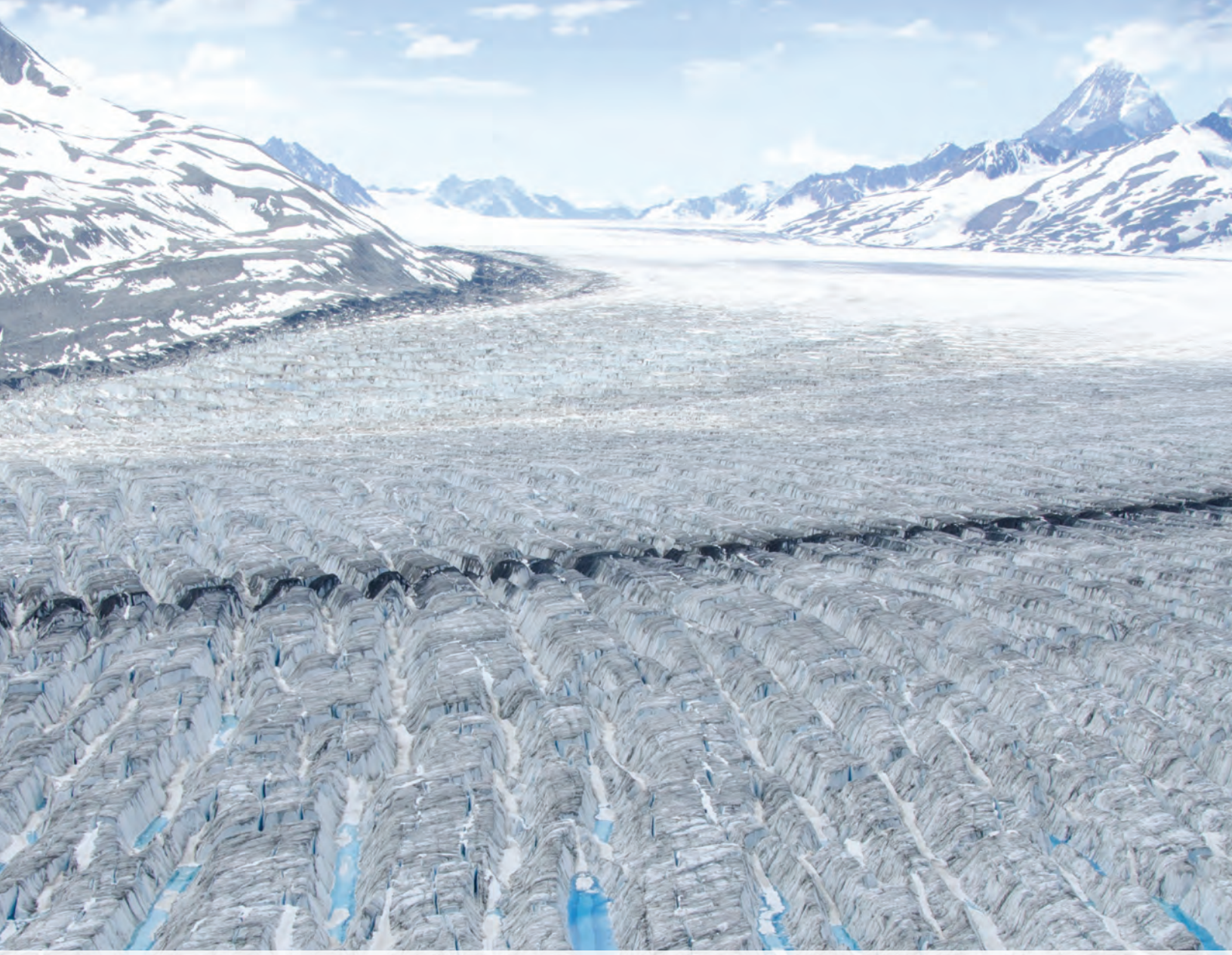

Compendium of Yukon Climate Change Science

2014 Supplement

Northern Climate ExChange
YUKON RESEARCH CENTRE · Yukon College

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Front cover photograph: Kluane National Park. Photo credit: Government of Yukon.

Foreword

The Compendium is intended to provide an overview of recent (2003-2014) climate change studies and reports that are specific to Yukon, or studies that occur outside the territory and include selected areas of Yukon. This document is intended to supplement the 2003-2013 version of the Compendium with climate change work that has taken place during 2013 and 2014. 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 Library
- Internet searches
- Internal knowledge
- Northern Research Institute Fellowship Grants list
- Forest Management in a Changing Climate: Compendium of Information Sources
- Government of Canada and Government of Yukon websites
- AANDC Present and Past Climate Change Adaptation Projects list

The Compendium is not an exhaustive list of climate change-related work in Yukon over the period 2003-2013. A greater emphasis was placed on information that is available online. That being said, the Northern Climate ExChange would appreciate being informed of any relevant information that should be included, or if there are any errors in the Compendium.

The Compendium is organized broadly by topic and subsequently separated into more detailed sections. The 'Local Relevance' section of each entry highlights information directly related to climate change in Yukon.

Entries can be searched by various keywords listed in the index, and all entries have been classified as south Yukon, south-central Yukon, central Yukon, north Yukon, or Yukon-wide. The keyword 'traditional knowledge' was used when the research integrated knowledge from First Nations communities, and the keyword 'local knowledge' was used when information was integrated from a multicultural community or broad area.

This supplementary 2013-2014 edition of the Compendium expands upon the previous edition (2003-2013). I would like to thank Lia Johnson, John Streicker, Bob Van Dijken, Rebecca World, Ryan Hennessey, Lacia Kinnear, Darcie Matthiessen, Aynslie Ogden and Alison Perrin for their assistance. I am also grateful to all of the Yukon First Nations that responded to our requests for information involving studies conducted in their respective traditional territories.

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May 2014

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COMPENDIUM

1. CHANGING CLIMATE

1.1 CLIMATE CHANGE ADAPTATION

Civil society organizations and adaptation to the health effects of climate change in Canada

Research Location: Canada

Publication Type: Journal Article

Publication Date: 2013

Summary: Background: Adaptation will be necessary to cope with the impacts of climate change on the health of Canadians. Civil society organizations (CSOs) have an important role in health adaptation, but it is unknown what actions they are undertaking. Objectives: To identify and examine what adaptations are being developed by CSOs to adapt to the health effects of climate change based on a systematic review of the activities of 190 organizations and 1196 reported adaptation actions. Results: There were six key findings: (1) health adaptation actions are predominantly led by environmental CSOs; (2) most actions are occurring at national and regional levels; (3) food and/or water contamination and air quality are dominant climate change stimuli for action; (4) responses predominantly reflect awareness and research activities, with limited evidence of substantive intervention; (5) consideration of vulnerable groups is limited; and (6) climate change is usually considered alongside other factors, if at all. Conclusions: The results indicate a deficit in terms of what needs to be done for health adaptation and what is being done; part of a broader adaptation deficit in Canada. Coordinated adaptation planning at federal and provincial levels is needed, involving collaboration between CSOs and public health bodies.

Local Relevance: This study examined the role of civil society organizations in Canada, including Yukon, in adapting to the impacts of climate change that have implications for human health. Civil society was defined as the separate sphere of associations outside of the individual, the government and business. Adaptation is an essential public health response to these risks in preventing, reducing and managing climate change-related risks. In total, 190 civil society organizations were identified, within which 1196 initiatives were being carried out. It was found that adaptation actions were primarily being undertaken by environmental organizations, as opposed to those with an explicit health mandate. Health-mandated organizations were more likely to act at the national level, while environmentally mandated organizations were more active at regional (watershed) and local levels, and research activity was dominated by larger national organizations. Activities were largely associated with air and water quality, and few targeted food quality. Activities undertaken were predominantly awareness and research, followed by networking, and evidence of substantive intervention was somewhat limited. Consideration of vulnerable groups was limited, and 1% of initiatives explicitly considered elderly populations, whereas 3% specifically considered indigenous populations. Of all initiatives, nearly two-thirds did not explicitly recognize climate change as a motivator, and of those that did, it was generally among several other factors. Activities with a primary focus on climate change adaptation were uncommon.

Keywords: air quality, civil society, climate change, climate change adaptation, health, Yukon

Available Online: Abstract http://www.sciencedirect.com/science/article/pii/S0033350613000711

Citation: Poutiainen, C., Berrang-Ford, L., Ford, J. and Heymann, J., 2013. Civil society organizations and adaptation to the health effects of climate change in Canada. Public Health, vol. 127, issue 5, p. 403-409, doi: 10.1016/j.puhe.2013.02.004

2. HYDROLOGY

2.1 YUKON RIVER BASIN

Influences of Glacier Melt and Permafrost Thaw on the Age of Dissolved Organic Carbon in the Yukon River Basin

Research Location: Yukon River Basin

Publication Type: Journal Article

Publication Date: 2014

Abstract: Responses of near-surface permafrost and glacial ice to climate change are of particular significance for understanding long-term effects on global carbon cycling and carbon export by high-latitude northern rivers. Here we report $\Delta^{14}C$ - dissolved organic carbon (DOC) values and dissolved organic matter optical data for the Yukon River, 15 tributaries of the Yukon River, glacial meltwater, and groundwater and soil water end-member sources draining to the Yukon River, with the goal of assessing mobilization of aged DOC within the watershed. Ancient DOC was associated with glacial meltwater and groundwater sources. In contrast, DOC from watersheds dominated by peat soils and underlain by permafrost was typically enriched in $\Delta^{14}C$ indicating that degradation of ancient carbon stores is currently not occurring at large enough scales to quantitatively influence bulk DOC exports from those landscapes. On an annual basis, DOC exported was predominantly modern during the spring period throughout the Yukon River basin, and became older through summer-fall and winter periods, suggesting that contributions of older DOC from soils, glacial meltwaters and groundwater are significant during these months. Our data indicate that rapidly receding glaciers and increasing groundwater inputs will likely result in greater contributions of older DOC in the Yukon River and its tributaries in coming decades.

Local Relevance: It is important to understand how near-surface permafrost and glacial ice respond to climate change and how this influences the global carbon cycle. Samples were collected from various points throughout the Yukon River Basin and analyzed for their content of dissolved organic matter. It was concluded that all catchments in the Yukon River are subject to the effects of climate change, and mobilization of aged dissolved organic carbon was assessed. Degradation of ancient carbon stores was found to not be occurring at large enough scales to quantitatively influence bulk export of dissolved organic carbon in landscapes dominated by peat soils and underlain by permafrost. Presently, some drainage basins (e.g., the Tanana) are experiencing melt of alpine glaciers and perennial snowfields, while still others are experiencing permafrost degradation, the formation of thermokarst features, and drying of areas where thermokarst lakes have drained. Continued thaw and melting within different catchments could profoundly influence the export of dissolved organic carbon from within the Yukon River basin.

Keywords: glaciers, hydrology, permafrost, Yukon River, Yukon River Basin, Yukon-wide

Available Online: Abstract http://onlinelibrary.wiley.com/doi/10.1002/2013GB004764/abstract

Citation: Aitken, G., Spencer, R., Streigl, R., Schuster, P. and Raymond, P.A., 2014. Influences of glacier melt and permafrost thaw on the age of dissolved organic carbon in the Yukon River Basin. Global Biogeochemical Cycles, doi: 10.1002/2013GB004764.

Early snowmelt events: Detection, distribution, and significance in a major sub-arctic watershed

Research Location: Yukon River Basin

Publication Type: Journal Article

Publication Date: 2013

Abstract: High-latitude drainage basins are experiencing higher average temperatures, earlier snowmelt onset in spring, and an increase in rain on snow (ROS) events in winter, trends that climate models project into the future. Snowmelt-dominated basins are most sensitive to winter temperature increases that influence the frequency of ROS events and the timing and duration of snowmelt, resulting in changes to spring runoff. Of specific interest in this study are early melt events that occur in late winter preceding melt onset in the spring. The study focuses on satellite determination and characterization of these early melt events using the Yukon River Basin (Canada/USA) as a test domain. The timing of these events was estimated using data from passive (Advanced Microwave Scanning Radiometer—EOS (AMSR-E)) and active (SeaWinds on Quick Scatterometer (QuikSCAT)) microwave remote sensors, employing detection algorithms for brightness temperature (AMSR-E) and radar backscatter (QuikSCAT). The satellite-detected events were validated with ground station meteorological and hydrological data, and the spatial and temporal variability of the events across the entire river basin was characterized. Possible causative factors for the detected events, including ROS, fog, and positive air temperatures, were determined by comparing the timing of the events to parameters from SnowModel and National Centers for Environmental Prediction North American Regional Reanalysis (NARR) outputs, and weather station data. All melt events coincided with above freezing temperatures, while a limited number corresponded to ROS (determined from SnowModel and ground data) and a majority to fog occurrence (determined from NARR). The results underscore the significant influence that warm air intrusions have on melt in some areas and demonstrate the large temporal and spatial variability over years and regions. The study provides a method for melt detection and a baseline from which to assess future change.

Local Relevance: This research characterizes early snowmelt events in the Yukon River Basin in Yukon and Alaska. The basin is experiencing higher average temperatures, earlier onset of snowmelt in spring, rain on snow events, changes to spring runoff, and more. The results show the importance of warm air intrusions on melt in some areas, which are projected to change in the context of global climate projections. They further provide a methodology for the prediction of future melt events.

Keywords: hydrology, impacts, snowmelt, Yukon River Basin, Yukon-wide

Available Online: Abstract http://iopscience.iop.org/1748-9326/8/1/014020

Citation: Semmens, K., Ramage, J., Bartsch, A. and Liston, E., 2013. Early snowmelt events: Detection, distribution, and significance in a major sub-Arctic watershed. Environmental Research Letters, vol. 8, no. 1, doi:10.1088/1748-9326/8/1/014020.

2.2 OLD CROW FLATS

Controls on water balance of shallow thermokarst lakes and their relations with catchment characteristics: A multi-year, landscape-scale assessment based on water isotope tracers and remote sensing in Old Crow Flats, Yukon (Canada)

Research Location: Old Crow Flats

Publication Type: Journal Article

Publication Date: 2014

Abstract: Many northern lake-rich regions are undergoing pronounced hydrological change, yet inadequate knowledge of the drivers of these landscape-scale responses hampers our ability to predict future conditions. We address this challenge in the thermokarst landscape of Old Crow Flats (OCF) using a combination of remote sensing imagery and monitoring of stable isotope compositions of lake waters over three thaw seasons (2007–2009). Quantitative analysis confirmed that the hydrological behavior of lakes is strongly influenced by catchment vegetation and physiography. Catchments of snowmelt-dominated lakes, typically located in southern peripheral areas of OCF, encompass high proportions of woodland/forest and tall shrub vegetation (mean percent land cover =~60%). These land cover types effectively capture snow and generate abundant snowmelt runoff that offsets lake water evaporation. Rainfall-dominated lakes that are not strongly influenced by evaporation are typically located in eastern and northern OCF where their catchments have higher proportions of dwarf shrub/herbaceous and sparse vegetation (~45%), as well as surface water (~20%). Evaporation-dominated lakes, are located in the OCF interior where their catchments are distinguished by substantially higher lake area to catchment area ratios (LA/CA = ~29%) compared to low evaporation-influenced rainfall-dominated (~10%) and snowmelt-dominated (~4%) lakes. Lakes whose catchments contain >75% combined dwarf shrub/herbaceous vegetation and surface water are most susceptible to evaporative lake-level drawdown, especially following periods of low precipitation. Findings indicate that multiple hydrological trajectories are probable in response to climate-driven changes in precipitation amount and seasonality, vegetation composition, and thermokarst processes. These will likely include a shift to greater snowmelt influence in catchments experiencing expansion of tall shrubs, greater influence from evaporation in catchments having higher proportions of surface water, and an increase in the rate of thermokarst lake expansion and probability of drainage. Local observations suggest that some of these changes are already underway.

Local Relevance: Climate change will result in changes to the amount and timing of rainfall and snowfall, composition of vegetation, and thermokarst processes. These changes are already occurring. For instance, as result of climate-related changes, greater snowmelt may occur in catchments where tall shrubs have expanded in influence. This research used water isotope tracers and remote sensing to relate controls on water balance of the shallow thermokarst lakes of the Old Crow Flats to characteristics of catchments, such as vegetation. This will help in predicting future change under different climate scenarios.

Keywords: evaporation, hydrology, north Yukon, Old Crow Flats, precipitation

Available Online: Abstract http://onlinelibrary.wiley.com/doi/10.1111/gcb.12465/abstract

Citation: Turner, K., Wolfe, B., Edwards, T., Lantz, T., Hall, L. and Larocque, G., (2014). Controls on water balance of shallow thermokarst lakes and their relations with catchment characteristics: A multi-year, landscape-scale assessment based on water isotope tracers and remote sensing in Old Crow Flats, Yukon (Canada). Global Change Biology, vol. 20, issue 5, p. 1585-1603.

3. PERMAFROST

Multi-decadal degradation and persistence of permafrost in the Alaska Highway corridor, northwest Canada

Research Location: northern British Columbia; southern Yukon

Publication Type: Journal Article

Publication Date: September 30, 2013

Abstract: Changes in permafrost distribution in the southern discontinuous zone were evaluated by repeating a 1964 survey through part of the Alaska Highway corridor (56° N - 61° N) in northwest Canada. A total of 55 sites from the original survey in northern British Columbia and southern Yukon were located using archival maps and photographs. Probing for frozen ground, manual excavations, air and ground temperature monitoring, borehole drilling and geophysical techniques were used to gather information on present-day permafrost and climatic conditions. Mean annual air temperatures have increased by 1.5 - 2.0°C since the mid-1970s and significant degradation of permafrost has occurred. Almost half of the permafrost sites along the entire transect which exhibited permafrost in 1964 do so no longer. This change is especially evident in the south where two-thirds of the formerly permafrost sites have thawed and the limit of permafrost appears to have shifted northward. The permafrost that persists is patchy, generally less than 15 m thick, has mean annual surface temperatures >0°C, mean ground temperatures between −0.5 and 0°C, is in peat or beneath a thick organic mat, and appears to have a thicker active layer than in 1964. Its persistence may relate to the latent heat requirements of thawing permafrost or to the large thermal offset of organic soils. The study demonstrates that degradation of permafrost has occurred in the margins of its distribution in the last few decades, a trend that is expected to continue as the climate warms.

Local Relevance: This research examines changes to permafrost distribution in areas of southern Yukon between 1964 and 2013, correlated with increases in mean average air temperature between 1.5 and 2°C. Significant degradation of permafrost was found to have occurred, and almost half of the sites which formerly featured permafrost do not feature permafrost now. Thawing was especially apparent in the southern areas of Yukon, and the boundary at which permafrost begins to occur appears to have shifted northward. The trend of degradation of permafrost in its marginal areas is projected to continue as the climate warms. Future thawing under conditions of climate change will affect local hydrology, vegetation, and carbon cycling.

Keywords: Alaska Highway, air temperature, impacts, permafrost, south Yukon

Available Online: Abstract http://iopscience.iop.org/1748-9326/8/4/045013

Citation: James, M., Lewkowicz, A., Smith, S. and Miceli, C., 2013. Multi-decadal degradation and persistence of permafrost in the Alaska Highway corridor, northwest Canada. Environmental Research Letters, vol. 8, no. 4, doi:10.1088/1748-9326/8/4/045013.

3.1 MODELLING AND MAPPING TECHNIQUES

Modelling and mapping climate change impacts on permafrost at high spatial resolution for an Arctic region with complex terrain

Research Location: Ivvavik National Park, Yukon

Publication Type: Journal Article

Publication Date: 2013

Abstract: Most spatial modelling of climate change impacts on permafrost has been conducted at a half-degree latitude/longitude or coarser spatial resolution. At such coarse resolution, topographic effects on insolation cannot be considered accurately and the results are not suitable for land-use planning and ecological assessment. Here we mapped climate change impacts on permafrost from 1968 to 2100 at 10 m resolution using a process-based model for Ivvavik National Park, an Arctic region with complex terrain in northern Yukon, Canada. Soil and drainage conditions were defined based on ecosystem types, which were mapped using SPOT imagery. Leaf area indices were mapped using Landsat imagery and the ecosystem map. Climate distribution was estimated based on elevation and station observations, and the effects of topography on insolation were calculated based on slope, aspect, and viewshed. To reduce computation time, we clustered climate distribution and topographic effects on insolation into discrete types. The modelled active-layer thickness and permafrost distribution were comparable with field observations and other studies. The map portrayed large variations in active-layer thickness, with ecosystem types being the most important controlling variable, followed by climate, including topographic effects on insolation. The results show deepening in active-layer thickness and progressive degradation of permafrost, although permafrost will persist in most of the park during the 21st century. This study also shows that ground conditions and climate scenarios are the major sources of uncertainty for high-resolution permafrost mapping.

Local Relevance: This research mapped climate change impacts at a high spatial resolution (10 m) for Ivvavik National Park in Northern Yukon. Active-layer thickness and distribution of permafrost were largely variable and comparable to those found in the other studies and in observations in the field. Ecosystem types had a stronger influence on active layer thickness than climate, which in turn had a greater affect than the amount of incoming solar radiation. Though the active layer if found to be thickening and permafrost degrading, permafrost will continue to exist throughout most of the park area for the remainder of this century. Ground conditions and climate scenarios are shown to be the two major sources of uncertainty for high-resolution permafrost mapping in the North.

Keywords: impacts, Ivvavik National Park, modelling, north Yukon, permafrost, permafrost mapping

Available Online: Full Document http://www.the-cryosphere.net/7/1121/2013/tc-7-1121-2013.html

Citation: Zhang, Y., Wang., X., Fraser, R., Olthok, R., Chen, W., Mclennan, D., Ponomarenko, S. and Wu, W., 2013. Modelling and mapping climate change impacts on permafrost at high spatial resolution for an Arctic region with complex terrain. The Cryosphere, vol. 7, p. 1121-1137.

4. FORESTRY

Dispersed Capacity and Weak Coordination: The Challenge of Climate Change Adaptation in Canada's Forest Policy Sector

Research Location: Yukon; other Canadian provinces and territories

Publication Type: Journal Article

Publication Date: 2013

Abstract: Constitutional and institutional legacies were combined to create a very decentralized forest policy sector in Canada. Where coherent policy requires a national response—as is the case with adaptation to climate change—the critical challenge is to locate the relevant decentralized policy capacity and steer it toward meeting national objectives. While there is some evidence that significant policy capacity exists in provincial forest and resource management departments, climate change adaptation has led to an expansion of departmental mandates that is not being addressed by better coordination of the available policy capacity. The relevant federal agencies are not well represented in information networks and forest policy workers report lower levels of internal and external networking than workers in related policy subsectors.

Local Relevance: This research discusses policy challenges in the forest policy sector in Canada and Canadian provinces and territories. The research indicated that the government of British Columbia was the most influential in a virtual policy network, followed by the government of Prince Edward Island, and finally by the governments of Manitoba, Nova Scotia, and the Yukon Territory. The researchers indicate that a lack of coordination exists in relation to climate change adaptation between different levels of government and departments concerned with forests and natural resource management.

Keywords: adaptation, policy, forest management, forestry, Yukon-wide

Available Online: Abstract http://onlinelibrary.wiley.com/doi/10.1111/ropr.12003/full

Citation: Rayner, J., McNutt, K. and Wellstead, A., 2013. Dispersed capacity and weak coordination: The challenge of climate change adaptation in Canada's forest policy sector. Review of Policy Research, vol. 30, issue 1, p. 66-90.

4.1 FOREST GROWTH

Recent advance of forest-grassland ecotones in southwestern Yukon

Research Location: South Yukon

Publication Type: Journal Article

Publication Date: 2014

Abstract: We investigated recent ecotone dynamics in the forest-grassland mosaics of southwestern Yukon. Our objectives were to determine (i) if forests are encroaching into grasslands, (ii) if rate and extent of encroachment varies by region or with topographic setting, and (iii) if encroachment is related to climate change and variability. Dendroecological techniques were used to obtain dates of establishment for 1847 trees (trembling aspen (Populus tremuloides Michx.) and white spruce (Picea glauca (Moench) Voss)) sampled from 28 sites divided between two different regions and three topographic settings. Generalized linear modeling was used to identify relationships between climate and tree establishment. Results

show that encroachment of forest, particularly aspen trees, into grasslands has been nearly ubiquitous on flat terrain and on south-facing slopes in both regions over the last 60-80 years. In contrast, spruce-dominated ecotones on north-facing slopes experienced little change. Aspen establishment was positively associated with spring temperatures and precipitation, although evidence suggests that other factors such as soil moisture interact with climate to mediate the timing and rate of tree encroachment. These results indicate that transformation of grasslands to aspen-dominated forest is an additional, but previously unexplored, element of the widespread ecosystem changes currently being experienced in northwestern North America.

Local Relevance: This research took place in the Kluane Lake and Aishihik Lake regions of southwest Yukon, in areas where forest-landscape dynamics are dominant. It was found that south-facing slopes and flat terrain have featured the encroachment of forests, especially aspen, whereas north-facing slopes featured little change. The transition from grassland to aspen-dominated forest is an unexplored aspect of ecosystem change and climate change in northern areas, and the sensitivity of grasslands to changes in climate has implications in the context of various future climate projections.

Keywords: aspen, forest management, forestry, grassland, modelling, precipitation, south Yukon, tree rings, white spruce

Available Online: Abstract http://www.nrcresearchpress.com/doi/abs/10.1139/cjfr-2013-0429#.U2lkVfldXTo

Citation: Conway, A. and Danby, R., 2014. Recent advance of forest-grassland ecotones in southwestern Yukon. Canadian Journal of Forest Research, vol. 44, no. 5, p. 509-520.

4.2 FOREST MANAGEMENT

Using an ensemble of downscaled climate model projections to assess impacts of climate change on the potential distribution of spruce and Douglas-fir forests in British Columbia

Research Location: British Columbia, Yukon

Publication Type: Journal Article

Publication Date: 2013

Abstract: Many of the world's forests are likely to face multiple stresses under a rapidly changing climate. Understanding the impact of climate change on tree species suitability is therefore crucial for forest management planning and policy development. We use the Douglas-fir and spruce (white spruce, Engelmann spruce, and interior spruce) forests of British Columbia as a case study. The impact of projected climate change on these forests was assessed using flexible bioclimatic envelope models appropriate for areas with sparse species locations records. Analysis of the model results focused on quantifying uncertainty due to differences between global climate models, emissions scenarios, and spatial resolution of climate data. To this end, future suitability was modelled using downscaled climate data from a collection of 10 climate projections that sampled across nine different global climate models and three different emissions scenarios (A2, A1B, and B1). All projections indicate a rapid shift in suitability for both spruce and Douglas-fir to higher elevations and latitudes relative to their current range. However, significant differences exist between the projections with regard to the pace, extent, and fine-scale details of these changes. This research was conducted as part of a collaborative interdisciplinary assessment involving both scientists and resource managers.

Local Relevance: This study modelled future changes in climatic suitability for forests in British Columbia, with inclusion of vegetation plot survey data from Yukon, using downscaled climate model projections. Spruce and Douglas-fir forests were projected by models to be more sensitive to changes in temperature than precipitation. Ranges of both types of forests were projected to shift rapidly upwards to higher elevations and latitudes, as areas climatically suitable for these forests expand and shift. This has a variety of implications for the range and distribution of other plant and animal species.

Keywords: climate modelling, Douglas-fir, forest management, forestry, impacts, population dynamics, precipitation, vegetation, white spruce, Yukon-wide

Available Online: Abstract http://www.sciencedirect.com/science/article/pii/s146290111200130x

Citation: Flower, A., Murdock, T., Taylor, S. and Zwiers, F., 2013. Using an ensemble of downscaled climate model projections to assess impacts of climate change on the potential distribution of spruce and Douglas-fir forests in British Columbia. Environmental Science & Policy, vol. 26, p. 63-74.

4.3 SHRUBS

Herbaceous community structure and function in the Kluane region

Research Location: Kluane Region, Yukon

Publication Type: Journal Article

Publication Date: 2014

Abstract: Our research on the herbaceous understory vegetation in the Kluane region, Yukon, has focused on the structure and function of natural forest understory and grassland communities. The research has involved two long-term projects. The first investigated fertilizer addition and mammalian herbivore exclosure in understory vegetation over a 20-year period and showed that nutrient availability, and not herbivory, controlled herbaceous biomass. Fertilization increased the amount and nutrient content of vegetation, but 13 species were lost, whereas natural levels of mammalian herbivory rarely affected this vegetation or its diversity. The second study investigated how removing plant functional groups from a grassland influences its functioning. Over a seven-year period, we determined that the identity of the functional group was important in determining ecosystem properties and that graminoids were more influential than expected from their proportional biomass. In both of these studies, short-term responses were transient and not indicative of longer-term responses of these communities. This finding reinforces the need for long-term experiments, especially in northern ecosystems. The long-term plots from both projects will continue to be valuable, and they may detect shifts in the plant community due to climate change or unique events in the area.

Local Relevance: This research involved the establishment of two field sites in the Kluane region of southern Yukon and the application of fertilizer to understory vegetation. It has been suggested that the application of nutrients to northern communities may simulate some of the same effects on plants that might be produced through climate change. Climate change processes such as increasing concentrations of carbon dioxide in the atmosphere and rising temperatures will have significant impacts on nutrient cycles. It has been argued that climate change will increase the supply of nutrients in northern ecosystems by stimulating decomposition processes, though there are limitations to extrapolating findings from experiments such as these to predicting the effects of global climate change. Findings showed

that there is an unmet need for longer-term experiments of herbaceous vegetation, especially in northern ecosystems such as those in Yukon. The plots established for this research have continuing value, and may reveal changes in vegetation due to climate change in the future.

Keywords: fertilization, forestry, forest management, grassland, population dynamics, south Yukon

Available Online: Abstract http://arctic.journalhosting.ucalgary.ca/arctic/index.php/arctic/article/view/4351

Citation: Turkington, R., McLaren, J. and Dale, M., 2014. Herbaceous community structure and function in the Kluane Region. Arctic 50th Anniversary Edition, p. 1-10.

5. GLACIOLOGY

Contemporary glacier processes and global change: Recent observations from Kaskawulsh Glacier and the Donjek Range, St. Elias Mountains

Research Location: St. Elias Mountains

Publication Type: Journal Article

Publication Date: 2014

Abstract: With an extensive ice cover and rich display of glacier behaviour, the St. Elias Mountains continue to be an enviable natural laboratory for glaciological research. Recent work has been motivated in part by the magnitude and pace of observed glacier change in this area, which is so ice-rich that ice loss has a measurable impact on global sea level. Both detection and attribution of these changes, as well as investigations into fundamental glacier processes, have been central themes in projects initiated within the last decade and based at the Kluane Lake Research Station. The scientific objectives of these projects are (1) to quantify recent area and volume changes of Kaskawulsh Glacier and place them in historical perspective, (2) to investigate the regional variability of glacier response to climate and the modulating influence of ice dynamics, and (3) to characterize the hydromechanical controls on glacier sliding. A wide range of methods is being used, from ground-based manual measurements to space-based remote sensing. The observations to date show glaciers out of equilibrium, with significant ongoing changes to glacier area, volume, and dynamics. Computer models are being used to generalize these results, and to identify the processes most critical to our understanding of the coupled glacier-climate system.

Local Relevance: This research examines recent changes to the area and volume of the Kaskawulsh glacier in the St. Elias Mountains in southwest Yukon, and places them in the context of historical changes in climate. The variability of response of glaciers to changes in climate is also examined. The glacierized region of the St. Elias Mountains made the second-largest glaciological contribution to global sea level from 1961-2011, with significant mass losses from this region. One important direction of future research noted in this paper is bridging of the gap between the spatial scales relevant to global climate models and those relevant and accessible to local and regional observations, e.g., through local downscaling or regional climate data.

Keywords: Donjek Range, glaciers, glaciology, St. Elias Mountains, south Yukon

Available Online: Abstract http://www.aina.ucalgary.ca/scripts/minisa.dll/289/2/3/79576?RECORD&DATABASE=ASTIS

Citation: Flowers, G., Copland, L. and Schoof, C., 2014. Contemporary glacier processes and global change: Recent observations from Kaskawulsh Glacier and the Donjek Range, St. Elias Mountains. Arctic 50th anniversary position, p. 1-13.

6. FISH AND WILDLIFE

6.1 FISH

Climate Change Influences on Marine Infectious Diseases: Implications for Management and Society

Research Location: North American Marine ecosystem; Yukon River

Publication Type: Journal Article

Publication Date: 2014

Abstract: Infectious diseases are common in marine environments, but the effects of a changing climate on marine pathogens are not well understood. Here we review current knowledge about how the climate drives host-pathogen interactions and infectious disease outbreaks. Climate-related impacts on marine diseases are being documented in corals, shellfish, finfish, and humans; these impacts are less clearly linked for other organisms. Oceans and people are inextricably linked, and marine diseases can both directly and indirectly affect human health, livelihoods, and well-being. We recommend an adaptive management approach to better increase the resilience of ocean systems vulnerable to marine diseases in a changing climate. Land-based management methods of quarantining, culling, and vaccinating are not successful in the ocean; therefore, forecasting conditions that lead to outbreaks and designing tools/approaches to influence these conditions may be the best way to manage marine disease.

Local Relevance: Infectious diseases are important drivers within ecosystems, and ecosystems are influenced not only by the direct effects of stressors on populations and species but also by changes in species interactions, including competition, predation, and parasitism. This paper considers the potential consequences of changes to climate-related factors (e.g., changes to temperature and rainfall, increased storms, etc.) on marine infectious disease outbreaks on culturally and commercially important species. Specifically, it examines the speculative linkage between ichthyophoniasis, an emerging disease of Chinook salmon with a physical manifestation of white lesions on internal organs, and the postulated impact of this disease on wild fishes in Yukon. The disease was found to affect commercial and subsistence fishers along the Yukon River, leading to culling of fish stocks prior to consumption and a decrease in remaining fish stocks. Empirical and field observations suggest that a linkage exists between ichthyophoniasis and climate change, and field observations from the Yukon River suggest that elevated river temperatures contributed to the progression of the disease. It is suggested that water temperatures could be integrated into adaptive fisheries management strategies for the Yukon River, and that improved diagnostic methods and management strategies are needed for all marine infectious diseases.

Keywords: impacts, infectious disease, microbes, pathogens, population dynamics, Yukon-wide

Available Online: Abstract http://www.ncbi.nlm.nih.gov/pubmed/23808894

Citation: Burge, C., Mark Eakin, C., Friedman, C., Hershberger, P., Hofmann, E., Petes, L., Weil, E., Willis, B., Ford, S. and Harvell, C., 2013. Climate change influences on marine infectious diseases: Implications for management and society. Annual Review of Marine Science, vol. 6, p. 249-277.

Historical growth of Bristol Bay and Yukon River, Alaska chum salmon (Oncorhynchus keta) in relation to climate and inter- and intraspecific competition

Research Location: Bristol Bay, Alaska; Yukon River

Publication Type: Journal Article

Publication Date: 2013

Abstract: We examined Bristol Bay and Yukon River adult chum salmon scales to determine whether climate variability, such as changes in sea surface temperature and climate indices, and high pink and Asian chum salmon abundance reduced chum salmon growth. Annual marine growth increments for 1965-2006 were estimated from scale growth measurements and were modeled as a function of potential explanatory variables using a generalized least squares regression approach. First-year growth of salmon originating from Bristol Bay and the Yukon River showed increased growth in association with higher regional ocean temperatures and was negatively affected by wind mixing and ice cover. Third-year growth was lower when Asian chum salmon were more abundant. Contrary to our hypothesis, warmer large-scale sea surface temperatures in the Gulf of Alaska were also associated with reduced third-year growth. Negative effects of high abundances of Russian pink salmon on third-year growth provided some evidence for interspecific interactions, but the effects were smaller than the effects of Asian chum salmon abundance and Gulf of Alaska sea surface temperature. Although the relative effects of Asian chum salmon and sea surface temperature on the growth of Yukon and Bristol Bay chum salmon were difficult to untangle, we found consistent evidence that high abundances of Asian chum salmon contributed to a reduction in the growth of western Alaska chum salmon.

Local Relevance: It was found that warmer regional temperatures and decreased ice cover significantly increased first-year growth of chum salmon originating from the Yukon River. Growth is important for survival and maturation age in chum in particular, as faster growing salmon may be better able to avoid predators and those with larger body size may have the lipid stores to enable survival when prey is less available. Counterintuitively, warmer sea-surface temperatures which typically promote salmon growth in northern regions were found to coincide with reduced chum salmon growth in Western Alaska. High abundance of Asian chum salmon was found to correlate with a lower abundance of western Alaska chum salmon.

Keywords: impacts, phenology, population dynamics, salmon, sea-surface temperature, Yukon River, Yukon-wide

Available Online: Abstract http://www.sciencedirect.com/science/article/pii/S0967064513001264

Citation: Agler, B., Ruggerone, G., Wilson, L. and Mueter, F., 2013. Historical growth of Bristol Bay and Yukon River, Alaska chum salmon (Oncorhynchus keta) in relation to climate and inter- and intraspecific competition. Topical Studies in Oceanography, vol. 94, p. 165-177.

6.2 MAMMALS

Genetic diversity in caribou linked to past and future climate change

Research Location: Alaska, Canada, Greenland, Svalbard, Norway, Finland, Russian Federation

Publication Type: Journal Article

Publication Date: 2013

Abstract: Climate-driven range fluctuations during the Pleistocene have continuously reshaped species distribution leading to populations of contrasting genetic diversity. Contemporary climate change is similarly influencing species distribution and population structure, with important consequences for patterns of genetic diversity and species' evolutionary potential. Yet few studies assess the impacts of global climatic changes on intraspecific genetic variation. Here, combining analyses of molecular data with time series of predicted species distributions and a model of diffusion through time over the past 21 kyr, we unravel caribou response to past and future climate changes across its entire Holarctic distribution. We found that genetic diversity is geographically structured with two main caribou lineages, one originating from, and confined to, Northeastern America, the other originating from Euro-Beringia but also currently distributed in western North America. Regions that remained climatically stable over the past 21 kyr maintained a high genetic diversity and are also predicted to experience higher climatic stability under future climate change scenarios. Our interdisciplinary approach, combining genetic data and spatial analyses of climatic stability (applicable to virtually any taxon), represents a significant advance in inferring how climate shapes genetic diversity and impacts genetic structure.

Local Relevance: Climate change influences the distribution and population structure of many species, including caribou. This research examines how caribou respond to past and future climate change, using data on caribou from Alaska, Canada (including Yukon), Greenland, Svalbard, Norway, Finland, and the Russian Federation. Regions with past climatic stability had high genetic diversity and were also largely predicted into experience higher levels of climatic stability under different scenarios of climate change.

Keywords: caribou, climate reconstruction, phenology, population dynamics, Yukon-wide

Available Online: Abstract http://www.nature.com/nclimate/journal/v4/n2/full/nclimate2074.html

Citation: Yannic, G., Pellissier, L., Ortego, J., Lecomte, N., Couturier, S., Cuyler, C., Dussault, C., Huntertmark, R., Irvine, J., Jenkins, J., Kolpashikov, L., Meger, K., Musiani, M., Parker, K., Røed, K., Sipko, T., Þórisson, S., Weckworth, B., Guisan, A., Bernatchez, L. and Côté, 2013. Genetic diversity in caribou linked to past and future climate change. Nature Climate Change, vol. 4, p. 132-137.

Linking climate change to population cycles of hares and lynx

Research Location: Yukon; other Canadian regions

Publication Type: Journal Article

Publication Date: 2013

Abstract: The classic 10-year population cycle of snowshoe hares (Lepus americanus, Erxleben 1777) and Canada lynx (Lynx canadensis, Kerr 1792) in the boreal forests of North America has drawn much attention from both population and community ecologists worldwide; however,

the ecological mechanisms driving the 10-year cyclic dynamic pattern are not fully revealed yet. In this study, by the use of historic fur harvest data, we constructed a series of generalized additive models to study the effects of density dependence, predation, and climate (both global climate indices of North Atlantic Oscillation index (NAO), Southern Oscillation index (SOI) and northern hemispheric temperature (NHT) and local weather data including temperature, rainfall, and snow). We identified several key pathways from global and local climate to lynx with various time lags: rainfall shows a negative, and snow shows a positive effect on lynx; NHT and NAO negatively affect lynx through their positive effect on rainfall and negative effect on snow; SOI positively affects lynx through its negative effect on rainfall. Direct or delayed density dependency effects, the prey effect of hare on lynx and a 2-year delayed negative effect of lynx on hare (defined as asymmetric predation) were found. The simulated population dynamics is well fitted to the observed long-term fluctuations of hare and lynx populations. Through simulation, we find density dependency and asymmetric predation, only producing damped oscillation, are necessary but not sufficient factors in causing the observed 10-year cycles; while extrinsic climate factors are important in producing and modifying the sustained cycles. Two recent population declines of lynx (1940-1955 and after 1980) were likely caused by ongoing climate warming indirectly. Our results provide an alternative explanation to the mechanism of the 10-year cycles, and there is a need for further investigation on links between disappearance of population cycles and global warming in hare–lynx system.

Local Relevance: This work uses historic fur harvest data from hare and lynx in Yukon and seven other Canadian regions. Recent population declines of lynx populations were likely indirectly caused by climate warming. Such explanations provide an alternative explanation of the 10-year population cycles of these species. Several pathways through which climate change affects rates of population change of hare and lynx were identified, including its effects on predation, local weather conditions, and population density in relation to density dependence.

Keywords: hare, impacts, lynx, phenology, population dynamics, Yukon-wide, North Atlantic Oscillation, Southern Oscillation

Available Online: Abstract http://onlinelibrary.wiley.com/doi/10.1111/gcb.12321/abstract?deniedaccesscustomisedmessage=&userisauthenticated=false

Citation: Yan, C., Stenseth, N., Krebs, C. and Zhang, Z., 2013. Linking climate change to population cycles of hares and lynx. Global Change Biology, vol. 19, issue 11, p. 3263-3271.

6.3 INSECTS

New species records for butterflies (Lepidoptera) on Herschel Island, Yukon, Canada, with notes on natural history

Research Location: Herschel Island, Yukon Territory

Publication Type: Journal Article

Publication Date: 2013

Abstract: Comparisons of past and current butterfly species distributions are being used to gauge the effects of climatic change in various parts of the world. Historic butterfly records from Herschel Island, Yukon, Canada, presented an opportunity to do such a comparison in an Arctic tundra region known to have a diverse butterfly fauna. We compared historic species records (1916-1983) with newly collected ones (2007-2009) to assess possible changes in species distributions. Of the 21 species documented for Herschel Island, six were newly found and two were not reconfirmed. We postulate that warmer temperatures facilitated the apparent

northerly range expansions of several species by making butterfly flight and dispersal possible. This is supported by interannual comparisons on a smaller time scale, 2007-2009. During this period, we observed accelerated butterfly phenology and higher relative abundance of butterflies associated with earlier snowmelt and with earlier and more intense early summer heating.

Local Relevance: Butterfly distributions from historic records were compared with current distributions to measure the effects of climate change. Six new species were found, and evidence of the presence of other species that formerly existed could no longer be found. Changes in species distribution are suggested to be a product of a greater number of days which are sufficiently warm to be conducive to butterfly flight. Persistent snow cover may be delaying adult emergence to a lesser extent, and the development of butterflies into their adult form can be accelerated by warmer temperatures. The observations suggest that the ranges of certain butterfly species are moving northwards in low arctic Canada.

Keywords: butterflies, Herschel Island, north Yukon, phenology, population dynamics

Available Online: Abstract http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8870321

Citation: Leung, M. and Reid, D., 2013. New species records for butterflies (Lepidoptera) on Herschel Island, Yukon, Canada, with notes on natural history. The Canadian Entomologist, vol. 145, special issue 2, p. 227-234.

Terrestrial arthropod abundance and phenology in the Canadian Arctic: Modelling resource availability for Arctic-nesting insectivorous birds

Research Location: Southampton, Herschel, Bylot and Ellesmere Islands

Publication Type: Journal Article

Publication Date: 2013

Abstract: Arctic arthropods are essential prey for many vertebrates, including birds, but arthropod populations and phenology are susceptible to climate change. The objective of this research was to model the relationship between seasonal changes in arthropod abundance and weather variables using data from a collaborative pan-Canadian (Southampton, Herschel, Bylot and Ellesmere Islands) study on terrestrial arthropods. Arthropods were captured with passive traps that provided a combined measure of abundance and activity (a proxy for arthropod availability to foraging birds). We found that 70% of the deviance in daily arthropod availability was explained by three temperature covariates: mean daily temperature, thaw degree-day, and thaw degree-day2. Models had an adjusted R^2 of 0.29-0.95 with an average among sites and arthropod families of 0.67. This indicates a moderate to strong fit to the raw data. The models for arthropod families with synchronous emergence, such as Tipulidae (Diptera), had a better fit (average adjusted R^2 of 0.80) than less synchronous taxa, such as Araneae (R^2=0.60). Arthropod abundance was typically higher in wet than in mesic habitats. Our models will serve as tools for researchers who want to correlate insectivorous bird breeding data to arthropod availability in the Canadian Arctic.

Local Relevance: Arthropods are the largest animal phylum and include insects, spiders, crustaceans, centipedes, and others. This research examined the relationship between weather and abundance of arthropods at several locations throughout Canada, including Herschel Island in northern Yukon. Approximately 70% of the differences in arthropod availability can be explained by differences in weather. Though these arthropods are essential prey for a variety of predators throughout the Arctic, their populations are susceptible to temperature variations associated with global climate change.

Keywords: birds, Herschel Island, north Yukon, phenology, population dynamics, spiders

Available Online: Abstract http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8870306

Citation: Bolduc, E., Casajus, N., Legagneux, P., McKinnon, L., Gilchrist, H., Leung, M., Morrison, R., Reid, D., Smith, P., Buddle, C. and Bêty, J., 2013. Terrestrial arthropod abundance and phenology in the Canadian Arctic: Modelling resource availability for Arctic-nesting insectivorous birds. The Canadian Entomologist, vol. 145, special issue 2, p. 155-170.

7. HAZARDS

7.1 INFRASTRUCTURE AND DEVELOPMENT

Evaluating climate change vulnerability assessments: A case study of research focusing on the built environment in northern Canada

Research Location: Yukon, Northwest Territories, Nunavut, Northern Quebec, Labrador

Publication Type: Journal Article

Publication Date: 2014

Abstract: Vulnerability assessments (VAs) have been widely used to understand the risks posed by climate change and identify opportunities for adaptation. Few studies, however, have evaluated VAs from the perspective of intended knowledge users or with reference to established best practices. In this paper, we identify and evaluate VAs focusing on the built environment in northern Canada. We document 16 completed VAs, which range from engineering-based studies of the vulnerability of specific infrastructural assets (e.g., building foundations, roads) to community-based assessments characterizing the vulnerability of the built environment in general in specific communities. We then evaluate projects based on the extent to which they incorporate best practices for vulnerability assessment, informed by a review of the scholarship and interviews with practitioners and knowledge users in the north (n = 21). While completed VAs have increased our understanding of the risks posed by climate change, none perform well across all evaluation criteria, and interviewees identified the need for improvement to VAs to inform decision making. Specifically, there is a need for greater emphasis on stakeholder engagement and effective communication of research findings, and interdisciplinary collaboration to capture the multiple drivers of vulnerability, cost impacts, and examine the performance of infrastructural assets under different climate scenarios.

Local Relevance: This research evaluates climate change vulnerability assessments (VAs) focusing on the built environment in the Canadian north, and examines more specifically the extent to which they incorporate best practices; interviews were conducted with the intended knowledge users in the North, and included respondents from Yukon. Sixteen vulnerability assessments were selected for evaluation. Three types of VAs were identified, including community-based vulnerability assessments, engineering-based vulnerability assessments, and

sectorial-based vulnerability assessments. Of the first type, six were supported through the CAVIAR (Community Adaptation and Vulnerability in Arctic Regions) research program, which examined vulnerabilities associated with urban infrastructure in the context of present and future climate change and other stresses; of the two studies examined of the third type, one was conducted by the government of Yukon examining territory-wide vulnerabilities in water use. The studies using a community-based vulnerability assessment approach were found to provide the most comprehensive assessment of vulnerability. A trade-off was found in terms of ability to capture multiple determinants of vulnerability; the community-based and sectorially based projects which provided breadth were primarily qualitative in nature and did not provide limited information in the vulnerability of specific infrastructural assets, engineering and design factors contributing to these shortcomings, and more. During the interviews, Yukon-based practitioners expressed that there is too much emphasis on the research and not the users, that VAs involving future scenarios are difficult where there is a lack of downscaled data, and that challenges exist around stakeholder engagement and communication.

Keywords: policy, vulnerability, infrastructure, Yukon-wide

Available Online: Abstract http://link.springer.com/article/10.1007/s11027-014-9543-x

Citation: Ford, J., Champalle, C., Tudge, P., Riedlsperger, R., Bell, T. and Sparling, E., 2014. Evaluating climate change vulnerability assessments: A case study of research focusing on the built environment in northern Canada. Mitigation and Adaptation Strategies for Global Change, doi: 10.1007/s11027-014-9543-x.

A geosystems approach to permafrost investigations for engineering applications, an example from a road stabilization experiment, Beaver Creek, Yukon, Canada

Research Location: Yukon

Publication Type: Journal Article

Publication Date: 2014

Abstract: The Alaska Highway crosses numerous terrain units underlined by warm and ice-rich discontinuous permafrost highly susceptible to thermal degradation. For years, this infrastructure, which is essential to transportation in northwestern Canada and Alaska, has been showing signs of road damage induced by permafrost degradation. In 2008, Yukon Highways and Public Works, and its international collaborators, implemented a road experimental site near Beaver Creek (Yukon) to test mitigation techniques aiming to control permafrost degradation. Permafrost investigations were done accordingly to a geosystem approach based on the hypothesis that permafrost has a distinctive sensitivity to climate and terrain conditions at a local scale and that changes (dynamics) in the system must be integrated in the analysis to obtain a holistic understanding of permafrost conditions and consequences of potential changes through time. Therefore, permafrost assessment at BC-RES came along with other components assessment such as local climate, natural terrain and embankment conditions.

Four main units identified were typically ice-rich, with the exception of one shallow sub-unit (2B) that was ice-poor, but which contained the top of inactive ice-wedges, and Unit 3 at depth. The extent of the syngenetic ice wedges was not encountered, but reached at least a depth of 10.7 m. Units 1 and 2 (likely eolian periglacial deposits) were fine-grained soils characterized by a potential to liquefy, if soils thaw and maintain their natural moisture content, and to differential thaw-settlement. Unit 3 (likely interglacial deposit) was mainly made of peat, while Unit 4

(likely glacial deposit) was a diamicton with a fine-grained matrix containing abundant excess ice. Impact from road embankment was measured at many locations in permafrost below the infrastructure. Isothermal profile under the road and embankment subsidence, assessed from core-drilling combination with GPR and ground temperatures, reflected the thermal impact of embankment and its interaction with other geosystem components (e.g., snow, groundwater) on the underlying ice-rich cryostratigraphic units. Thaw depth below embankment sideslopes had mostly reached sub-unit 2B, exposing now excess ground ice from the underlying very ice-rich sub-unit 2C and ice wedge to melting. In this context, an increase in permafrost degradation is expected in the near future, regardless of the mitigation technique performance.

Application of the geosystem approach for road infrastructure in permafrost regions was beneficial at the BC-RES to identify the comprehensive critical engineering conditions that should be considered at the infrastructure spatial scale for road sustainability through timescale of its life. This approach emphasized the importance of changes in properties and processes, including their variability and dynamic related to interactions within the system. Overall, engineering studies in permafrost regions, which are typically sensitive to changes in conditions, would clearly benefit from applications of the geosystem approach, which can be adapted to spatial and time scales of these studies.

Local Relevance: The Alaska Highway, linking northern British Columbia to Alaska through the Yukon Territory, is a crucial transportation infrastructure for northwestern Canada and the United States. Hundreds of kilometres of this highway have experienced road damage due to permafrost degradation, along segments associated with warm and highly thaw-susceptible, ice-rich, discontinuous permafrost. In order to look for long-term solutions to cope with permafrost degradation along the highway, the Yukon Government and its collaborators established an experimental road site in 2008 near Beaver Creek for testing a range of techniques for mitigating permafrost degradation along the highway. The main objectives of the research discussed in this paper were to perform a geosystem approach assessment of the conditions at the test site, with an emphasis on the permafrost component, including identifying types of permafrost present on site, determining their typical properties, and measuring changes induced to permafrost by the road embankment.

Keywords: adaptation, Alaska Highway, Beaver Creek, infrastructure, permafrost, permafrost modelling, soil, south Yukon

Available Online: Abstract http://www.sciencedirect.com/science/article/pii/S0165232X1300205X

Citation: Stephani, E., Fortier, D., Shur, Y., Fortier, R. and Doré, G., 2014. A geosystems approach to permafrost investigations for engineering applications, an example from a road stabilization experiment, Beaver Creek, Yukon, Canada. Cold Regions Science and Technology, vol. 100, p. 20-35.

8. FOOD SECURITY

The impacts of climate change on tribal traditional foods

Research Location: Alaska

Publication Type: Journal Article

Publication Date: 2013

Abstract: American Indian and Alaska Native tribes are uniquely affected by climate change. Indigenous peoples have depended on a wide variety of native fungi, plant and animal species for food, medicine, ceremonies, community and economic health for countless generations. Climate change stands to impact the species and ecosystems that constitute tribal traditional foods that are vital to tribal culture, economy and traditional ways of life. This paper examines the impacts of climate change on tribal traditional foods by providing cultural context for the importance of traditional foods to tribal culture, recognizing that tribal access to traditional food resources is strongly influenced by the legal and regulatory relationship with the federal government, and examining the multi-faceted relationship that tribes have with places, ecological processes and species. Tribal participation in local, regional and national climate change adaption strategies, with a focus on food-based resources, can inform and strengthen the ability of both tribes and other governmental resource managers to address and adapt to climate change impacts.

Local Relevance: Indigenous populations face unique and disproportionate challenges due to climate change, many of which are still not well understood. This paper explores one of these challenges in particular: the impacts of climate change on traditional food sources and its limitations on access thereto. Though this article focuses on the impact of climate change on traditional food sources for American Indian and Alaska Native peoples, there are some concerns that also apply to aboriginal populations in Yukon. For instance, along the Yukon River and its tributaries, Chinook salmon are now commonly infected with a single-celled parasite previously unknown in these salmon populations, indicating a broadened geographic range of the parasite under conditions of climate change and an increased risk to salmon and other species.

Keywords: berries, environment, impacts, food security, policy, salmon, Yukon-wide

Available Online: Abstract http://link.springer.com/article/10.1007/s10584-013-0736-1

Citation: Lynn, K., Daigle, J., Hoffman, J., Lake, F., Michelle, N., Ranco, D., Viles, C., Voggesser, G. and Williams, P., 2013. The impacts of climate change on traditional foods. Climatic Change, vol. 120, p. 545-556.

9. GENERAL

9.1 YUKON GOVERNMENT INITIATIVES

Yukon State of the Environment Report 2014

Research Location: Yukon

Publication Type: Government Publication

Publication Date: 2014

Summary: This State of the Environment Report presents information on climate change, air, water, land, and fish and wildlife. It provides insight into whether Yukon is achieving the goal of maintaining and enhancing the quality of Yukon's natural environment for present and future generations. The report is prepared in accordance with the Environment Act. It provides early warning and analysis of potential problems for the environment; allows the public to monitor progress toward the achievement of the objectives of the Act; and provides baseline information for environmental planning, assessment, and regulation. The best available and most recent information has been used in the report. The base year for comparing trend information is 2011.

In 2011, the most recent year for which data is available, 0.374 megatonnes of greenhouse gas emissions were generated in Yukon, a 30 percent decrease from 1990 but a 10 percent increase from 2010 due to increased industrial activities during this period. Yukon emissions account for 0.05 percent of the Canadian total. In 2013, Yukon had an average annual temperature 1.6°C higher than the average annual temperature from 1948 to 2013 – making it the 10th warmest year here since 1948. The Yukon Research Centre provided digital access to weather data from the White Pass and Yukon Route log books from 1902-1957. This will enable analysis of climate during this period. The transportation sector contributes the largest share of GHG emissions in Yukon. It is challenging to reduce GHG emissions in Yukon because of the high energy input required to live long distances from production centres and to heat buildings during cold winters.

Local Relevance: This report highlights environmental and climate change trends and impacts in Yukon, as well as actions that the Yukon government has supported to address climate change. A breakdown of greenhouse gas emission sources for Yukon is provided; for example, the majority of Yukon's greenhouse gas emissions come from transport, followed by stationary combustion sources. The average winter temperature in Yukon has increased 5.4°C since 1948. Climate change initiatives that are highlighted include a Pan-Territorial Permafrost Workshop, the Energy Strategy for Yukon, and the Yukon Government Climate Change Action Plan. Trends include warming temperatures and increased winter precipitation, with winter temperatures and precipitation increasing at higher latitudes.

Keywords: air quality, air temperature, emissions, energy, environment, greenhouse gases, impacts, mitigation, policy, precipitation, wildlife, Yukon-wide

Available Online: Full Document http://www.env.gov.yk.ca/publications-maps/documents/SOE_2014_Web.pdf

Citation: Government of Yukon, Environment Yukon, 2014. Yukon state of the environment interim report 2014. Policy, Planning, and Aboriginal Relations, Whitehorse, Yukon, 70 p.

9.2 RESEARCH NEEDS

Assessing the 'usability' of climate change research for decision-making: A case study of the Canadian International Polar Year

Research Location: Yukon Territory, Northwest Territories, Nunavut

Publication Type: Journal Article

Publication Date: 2013

Abstract: The creation of 'usable science' is widely promoted by many environmental change focused research programs. Few studies however, have examined the relationship between research conducted as part of such programs and the decision-making outcomes that the work is supposed to advance, and is constrained by limited methodological development on how to empirically assess the 'usability' of science. Herein, this paper develops a conceptual model and assessment rubric to quantitatively and systematically evaluate the usability of climate change research for informing decision-making. We focus on the process through which data is collected, analyzed and reported and examine the extent to which key principles of usable science are integrated into project design, using grant proposals as our data source. The approach is applied to analyze climate change research conducted as part of the International Polar Year in Canada, with 23 projects identified as having explicit goals to inform decision-making. While the creation of usable science was promoted by funded projects in the International Polar Year, this was not generally reflected in research design: fewer than half determined objectives with input of decision makers, decision context was not widely considered, and knowledge users were not widely reported to be engaged in assessing the quality of data or in resolving conflict in evidence. The importance of science communication was widely emphasized, although only 8/23 projects discussed tailoring specific results for end user needs. Thus while International Polar Year research has made significant advances in understanding the human dimensions of Arctic climate change, key attributes necessary for determining success in linking science to decision-making (pertinence, quality, timeliness) were not captured by many projects. Integrating these attributes into research design from the outset is essential for creating usable science, and needs to be at the forefront of future research programs which aim to advance societal outcomes. The framework for assessing usability here, while developed and tested in an Arctic climate change context, has broader applicability in the general environmental change field.

Local Relevance: The fourth International Polar Year (IPY) was the largest-ever international programme of scientific research focused on the Arctic and Antarctic, including Yukon. Climate change was a major focus, and the creation of 'usable science' to inform decision-making was promoted as a broad objective through IPY planning documents, themes, and criteria for project endorsement. Furthermore, climate policy throughout the north has focused on a need for adaptation, with recognition by Yukon government and others of a need for research that integrates traditional knowledge and science to inform decision-making. This article evaluates the extent to which research conducted as part of IPY in Yukon and the rest of the Arctic was designed to be effective in informing decision-making. Overall, of twenty-three projects evaluated, it found that the creation of science for use in decision-making was not a major consideration in the design of most IPY research projects, and most projects did not integrate

timeliness or quality considerations into their research design. Social science and health science projects were significantly more likely than biophysical science projects to have integrated key attributes of usability into their research design. IPY was characterized as a 'missed opportunity' to connect northern science and decision-making.

Keywords: education, policy, research needs, Yukon-wide

Available Online: Abstract http://www.sciencedirect.com/science/article/pii/S0959378013001003

Citation: Ford, J., Knight, M. and Pearce, T., 2013. Assessing the 'usability' of climate change research for decision-making: A case study of the Canadian International Polar Year. Global Environmental Change, vol. 23, issue 5, p. 1317-1326.

APPENDICES

APPENDIX A: INDEX

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