increases, snowmelt occurs earlier, monthly precipitation increases for more than half the year, the spring runoff peak commences earlier and ends more quickly, and a greater proportion of total precipitation falls in the form of rain. The interaction between the Yukon River Basin and the global water cycle increases under the doubled CO_2 conditions, and the region has a decreased role in the regional water cycle due to an increase in precipitation that is greater than the increase in evapotranspiration.

Citation: Li, Z., Bhatt, U. S., Mölders, M. 2008. "Impact of Doubled CO_2 on the Interaction between the Global and Regional Water Cycles in Four Study Regions." *Climate Dynamics* 30: 255-275.