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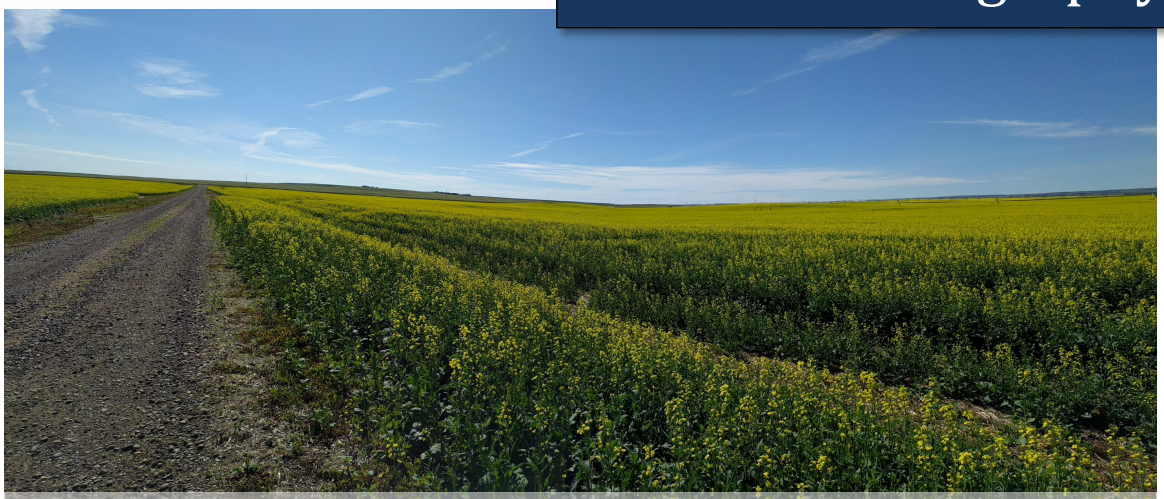

Cover Images: C.A. Coburn

Western Geography – Editors' Note

Volume 4 2019/22.

It is with great sadness that I must announce that this volume is my final as Editor of Western Geography. The COVID-19 pandemic has taken a toll on everyone and our ability to attract papers without holding in-person conferences as well as the dramatically increased academic workload due to the devastating cuts to post - secondary education have further limited our ability to get timely reviews for authors.

Western Geography will continue with a new editor and a new vision for how best to serve Geographers and Geography in Western Canada. We will be rolling out these changes at the upcoming Annual Meeting of the WDCAG held at University of the Fraser Valley.

This volume continues the online format tradition in that in contains both Research Papers and Research Notes. There is a wide range of research presented and I would like to extend a special thank you to all the authors who waited patiently for me to get the reviews looked after, typeset the journal, and finally assemble the last volume. It has been a three year wait for some. That is far too long a wait to amass sufficient articles to warrant a volume.

I would like to thank the editorial team over the years including Tom Waldichuk, Pam Shaw and Joanne Moyer. I would also like to thank all those across Canada and the USA who agreed to serve as anonymous peer-reviewers. Finally, to all the authors who selected Western Geography as an outlet for their work – thank you. I believe that since I took over the role as Co-Editor in 2014 and now as Editor of this journal that the experience of getting an article published was made a little less intimidating for first-time authors. I did my very best to uphold the standard set by the previous editor – Dr. Jim Windsor.

The Editor

Editor: Craig Coburn, University of Lethbridge
Associate Editor: Joanne Moyer, King's University

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Using GPS technology to track hitchhiker activity in Northern BC

Shannon Hyrcha, Roy V. Rea, Rory McClenagan, Scott Emmons, and Roger Wheate
Faculty of Environment, University of Northern British Columbia, 3333 University Way, Prince George, BC, V2N 4Z9

Abstract: *Understanding the demographics of hitchhiking can help inform agencies involved in hitchhiking risk and crime prevention to make evidence-based decisions. Using dash-mounted GPS devices designed specifically for this purpose, we partnered with five courier companies to collect temporal and spatial data on hitchhiking activity in northern British Columbia between June 2012 and October 2014. Data collected were: location, time of day, gender, and whether or not the hitchhiker was alone (or in a pair or group). Some citizen science GPS data were also gathered (February to November 2012), along with hitchhiker interview information collected by local highway patrol officers. A total of 775 records revealed that the largest number of hitchhikers in northern British Columbia were First Nations and male between 20 and 49 years of age. Our data suggest that most hitchhikers traveled alone, in the summer, and in the early evening hours. Findings from our study have been mapped and provided to the local Office of the Highway Patrol for risk and crime prevention purposes.*

Keywords: Bus, First Nations, GIS, Highway of Tears, Highway Patrol, Mapping

Introduction

The phenomenon of hitchhiking is poorly represented in the peer-reviewed literature (Chesters and Smith 2001). The literature that exists in North America provides little quantitative information (Compagni Portis 2015), and few data other than anecdotal accounts have been recorded on where hitchhiking hotspots are located and/or the characteristics of hitchhikers in northern British Columbia (BC), Canada. The prominence of hitchhiking in the literature has declined since the 1970s along with the decline in the popularity of hitchhiking (Compagni Portis 2015). This decline in literature has created a knowledge gap that makes it difficult to pinpoint or analyze hitchhiking trends, which would be useful in addressing violence against hitchhikers and for hitchhiking mitigation campaigns. To date, a single report appears to be the only existing study throughout all of North America that broadly characterizes hitchhiking. This report from the California Highway Patrol (1974) found that in 71.7% of major crimes related to hitchhiking, the hitchhiker and not the driver, was the victim of foul play, although drivers can also be targeted by hitchhikers. Although hitchhikers, rather than drivers, generally face a disproportionate level of danger, British Columbia's laws that relate to

pedestrians and solicitation on roadways address collision mitigation and driver safety, rather than the safety of hitchhikers. In comparison with other parts of Canada, Ontario has similar laws to British Columbia: both provinces disallow pedestrians from freeways or restrict pedestrians to the shoulder of certain categories of highways while limiting solicitation to obtain a ride to commercial passenger vehicles only (Highway Traffic Act 1990, Motor Vehicle Act 1996, Safe Streets Act 2004). British Columbia's neighbouring province of Alberta, in contrast, does not have any language in its Traffic Safety Act (2000) to restrict pedestrian activity. Overall, data collected on hitchhiker activity could be a valuable tool for prevention of related violent crimes, and could also inform legislation and hitchhiking mitigation campaigns.

The objective of this project was to determine spatial and temporal trends in hitchhiker activity and characterize the types of hitchhikers traveling throughout northern BC (i.e., generate trends to help us better understand the "who, what, when, and where" of hitchhiking). Our prediction was that hitchhiking activities would be concentrated in geography and time (season and time of day) and that our data could help to elucidate patterns needed to mitigate undesirable consequences of hitchhiking. Because little is known about the proportion of males to females and solo to group hitchhiking (Greenley and Rice 1974), we sought to describe patterns endemic to northern BC.

Background

Hitchhiking is a common method of travel that has been used for decades throughout much of North America (Schlebecker 1958, Mahood 2018). It is often the only option available for people living in small, remote communities where public transportation is rare or non-existent (Morton 2016) and other forms of ride-sharing do not exist (Mote and Whitestone 2011). Many people hitchhike in order to obtain basic needs and services that are not available in smaller communities, such as attending medical or dental appointments, buying groceries, and filling prescriptions. Hitchhiking is a high-risk activity (Miller 1973) that is believed to have played a part in the disappearance of young females across Canada (Mahood 2016) and women from northern British Columbia along what has come to be known as the Highway of Tears (Harper 2006, Leidli T'enneh First Nation et al. 2006). This Highway mostly comprises a 724-km stretch of the Yellowhead Highway 16 between Prince George and Prince Rupert, although some of the victims associated with this phenomenon were also found near Highway 5, which runs from Tete Jaune Cache to Hope, British Columbia, and Highway 97 which runs from Dawson Creek to the United States border near Osoyoos.

Methods

Partner and Citizen Science Data

We worked with Persentech Industries (Winnipeg, Manitoba) to design and develop a mobile GPS device that could be easily used by drivers to record various types of hitchhikers at the push of a button. We helped design units (referred to here as Otto

Hitchhiker units) that were used to gather data from courier and trucking companies that travel highways throughout northern British Columbia. Vehicles were equipped with Otto Hitchhiker units recording date, time, and location of the hitchhiker sighting with the driver pressing one of five buttons: Female (Single), Male (Single), Unknown (gender; Single), Couple (gender irrelevant), or Group (gender irrelevant) (Figure 1).

Figure 1. Persentech Otto hitchhiker units modified to gather information on hitchhikers by pressing Group, Couple, Unknown, Female, or Male buttons. A red error button was later added.

To conduct the work, we partnered with five courier companies—Valhalla Transport (route: Prince George to Prince Rupert), BNS Transport (Prince George to Fort St. James), LTC Transport (100 Mile House to Prince George), Rosenau Transport (Prince George to Fort St. John, Prince George to Quesnel), and Two Rivers Transport (hotshot service in/around Prince George) who helped us collect data from 2012 to 2014 along two major highway routes bisecting Prince George, BC. Our goal was to collect hitchhiker data that would be of use to the BC Highway Patrol for ongoing highway safety and violent crime prevention measures.

These data were vetted and compiled at the University of Northern British Columbia to determine the proportion of each type of hitchhiker and the times of year and day that hitchhikers were seen. In addition, maps were generated using Google Fusion Tables to give a spatial representation of hitchhikers according to time of year and type of hitchhiker. The mapped data portray records from June 1, 2012, to October 20, 2014, but have been kept confidential (and jittered in our maps below; see methods) as locations of hitchhikers are seen as particularly sensitive information. The majority of vehicles (but not all) outfitted with our Otto Hitchhiker units had regular schedules, traveling through certain cities at specific times; consequently, we were not able to ascertain if there were any time-of-day peaks in hitchhiking in specific locations, and can only judge times on a broad scale. To this end, sighting data reported here should not be interpreted beyond the

scheduling constraints of the vehicles and their drivers' operating the units, although we contend that our findings such as season of hitchhiking and composition of hitchhikers (male vs. female) should not be influenced by courier scheduling constraints.

Because Otto Hitchhiker units were added and removed from routes by couriers at various times according to scheduling requirements, the number of hitchhikers at some times of year could not be accurately compared when all of the data were compiled. To control for these fluctuations, we analyzed the yearly trend of hitchhiking sightings within Otto units. We focused on the three longest running units: Units 1 and 2, which traveled from Prince George to Prince Rupert; and Unit 4, which traveled from Prince George to Fort St. James.

In addition to data collected by our partner vehicles, a citizen science aspect of our project which employed the use of personal GPS devices, provided us with opportunistic GPS data with the type, day, and time of hitchhiker sightings from north central BC during the same years. These data were not restricted to main travel routes, and locations were considered to represent a general area rather than a specific location (because of the time required to gain a GPS signal using handheld devices). Citizen science data were vetted by the same standards as the Otto Hitchhiker unit data, but due to the clarity of submitted records, no data needed to be removed.

RCMP Data

One hundred twenty-six records were collected between February 1, 2012, and November 17, 2012, from RCMP street checks that allowed us to compare time and type of hitchhiker with our GPS data, as well as analyze age and ethnic background. The type of hitchhiker recorded by RCMP members were either male or female, so we investigated time, location, and officer notes to determine which individual records were actually people traveling in couples or groups. Due to our subsequent combination of records, some analyses may not sum to 126 records. Unknown genders were not an issue as highway patrol officers stopped and spoke with each hitchhiker. It is important to note that RCMP data represent the number of hitchhikers seen at a particular day and time, as opposed to the GPS data which represent number of sightings and could include multiple people. This was a minor issue when there were few RCMP sightings of couples or groups, but should be considered when there were several sightings. To determine the age distribution of hitchhikers we divided age into general categories of 0-19, 20-29, 30-39, 40-49, 50-59, and 60+. Ethnic background was categorized into three main groups: First Nations, Caucasian, and Other. The "Other" category represented Asian, Black, Hispanic, and unknown.

Vetting

Data vetting was completed using driver input and data analysis with Microsoft Excel 2007. GPS units were equipped with an error button which allowed drivers to inform us if they accidentally pressed an incorrect button. Any record occurring in the minute previous to an error message was therefore deleted. Multiple records that were exactly

the same (duplicates) were assumed to be the result of a button sticking and all but one of such records were deleted. Records that occurred at the exact same time and location but were different types were assumed to be from accidentally pressing more than one button at the same time; in these cases, only one record was retained and the hitchhiker type was changed to unknown. Finally, some records occurred in a series where many buttons were pressed at the same time or within a few seconds of each other, which is unlikely given the driver was instructed to just hit "group" if multiple hitchhikers were in the same place. When this pattern occurred all records were deleted, assuming something was accidentally placed on the keypad, causing multiple buttons to be pressed. After vetting was completed, 775 GPS records were available for analysis.

Results

Mapping hitchhiker locations

Our results show that hitchhiking occurs throughout northern BC on the Highway of Tears as well as other numbered highways. Prince George may be a particularly large hub for hitchhikers, although couriers travelled in and out of Prince George more than other northern cities (Figure 2). The towns and cities of Vanderhoof, Smithers, Terrace, and Prince Rupert also appear to be used more often by the hitchhiking community than smaller centres such as Fort St. James and Fraser Lake (Figure 2). Although proportions varied slightly by location (Figure 2), GPS records for the proportion of types of hitchhikers of the 775 records we recorded revealed that the majority of hitchhikers were single males (73%), 14% of hitchhikers were single females, and 4% of hitchhikers were traveling alone, with gender unable to be determined. There were fewer incidents of hitchhikers traveling together: 8% of hitchhiker sightings were couples and only 1% of the sightings were groups. This pattern was consistent throughout the year, with males comprising the largest number of hitchhiker sightings regardless of season.

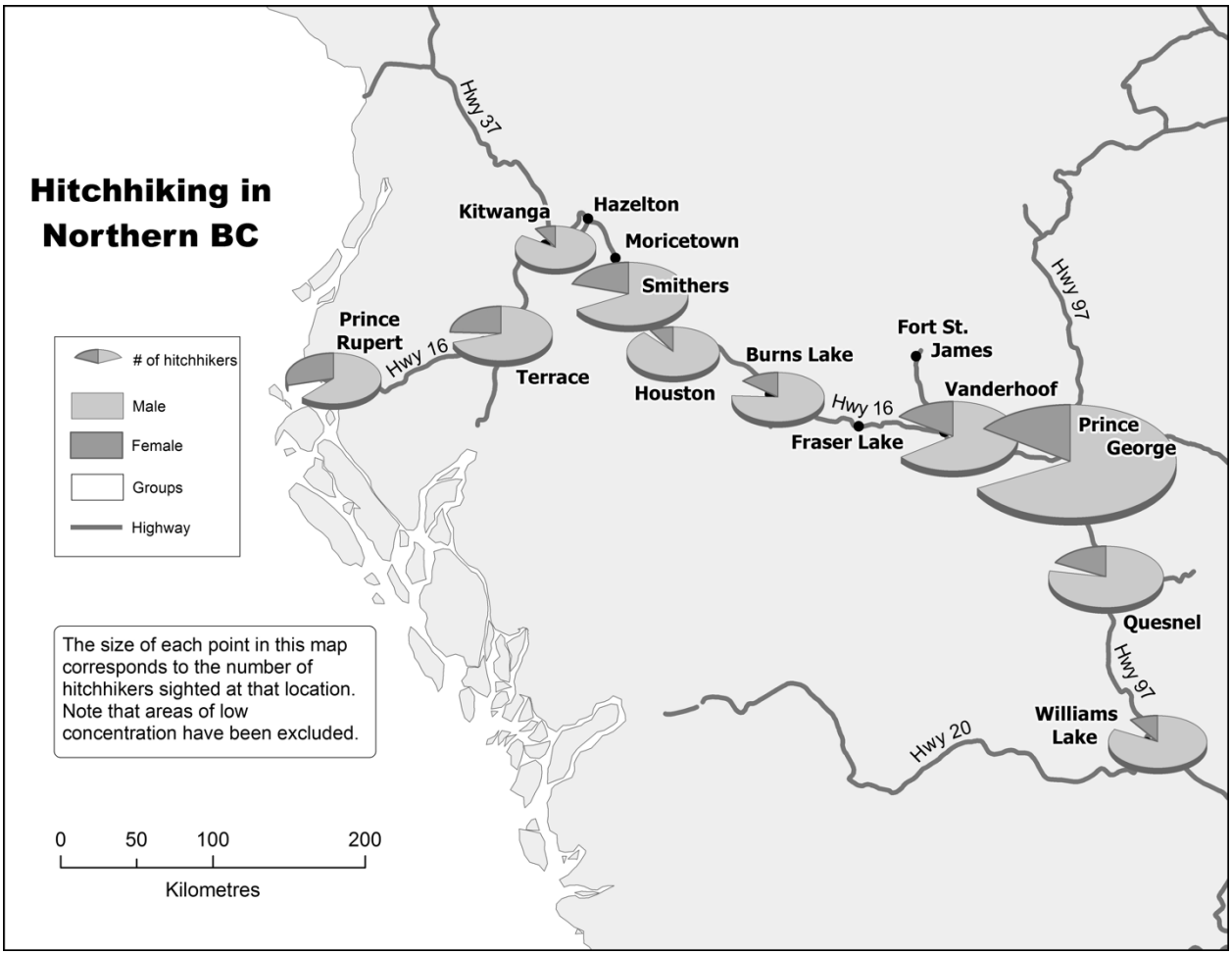

Figure 2. Variations in the proportion of hitchhikers made up of males, females, and groups recorded at various locations along the Highway of Tears (Highway 16 –shown between Prince Rupert and Prince George) and other numbered highways in northern BC as obtained by Otto Hitchhiker units between June 2, 2012 and October 20, 2014.

How hitchhikers distributed themselves to obtain rides also varied within cities, as depicted for Prince George in Figure 3.

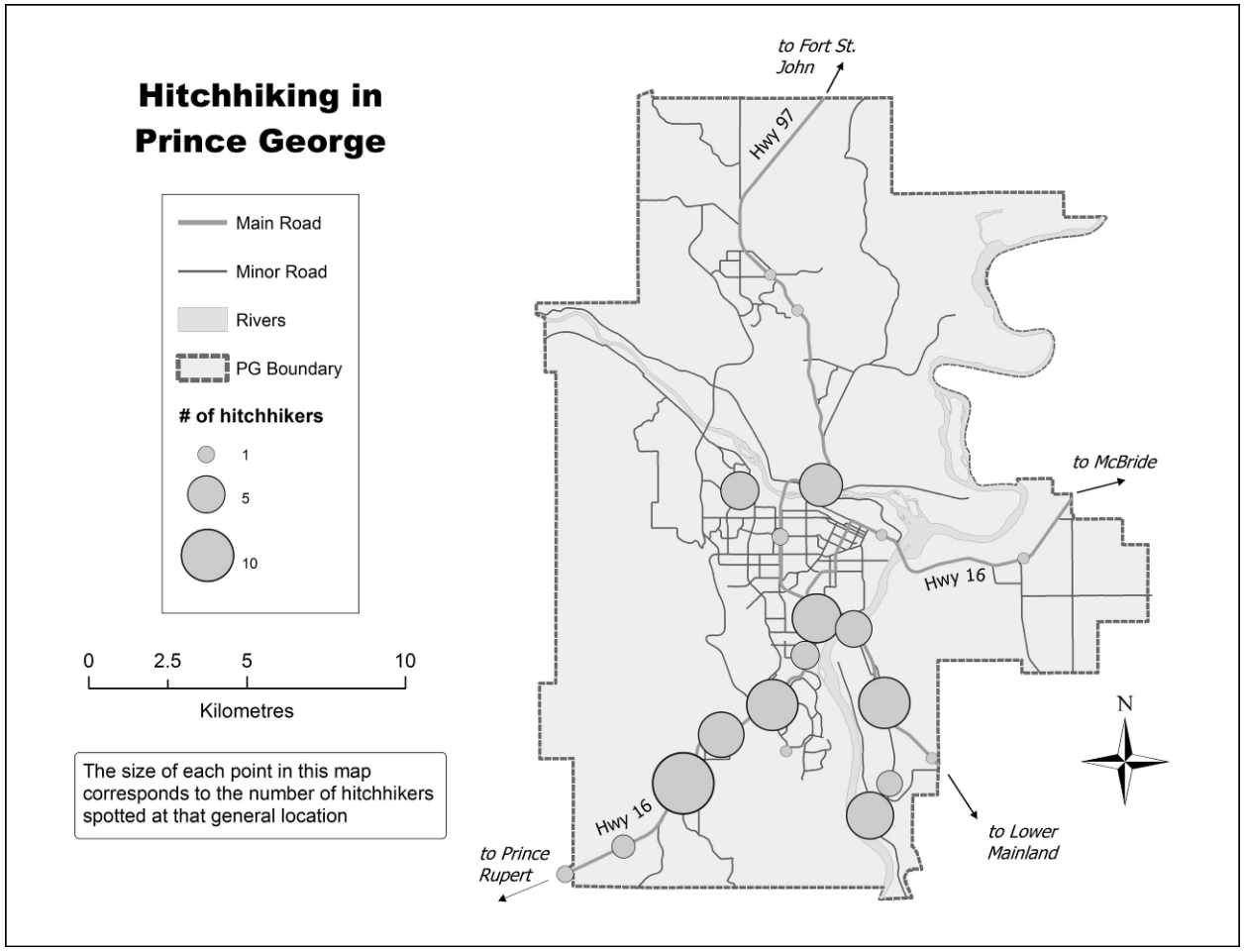

Figure 3. Distribution of hitchhiker sightings within the city of Prince George, British Columbia as obtained by Otto Hitchhiker units between June 2, 2012 and October 20, 2014. Note: Locations shown here have been jittered to obscure the actual locations.

Partner and Citizen Science Data

The number of hitchhiker sightings was lowest during the winter for both the compiled data (Figure 4) and the three longest-running units: the two units traveling from Prince George to Prince Rupert rarely reported hitchhiker sightings during December and January, and the unit traveling from Prince George to Fort St. James reported only a few sightings in winter.

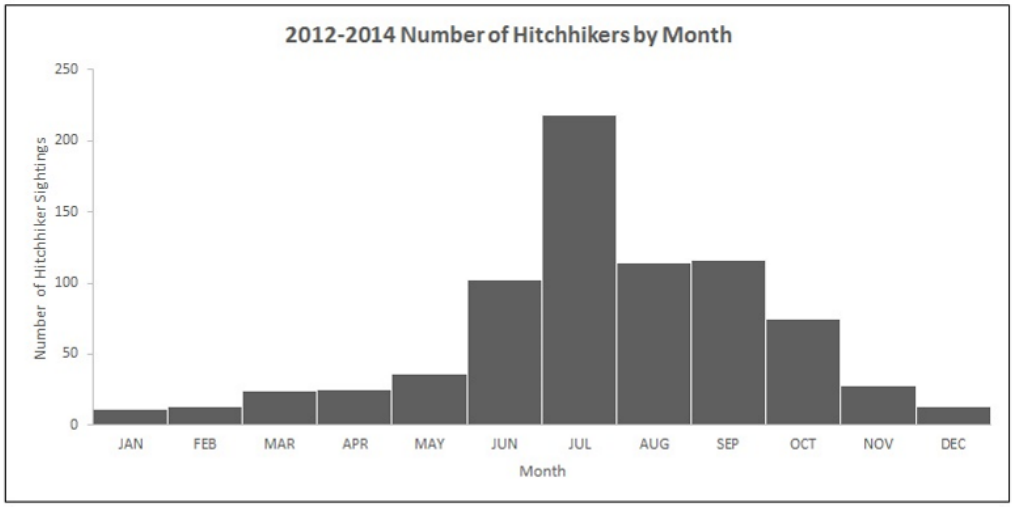

Figure 4. The number of hitchhiker sightings in northern BC obtained from all Otto Hitchhiker units by month from June 1, 2012 to October 20, 2014.

There was a peak in hitchhiker sightings from approximately 2:00 p.m. to 8:00 p.m. (Figure 5), which coincided with when we expected evening traffic flow to be the highest. Hitchhiker sightings dropped sharply at approximately 9:00 p.m. and continued to be low through the early morning hours until approximately 9:00 a.m.

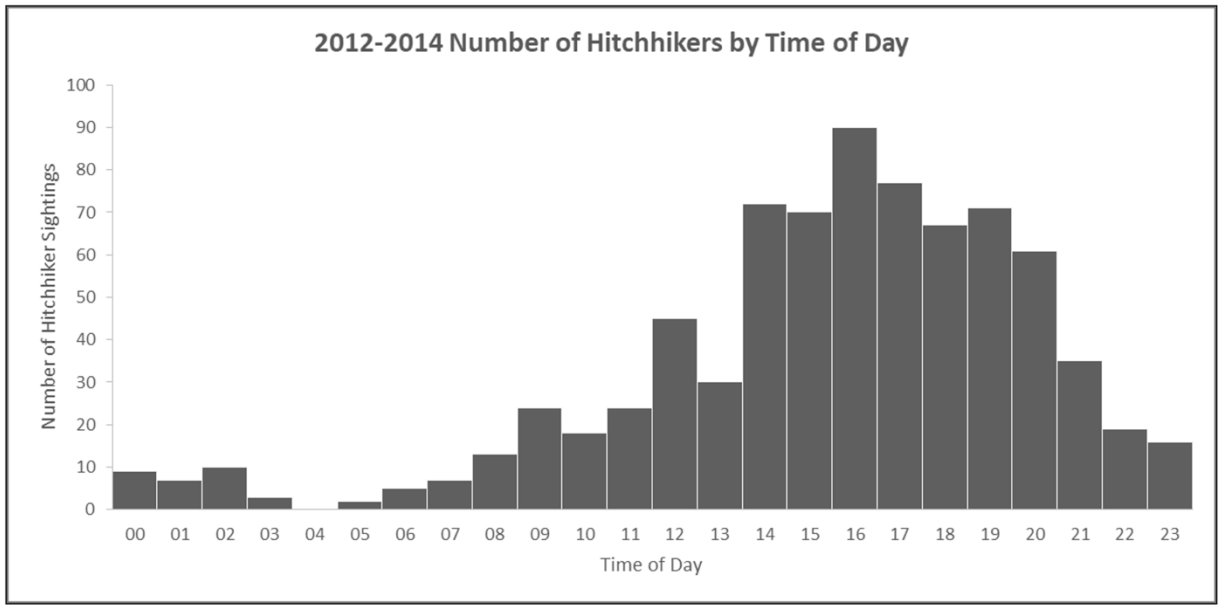

Figure 5. The number of hitchhiker sightings obtained from all Otto Hitchhiker units according to time of day from June 1, 2012 to October 20, 2014 in northern British Columbia. Time of Day axis reflects a 24-hour clock. For example, 00 includes sightings from 00:00-00:59, 01 from 01:00-01:59, etc.

RCMP Data

Data provided from RCMP street checks in 2012 showed a similar trend to our Otto data - hitchhikers were comprised of 68.5% males, 17.1% females, and 14.4% couples. Time of day was also similar to our Otto data with the majority of hitchhikers being seen at night and fewer hitchhikers being on the road during early morning hours (Figure 6).

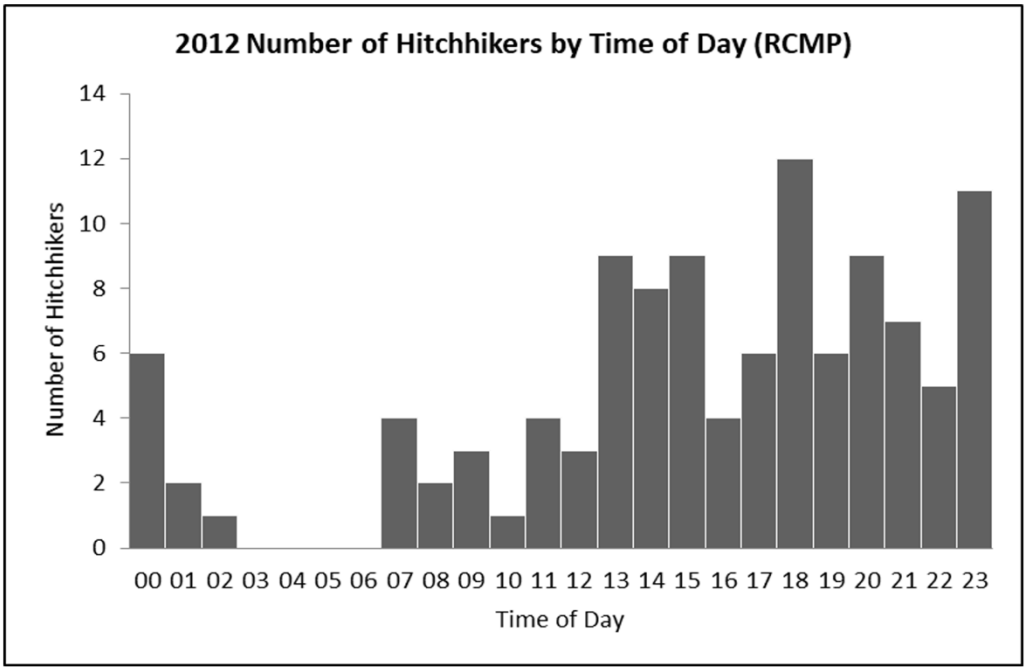

Figure 6. The number of hitchhikers according to time of day from February 1, 2012 to November 17, 2012 provided by British Columbia RCMP street check records. Time of Day axis reflects a 24-hour clock. For example, 00 includes sightings from 00:00-00:59, 01 from 01:00-01:59, etc.

Hitchhiker age was diverse with the largest number of hitchhikers in the 20-49 year old range, and a slight peak of 28% in the 40-49 year range (Figure 8). Age groups of 20-29 and 30-39 were slightly lower, with 21% and 22% of hitchhikers, respectively (Figure 8). The 0-19, 50-59, and 60+ age groups, comprised only 6%, 15%, and 8% of hitchhikers, respectively (Figure 7). Hitchhikers were 61% First Nations, 25% Caucasian, and 14% Other.

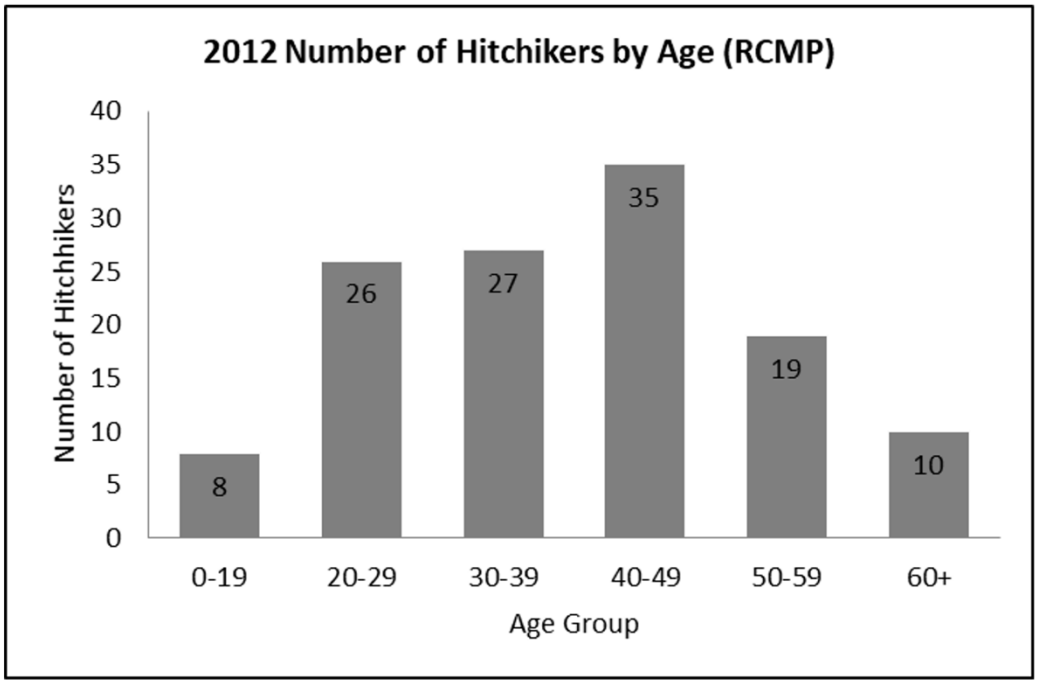

Figure 7. The number of hitchhiker sightings in each age group according to RCMP street checks in Northern British Columbia from February 1, 2012 to November 17, 2012.

Discussion

An overwhelming majority of northern BC hitchhikers, both male and female, appear to travel alone. It is presumably considered safer to hitchhike with at least one other person, however, a driver may not pick up two or more hitchhikers for safety concerns or because there are too few seats in the vehicle. Although much interest in the hitchhiking phenomenon has focused on female hitchhikers, our results show that females (comprising 50.4% of the BC population; Statistics Canada 2011) actually represent a much smaller proportion of hitchhikers than males. These results are consistent with a California Highway Patrol (1974) report showing that only ~9-12% of hitchhikers were female. However, if circumstances for our study are similar to the 1974 study, which showed female hitchhikers to be seven to ten times more likely than males to be victims of crime, attention should be disproportionately focused on understanding female hitchhiker behaviour and keeping them safe. In addition, the 1974 study also revealed that 80% of crimes against female hitchhikers were sex-related. Although it is less publicized, males are also at risk of becoming victims of criminal activity. As a result, both males and female should be targeted by hitchhiking mitigation campaigns used by the RCMP and government officials to discourage hitchhiking through the use of roadside discussions, signage, and literature.

As anticipated, hitchhiker sightings were most frequent during summer months. Although sightings were distributed along highways, hotspots in certain communities were identified indicating campaigns to reduce hitchhiking should be designed for

spring and summer release and focused in certain locations. Some hitchhiking did continue into winter, despite less agreeable weather conditions (e.g., Prince George to Fort St. James).

The majority of transport trucks equipped with Otto Hitchhiker units traveled during the day, so it was possible that early morning hitchhikers were under-represented because the vehicles did not travel during this time. It is also possible, however, that hitchhikers chose to travel when they were most likely to get picked up (i.e., when traffic flow was highest), in which case few hitchhikers would travel at night when traffic flow is typically lower. Hitchhikers may also feel more visible and safer during the day. It is interesting that RCMP time-of-day data (traveling at all times of the day) corroborate our Otto Hitchhiker (mostly daytime driving) data. Upon examining these data together, we contend that there are likely fewer hitchhikers traveling in the early morning hours.

Although the largest number of hitchhikers were in the 40-49 year age category (RCMP data), a large proportion of hitchhikers from each age group were recorded. It was expected that most hitchhikers would be younger since they are more likely to engage in risky behavior (Chesters and Smith 2001). The fact that only 6% of hitchhikers were 19 or younger may suggest an increased awareness of the dangers of hitchhiking among the younger generation, but the widespread age of hitchhikers also suggests that the root causes for hitchhiking affect all ages.

Assuming people of all ethnic backgrounds were checked with equal regularity, First Nations appeared to be over-represented in the hitchhiking data we analyzed. Aboriginal peoples only make up 5.4% of the British Columbia population (BC Stats 2011), and 13-30% of the Northern Interior and Northwest regions of British Columbia, respectively (Foster et al. 2011), but made up 61% of the hitchhikers interviewed by RCMP, with Caucasians making up 25% and 'Other' making up 14%. These data could be used to help inform the creation of hitchhiking mitigation campaigns and lead researchers to specific communities to determine why groups use hitchhiking for travel and what could be done to overcome these trends. More survey work and qualitative data collected with an aim to specifically disentangle the variety of reasons why people of different demographic groups are inclined to hitchhike would help to answer many of the questions surrounding this phenomenon and could be useful in mitigation planning.

Conclusion

Overall, the largest group of hitchhikers in northern British Columbia were First Nations and male, traveling alone, in the summer, and in the early evening. The largest number of hitchhikers was in the 40-49 year age range. We recommend further and expanded data collection and continued work by organizations campaigning against hitchhiking for females, but also suggest that similar campaigns be tailored to males. Our data suggest that these campaigns should target spring and summer promotional

releases—when people are most likely to begin hitchhiking. Hitchhiking mitigation campaigns do not necessarily need to target specific age groups because ages of hitchhikers in northern BC were widespread. Specific efforts should instead be made to address the reasons why First Nations and other people hitchhike, such as those mentioned in the Highway of Tears Symposium Recommendation Report (e.g., to visit the doctor or get groceries; Leidli T'enneh First Nation et al. 2006). We recommend that more hitchhiker data (both survey and other forms) be collected so that a more robust data set can be generated from which broader inferences can be made. Data collection efforts should also be targeted as a province-wide initiative. Smartphone apps could help in the development of a citizen science project designed to understand hitchhiking in the same way some apps have recently been designed to map the use of roadside areas by wildlife for wildlife-vehicle collision mitigation purposes.

Acknowledgements

We would like to thank the managers, office staff, and drivers at Valhalla Transport, BNS Transport, LTC Transport, Rosenau Transport, and Two Rivers Transport who helped us collect data. We would also like to thank Imagine Grants for funding this research, and acknowledge Eric Brewer and Gord Flewelling from the RCMP, Jacqueline Holler from UNBC, Gayle Hesse from the Wildlife Collision Prevention Program, and Frank Franczyk from Persentech Industries for their help in designing this study. We'd like to thank the editorial staff of Western Geography and two anonymous reviewers for constructive feedback on an earlier draft of the manuscript.

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"Discovering" Inuit Women: Photographer Geraldine Moodie and the Advancement of Canadian Sovereignty in the Arctic

Maura C. Hanrahan
Department of Geography and Environment, University of Lethbridge, University Drive, Lethbridge, Alberta

Abstract: *Geraldine Moodie arrived in the Arctic in 1904 as part of a Canadian expedition charged with extending Canadian sovereignty. As the wife of the expedition's leader, Moodie normalized colonial men who usually appeared without their families, shaping the Arctic as a site of heroic masculine performance. As a professional photographer and as a western woman, Moodie established relationships with Inuit women. Her studio work created images of Inuit women that would become popularized and associated with the Arctic and Canada's possession of the north. Rooted in Fanon's, Said's, and Smith's understandings of the processes of colonialization, including European concepts of "discovery," Geraldine Moodie can be said to have "discovered" Inuit women, presenting them to her western audience as different, exotic, decontextualized and othered. This archives-based study explores the gendered role of Moodie, a colonial woman, in the absorption of Inuit and their land into Canadian jurisdiction and the "discovery" and "creation" of Inuit women in the colonial imagination.*

Keywords: Geraldine Moodie; Arctic exploration; Arctic women; Arctic photography

Introduction

This paper situates Canadian photographer Geraldine Fitzgibbon Moodie (1854-1945) in the narrative of Arctic "discovery" and colonization. As the first woman to photograph Inuit, Moodie's Arctic presence and work advanced British-Canadian sovereignty in the north. Reflexively, as the wife of a colonial official, Geraldine Moodie acted as the friendly, feminine, congenial face of colonialism. The colonization of the Arctic would not be effective or complete until colonial women were present in the region; while men claimed land for the imperial centre, women would, as wives, normalize the men who claimed the land. Geraldine Moodie came to Hudson Bay in 1904 with her husband, Major John Douglas Moodie of the North-West Mounted Police, who was charged with establishing Canadian law and policing in the Eastern Arctic. Geraldine Moodie's presence and photographic work served to enhance Inuit reception to colonial men and their activities

and smooth over the colonization process. This paper builds on previous analyses of Moodie's work as photo-colonialism by emphasizing the importance of Moodie's very presence in the north in addition to her photography. The paper demonstrates how Moodie used a domestic focus as a bridge to Inuit women, whom she photographed as a form of "discovering" and claiming. Although it has not been fully recognized as such, Moodie's work ran parallel to and supplemented the sovereignty-advancement work of colonial men. Merely by her relatively long-term presence, she brought a new dimension to colonialism that helped seal Inuit fate in what is now Canada.

This paper responds to Laura Nader's call to study the colonizer (1972), rather than those colonized; this call has been more recently echoed by Kim TallBear (2013). It aims to situate Moodie in Arctic colonial history and explain her role in this history as the "discoverer" of Inuit women. Here, I address the specifics of how colonization was performed in the Arctic by a Euro-Canadian woman in the early 20th century. The Arctic is viewed as a site of intentional colonial activity buoyed by European legal and ideological concepts. The Arctic is also understood as an exclusive sphere for the performance of the heroic masculine ethic. Besides her novel presence on Inuit land, Geraldine Moodie's primary tool of communication (to Inuit as well as to others) was photography of Inuit women, and an emphasis on domestic activities, such as clothes production, common to Moodie and to northern Indigenous women. The paper aims to situate Moodie in the history of "discovery" and the colonization of what is now Canada's north and develop an understanding of the nature of Moodie's photography.

Background

The long-held colonial view of Inuit lands as empty space (terra nullius) and thus ripe for acquisition and resource exploitation (Hanrahan 2017; McGhee 2005; Banner 2005; Levere 1993; Richardson 1993) has become so engrained in western society that it has influenced academic research (Smith 2012). Much research reinforces the concept of Indigenous people and the land on which they live as "discovered," then named and claimed (Smith 2012). Following Said (1978), Indigenous people and the land on which they live are without agency and othered. "Discovery," as understood and enacted by Europeans, renders Indigenous people and the complexities of Indigenous societies invisible (Smith 2012). According to Greenlandic Inuit scholar Karla Jessen Williamson, "It has been very trying for Indigenous populations to have their existence annulled – that's what the last 150 years [since Canada was founded] have been" (MacDonald 2017). During this time, Inuit lost agency and Inuit population health has suffered accordingly. Despite political accomplishments such as the establishment

of Nunavut, food insecurity is a pressing problem throughout Inuit regions (Ford and Berrang-Ford 2017; Beamier and Ford 2010). Accidents, suicides, violence, and substance abuse are now of "major importance" in most Inuit communities and the prevalence of chronic disease is increasing (Bjerregaard, Young, Dewailly, & Ebbesson 2004). The Inuit suicide rate is among the highest in the world, at least partly because of colonialism, especially the intrusive government initiatives of the 1950s and 1960s, which altered Inuit social structure (Kral 2012). Williamson asks, "…what kind of Canada is it when 70 percent of people in Nunavut are hungry? (MacDonald 2017). Yet, as Inuit leader Sheila Watt-Cloutier asserts, Inuit thrived in the Arctic, nunangat, their land, for millennia (2015). Inuit had their own systems of law and order, their own legal concepts and practices, before colonization, as Labrador Inuit lawyer Elizabeth Zarpa reminds us (White 2020). These Indigenous systems were eroded, even to the point of erasure, through the process of colonialization, which began in the Arctic with exploratory voyages from Europe. Accordingly, there is a through-line from the early polar explorers to Canada's expeditions from the 1880s onward to the establishment of Canadian law and other institutions on Inuit land to present-day scientific and social science research in the Arctic. Geraldine Moodie and her photography were part of this through-line.

Colonialism is a tool of imperialism, the goal of which is to take ownership of the territories of others so that the imperialist centre can establish dominance and accrue wealth through resource extraction and other means. Franz Fanon (1963), Edward Said (1978), and Linda Smith (2012) have increased our understandings of colonialism as an ongoing violent process that maintains harmful power imbalances, further leading to negative impacts on populations that become othered, subaltern, and dehumanized, as would happen to the Inuit of Canada's Arctic.

The Canadian Arctic was among the last regions to be successfully incorporated into British imperialism, long after parts of Asia and Africa. Polar exploration has additional layers, given the harshness of the geophysical environment and explorers' relatively late access to the Arctic. Initial exploration of the Arctic and other spaces was carried out in the interests of empires and states, and had at its foundation "a complex ideology …" (Smith 2012, 23) that included strands of racism and European legal theory (Banner 2005) as well as romanticism (Spufford 1996). Explorer and expedition narratives advanced this view (Kent 1861; Hayes 1871; Peary 1910; Bartlett 2006, first pub. 1926; Green 1926; Cox, Vanier, and Mill 1936) and continue to inform Arctic discourse and policy (Hanrahan 2017; Rosner 2009; McRae 2007). The Arctic and other regions of the world presented opportunities for "discovery"; as understood by Europeans and by North Americans of European origin, "discovery" meant finding land for the first time, being the first human

being to ever see an island or a peninsula, and "claiming" it for one's own country. "Discovery" is linked to naming, claiming, and categorizing, as per Smith (2012). "Discovery" even extended to people; as anthropologist Diamond Jenness wrote in 1921, "Intense interest was aroused in the scientific world when Mr. Stefansson [the Icelandic-Canadian explorer, Vilhjalmur Stefansson] announced his so-called discovery of 'blond Eskimos' in Victoria Island" (257). A premise of this paper is that through exploration and discovery (as Europeans conceived it), colonialism was imposed and a power imbalance established; in the words of Inuit writer and activist Zebedee Nungak, "Not a thought was given to consulting or even informing the Aboriginal inhabitants of these lands, as their lands were carved up and allocated willy-nilly among governing units who held dictatorial powers over all they surveyed…" (2017, 88). In his memoir Labrador Inuk Paulus Maggo stated, "No prior discussions were held between the non-Natives and us, and community ethics have been totally disregarded" (1999, 150).

"Discovery" and exploration were gendered processes. Sites of "discovery" and exploration, such as the Arctic and, perhaps especially the Arctic, constituted an exclusively masculine sphere; Ernest Shackleton once refused three female applicants to a polar expedition by bluntly stating "[there] are no vacancies for the opposite sex on the Expedition" (Leane 2012, 99). The polar regions were shaped as solely male spaces, where western men could carry out acts of heroism and endurance; if women were present, this would not have have been possible. Margaret Atwood understood this when she wrote of the Arctic as a man's world: "even though the North itself, or herself, is a cold and savage female, the drama enacted in it—or her—is a man's drama, and those who play it out are men" (Hulan 2002, 90). Explorers wanted to maintain this state if they could. As Lisa Bloom put it, "polar exploration narratives played a prominent part in defining the social construction of masculinity and legitimized the exclusion of women from many public domains of discourse" (1993, 6). Thus, much is understood about the roles western men played in the Arctic, but little is known about western women who are absent from many narratives (e.g. Peary 1910) and, indeed, the Arctic itself. There is, then, a further need to understand colonial women's significant role in imperial acquisition of the Arctic.

European men had long come to the Arctic as explorers, "discovering" and then naming lands thought to be uninhabited as per the legal doctrine of *terra nullius*. Though they did not see the Arctic as a viable place to live (Bergmann 1993), they made claims of ownership, a vital step in the colonization process. Their accounts portrayed the Arctic as hostile and dangerous, the perfect site for the display of hyper-masculine prowess. Explorers wrote enthusiastically of the Arctic as a place of western male bravery and

courage (Cox, Vanier, and Mill 1936; Green 1929; Bartlett 2006 first pub. 1926; Green 1926; Hayes 1872; Kane 1861). Colonial women were excluded from colonializing exploits unless they "duplicated their domestic roles when traveling abroad," (Prasch 1995, 175). When they appear, these women are usually depicted in supporting roles, as aides to their husbands, lacking agency themselves, but providing a feminized and civilizing role in a wild masculinized space (Herbert 2012).

Josephine Diebitsch-Peary, for instance, wife of Robert Peary, went to the Arctic as an adjunct of her husband, who controversially claimed to have reached the North Pole in 1909 (Dick 2004; Harmon 2001; Bryce 1997; Rawlins 1991). With tablecloths and silver cutlery, Diebitsch-Peary recreated Thanksgiving dinners in Greenland, acting the part of a dutiful wife and skilled hostess (Herbert 2012; Diebitsch-Peary 1893). On a lengthy visit to Greenland in 1893, Josephine gave birth to a daughter, Marie, who was dubbed "the Snow Baby" in the popular books her mother wrote about her (Diebitsch-Peary 1901). Diebitsch-Peary did indeed her enact her domestic role in the Arctic as her husband pushed to plant a United States flag at the north pole. Robert Peary's actions in propelling the colonial project are well-understood but Josephine's complicity has been underestimated, as is the case with so many colonial women (Prasch 1995).

The wife of one of the men who led Canadian intrusion into the Arctic, Geraldine Moodie is generally known as an early Canadian photographer; she was one of the first women photographers in Western Canada. From its earliest days in the 1830s, photography has been associated with authority; police used it frequently as a tool of law enforcement (Geller 2004). Photography became established as a visual form of communication much later in the nineteenth century when newspapers and other publications began to feature photos (Geller 2004). By then, photographs were important, carrying, by consensus, an inherent "undisputed truth" (Geller 2004, 9); we still see truth in photographs (Close 2007). Instead of undisputed truth, photographs have meanings attached, messages from the photographer to consumers of photography. In addition, photographs do not necessarily contextualize, which strengthens the message of the photograph itself. These aspects of photography allowed Western interlocutors to shape the colonial narrative of the Arctic with their pictures. A notable example was Albert Peter (A.P.) Low (1905), the geologist on J.D. Moodie's expedition who took and published many photographs of Inuit. Lowinvited Inuit to formal photo sessions; some Inuit looked uncomfortable in Low's posed pictures, and women's face paint was emphasized, highlighting the "otherness" or exoticized difference of the Inuit (see Low 1906, 168-170). Low's pictures

were designed to emphasize the allegedly poor health of the Inuit and have been described as unsympathetic (Hatfield 2018, 104). Echoing many colonial justifications, Low described Inuit as "destitute" (1906, 66) and "lawless" (1906, 87). Such offensive descriptors (and worse) were common in exploration narratives, though the concept of "race hatred" (what is now called racism) would not gain currency until the 1930s. Low also delegated charge of one Eskimo "tribe" [sic] (1906, 27) to Captain George Comer and another to himself. In these ways, Low reinforced and maintained his status and power as a colonial white man. Further, the objectification of the Inuit extended beyond Low's photography to an appendix in his book that recorded the physical characteristics -- age, weight and head circumference -- of Inuit whom he does not name (1906, 343). This material, presented in chart form, reduced individuals to medical specimens and numbers, serving to dehumanize, objectify, and other Inuit. The material foreshadowed the federal government's later practice of assigning numbers on dog tags to individual Inuit in what by then was Canadian territory. Low's commentary corresponds to the narratives of Arctic explorers who ventured to Greenland, Canada, and Alaska both before and after Moodie's Arctic presence (Hanrahan 2018). Arctic photography reduced and othered Inuit, rendering Inuit objects of gaze rather than equal human beings.

Arctic photography became established and large collections of images accrued as Canada sought to advance its sovereignty in the north (Condon 1989; King and Lidchi 1989). Governments commissioned photographs, indicating that officials had some sense of the value of photography in claiming land and territory. Notably, Inuit photographic subjects were rarely named, people were not individuated, leading to the creation of Project Naming by Library and Archives Canada decades later (Smith 2008). As methods of communication conveying concepts, photographs constructed the Arctic and Inuit in terms that corresponded to the political goals of the Canadian government (and before it, European powers). Naming specific locations in "empty lands", after "discovering" these sites, was central to the colonization process. Photography was an effective way to appropriate these places. Photos from Captain Joseph Elzéar Bernier's two expeditions between 1903 and 1911 bear this out. Bernier was pictured building a cairn and planting the British flag in the Arctic, thus helping to produce an official record of advancing Canadian sovereignty in the region (Geller 2004). Later the federal government's Department of the Interior set up a Northwest Territories and Yukon Branch, largely to create a substantial archival photography collection (Geller 2004). For Geller, these collections were "illusions of possessions," with the camera

as a metaphor for Canada's extension of power in the Arctic (2004, 166).

Photography was a leisure activity for some nineteenth century British noblewomen (Rosenblum 2010) but women had few entries into professional photography (Birrell et *al.* 1983). One route was as part of family businesses, often as widows (Denny 2009). The 1848 Gold Rush was one of the first times women engaged in paid photography, but barriers remained. Women were strongly associated with portraits of other women and children, reflecting the prevalent idea that they were better suited to taking these kinds of pictures because of their maternal nature (Williams 2009, 129).

Methods

This paper is based on archival research at the Glenbow Museum, Calgary, which recently acquired the Geraldine and Douglas Moodie Fonds. These fonds contain material from 1813-1967, constituting 1.05 m of textual records and 1014 photographs, most taken by Geraldine Moodie, and many taken in what is now Nunavut. The fonds includes the diaries kept by Geraldine Moodie during her time in the north, as well as photography registers and copyright records. With student research assistance, these materials were collected, reviewed, synthesized, and categorized by theme. This paper is also the result of an intensive literature review with identified papers undergoing close readings. The relevant literature was shaped into an annotated bibliography with themes from archival materials highlighted to enhance veracity and analysis. Important search terms while conducting the literature review included such stem words as Arctic, photography, and sovereignty, and terms such as colonial women, settler women, Arctic women, and early women photographers. Research materials were examined using feminist, Indigenist (or decolonized) understandings. In addition, I took a grounded theory approach, as I sought to determine the meaning and impact of Geraldine Moodie and her photography in the early 20th century Arctic and the history of colonial "discovery".

The Moodies in the Arctic

Born in 1854 in Toronto in what was then Canada West, Geraldine Fitzgibbon Moodie came from a creative family whose female members helped shape perceptions of Canada's geography here and abroad. Moodie was the granddaughter of English memoirist and novelist Susanna Strickland Moodie, author of the iconic settler narrative *Roughing it in the Bush* (1852). She was the great-niece of Agnes Strickland, a celebrated Victorian biographer, and of Catherine Parr Traill, author of another famous settler narrative, *The Backwoods of Canada* (1836).

After meeting him in England, Geraldine married John Douglas (J.D. or Douglas)

Moodie, a distant relative, in 1878. Later Moodie set up her own photography studios in three locations in western Canada (Denny 2009, 185), making her the first professional female photographer on the prairies (White 1998). J.D. joined the North-West Mounted Police in 1885 (White 1998) and his career would in many ways determine that of his wife. Of most interest here is the Dominion Government Expedition of 1903-1904, aimed at extending Canadian sovereignty into the Arctic through the establishment of policing in the region. On this expedition, J.D. Moodie set up a police station at Fullerton in Hudson Bay (Qatiktalik in Inuktitut, and now part of the Kivalliq Nunavut, although it is abandoned). In doing so, he initiated the enforcement of Canadian law in the north. In sending Moodie north, officials in Ottawa, including Prime Minister Laurier, were reacting to the ongoing activity of American and Scottish whalers in and beyond Hudson Bay because they had realized that occupation was key to securing jurisdiction of the area.

Geraldine joined the expedition in 1904 and over-wintered at Fullerton. There she became the first colonial woman to take pictures of Inuit women (Forster 2004; Polk 2001). Commissioned by the Government of Canada, Geraldine took numerous photographs at Fullerton. She returned north in 1906, accompanying J.D. to Fort Churchill, Manitoba, where he set up another NWMP post. The Moodies stayed in Manitoba for three years while Geraldine continued her photographic work among Inuit. In 1910, after their posting ended, the Moodies remained keen to be sent north again. One Northwest Mounted Police (NWMP) official wrote to another, "I gathered from him [J.D.], as also from Mrs. Moodie that their desire is to be stationed in the North, as far away as possible from civilization, Athabaska [sic] preferred" (White 1998, 152). The Moodies did not get an Athabasca assignment but in 1912 they started a three-year stay in Dawson, Yukon. J.D. Moodie retired in 1917 for health reasons, probably arthritis, which ended the Moodies' northern activities (White 1998). Collections of Moodie's photographs are held at the British Museum, the Royal Canadian Mounted Police (RCMP) Museum in Regina, SK, Library and Archives Canada, the Glenbow Museum in Calgary, and elsewhere. Moodie took care to copyright many of her photographs, which was unusual for a woman of her time, and indicated her commitment to photography as a career.

Discussion

By the time Geraldine Moodie arrived in Hudson Bay, the Arctic had long been a site of colonial activity, with forays aimed at the acquisition of Inuit lands and resources (Hanrahan 2017), with the imperialist centre shifting from Britain to Canada after the latter gained dominion status in 1867.

Bolstered by an objectification of the Inuit that framed them as inferior, colonialism would render Inuit subordinate in their own lands. As the Moodies arrived in Hudson Bay, London continued to extract raw material for its industries from Canada, India, the Caribbean, and other territories that were British pink on the map, treating "discovered" and "empty" lands as their own.

The Moodies are another example of this phenomenon. The work and impact of John Douglas Moodie has been discussed in the literature and its impact understood (Hatfield 2016; Cavell 2011). A Scot, J.D. Moodie had a long career with the North-West Mounted Police, often in leadership positions, extending the reach of the force in the north. Moodie oversaw detachments at Churchill, Manitoba, and at Dawson City, Yukon, retiring in 1917. Geraldine Moodie has been recognized and celebrated (Forster 2004; White 1999; White 1998) and, at times, critiqued and criticized as an early colonial photographer (Hatfield 2018; Hatfield 2006; Close 2007). Her central role in advancing Canadian sovereignty in the Arctic and shaping colonial Canadian views of the region and its people, the Inuit, have been underestimated. There has been a great deal of attention on Moodie's photography but not as much on the meaning of her Arctic presence and, through it, her role as an agent in colonization. I demonstrate here that Moodie's presence, as a woman who was part of a government expedition to the Arctic, propelled Canadian colonial goals. This would have been the case even without her photography. The northern presence of Moodie, wife, mother, and photographer, normalized official colonial activity for Inuit; until she came, this activity had been almost entirely composed of single white men or white men whose wives were far away and invisible. The wives of missionaries were exceptions in that their functions were similar to Moodie, but their efforts served the church while Moodie's more directly served the state.

Figure 1: Moodie took this studio photo of Nanowk at Fullerton Harbour, Hudson Bay. File number: ND-44-27, Geraldine and Douglas Moodie Fonds, Glenbow Museum; [1904-1905]. Printed with permission.

Geraldine Moodie was part of the history of women in the Arctic, solidifying her place in the profession of photography in 1895 when she opened her three portrait studios

in Saskatchewan and Alberta, later bringing her skills to the Arctic and, as a photographer, playing a key role in the imperialist push. Thus, this paper goes beyond Geller (2004) to see Arctic collections, including photography, as more than illusions of possessions; such collections are part of the process of acquisition or possession so intrinsic to colonialization, as Smith (2012) asserts. Hence the repatriation of museum artifacts previously collected from Indigenous lands and Indigenous people, as such repatriation is consciously part of decolonization processes. Moodie's photographing as a colonial woman, photographing Inuit women she barely knew, also has an element of possession. And it is not an illusion since photographs have an air of authority dating from their early use by police and, in Moodie's time, because of their novelty. In addition, images captured on film continue to be associated with what are considered objective truths (Close 2007). As the wife of the man charged with extending Canadian policing into the eastern Arctic, Moodie was afforded prestige, jurisdiction, and influence, if not command.

On October 22, 1904, not long after arriving in Hudson Bay, Geraldine Moodie noted that one of the first Inuit women she met had never seen a white woman before (October 22, 1904, FONDS). Inuit had, however, had contact with explorers and whalers for more than 150 years and all of them had been male. Moodie's appearance thus had great significance for this and other Inuit women by adding a whole new dimension to the presence of colonial men. Moodie invited Inuit women into her makeshift studio where she would pose and photograph them. Of Inuit she wrote on March 10, 1905, "They make splendid subjects, never look awkward, even the children take kindly to being photographed" (March 10, 1905, FONDS). It was important to Moodie that Inuit pose in Inuit clothing, featuring sealskin, caribou skin, and fur: "They look so much better in their native clothing than in 'kabloona' [white] garments" (March 10, 1905, FONDS). Moodie occasionally took pictures of men, such as Tululick, but her main interest was women. As photographic subjects, these women wore Inuit clothing such as *amautis* (parkas with large hoods to carry babies or young children) or they posed in *qulittaqs* (parkas with fur sides over the top). Some women wore *attigis*, a beaded under-layer top. Beads sometimes featured in the clothing of Moodie's photographic subjects. Her choice then, was to record what she perceived as her subjects' Inuitness, the characteristics and adornments that made them different from the westerners who would consume Moodie's photographs at a distance. Moodie wanted to capture on film the Inuit tattooing tradition. An example of this occurred in March of 1905 when she discussed her attempt to photograph a woman whose clothing featured a coloured pattern of a caribou. She wrote, "It is impossible to get

the ta-too [tatoo] marks to show in the picture, they are ta-tooed in blue which is about dark enough to take the same as their yellow skins. I am painting over some to see how that works" (March 10, 1905, FONDS). For some shoots, she positioned a woman with her child, who might be completely naked except for a beaded decoration. Inuit babies were often not clothed and were kept warm in their mothers' fur hoods. Moodie wrote about this aspect of Inuit child-rearing, amazed by it, and determined to include it in her staged images. Like other Arctic photographers, her ambition was to demonstrate how different, if not strange, Inuit were rather than emphasizing the humanity they shared with the consumers of her photographs. With this approach, Moodie othered Inuit and her memorable images were widely circulated in the south, where they helped establish colonial constructions of Inuitness, especially of Inuit women. These constructions appear in the large Project Naming collection.

Figure 2: Moodie created this portrait of Ooktook with a naked child. File number: NC-81-60, Geraldine and Douglas Moodie Fonds, Glenbow Museum; [1904-1905]. Printed with permission.

Moodie's photographs revealed at least as much about her as a domesticated wife in the Arctic of the early 20th century as they did about her subjects, but they are rarely viewed from that perspective. Moodie maintained her established identity despite her new surroundings and her new status as a member of a small white minority. Kelcey concluded that this stance was automatically adopted by colonial women in the north; women "sustained familiar customs in isolated settings because they needed to remember who they were, where they came from" (2001, 35). In addition, colonial women sometimes tried to impose their own cultural practices and norms in the Arctic; the Pearys' Thanksgiving dinner in Greenland is an example of this. Reproducing one's own culture was in keeping with colonial objectives. Women could and did reproduce the slate of ascribed

female domestic responsibilities, which served to help normalize colonial encroachments. For instance, when an Inuk told Moodie that she didn't have a petticoat, Moodie saw this an important matter and hastened to give the woman one, made of Turkey red cotton.

Geraldine Moodie played a role in the ongoing process of colonization relatively early on and her role was important. Other images of Inuit existed by Moodie's time; "Lady Travellers," upper class British women tourists, had gone to the reaches of the British Empire and produced travel sketches, including some of Inuit (Reeploeg 2017, 36), but, unlike Moodie's, their northern stays would be brief and not attached to official expeditions. Colonial men, such as the geologist A.P. Low who worked with J.D. Moodie, had also photographed Inuit. Yet Moodie was not just one of a series of photographers who contributed to the construction and meaning of Inuit women and men in Canadian society. Her gender meant that her role was pivotal and her nearly year-round presence in Fullerton was necessary to the project's endeavours. Lady Travellers set on exploring the far-flung British Empire were more transitory than Moodie who spent a year in Hudson Bay; they had no official functions and were passers-through. Moodie, on the other hand, was part of an official expedition with the specific purpose of advancing Canadian sovereignty in the Arctic.

With his military background and title of superintendent of the North-West Mounted Police, J.D. Moodie's status and authority automatically projected on to his wife. Here was a representative of the Canadian government building a house in Hudson Bay where he would live with his wife. Inuit were well-used to seeing single colonial men, some travelling through their territory, others, like explorers Vilhjalmur Steffanson, over-wintering in the Western Arctic from 1913 for several years (Steffanson 1921). Some, like Robert Peary and his African-American colleague, Matt Hanson, fathered Inuit children but the men themselves were never more than temporary visitors to polar Greenland and lost contact with their polar families (Hanrahan 2018; Hanson 1969, first pub. 1912). The Moodies were the first government-sponsored married couple to set themselves up in the Canadian Arctic, reinforcing colonial gender constraints while advancing alien sovereignty.

There had been and continued to be missionary women in the Arctic during Moodie's time there. Missionary women interacted with Indigenous people in the Arctic because they were propelled by their desire to teach Inuit, Inupiat, and Dene about "the eternal things that matter" (Kelcey 2001, 122). Female missionaries among the Inuit were more tangential to the colonization process than was Moodie; these women might have helped establish occupation as the foundation of ownership

claims, but their work was less tied to strategic government purposes. The Moodies were stationed north directly because of government ambition. Theirs was not the flag of a Christian church but that of an Empire.

As part of a colonial couple and family, both Moodies had an easier entry into Inuit society, which facilitated Geraldine's photography activities. The Moodies spoke of their children down south and their son, Alex, accompanied them to Hudson Bay and hunted with Inuit. On November 4, 1904, Geraldine wrote, "Alex has won the hearts of all the natives. Susie [an Inuk] says 'your piccannie [sic] [child] good me like him'" (November 4, 1904, FONDS). Indeed, early in the Moodies' Arctic tenure, Alex Moodie was given gifts by Inuit: sealskin boots, mittens, and a tobacco pouch. Alex's presence, as the offspring of two colonial parents, served to normalize the Moodies and their presence, which promoted their acceptance by Inuit. To the Inuit, the Moodie family would have appeared more conventional and less odd or eccentric than the colonial men who left their wives behind to engage in heroic adventures in the north. If Inuit women felt threatened or intimidated or even baffled by colonial men, the appearance of a colonial woman alongside one of them might have reassured them. After all, like them, Geraldine Moodie sewed and cleaned house, as they did, and she was a mother whose relationship with her son they witnessed. Moodie noted that most Inuit women she encountered had only one or two children and, because of this, they admired her for having five children. In addition, several of Moodie's children were sons, highly valued by Inuit because of men's ascribed hunting role. It is likely that Inuit women could relate to Moodie, a mother like most of them, which would have made them more comfortable in her studio than posing for, say, A.P. Low.

Moodie's presence and her growing intimacy with Inuit women through photography meant that colonial activities had a less threatening edge, their political goals layered under reciprocity so highly valued by Inuit. Given the expedition's mission to bring and begin to enforce Canadian law in the region, John Douglas Moodie "faced the delicate task" of notifying Inuit (as well as foreign whaling crews) that they were now subject to an authority far away (Ross 1976, 100). Lorris Elijah Borden, the expedition's young surgeon and botanist, described Moodie's ceremonial approach, similar to others enacted elsewhere in the colonies, including Inuit lands such as Labrador as far back as 1775: "The Major had about eight gallons of tea made and with five pounds of hard tack [bread] and other biscuits soon disappeared. A clay pipe and a bit of tobacco was given to each of the twenty-five natives present…Major told the natives that there was a big chief over them…King

Edward VII [who] had the welfare of all his peoples at heart. [The king] had sent the major as his personal representative…The Major wanted them to do what was right and good and to settle all quarrels but he would punish all offenders" (Ross 1976, 100). This was followed by a gift-giving ceremony during which the Inuit present were given woolen underwear, tuques, mittens and sashes. Still, Borden reported that the Inuit appeared baffled and amazed. Some of them might have been thinking about their close ties to American whalers as well as the spuriousness of British-Canadian claims to their land.

All the Inuit present seem to have been men, but women were involved in the celebration of the king's birthday that came soon after the ceremony. This is largely because of Geraldine Moodie, who knew the women, was photographing them regularly, and now played hostess on board the ship. Moodie wrote that the walls were draped with flags and portraits of the king and Queen Mary hung on the walls. Beforehand, her husband had given each of the Inuit women five yards of material to make a print dress. Geraldine wrote, "The ladies arrived in their new dresses, they had sat up most of the night making them. It is marvelous how they make the five yards go so far. Princess dresses with leg of mutton sleeves. Some of them improvised trimming out of other material…All the young women had their hair hanging down, and most of them had very long hair but a little coarse…They have all square dances to music by our interpreter on a concertina. Douglas had the organ brought up, this greatly fascinated the na [native] men who do not join the dance" (November 11, 1904 FONDS). After the dance, Geraldine served the Inuit guests, now British subjects, cakes and coffees, "a treat to them all" (November 11, 1904 FONDS). In playing this role, Geraldine Moodie echoed the actions of Robert Peary's wife in Greenland a decade before. In Fullerton, she instructed Inuit women in how to wear blouses and she consulted with them about the design of their dresses. Of an Inuit woman she called Chuck, Moodie wrote, "I gave her a collar to finish off [her dress] and she looks quite 'kabloona' [white]" (Jan. 8, 1905, FONDS). By the New Year's Eve dance and certainly by the St. Patrick's Day festivities in March 1905, Inuit women were experienced in the enthusiastic copying of the dresses Moodie herself wore. Moodie helped Britain ease into the Arctic, and, finally, into the lives of Arctic women. Through gifting dress material and food, she and her husband demonstrated reciprocity. Her presence there was an advantage for the Dominion Government Expedition of which she was part, smoothing its way. Inuit women had a relationship with Moodie, taking part in the photographic sessions that would result in the longstanding southern gaze on and depiction of Inuit women, the kind of "discovery" that is inherent in the colonial process.

Figure 3: Geraldine Moodie's photo of Koo-too-took featured on a Canada Post stamp issued in 2013. The photo was taken in 1905.

Moodie rarely photographed Inuit women in their new western-style dresses, Niviaqsarjuk and Jennie adorned in their hats being two exceptions. Generally, Moodie posed her subjects wearing Inuit attire. She created "quite a good Rembrandt lighting" in her front room (Feb. 10, 1905 FONDS) while planning the portrait that become her most famous. She noted her interest in photographing "a deaf and dumb Innuit [sic] girl who has a very expressive face. If one could only get her with a natural smile it would be a picture worth having. Sush [such] fine dark eyes and perfect teeth" (Feb. 10, 1905 FONDS). Here, in writing of the young woman called Koo-tuck-tuck, Moodie provides readers with a striking example of othering. But two days later, she referred to Koo-tuck-tuck's obvious intelligence and her ability to speak animatedly in sign language (Feb. 12, 1905 FONDS). She estimated Koo-tuck-tuck's age at 15 and noted that she was pregnant with her fourth child. Like other colonial writers, Moodie occasionally seemed to respect her Inuit subjects but she usually saw them as exotic and she largely othered them. As Close asserts, "in Moodie's time, the subjects are people who were most commonly photographed by ethnographers or anthropologists seeking only to illustrate specimens or exemplary types" (2005, 53).

Moodie's image of Koo-tuck-tuck was her most influential. The British Museum used the photograph for publicity for a 1998 exhibit and conference Imaging the Arctic. The image appeared on a Canadian postage stamp in 2013 and more than half a million stamps were issued (Koo-tuck-tuck Photograph, n.d). In the photography, Koo-tuck-tuck is alone, holding up a curtain of the type that is seen in photography studios; this position of her seems to extend an invitation and even hints at the young woman's sexuality. Like most of Moodie's subjects, Koo-tuck-tuck holds a conventional pose. Her hair is long and loose. She wears heavy Inuit clothing, elaborately embroidered. She holds a pensive stance and is beautiful. She is alone, decontextualized without her family or community, away from her own home and in what is a contact zone (Close 2017) devised by the photographer. For many in the south (even today most Canadians never venture to the Arctic), Koo-tuck-tuck would become the embodiment of Inuit

womanhood. Yet what we know of Koo-tuck-tuck, how we see her – these things are the creation of Geraldine Moodie's Arctic imagination, Moodie's western perspectives, her feminized views, and the traditions of contemporary photography. This is the Koo-tuck-tuck who endures.

There is little agreement on the meaning of Geraldine Moodie's photographic work in the Arctic. For Osborne, Moodie's photos captured "the dignity and essence of each person" (2013, 206). Newman saw Moodie's photographs as "intuitive" and "detail-oriented" (1998, 90-91). Hatfield compared Moodie favourably to Low, asserting that Moodie's images were less stereotyped (2008, 12-13) and "more sympathetic to the sitter" (29-30); he goes as far as to say that Moodie's photographs were "an expression of the creativity and personality of the individual [being photographed]" (32). Hatfield based his conclusions on the fact that Moodie's subjects were often seated, like guests, for their sessions, and the images Moodie created revealed an artistic and domestic style. Yet Hatfield allowed that Moodie's images "convey[ed] cultural exoticism" (2018, 104), as did Rosenblum (2010), and that since Moodie was part of a colonial venture, her presence served to advance Canadian sovereignty. Newman (1998) agreed that Moodie othered or objectified Inuit women, noting that, for instance, the photographer was not self-reflective and was inconsistent in naming her subjects. My review of Moodie's notes and diaries led me to the same conclusion.

Conclusion

Although she would not have viewed it as such, Moodie's presence as well as her photography became effective tools for imperial goals – possession and charge -- in Inuit lands. So did her very presence: as wife, mother, member of a colonial expedition, and semi-permanent resident of, rather than traveller through, the Arctic. Moodie's work and presence demonstrated clearly that women could be colonizers, too, especially if they conformed to assigned female roles focused on the domestic, as Moodie did and as most Lady Travellers did not. Thus, Moodie helped to define women's role as colonizer. Like the missionary women, Moodie "introduced civilization" to Inuit, as Kelcey put it (2008, 35) but she went farther; she "discovered" Inuit women, who had been largely out of sight for Europeans and North Americans, making them invisible residents of the Arctic. Moodie's image-making presented Inuit women as different, as curious objects to be gazed at; generally, the women in Moodie's enduring work are depicted alone and adorned and without naming. This practice helped to establish the tradition of photographing Inuit without contextualization and without naming them, a process that has not served Inuit. The objectification and othering of Inuit facilitated ongoing colonialism and Inuit continue to live with the damaging effects of

this process of which Geraldine Moodie was part.

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Examining Food Security in Inuit Communities

Deanna Andreschefski and Megan Fisk
Department of Geography and Environment, University of Lethbridge, University Drive, Lethbridge, Alberta

Abstract: *Food insecurity in Inuit communities in Canada is an increasing concern for Inuit families and, as a complex issue, needs to be fully understood to be properly addressed. We analyzed peer-reviewed articles from the University of Lethbridge data base to understand the complexities of the Inuit food security issue. Inuit people are in a time of nutritional transition, as they move from nutrient-dense traditional foods to highly processed nutrient-deficient westernized foods, compromising food accessibility and affordability. Food insecurity is exacerbated by intersecting socioeconomic and environmental factors, including high rates of unemployment and poverty, high food prices in grocery stores, an increase in the frequency of extreme weather events, declining animal populations, altered seasonal sea ice cycles, and failed attempts to mitigate some of these issues. This paper will discuss each of the factors and their health impacts and will identify possible solutions to the issue of Inuit food insecurity.*

Keywords: Food Insecurity; Inuit Health; Inuit; Inuit nutritional transition; climate change.

Introduction

Food insecurity among Inuit communities in Canada has become increasingly concerning over the last decade. As a complex issue with many adverse effects on individuals and communities, it requires a comprehensive review of its contributing factors to design effective mitigation strategies. While the literature in this report predominantly focuses on Nunavut, the concepts and findings apply to all Canadian Inuit communities. There are a variety of factors that contribute to food insecurity; however, our primary focus is on the socioeconomic and climatic factors, which have numerous implications to Inuit health and wellness. Through this literature review, we aim to gain an understanding and appreciation of the complexity of Inuit food insecurity and discuss mitigation strategies that have been recently implemented or proposed.

Background

The Inuit are the Indigenous peoples of the Arctic and Subarctic regions of Alaska, Canada, and Greenland. In Canada, there are just over 65,000 Inuit people, making up less

than 1% of the country's total population (Inuit Tapiriit Kanatami, 2018; Leblanc-Laurendeau, 2020). Inuit in Canada mainly live within Inuit Nunangat, which are traditional Inuit lands in the Northwest Territories, Nunavut, Northern Québec, and Northern Labrador (Inuit Tapiriit Kanatami, 2018). Although they make up such a small proportion of Canada's population, the Inuit experience disproportionately high rates of food insecurity (Leblanc-Laurendeau, 2020). In 2018, 57% of Inuit households in Nunavut experienced some level of food insecurity, which is more than triple the national rate of 12.7% (Leblanc-Laurendeau, 2020). Research has identified Inuit elders, single mothers, and children as those who are at the greatest risk of food insecurity within their communities, with 78.7% of households with children in Nunavut reporting food insecurity in 2018 (Beaumier & Ford, 2010; Leblanc-Laurendeau, 2020; Man Chan et. al., 2006).

In little more than a decade, Nunavut's food insecurity rate has been remarkably unstable, while the national average has remained steady. The number of food insecure households in Nunavut grew more than 20% from 2006 to 2008, while the national average only grew by 7% (Leblanc-Laurendeau, 2020). This statistic demonstrates the discrepancy between Inuit and non-Inuit Canadians' access to food.

Researchers have identified that the Inuit diet is composed of foods which fall into two gross categories: market foods or traditional foods. Market foods, also classified as retail or store foods, are items that are imported into Inuit communities such as fresh produce, grains, and dairy products (Huet et. al., 2017). Traditional foods, sometimes referred to as country foods, consist of the plants and animals that are part of the traditional Inuit diet such as fish, seals, caribou, whales, berries, and eggs (Huet et. al., 2017). Inuit communities are currently undergoing a nutritional transition, in which they are relying more heavily upon market foods to supplement the traditional foods in their diets, which have become increasingly difficult to obtain (Beaumier & Ford, 2010; Egeland et. al., 2011). This dietary shift presents health implications which will be discussed further on in this paper.

Food security is determined by four factors which must occur simultaneously: availability, accessibility, quality, and usefulness (Beaumier & Ford, 2010; Nunavut Food Security Coalition, 2014; Wakegijig et. al., 2013). The severity of food insecurity increases with each factor that is not fulfilled (Nunavut Food Security Coalition, 2014; Man Chan et. al., 2006). Moderate food insecurity includes a lack of food variety, reduced food quality, and undesirable market food options, while severe food insecurity involves skipping daily meals such as breakfast or lunch, eating smaller portions for each meal to preserve food, and being without food for days at a time (Man Chan et. al., 2006). The severity of food insecurity

is closely related to a family's socioeconomic status.

The determinants of food security are each fulfilled by different criteria. Food availability is achieved when both market and traditional foods are plentiful; therefore, animal populations must be large and stable, and there must consistently be enough market food to supply the whole community (Nunavut Food Security Coalition, 2014). Conversely, a shortage of market foods, delayed shipments, and declining wild animal populations limit food availability within Inuit communities. The accessibility of food builds upon availability and refers to the socioeconomic status of individual households (Nunavut Food Security Coalition, 2014). Market food becomes inaccessible when it is overpriced or when there is limited household knowledge in storing, preparing, and serving different foods (Man Chan et. al., 2006; Nunavut Food Security Coalition, 2006). Traditional foods can become inaccessible to Inuit families when hunting equipment is unaffordable or when there are fewer full-time hunters within the community (Beaumier & Ford, 2010; Man Chan et. al., 2006; Nunavut Food Security Coalition, 2014). Regardless of availability and accessibility, the food must also be deemed good quality, meaning that it is nutritious, that market foods are not approaching or past their expiration dates, and wild animals are not diseased or malnourished (Kenny et. al., 2018; Rosol et. al., 2010). The usefulness of foods is the keystone of food security, as it refers to the accessibility and knowledge to store, prepare, and cook market foods (Nunavut Food Security Coalition, 2014). Without this knowledge, useless foods simply take up space on market shelves and limit the availability of other, more useful food products.

Socioeconomic Factors

High rates of unemployment and poverty are one of the primary causes of food insecurity in Inuit communities (Leblanc-Laurendeau, 2020; Man Chan et. al., 2006; Rosol et. al., 2010). There are fewer job opportunities in many areas because of their small populations and remoteness (Beaumier & Ford, 2010). The limited job availability results in many Inuit households relying on income assistance from the federal government, which often falls short of monthly household expenses (Duhaime & Édouard, 2014; Inuit Tapiriit Kanatami, 2018). In addition to limited family income, many Inuit people have admitted that they are unfamiliar with the Western concept of budgeting, making it more difficult to properly manage their finances (Wakegijig et. al., 2013). Unemployment and poverty place both economic and social strain on individuals, families, and communities, causing food insecurity as well as contributing to intergenerational trauma (Aguiar & Halseth, 2015).

The high price of market foods in Inuit grocery stores is another leading factor of inaccessibility to food, especially as it

overlaps with limited household finances. Many Inuit communities are remote and are therefore only accessible by airplane or boat (Huet et. al., 2017). Communities that are accessible by boat must also rely on airplanes for most of the year when seasonal sea ice prevents shipping (Huet et. al., 2017). This reality makes the delivery of market foods more difficult, expensive, and longer than compared to food deliveries in the southern provinces (Man Chan et. al., 2006). Delivery companies have higher overhead costs to transport food to remote Inuit communities, including higher qualifications required to operate planes and ships, higher fuel prices for these types of vehicles, and more labour hours for employees (Beaumier & Ford, 2010; Kenny et. al., 2018). These costs are then transferred onto the consumers by increasing the prices of market foods. Perishable food items like produce and dairy experience higher rates of inflation because they must be delivered on a tighter deadline than non-perishables (Huet et. al., 2017). There is also the potential for delayed food deliveries due to inclement weather (Beaumier & Ford, 2010), which affects food quality, accessibility, and availability.

Traditional hunting practises have also been in decline because of restricted accessibility to hunting equipment and fewer full-time hunters in each community. Modern hunters utilize snowmobiles and motorboats for hunting and fishing, which require costly fuel to operate, as fuel prices are subject to the same factors of inflation as market foods (Beaumier & Ford, 2010; Huet et. al., 2017; Wakegijig et. al., 2013). Other hunting necessities such as rifles, ammunition, camping gear, and safety equipment are also quite expensive for the same reason, making them largely inaccessible to community hunters (Newell et. al., 2020).

In addition to the economic limitations above, fewer people are acting as full-time hunters in their communities because of education and employment constraints. Those who do have full-time jobs are restricted by their work week from participating in hunting exhibitions, which can last several days at a time. Inuit youths are in a similar situation with regard to the education system (Man Chan et. al., 2006). Adult hunters and students may take time away from school and work to attend these trips, but they risk the financial strain of lost wages and falling behind their peers academically (Man Chan et. al., 2006). These restrictions have limited the cultural transmission within Inuit communities, as there are fewer people to teach the youth how to hunt, and fewer youths capable of missing several days of school in order to learn (Beaumier & Ford, 2010; Man Chan et. al., 2006).

The final socioeconomic factors of food insecurity that have been identified by researchers are substance abuse and gambling addictions, which are widespread in Inuit communities. These dependencies are often incorrectly perceived as self-

inflicted. Addiction and substance dependencies are part of a cycle of trauma, which includes the ongoing financial instability and food insecurity of Inuit families, but also relates to the cultural genocide by the Canadian government in the form of residential schools, forced resettlements, and other systems of oppression (Aguiar & Halseth, 2015; Beaumier & Ford, 2010; Man Chan et. al., 2006). Many adults have become reliant on alcohol and gambling as a coping mechanism for their trauma, which exacerbates their financial strain and food insecurity, and repeats the traumatic cycle (Aguiar & Halseth, 2015). The unaddressed trauma of older generations is passed onto younger generations through the resulting instability (Aguiar & Halseth, 2015). It is important to remember that intergenerational trauma in the overall narrative of food insecurity needs to be addressed in future mitigation strategies.

Environmental Factors

The climate has its own complicated role which exacerbates food insecurity. Climate change has been well-documented since the 1980s and it is generally accepted that it occurs at a greater rate in the North due to a phenomenon called Arctic Amplification (NASA, 2013). This trend is caused by the melting polar ice caps which lowers the Earth's ability to reflect rather than absorb heat from the sun, resulting in faster warming trends in the North (NASA, 2013). Inuit fishers have noted that the previously reliable timing of the formation and retreat of coastal sea ice has been occurring unpredictably in recent years (Beaumier & Ford, 2010; Newell et. al., 2020; Wakegijig et. al., 2013). The freeze-up of the sea ice is occurring much later in the year than in the past, and break-up occurring much earlier, resulting in prolonged "shoulder seasons" (Huet et. al., 2017, pp. 3) and a shortened period in which the sea ice is stable (Beaumier & Ford, 2010; Newell et. al., 2020; Wakegijig et. al., 2013).

This shortened ice season impacts Inuit hunters and fishers in their ability to use traditional hunting routes (Newell et. al., 2020; Wakegijig et. al., 2013). The longer shoulder seasons, during which the sea ice is present but unstable, prevents access to marine resources as it is impossible to navigate boats through the ice flows (Huet et. al., 2017; Wakegijig et. al., 2013). Several traditional hunting routes have also been abandoned due to coastal erosion and ice instability as they have become too hazardous to traverse (Wakegijig et. al., 2013).

Inclement weather conditions such as blizzards, high winds, and fog are also becoming more frequent. These conditions can prevent scheduled food deliveries by airplane and can be too dangerous for traditional hunting activities (Beaumier & Ford, 2010). Delayed food deliveries greatly reduce the quality of market foods, especially dairy and produce items, which often arrive wilted, rotten, or expired

(Beaumier & Ford, 2010). The availability of market foods is limited by these delays as well, as they create a temporary food shortage within community grocery stores (Beaumier & Ford, 2010).

Wild animal populations are in decline due to climate change, pollution, and industrialization (Dennis, 2018). The prolonged ice-free season in the summer provides greater opportunities for shipping activity to more remote locations, but it has an adverse effect on marine life; both noise pollution and physical pollutants, like fuel and non-biodegradable waste products negatively impact the health of seals, whales, and fish (Newell et. al., 2017). In Northern Québec and Labrador, the George River caribou herd is just beginning to recover from a devastating population crash (Dennis, 2018). The herd has been part of the Inuit subsistence in this region for centuries, but recently the vegetation that sustains the herd has been less nutritious due to altered climate cycles inhibiting nutrient absorption (Dennis, 2018). The herd has also suffered from habitat loss from industrialization (Dennis, 2018). Inuit used to heavily rely on wild game for subsistence but have had to transition towards more reliance upon market foods due to these environmental impacts.

Effects of Food Insecurity

Food insecurity has many adverse cultural and health implications on Inuit communities. The food transition from the traditional to market foods has resulted in an overall decrease in quality of the Inuit diet (Egeland et. al., 2011). The types of market foods that are less expensive, and therefore more accessible to Inuit families, typically lack necessary vitamins and nutrients, while being high in sodium, sugar, and trans fats (Huet et. al., 2017; Kenny et. al., 2018; Man Chan et. al., 2006). The lack of important nutrients can lead to increased rates of malnutrition, infections, obesity, Type 2 Diabetes, and cardiovascular disease (Inuit Tapiriit Kanatami, 2018; Leblanc-Laurendeau, 2020; Wakegijig et. al., 2013). Mental health is also negatively impacted by food insecurity, as researchers have linked it to higher rates of depression, social ostracization, suicidal ideation and attempted suicide among Inuit youth and adult men (Inuit Tapiriit Kanatami, 2018; Leblanc-Laurendeau, 2020).

Inuit cultural continuity is threatened by food insecurity in multiple fashions. As previously mentioned, the barriers caused by employment and education systems as well as higher rates of depression and suicide prevent younger generations from learning how to hunt (Man Chan et. al., 2006). Traditional food sharing practises are also struggling due to limited finances and fewer hunters in each community being able to share the spoils of their hunt (Beaumier & Ford, 2010). Cultural continuity is an important aspect of Inuit wellness and must be considered in proposed mitigations for food insecurity.

Mitigation Attempts, Proposed Strategies, and Ongoing Aid

There have been many proposed solutions and attempts to reduce the rate of food insecurity within Inuit communities in the last decade. These suggestions and strategies have been developed and implemented at both the community and government level. Qualitative studies within communities have produced requests for food banks and communal freezers to enhance food sharing networks (Huet et. al., 2017; Kenny et. al., 2018; Man Chan et. al., 2006; Nunavut Food Security Coalition, 2014). Proposed solutions at the government level include providing subsidies to market foods and hunting equipment, wages for full-time community hunters, and education campaigns to improve household knowledge about market foods (Man Chan et. al., 2006; Nunavut Food Security Coalition, 2014; Wakegijig et. al., 2013). These policies help to increase food availability and accessibility and help to broaden the selection of market foods with better knowledge about storage, preparation, and serving different food items.

The Government of Nunavut released a publication in 2007 entitled *Tampata: Building our Future Together*, in which the basic needs of Nunavummiut are emphasized including housing, food, health, and education (Wakegijig et. al., 2013). The publication was also the first to declare a food insecurity crisis in Nunavut (Wakegijig et. al., 2013). The *Tampata* is credited for the establishment of many subsequent policy proposals and working groups like the Nunavut Food Security Coalition (Wakegijig et. al., 2013). This publication has been an essential document in the development of mitigation strategies for Inuit food insecurity.

The Nunavut Food Security Coalition is a collaborative organization composed of governmental offices, non-governmental organizations, private sector institutions, and Inuit organizations (Nunavut Food Security Coalition, 2014; Wakegijig et. al., 2013). The Coalition was established following the release of the *Tampata* report and has produced multiple issues of the Nunavut Food Security Strategy and Action Plan (Nunavut Food Security Coalition, 2014). This plan outlines six areas of interest: traditional foods, market foods, local food production, life skills, programs and community initiatives, and policy and legislation (Nunavut Food Security Coalition, 2014). Each area of interest provides objectives for improving food security, including shifting the primary source of nutrition back towards traditional foods; providing financial support for full-time hunters; providing education in communities and schools about nutritious market and traditional foods; reducing the reliance on imported market foods by exploring the possibility of local food production in greenhouses; financial literacy campaigns; and establishing programs in

communities and school curriculums that enhance knowledge, employment opportunities, and training (Nunavut Food Security Coalition, 2014).

The Nutrition North Canada program is one of the present initiatives that assists Inuit communities with affordable and nutritious market foods. The program provides funding that is used to subsidize eligible food and hygiene products that are imported by air, ice roads, sealift, and barge (Government of Canada, 2020). The subsidy rates depend on the type of transportation used to import the products, the location and remoteness of each community, and the category of eligible products, which can be low, medium, or high (Government of Canada, 2020). Higher subsidies are provided to offset the costs of more nutritious and perishable items like produce, and lower subsidies are provided for non-perishable foods and non-food items (Government of Canada, 2020). The program, however, faces many challenges and has recently implemented improvements such as cooking classes, providing healthy food samples, and gardening (Government of Canada, 2020). This program is helping Inuit communities become more familiar and comfortable with healthy food options, especially in light of the nutritional transition.

Another initiative that is ongoing is the Nunavut Harvester's Support Program. This initiative provides subsidies on hunting necessities such as camping gear, safety equipment, rifles, ammunition, knives, and personal items (Qikiqtani Inuit Association, 2017). The program also provides funding for groups or organizations to participate in community hunts depending on the community size, number of harvesters, and nature of the hunt (Qikiqtani Inuit Association, 2017). This type of program helps to support Inuit cultural continuity by improving the accessibility of traditional foods.

The Government of Canada has also increased funding to relief programs in the wake of the COVID-19 pandemic. In 2020, the federal government allocated $17.3 million to the governments of the Yukon, Northwest Territories, and Nunavut to subsidise air transport of essential goods and services to remote communities (Agriculture and Agri-Food Canada, 2020). Nunavut also received an additional $1.1 million to help Nunavummiut families with the social, economic, and health impacts of COVID-19 (Agriculture and Agri-Food Canada, 2020). The Nutrition North Canada program received $20 million to increase subsidies on market food and hygiene products to support Inuit nutrition (Agriculture and Agri-Food Canada, 2020). Despite the increase in funding towards these programs, however, there are many factors of food insecurity that remain unaddressed by these initiatives and families continue to struggle with food accessibility.

Conclusion

The complexity of food insecurity in Inuit communities raises many areas for concern

which must all be addressed. The federal and territorial governments have placed an emphasis on the economic aspects of food insecurity such as unemployment, poverty, and high food prices. While relatively successful in reducing the high costs associated with healthy market foods and hunting equipment, these policies and programs fall short in addressing the contributing social factors, addiction and trauma, as well as climatic factors. The governmental policies should also include easily accessible mental health support and more aggressive action to reduce the effects of climate change. Food insecurity is not a simple issue, but a holistic approach will be able to mitigate its severity.

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Key Ingredients for University Leadership in Fostering Climate Action

Don Alexander

Geography Department and Master of Community Planning program, Vancouver Island University, Nanaimo, BC.

Abstract: *British Columbia has been badly hit by the effects of the climate crisis over the past year. This makes examining university climate policies especially timely. In what follows, the policies of three universities are singled out for examination – Royal Roads University, University of British Columbia, and Simon Fraser University – based on the leadership roles they have undertaken to date. The paper analyzes the factors that have facilitated this leadership. This is then contrasted with the performance of the author's home institution, Vancouver Island University. It offers a brief profile of each institution and summarizes the results in a table towards the end of the paper that compares their performance and their respective strengths and weaknesses.*

Keywords: climate crisis, response of B.C. universities, Royal Roads University, University of British Columbia, Simon Fraser University, Vancouver Island University

Introduction

Social justice, Indigenous rights, the transboundary movements of populations, future wars and conflicts, and biodiversity; these and more hang in the balance because of our current climate crisis (Bhatt, 2021; UNHCR, 2021; World Wildlife Fund, 2022). Scientists, government bodies, and the public have become increasingly aware of climate change over the past half century, with the issue especially gaining attention since the 1980s. As noted by NASA (2022), as early as 1896, the theory of global warming had been advanced by Swedish chemist, Svante Arrenhius, building on the work of earlier scientists. If anyone needed proof that the global warming crisis was upon us, this past year in British Columbia furnished it in spades – a heat dome that killed 619 people, 1.3 million farm animals, approximately a billion coastal sea creatures, and broke temperature records, fostering one of the worst fire seasons on record that destroyed the town of Lytton and buildings on the nearby First Nation reserve. November saw massive flooding, landslides, and highway destruction throughout the province, and December saw unprecedented snowfall in some parts of the province (CBC News, 2022; Baum, Semeniuk & McClearn, 2021; Labbé, 2021; Hill, 2021).

How have B.C.'s universities responded to these emergencies? Obviously, this depends on the resources at their disposal, and the extent to which administrators, faculty members, and students take the climate issue seriously. In the following sections, the climate actions of four post-secondary British Columbia institutions of different sizes will be examined and evaluated.

Background

At their best, universities and colleges provide leadership in diagnosing and suggesting courses of action for addressing the serious social and ecological issues confronting society. There have been a range of responses from the sector in relation to the climate crisis, which is the direst threat humanity has faced since the risk of nuclear annihilation during the years of the Cold War. These have ranged from pro-active and aggressive engagement with the issue to relative passivity, depending on the university involved. Several international studies have been conducted as to why Higher Education Institutions (HEI) should engage with climate issues, what they can constructively contribute, and what their actions have consisted of (Henderson, et al., 2017; McCowan, 2020; McCowan, et al., 2021; Besenyi, 2020; Zalėnenė & Pereira, 2021). In this paper the policies of three universities are singled out for examination: Royal Roads University (RRU), the University of British Columbia (UBC), and Simon Fraser University (SFU) based on the roles they have undertaken to date. It then analyzes the factors that have facilitated this leadership, which is contrasted with the somewhat modest performance of the author's home institution, Vancouver Island University (VIU). It offers a brief profile of each institution and summarizes the results in a table towards the end of the paper that compares the performance and respective strengths and weaknesses of each one.

The paper focuses on climate action plans. For the present purposes, a climate action plan involves making commitments around operations, such as promoting energy efficiency, transitioning to renewable energy, and changing procurement policies. It may also involve encouraging faculty to do more climate-related research, injecting more climate content into courses, and facilitating dialogue and discussion on campus and in the wider community, including building alliances for common action, including with other Higher Education Institutions (HEIs).

Of course, there are those who are of the opinion that HEIs should stay outside the hurly-burly of global, national, and local policy issues, and cannot influence them in any event. This is not a view shared by the author, nor is it shared by the studies cited above. Universities occupy a privileged position. In addition to the more mundane task of training students for future job markets, they have an obligation to encourage the development of all-round citizens with a higher-level awareness of the challenges facing society and the biosphere. We know that many corporations, especially those engaged in fossil fuel production, will not take the lead, and many governments have proved indecisive on the climate issue. Shall it be left exclusively to under-resourced non-profit environmental groups to provide leadership? Universities have the research capacity and teaching capacity, the ability to model solutions in their own operations, and to promote discussion and dialogue in the wider society. "We know the climate emergency poses an extreme threat to every facet of our global society. The level of this challenge is unlike any humanity has faced. It's a social, environmental, health and economic threat, and there's no time to waste," says Royal Roads President Philip Steenkamp. "Royal Roads is taking a stand. We're going to drastically reduce our greenhouse gas emissions, incorporate climate change and climate solutions wherever we can, and equip our students to become powerful climate leaders" (qtd. In Dal Monte, 2022).

Methods

The research for this paper was conducted by means of analyzing the relevant policy documents of the case study institutions. In addition, it involved a Zoom meeting with the main leaders of the Climate Action Plan and related programming at Royal Roads University (RRU) to better learn from their experience and to suggest possible contacts at VIU they could liaise with. Furthermore, the author received very useful information from Linda Nowlan (Senior Director, UBC Sustainability Initiative) and Meghan Wise (Coordinator, UBC Climate Hub) about UBC's extensive climate action program. With respect to Simon Fraser University, Candace LeRoy, Executive Director, SFU Sustainability provided a wealth of resources about SFU's climate programming. This was supplemented by attending a webinar sponsored by the SFU Public Square entitled "From Gibsons to Glasgow: Local Leadership Towards COP26," which featured key players at SFU implementing climate research and action policies that occurred on October 28th, 2021, and by discussions with Dr. Alison Shaw of SFU's Action on Climate Team (ACT). These individuals were singled out because they are at the heart of shaping and implementing the innovative work occurring at their respective institutions.

The author's knowledge of the level of climate discourse at VIU is based on over eighteen years of working and teaching about a number of aspects of climate and sustainability issues, serving on the university's Sustainability Advisory Committee for seven years and, along with others, attempting to persuade the institution to adopt a more muscular climate policy with limited success. However, the institutional landscape is changing, in part in response to an 'open letter' campaign that the author co-initiated. The letter to the administration strongly urging robust climate policies and actions was signed by numerous groups and individuals on campus and off. These activities can be described as a mix of 'participant-observation' of institutional operations, through serving in various capacities, and action research i.e., through directly trying to impact the organization's behaviour

Discussion

Three Universities Lead in Addressing the Climate Crisis

Royal Roads University

Each of the three institutions is taking a somewhat different approach. Given its relatively small size, Royal Roads' accomplishments are impressive. To date, RRU

- has established a Climate Action Task Force that developed a comprehensive Climate Action Plan for the university as a whole;
- has launched an M.A. in Climate Action Leadership;
- has launched a Graduate Certificate in the Science and Policy of Climate Change;
- has hosted numerous climate-related webinars focusing on "The Case for Climate Action in Economic Recovery," "Leadership in Climate Action, Governance," and "Changing the Narrative: Stories that Motivate Climate

Action," all directed at the wider public (Cox, 2021);

- has coordinated and is leading the *Adaptation Learning Network*, an alliance of post-secondary institutions that has developed on-line courses for professionals and government employees on climate policy and action (ibid.; Adaptation Learning Network, accessed 2/1/22), and
- is in the process of developing a new certificate program consisting of eleven courses related to climate adaptation.

According to Cox (2021), Program Head of the graduate program in Climate Action Leadership and Director of the Resilience by Design Lab, "the work [at Royal Roads] is primarily a function of individuals who drive these [initiatives] forward; that said we also have a President, Executive and Board of Governors who are committed to climate action as evidenced in the launch of the Climate Action Task Force to develop the leadership plan." Dr. Ann Dale (qtd. in Dal Monte, 2021), also a professor at Royal Roads, sees a link between climate action, a regenerative economy, and forming partnerships with Indigenous people: "'I think that we are at a crisis tipping point and so we [as academics] need to develop regenerative narratives, new stories about acting now and how to move people more urgently toward climate actions.' None of this can happen… without partnerships with Indigenous peoples, which means reconciliation is fundamental to building new paths forward. She also notes that in many rural areas in Canada, Indigenous people are already environmental stewards, providing leadership, and innovation to create new protected areas" (qtd. In Dal Monte, 2021).What are potential factors that distinguish RRU from other institutions? RRU is unique amongst universities in B.C. in having a unicameral system of governance, i.e., it lacks a Senate comprised mainly of faculty members. It has only a Board of Governors who, combined with senior administrators, make the key decisions that set the future direction for the institution. This gives it a certain nimbleness, allowing it to enact changes quickly, whereas other institutions may move more ponderously, when time is of the essence. But this still relates to institutional will and priorities, as has been shown at UBC and SFU, which have managed to move forward quickly even with a bi-cameral structure.

University of British Columbia.

In 2019, UBC was named the #1 global university taking urgent action to combat climate change and its impacts by *Times Higher Education.*[1] The Times also noted that UBC has set some of the most aggressive greenhouse gas (GHG) emission GHG reduction targets in North America in terms of its operations (University of British Columbia, 2021a). In December of 2021, UBC released its new Climate Action Plan (CAP) 2030 (UBC press release, 2021a; University of British Columbia, 2021b), which was accompanied by a new plan for UBC's Okanagan campus (Nowlan, 2022). In tandem with these plans, it established a new website, Sustainability Dashboards, where information on key metrics, such as baseline data, benchmarks, and progress towards targets is available to enable stakeholders to track the

[1] Every year, *Times Higher Education* (2022) rates higher education institutions on their performance with respect to climate action and the UN Sustainable Development Goals more generally.

university's progress in meeting its goals (University of British Columbia, 2022).

UBC's climate commitments are well-expressed in its most recent Annual Sustainability Report: 2020/2021 (University of British Columbia, 2021c), where it is stated that the university seeks to:

- accelerate emissions reductions at UBC Vancouver and UBC Okanagan in response to the Climate Emergency: Climate Action Plan 2030;
- expand, strengthen and coordinate climate research at UBC;
- expand climate education opportunities and resources for the UBC community and broader public;
- foster a culture of engagement and advocacy on climate action on campus and in the public realm;
- demonstrate institutional leadership on climate justice[2];
- establish mechanisms and processes that ensure Indigenous perspectives, communities and worldviews help shape the development and implementation of its climate-related policies and initiatives;
- support community wellbeing in the face of the climate crisis, and
- develop new and strengthen existing partnerships to tackle the climate emergency (see below).

Regarding climate wellbeing, Meghan Wise (coordinator, UBC Climate Hub, 2022) has noted that "[d} uring the UBC Climate Emergency community engagement process in 2019, Climate Wellbeing was identified numerous times by students, staff, faculty, and community groups or partners" as being a key concern. "Over the Climate Emergency Community Engagement process, Climate Wellbeing evolved into one of UBC's Climate Emergency Report and Recommendations 9 Strategic Priority areas. This Climate Wellbeing Strategic Priority indicates UBC can and should take a leadership role in supporting and advancing climate wellbeing and community preparedness at the individual, community and system levels to meet magnifying climate mental and physical health impacts."[3]

Regarding partnerships, UBC is a member of the global *University Climate Coalition* (UC3), which describes itself as a "program… that connects 23 of the world's leading research universities and university systems committed to accelerating climate action on campus, in communities, and at a global scale," and UBC's president, Dr. Santa Ono, is currently in the leadership of that organization (UC3, 2022). It's noteworthy that the University credits students with nudging it towards adopting a more activist stance: "On December 5, 2019, the President and Board of Governors declared a climate emergency, driven by student leadership at UBC" (University of British Columbia, 2021a). This initial declaration of a climate emergency led to the creation of a Climate Emergency Task Force co-chaired by a student and a faculty member. With help from student tuition, it has created a *Climate Emergency Fund* to accelerate progress on

[2] "Climate justice" refers to the fact that the groups and individuals who suffer most from the effects of the climate crisis are usually those that have contributed to it the least (Climate Action, 2022).

[3] For more on this, see M. Wise (2020).

recommendations from the Climate Emergency Task Force.

In terms of governance, UBC has something that exists to date nowhere else in B.C.: a *Sustainability and Climate Action Committee* of the Board of Governors which takes accountability around the climate issue to the highest level (UBC Sustainability & Climate Action Committee, 2021). This commitment to climate action is reflected in grants to faculty members to incorporate more climate content into existing courses (University of British Columbia, 2021b). Courses relating to climate change can be easily learned about by means of a central website, the UBC Sustainability Initiative, which showcases 48 courses in 24 disciplines from seven faculties including course descriptions, instructor details and often links to syllabi (UBC Sustainability, Climate Change Courses, 2022). It has also developed a new Bachelor degree in Sustainability at its Okanagan campus and has three graduate programs that explicitly address sustainability (Nowlan, 2022).

On the operational side, a special institutional focus has been to reduce UBC's carbon footprint. For instance, the university is initiating, with financial support from the province, a Renewable Energy Hub. As described in a recent press release, "[t]he Renewable Energy Hub will be built at the corner of Wesbrook Mall and Thunderbird Boulevard. The project will include a solar panel system that harnesses the sun's energy to charge electric vehicles. That same solar power [will provide] energy to a water electrolyzer that produces 'green' hydrogen.[4] The hydrogen [will] then [be] sent to a hydrogen vehicle refuelling station to service light- and heavy-duty fuel cell vehicles" (BC Government News, 2021). In addition to reducing its carbon footprint, UBC has opted to completely divest from fossil fuel companies by 2030 (Santa Ono, President's Community Update, 2021; Asuncion, 2021).

Worthy of emulation is UBC's Climate Hub, a student-driven initiative that is also supported by various offices and initiatives at UBC. The Hub is funded by one-time grants from the administration and one-time funding from the Climate Emergency Fund created from incremental funding from tuition fees. The Fund supports diverse climate-related student projects, and the Hub works to mobilize the power of youth, community and storytelling initiatives to inspire hope and action to address the climate crisis (UBC Sustainability, 2021).

One of the Hub's six core projects, the Climate Justice Research Collaborative, focuses on creating opportunities for student research on climate justice issues (UBC Climate Hub, 2022). Another initiative is the Youth Climate Ambassador Program, which trains university students to lead climate storytelling workshops with community youth to support and engage them as climate leaders in their

[4] So-called 'green hydrogen' uses renewable energy (wind or solar) to use an electrolyzer to split water molecules to release hydrogen gas, which can be used as a non-polluting fuel to power specially-adapted vehicles and as fuel for other processes (Deign, 2020).

communities. UBC also has funding for student sustainability action projects that are campus-focused (UBC Climate Hub, Youth Ambassadors Climate Action Project, 2022; Nowlan, 2022).

Climate Justice is a strong theme in the Climate Emergency Plan, with explicit recognition of the necessity to address how Black, Indigenous and People of Colour are affected by the climate crisis (University of British Columbia, 2021b). This is reflected in the Sustainability Hub's series of climate justice webinars (UBC Climate Justice Series, 2021).

Simon Fraser University

Like UBC, SFU's commitment to sustainability and climate action goes a long way back. For its part, Simon Fraser University has a *2025 Sustainability Plan*, which employs justice, equity, diversity, and inclusion lenses. It has three main goals:

- developing and applying innovations in climate change mitigation to all operational decisions;
- mobilizing teams of researchers, instructors, students, staff, and community members to identify, test, and pilot solutions to climate change at and beyond the university's geographical boundaries, and
- providing opportunities for staff, faculty, students, alumni, and external community members to be literate as to the causes and impacts of climate change and competent in their individual roles as learners, teachers, researchers, and employees (Simon Fraser University, 2020a).

This plan has set itself aggressive targets and has been ranked 7th in the world and 2nd in Canada on Sustainable Development Goal (#13), the one focusing on climate action,[5] by the *Times Higher Education Impact Rankings* for climate action (Le Roy, 2022). The plan seeks to use a variety of strategies, or 'levers' that represent a holistic approach to achieving success (ibid.). As part of this effort, SFU has joined the United Nations' "Race to Zero" campaign as one of 1,039 institutions of higher learning world-wide (for more on Race to Zero, see UNCC, 2022). To date, SFU has achieved considerable reductions in its Scope 1 and Scope 2 carbon emissions, as has UBC, and both institutions are targeting reducing Scope 3 emissions.[6] One of the ways it is doing this is through its new waste-to-energy plant that converts wood waste formerly destined for the landfill into space heating and cooling energy for buildings (Lim, 2021).

On the student engagement front, SFU launched a Climate Action Student Collaborative (CASC) in January 2022 that enables students to:

[5] The 17 Sustainable Development Goals (SDGs) relate to interrelated social and ecological issues and were adopted by the United Nations in 2015 after extensive consultation (United Nations, 2022).

[6] Scope 1 emissions are those directly generated by the institution themselves. Scope 2 are from purchased electricity, steam, heating and cooling, and Scope 3 are indirect – from investments, procurements, transportation, and waste, etc. (Plan A Academy, 2022).

- explore the meaning of climate action through self-paced online modules, including readings, activities, and individual assignments;
- learn about project management and social change leadership through a climate action lens;
- think about climate action critically through equity and climate justice lenses;
- meet like-minded peers in live, virtual dialogue sessions, and
    - gain the tools needed to work on future climate action projects with others (Simon Fraser University, 2022).

Though not part of CASC, SFU students have worked with the City of Vancouver on a number of projects to help the latter meet its climate goals (Russell, 2020), and it was a student activist group (SFU 350) that persuaded the university to commit to divesting itself of all fossil fuel investments by 2025 (Le Roy, 2022; Simon Fraser University, 2021). Complementing CASC, the university has a number of other resources and institutional initiatives that promote climate literacy on campus, including an on-line primer on climate change, a list of resources on climate science and, prior to COVID-19, the university held a series of face-to-face engagement sessions (Simon Fraser University, 2020c). Finally, its Strategic Research Plan is committed to fostering the development of research clusters around climate issues. Among these is an Action for Climate Team (ACT) that works with municipalities to develop "low-carbon resilience plans," with a strong emphasis on equity (Action on Climate Team, 2021; Shaw, 2021). The university, through its Morris J. Wosk Centre for Dialogue, is also currently partnering with the City of Burnaby on a Climate Resiliency Initiative (Huang, 2021; Le Roy, 2022).

Like UBC, it has a considerable number of courses that include climate content. While its central hub doesn't distinguish these from courses that focus on sustainability more generally, it has achieved an impressive degree of student participation with nearly 40,000 students having taken courses related to sustainability or sustainable development since 2018 and almost 1700 Master's and PhD theses addressing one or more of the Sustainable Development Goals (SDGs) (Le Roy, 2022; Simon Fraser University, 2020d). Moreover, it has two new schools – Environmental Science and Sustainable Energy Engineering – that address sustainability and climate.

SFU has a strong commitment to climate justice and equity, diversity, and inclusion (EDI), and reconciliation/ decolonization. This is reflected in its Sustainability Advisory Council, which includes faculty, staff, and students, including from marginalized groups, and a variety of other internal partnerships (Le Roy, 2022). It is also reflected in its aforementioned Public Square programming where Black, Indigenous, and People of Colour (BIPOC) voices are prominently featured. In keeping with Sustainable Development Goal #17, SFU has built strong web of partnerships domestically and internationally to further its climate goals (Le Roy, 2022).

Vancouver Island University (VIU)

Vancouver Island University has an established history of engaging with sustainability issues. It has commissioned research under its previous president from the *Mount Arrowsmith Biosphere Regional Research Institute* (MABRRI), which is part of the university, to examine the extent to which the SDGs are already being applied at the institution and areas where their application

could be further strengthened (MABRRI, 2020).[7] Also, MABRRI has conducted considerable baseline ecosystem data collection that will be useful for measuring the impacts of a changing climate in the surrounding region (MABRRI, 2022)

VIU has a number of additional strengths. It has established a geo-exchange system, the first in Canada on a college or university campus, that provides space heating and cooling for two of its buildings thus far (VIU News, 2018). It has had a Sustainability Advisory Committee (SAC) for over ten years, and a knowledgeable and skillful staff member in the Facilities and Ancillary Services Department who has devoted half her time to sustainability issues. It also has a student club mentored by faculty members – the Awareness of Climate [Change] through Education and Research (ACER) – which conducts educational work on climate issues on and off campus, and another active student EcoClub which in involved in numerous sustainability initiatives. The work of these organizations has been supplemented by an Annual Urban Issues Film Festival, now in its fifteenth year, which has focused on aspects of sustainability, and an annual Global Citizens' Week where sustainability issues have often been at the forefront.

Moreover, VIU has other strengths, including in areas covered by certain of the SDGs on the social sustainability side. It has one of the best records in the province for Indigenizing its curriculum, providing support services for Indigenous students, and providing access to non-traditional learners (Vancouver Island University, 2022.; VIU, 2018). Its decision to provide free tuition for students who had been in foster homes was adopted as provincial policy by the NDP government five years ago (Kines & Watts, 2017). All this occurred despite having a Senate, showing that overall institutional will is the key driving factor in innovative action, not organizational structure.

While VIU has undertaken a number of positive initiatives, it is one of the few post-secondary institutions in the province that lacks an Office of Sustainability and it has no policy on the climate crisis. VIU tabled a new Strategic Plan in September 2021 (Vancouver Island University, 2021). The word 'climate' did not appear in it at all; however, there was a commitment to integrating the SDGs into the sub-plans to be developed in accordance with the plan. And meanwhile there are very talented scholars who conduct research on climate change and teachers on campus who bring climate issues into their courses, but no free-standing climate course exists that all students can, and are encouraged, to take. There is a committee on Indigenous Commitments in Senate, but no equivalent committee for Climate and Sustainability Commitments. Overall, the situation is one of talented and committed individuals working in relative isolation without an overarching coherent framework. To date, climate action leadership has largely been lacking at VIU.

Things are beginning to change however – in part as the result of two initiatives that took place in the fall of 2021. First, two faculty members submitted a policy note with the support of their respective deans, strongly suggesting the need for VIU to have a strong climate policy which received a positive reception. Second, an Open

[7] MABRRI (2022) has recently released a new report on the SDGs and the university.

Letter to VIU was drafted and sent to senior members of the administration that was signed by the faculty union, individual faculty members, the students' union, student clubs, individual students, other employees, and several community organizations as well as many individuals – over 120 groups and individuals in total. These two actions seem to have caught the administration's attention. As a result, a President's Task Force on Climate Action and Sustainability was established in February 2022; the author is the Chair of one of four Working Groups, its Environmental Scan Group. Things may at last be changing at VIU on the climate front.

TABLE 1: Overview of Climate Action Plans at B.C. Universities

Institution & Attributes of Climate Action Policies	***Royal Roads University***	***University of British Columbia***	***Simon Fraser University***	***Vancouver Island University***
operations	integrated into all	integrated into all; Renewable Energy Hub	integrated into all; biomass plant	geo-exchange system
research	extensive support for	extensive support for, including grants for students	major focus	scattered, but especially significant is the role of the Mount Arrowsmith Region Research Institute (MABRRI)
teaching & learning	integrated into all	central hub of courses; grants for incorporating climate content into courses	central hub of courses, with high uptake and major focus for theses	fragmented, but with strong individual commitments
student engagement	seeks to engage all university stakeholders	extensive – for instance, through the Climate Hub and student representation on the Emergency Task Force	extensive, especially through the new Student Climate Collaborative	Awareness of Climate through Education and Research (ACER); EcoClub, and Urban Issues Film Festival
public and professional outreach	coordinates Adaptation Learning Network	Youth Climate Ambassadors, Climate Justice Series; provides sustainability & climate leadership globally (UC3)	excellent outreach through SFU Public Square; works with municipalities through the Action on Climate Team (ACT)	through the work of MABRRI and some through ElderCollege and ACER
Commitment to Indigenous perspectives, climate justice and EDI	makes mention of partnering with First Nations	very strong	very strong	strong record on reconciliation and support for First Nations students and perspectives, but not related to climate yet

Conclusion

In the case of UBC and VIU, pressure from students and faculty (and community members, in the case of VIU) seems to have played a significant role in moving the needle on climate action. At both UBC and SFU, once the administrators got on board, they threw themselves into taking action wholeheartedly.[8] Having a Sustainability and Climate Committee of the Board plus a student Climate Hub, as UBC has, helps to make climate issues part of the institutional culture, though the need for consistent funding remains an issue. At SFU, the Student Climate Collaborative – along with a climate change primer and list of resources on climate science – amplifies what students are able to learn from formal courses. As universities develop a reputation for taking an activist stance on climate and sustainability issues and offering opportunities to gain the desired knowledge and skills in these areas, it creates a self-reinforcing 'virtuous cycle' of attracting even more students who want to make a positive difference.

While it's crucial to have faculty members who are key advocates for embracing a pro-active agenda, it's also essential to have senior administrative and institutional buy-in, including an advocate or advocates at the highest levels. This exists at Royal Roads with its president, Philip Steenkamp. Similar champions exist, and have existed, at Simon Fraser University – for instance, SFU's current Vice-President, Research and International, Dr. Dugan O'Neil. Stephen Toope was an early champion at UBC, as is UBC's current president, Dr. Santa Ono.[9] The noteworthy quality about the new Climate Action Plan recently approved by Royal Roads' Board is that it applies to *all aspects* of the University's endeavors, from curricular offerings to its facilities' operations. This comprehensiveness is also reflected in UBC and SFU's climate action plans.

If VIU were to develop a similarly all-encompassing plan, it could take advantage of having deep roots in the community and region through existing outreach programs.[10] These include MABRRI and the Elder College program, and strong relations with local First Nations. This strong commitment to public outreach is something SFU also shares. One arena where it carries out much of its public education on climate is through the Morris J. Wosk Centre for Dialogue which operates the *SFU Public Square* at the downtown Vancouver Harbour Centre campus. Its programming in this area has been exemplary. Notable examples include recent webinars such as "From Gibsons to Glasgow: Local Leadership Towards COP26," and "Hope in Resistance: Stories of Climate Justice."

On Vancouver Island, the idea has been mooted of an alliance of post-secondary institutions to

[8] UBC has long been in the forefront of climate and sustainability action. It was the first university in the country to adopt a sustainable development policy (1997) and the first to open a Sustainability Office (1998). In 2008, UBC's then-president, Stephen Toope – along with five other BC university and college presidents – was the first to sign the *Climate Change State of Action for Canada*. See https://sustain.ubc.ca/news/history-ubc-campus-sustainability. It has probably the most comprehensive approach to integrating sustainability into all aspects of its work, from teaching and applied learning to research, and campus operations to student engagement, though SFU and RRU are close behind.

[9] Dr. Santa Ono has moved on to assume the presidency of the University of Michigan.

[10] Unfortunately, VIU chose to end its Continuing Studies Program a few years ago, but still has an Elder College and a professional development and training program.

coordinate initiatives and share the process and experience of Royal Roads as other institutions develop their own climate action policies. This is very much in the spirit of Sustainable Development Goal #17 on strengthening partnerships for sustainable development and should perhaps be expanded to include business and civil society groups to make it even more effective. Such an alliance could learn from what has been accomplished by UBC and SFU, while recognizing that each institution must take into account its own unique situation and state of resources.

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GIS assessment of riparian reserve widths in critical habitat for the Salish Sucker (*Catostomus* sp.) in British Columbia since the Species at Risk Act was enacted

Natalie Bruner[1], Karen Steensma[1], and Mike Pearson[2]
[1]Department of Geography and Environment, Trinity Western University, Langley, BC.
[2]Pearson Ecological

Abstract. *The Salish Sucker (Catostomus sp.) is a Species at Risk, primarily due to habitat loss. Riparian vegetation is an important part of Salish Sucker habitat, because it buffers stream temperatures, prevents erosion, and provides suitable habitat. In this research, the changes in riparian vegetation widths, within critical habitat for Salish Suckers that have occurred in the 17 years since the Species at Risk Act (SARA) was enacted, were measured. This was done using ArcGIS Pro to compare the 2007 and the 2021 riparian vegetation widths in the eleven watersheds containing Salish Sucker. A key finding is that watersheds west of Chilliwack experienced only a decrease in riparian vegetation, while watersheds in and east of Chilliwack experienced increases and decreases in riparian vegetation. There is a loss of 102,045 m^2 and a gain of 82,060 m^2. Therefore, the net effect is a loss of 19,985 m^2. The findings indicate where habitat restoration efforts should be focused.*

Introduction

The Salish Sucker (*Catostomus* sp. cf. *catostomus*) is a threatened species located in the Puget Sound region of Washington and in the Fraser Valley in Southwestern British Columbia, Canada. The Species at Risk Act (SARA) is a collaboration between Canada and British Columbia and it provides legal protection of wildlife species to prevent extinction and create actions for their recovery (The Government of Canada 2005). A recovery strategy for the Salish Sucker was proposed under SARA in 2012 (Recovery Strategy 2012), implemented in as an Action Plan in 2016 (Action Plan 2016) and received its first amendment in 2020 (Action Plan 2020). The purpose of this recovery strategy is to ensure long-term viability of the species and increasing riparian reserves is of 'High-Priority' under the action plan (Action Plan 2016).

Species Description

The Salish Sucker species developed when a Longnose Sucker population was geographically isolated in the ice-free refuge of Washington during the Pleistocene glaciations (Action Plan 2020). Therefore, it can be considered a "species in the making" (McPhail, 1987) and an evolutionarily significant unit (McPhail et al. 1999).

The colour of the body is dark-green and mottled with black on the back and white on the belly. A red stripe develops in males during the spring spawning season as shown in Figure 1. It has a short and blunt snout (Action Plan 2020). It is small, with few males exceeding a length of 200 mm and few females exceeding 250 mm; they may be sexually mature at slightly less than 100 mm (Pearson et. al. 2003).

Figure 1. Salish sucker (Salish 2017) Photo. A Rocha Canada.

Taxonomy

The Salish Sucker is in the Phylum Chordata, Subphylum Vertebrata, Class Osteichthyes, Order Cypriniformes, Family Catostomidae, Genus Catostomus, Species *Catostomus* sp. cf. *catostomus*. Its common name is Salish Sucker or Meunier de Salish. There is uncertainty that remains around the taxonomic status, because of evidence that it is a type of Longnose Sucker (*C*. sp. cf. c*atostomus*) that is different both genetically and morphologically from other Longnose Sucker lineages found in Canada and the geographic ranges of the Longnose Suckers and Salish Suckers do not overlap (COSEWIC 2012).

Range

The global range of the Salish sucker is the Puget Sound region of Washington and the Fraser River Valley in British Columbia, as shown in Figure 2. It has been found in eleven watersheds in the Fraser Valley of British Colombia (Action Plan 2020). Canada contains approximately 9.3 percent of the global range (Action Plan 2020). The Salish Sucker populations inhabit small, concentrated areas of the watersheds. Most of the population is located in only a few sites (Action Plan 2020).

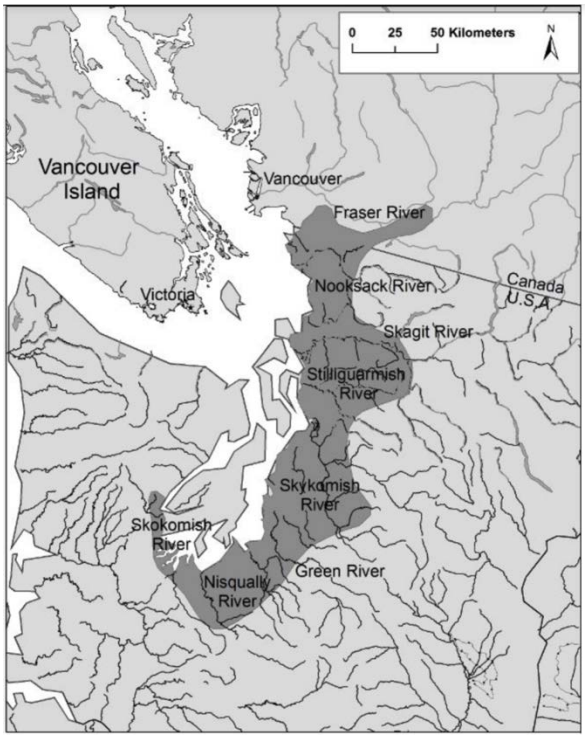


Figure 2. The Global Range of the Salish Sucker (Recovery Potential Assessment 2015).

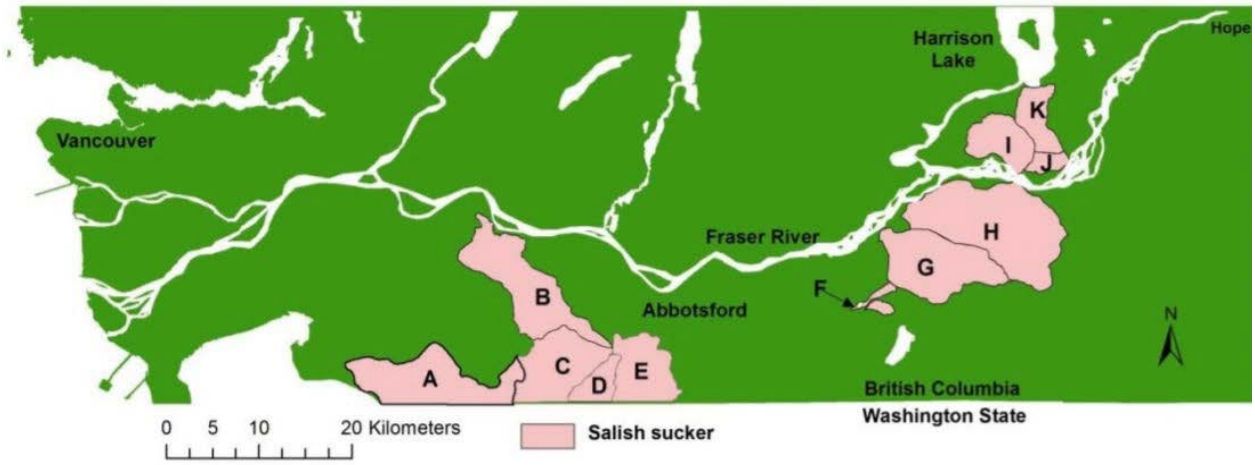


Figure 3. Salish Sucker populations are concentrated in small areas of the watersheds they inhabit (Recovery Potential Assessment 2015). (A) Campbell Creek, (B) Salmon River, (C) Bertrand Creek, (D) Pepin Brook, (E) Fishtrap Creek, (F) Salwein Creek/Hopedale Slough (F), (G) Chilliwack Delta (Atchelitz/Chilliwack/ Semmihault Creeks), (H) Elk Creek, (I) Mountain Slough, (J) Agassiz Slough, (K) Miami River.

Status

The Salish Sucker was listed as Endangered by both COSEWIC and the Species at Risk Act (SARA) until it was re-classified as Threatened under COSEWIC in 2012 and SARA in 2019 (Action Plan 2020). It was reclassified because new populations have

been discovered and one population that was previously thought to be extirpated was rediscovered (Action Plan 2020).

Critical Habitat

Critical habitat is defined by SARA as "the habitat that is necessary for the survival or recovery of a listed wildlife species" (Action Plan 2020). SARA prohibits the destruction of any part of designated critical habitat. Salish Sucker critical habitat includes all reaches in streams currently containing populations and has more than 50 m of continuous pool that exceeds 70 cm depth at low flow (Pearson 2007).

The critical habitat includes both the aquatic habitat and riparian reserve strips of native vegetation on both banks for the entire length of the reach (Action Plan 2020). The total length of the aquatic critical habitat for the Salish Sucker is determined to be 196.5 km out of the 384.2 km of surveyed stream channel (Recovery Strategy 2020). Riparian critical habitat extends inland from the top of the bank to a width equal to the widest zone of sensitivity. The total area of riparian critical habitat adjacent to the aquatic critical habitat for the Salish Sucker is 818.1 hectares (Action Plan 2020).

Riparian Vegetation

Riparian vegetation is included as critical habitat because a lack of adequate riparian vegetative cover is highly likely to cause a population-level impact (Pearson, 2007) since benthic insectivores, such as Salish Sucker, are some of the most sensitive fish species to a loss of riparian areas (Stauffer, 2000). SARA states riparian reserves "must be sufficient to control sediment entry to the stream from overland flow, to prevent excessive bank erosion and to buffer stream temperatures" (Recovery Strategy 2012).

Without adequate riparian reserve, the lack of shade from forest canopy can cause an increase in water temperatures to harmful levels (>23° C) causing reduced fitness and increased mortality (Lynch 1984; Richardson 2010). Furthermore, the lack of root structures provided by riparian vegetation can result in poor bank stability and increased erosion which can cause sediment deposition in riffles increasing embeddedness and decreasing interstitial habitat (Waters 1995; Richardson 2010). This can impair spawning and incubation and decrease the abundance of invertebrate prey (Richardson 2010).

Lastly, riparian vegetation also provides a buffer from the harmful impacts of adjacent land (Recovery Potential Assessment 2015). The vegetation serves as a buffer to control nutrient input and erosion since the root systems stabilize the ground filter nutrients and water pollution (Recovery Potential Assessment 2015).

The amount of required riparian vegetation varies among reaches but some generalizations can be made. Riparian reserve strips should be continuous because more continuous riparian vegetation is more effective than discontinuous segments in preventing materials such as sediments, nutrients, toxins, and fertilizers from entering a stream (Weller et al. 1998).

Riparian vegetation of at least 10 m width is necessary for maintaining terrestrial food inputs that are like forested landscapes (Culp & Davies 1983). Riparian vegetation widths of more than 30 m may be required for full mitigation of stream warming (Castelle et al. 1994).

In 2007, a mapping assessment performed by Michael Pearson found that the average riparian vegetation to be 21.4 m with 60% of bank length containing discontinuous bands of vegetation less than 5 m wide (Pearson 2007). Figure 3 shows pie charts of proportions riparian vegetation in each critical habitat reach watershed.

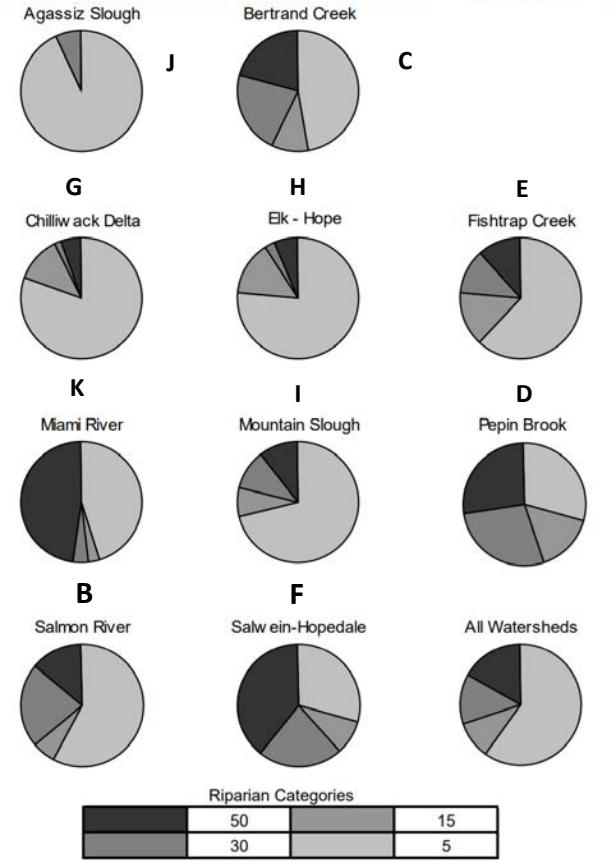


Figure 4. Proportion of potential critical habitat by bank length bordered by riparian vegetation of differing width categories (Table 3 for definitions) (Pearson, 2007).

Habitat

The habitat of the Salish Sucker is headwater streams and small sloughs (Action Plan 2020). Optimal conditions for Salish Sucker populations are extensive areas of deep water close to spawning riffles. Additionally, optimal habitat has adequate water quality and low predation (Pearson 2007). Adults are most often found in marshes and American Beaver (*Castor canadensis*) ponds, while the young-of-the-year are more commonly found in shallow pool and glide habitats that contain abundant vegetation

(Pearson, 2007). Salish Suckers typically spawn in gravel riffles (COSEWIC, 2012).

Threats

The biggest limiting factor of Salish Sucker populations is the availability of high-quality habitat (Action Plan 2020). Historically, the largest threat to Salish Sucker is the physical destruction of habitat through channelization, dredging, and infilling. Additionally, habitat has been fragmented by flood gates, beaver dams and low oxygen environments, with most barriers occurring within the past 50 to 130 years (COSEWIC 2012).

The most severe threats to the Salish Sucker today are identified by SARA to be hypoxia, seasonal low-water conditions, harmful substances, sediment deposition, physical destruction of habitat and the fragmentation of habitat (Action Plan 2020). The most widespread and highest risk threat is severe hypoxia which degrades habitat and can kill many fish quickly; the frequency and intensity of this threat is increasing (Pearson 2004; Recovery Potential Assessment 2015). Table 1 shows activities that likely result in destruction of potential critical habitat and Table 2 shows the concern for this applied to each watershed.

Table 1. Activities likely to result in destruction of potential critical habitat for Salish Sucker. (Pearson 2007).

Activity	Result
Over application of Fertilizer	Nutrient loading of streams through excessive application of manure is the most common cause of the chronic late summer hypoxia that affects many reaches inhabited by Salish sucker (Schreier et al., 2003).
Drainage projects	Dredging, dyking, and channelization works directly destroy habitat, cause sediment deposition in riffles, and reduce base flow,
Urban storm drainage	Storm drain systems that discharge directly to creeks are major sources of toxic contamination and sediment. They also reduce baseflow by inhibiting water infiltration to aquifers.
Riparian vegetation removal	Loss of riparian vegetation exposes a stream to increased erosion and sediment deposition, elevated water temperatures, reduced supplies of terrestrially derived food, and increased nutrient loading
Livestock access to creeks	Livestock damage habitat by trampling or causing erosion that clogs riffles with sediment. Access also contributes to nutrient loading.
Excessive water withdrawal	Water extraction (surface or ground) during dry periods reduces flows, which may contribute to hypoxia and drying of riffles needed for spawning.
Excessive sediment releases	Sediment deposition in spawning substrate and inhibition of the flow of oxygen-rich water to eggs and larvae during incubation.

Table 2. The projected risk of activities likely to result in the destruction of potential critical habitat for the Salish Sucker (Pearson 2007).

Activity	Bertrand Creek	Pepin Brook	Fishtrap Creek	Upper Salmon River	Salwein/ Hopedale Slough	Atchelitz/ Chilliwack/ Semmihault	Miami Creek	Mountain Slough	Agassiz Slough	Elk Creek/ Hope River
Over application of l fertilizer	+++	++	+++	+++	++	+++	+++	+++	++	+++
Drainage projects	++	+	+++	++	++	+++	+++	+++	+	+++
Urban storm drainage	+++	-	+++	-	-	+++	++	-	+++	++
Riparian vegetation removal	++	+	+++	++	+++	+++	+++	+++	++	++
Livestock access to creeks	+	+	+	++	++	++	++	++	+	++
Excessive water withdrawal	+++	+	++	+++	+	++	++	++	++	++
Excessive sediment releases	+	+++	++	+	+	++	+	+++	+	+

+++	major concern	+	minor concern
++	moderate concern	-	not a concern

Species at Risk Act (SARA)

SARA was created to provide the necessary legal protection of wildlife species to prevent wildlife species from becoming extinct and to secure actions for their recovery (The Government of Canada 2005). The SARA recovery plan was created with the purpose "To ensure long-term viability of Salish Sucker populations throughout their natural distribution in Canada" (Action Plan 2016). The strategy rates increasing the integrity and function of all riparian habitats as a "High Priority" objective (Action Plan 2016). Table 3 shows the proposed SARA strategy to increase the integrity and function in all riparian habitats and the specific activities that should be performed and the outcomes or deliverables that will done.

In the 2020 Amended SARA Strategy, it describes that native plants and livestock fencing have been provided and installed for landowners of riparian habitats along reaches that contain the Salish Sucker in Agassiz Slough, Mountain Slough (I), Miami River (K), Salmon River, Bertrand Creek (C), Pepin Brook (D), the Little Chilliwack River, and Elk Creek (H) (Action Plan 2020).

Table 3. Broad strategies, research activities and management activities to support the recovery objectives for the Salish Sucker (Adopted from Action Plan 2016)

Broad Strategy	Threats Addressed	Specific Activities	Outcomes or Deliverables
Increase the integrity and function of all riparian habitats.	Sediment deposition, Physical destruction of habitat, Toxicity, Hypoxia	Conduct riparian assessments in all critical habitat reaches and make recommendations for reserve zones and other mitigative measures. Identify, prioritize and develop riparian planting projects in cooperation with landowners, stewardship groups and government agencies. Develop and distribute public education materials to landowners on riparian reserve strips	Riparian assessments completed as the basis for establishing defensible reserve zones to protect instream critical habitat. Riparian planting projects completed in high priority areas. Educational materials developed and included in landowner contact programs and other public education applications.

Research Question

Given the emphasis on habitat improvement for this species since SARA was first proposed in 2012, measurement of current riparian habitats in comparison to previous data provides a means to measure the effectiveness of the outreach efforts listed in Table 3. Thus, the research question. What changes in riparian reserve size in Salish Sucker critical habitat has occurred in the nine years since SARA was first proposed for the Salish Sucker and the fourteen years since it was last mapped?

Methods

The data sets used were taken from Mike Pearsons' assessment from 2007 entitled "An Assessment of Potential Critical Habitat for Nooksack Dace (Rhinichthys cataractae ssp.) and Salish Sucker (Catostomus sp.)" (Pearson 2007). The location of potential critical habitats for the Salish Sucker were defined in Pearson 2007 through using reach-scale, in-stream habitat characteristics such as the reaches that were fish bearing, the nature of the stream flows, and the status of streamside vegetation.

There were two datasets for each watershed which were the lines on river and categories and the permanent structures. The first dataset includes polyline files that are within Salish Sucker potential critical habitat that follow each side of the river labeled with a with a reach ID followed by R or L to indicate the right and left sides of the river. Each reach has a different category of length of the riparian reserve that extends outwards from the river in the attribute table. A permanent structures dataset from Pearson 2007 was also used and it included lines where all the permanent structures that exist within 50m of the river. Examples of permanent structures are any buildings with foundations, roads, and utility works (British Columbia 2005). We set the projection to NAD 1983 UTM Zone 3N through using the "Define Projection" tool.

Measuring and Classification

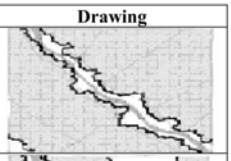
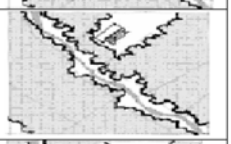
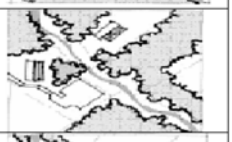
The methodology of finding the measurement and classification of the riparian reserves was done following the simple assessment described in the BC Riparian Area Regulation Assessment Methods (RAR) (British Columbia 2005) with a few adaptations that follow the adaptions made in Pearson 2007. The reasons for these changes are due to the difference in scale and intent of this report and are as follows. Firstly, the assessments cover large portions of watersheds instead of the individual land parcels that RAR is intended for. Secondly, RAR methods assess existing or potential streamside vegetation. In this report and in Pearson 2007, only existing vegetation is mapped to create an accurate comparison to the current state of riparian vegetation. Lastly, in RAR, three categories exist to group riparian reserve widths which are >30 m, 15 m to 30 m, and 5 m to 15 m (British Columbia 2005). A fourth category was created in Pearson 2007 which is > 50 m and between 30 m to 50 m instead of the > 30 m category.

To categorize the width and continuity of the riparian reserve we used ArcGIS Pro. We used a mouse to measure the width of riparian reserves using the measuring tool

creating right angles from the river to the first permanent structure at least every 40 m. We demarcated new permanent structures as lines in a separate feature class. Categorization of the width and continuity of the riparian reserve was assessed using the adapted RAR methodology from Pearson 2007 as shown in Table 4. We cross referenced with Google Earth Historical Imagery which showed satellite imagery from 2007 so we could perform a side-by-side comparison to what was observed in 2007 to the most recent imagery from ArcGIS Pro to confirm that changes had occurred and were not due to a difference in assessment from Pearson 2007.

Using the existing polylines from Pearson 2007 to ensure consistency, we changed the width categories in the ArcGIS Pro attribute table for the reaches that experienced a change in riparian reserve width. Some of the polylines were not accurate to the area that experienced changes, so we used the clip tool to divide the existing polyline and then assigned the new line segments with an ID. In ArcGIS Pro we changed the riparian reserve width category (5 m, 15 m, 30 m, 50 m) in the attribute table through changing the particular Reach ID's riparian reserve category. We then recalculated the length in meters of the reach column to confirm the reach length was updated.

Table 4. Categories of existing riparian vegetation (Pearson 2007). Adapted from the British Columbia Riparian Area Regulation Assessment Methods (British Columbia 2005).

Category	Description	Drawing
50	Intact and continuous areas of existing vegetation equal or greater than 50 m wide	
30	Limited but continuous areas of existing vegetation equal to 30 metres wide or discontinuous but occasionally wider areas of existing vegetation between 30 and 50 m wide.	
15	Narrow but continuous areas of existing vegetation equal to 15 metres wide or existing vegetation between 15 and 30 m wide.	
5	Very narrow but continuous areas of existing vegetation up to 5 metres wide or discontinuous but occasionally wider areas of existing vegetation between 5 and 15 metres wide interspersed with permanent structures.	

Analysis

In Excel, notations were made of the reach ID that experienced changes, the length of the reach, the past riparian reserve width, the current updated riparian width, and the updated land use. Then, we multiplied the length times the width of the riparian reserves that went through changes to find the area of the riparian reserves.

After this, we constructed maps to show the results. We constructed maps of the eleven watersheds displaying the updated riparian reserves with the riparian reserve widths in categories of 5 m, 15 m, 30 m, and 50 m.

Creation of Proportional Symbol Map

We used the area data calculated in Excel to construct a proportional symbol map showing the changes in each watershed. This was done through the creation of two point-data files, one for gained riparian reserves and one for lost riparian reserves. We added the coordinates the visual center of each of the watersheds, then we used the "XY Table to Point" geoprocessing tool in ArcGIS Pro to convert the coordinates into a readable format. From there, we added the area of riparian reserve gained and lost to the respective rows of locations. Then, we created a new column entitled "Weighted_Meters" which included the square meters multiplied by 1,000. We chose 1,000 because it yielded the best data visualization. We made the symbology proportional symbols represented by meters so that both the meters gained and meters lost were on the same scale to accurately compare them.

Results

There was a net loss across the watersheds in British Columbia that Salish Sucker inhabit. Across all reaches, there was a loss of 102,045 m^2 and a gain of 82,060 m^2 as shown in Table 5. Eight of the eleven watersheds experienced a net loss in riparian vegetation and four watersheds experienced a net gain. Figure 4 is a proportional symbol map that shows the distribution of the changes in riparian vegetation in each watershed.

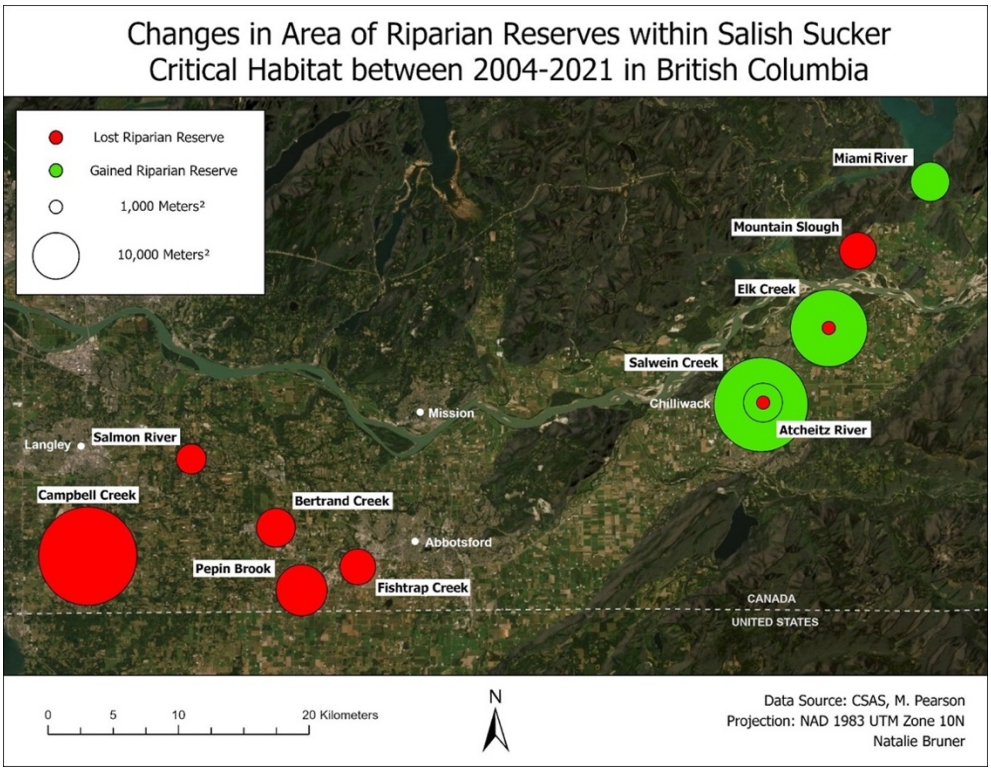


Figure 5. Proportional symbol map of the changes of riparian reserves within Salish Sucker critical habitat between 2007-2021 in British Columbia.

Table 5. Table of Changes in Riparian Reserve Area.

ID	Reach	Loss (m^2)	Gain (m^2)
A	Campbell Creek	44,560	0
B	Salmon River	4,145	0
C	Bertrand Creek	27,180	0
D	Pepin Brook	12,080	0
E	Fishtrap Creek	5,900	0
F	Salwein Creek	0	40,650
G	Atchelitz River	1,120	7,065
H	Elk Creek	27,360	810
I	Mountain Slough	0	6,250
J	Aggasiz Slough	0	0
K	Miami River	0	7,065
	Total	**102,045**	**82,060**

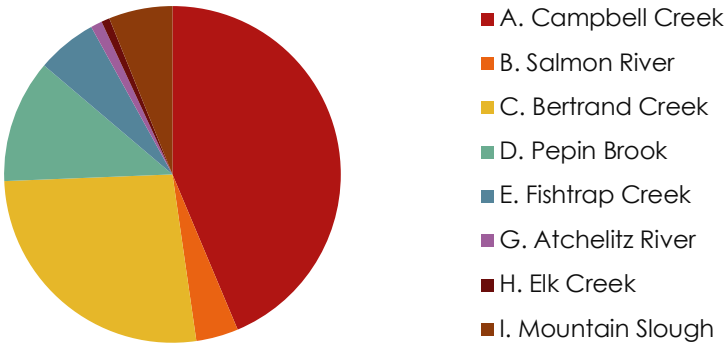


Figure 6. Loss in riparian vegetation area.

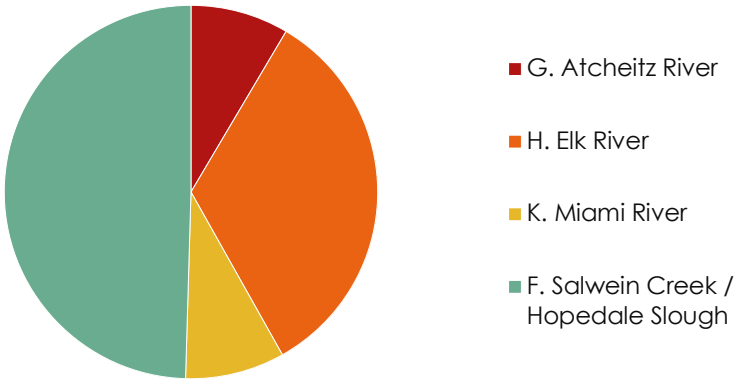


Figure 7. Gain in riparian vegetation area.

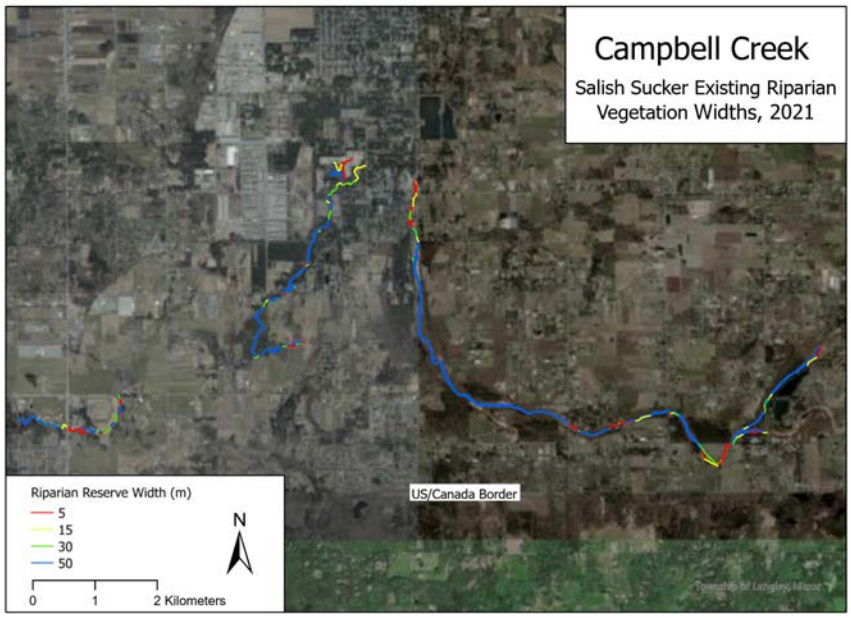


Figure 8. Map of riparian vegetation widths in the Campbell Creek (A)..

Table 6. Riparian vegetation widths, areas, and reason for change in the Campbell Creek (A).

Reach	Length	Original	Update	Loss	Loss Area	Reason
LCR 18 L	103	50	30	20	2060	Cleared Lot
LCR20 L	95	30	15	15	1425	Grass Lawn
LCR 63 R	534	50	5	45	24030	Cleared Lot
LCR 63 L	77	30	5	25	1925	Cleared Lot
LCR 63 L	298	50	15	35	10430	Cleared Lot
LCR 18 L	145	50	30	20	2900	Cleared Lot
LCR 24 L	179	15	5	10	1790	Grass Lawn

Campbell Creek (A) experienced the most loss of any watershed with a total loss of 44,560 m^2 as shown in Table 5. Seven different sites lost area. The majority of the loss is in a large cleared lot, that appears to have been cleared in the mid-2010s.The lot remains vacant. The lot is off 196th St. and 24th Ave. in Surrey, BC. The second most common reason for the clearing of riparian vegetation was for the creation of grass lawns on several lots.

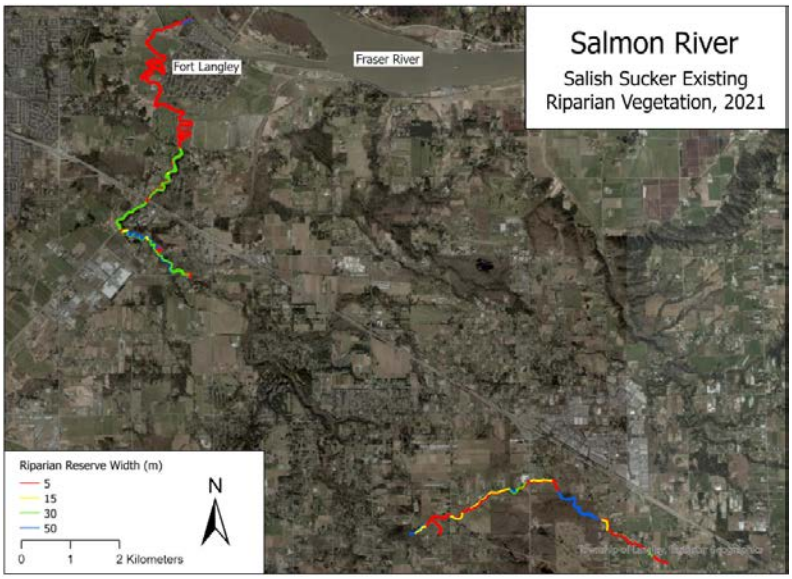


Figure 9. Map of riparian vegetation widths in Salmon River reach

Table 7. Riparian vegetation widths, areas, and reason for change in Salmon River reach

Reach	Length	Original	Update	Loss	Loss Area	Reason
SLN 5 R	173	15	5	10	1730	Cleared grass field
SLN 5 R	161	30	15	15	2415	Cleared grass field

The Salmon River experienced a loss in the area of riparian vegetation of 4,145 m². It had two reaches of losses. Both of the losses occurred in areas where natural riparian vegetation was converted to a grass field.

Figure 10. Map of riparian vegetation widths in Bertrand Creek (C) reach.

Table 8. Riparian vegetation widths, areas, and reason for change in the Bertrand Creek (C) reach.

Reach	Length	Original	Update	Loss	Loss Area	Reason
BTD16 R	94	50	30	20	1880	Houses
BTD15 R	454	50	30	20	9080	Houses
BTD14 R	71	30	15	15	1065	Farmland
BTD14 R	235	50	15	35	8225	Farmland
BTD11 R	462	30	15	15	6930	Houses/Lawn/Shed

Bertrand Creek (C) experienced a total loss in the area of riparian vegetation of 27,180 m². Most of the losses occurred in riparian vegetation widthsof 50 m. The most common land conversions were to houses and farmland. Bertrand Creek (C) experienced the second greatest loss.

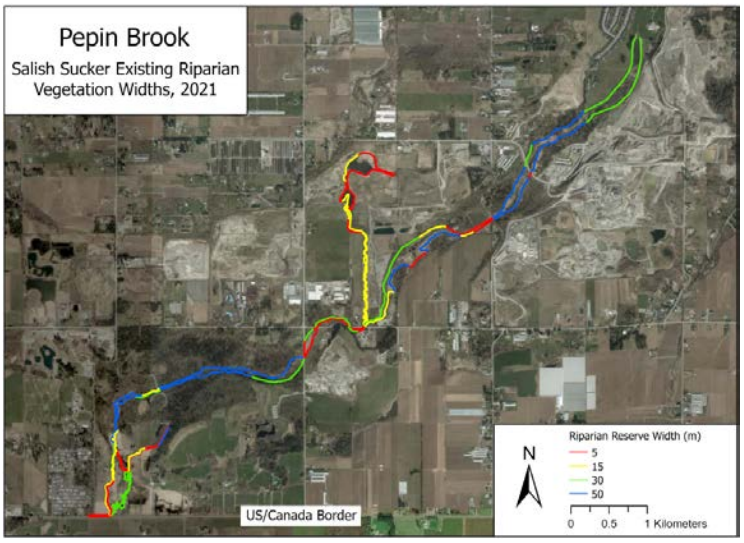


Figure 11. Map of riparian vegetation widths in Pepin Brook (D) reach.

Table 9. Riparian vegetation widths, areas, and reason for the change in the Pepin Brook (D) reach.

Reach	Length	Original	Update	Loss	Loss Area	Reason
PEP 20 L	281	30	5	25	7025	Cleared land
PEP 5 R	337	30	15	15	5055	Road

Pepin Brook (D) experienced a loss of 12,080 m². The reason for its loss its lost area is cleared land and a newly constructed road.

Figure 12. Map of riparian vegetation widths in Fishtrap Creek (E).

Table 10. Riparian vegetation widths, areas, and reason for the change in the Fishtrap Creek (E) reach.

Reach	Length	Original	Update	Width Lost	Area Lost	Reason
FTP 4 R	295	50	30	20	5900	Pull Outs Along Road

Fishtrap Creek (E) experienced a loss of 5,900 m² because of clearing for pullouts along the road.

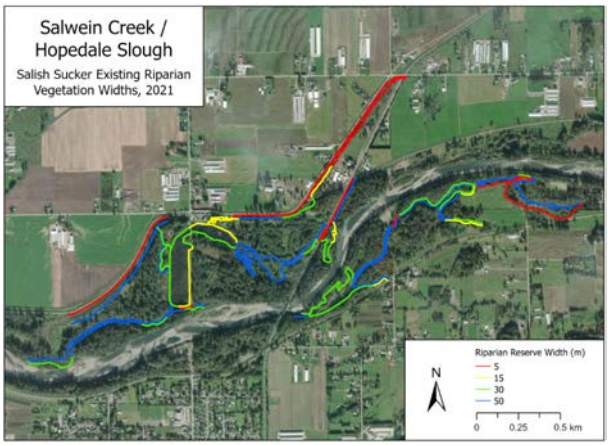


Figure 13. Map of riparian vegetation widths in Salwein Creek / Hopedale Slough (F) reach.

Table 11. Riparian vegetation widths and areas in the Salwein Creek / Hopedale Slough (F) reach.

Reach	Length	Original	Update	Width Gained	Area Gained
SWN 13 R	141	15	50	35	6345
SWN 13 R	265	5	30	25	6625
SWN R	176	5	15	10	1760
SWN 3 L	576	5	50	45	25920

Salwein Creek / Hopedale Slough (F) experienced a total gain of 40,650 m². It experienced the most gain of any reach accounting for roughly half of the total gain in riparian reserves. This is due to riparian vegetation being restored

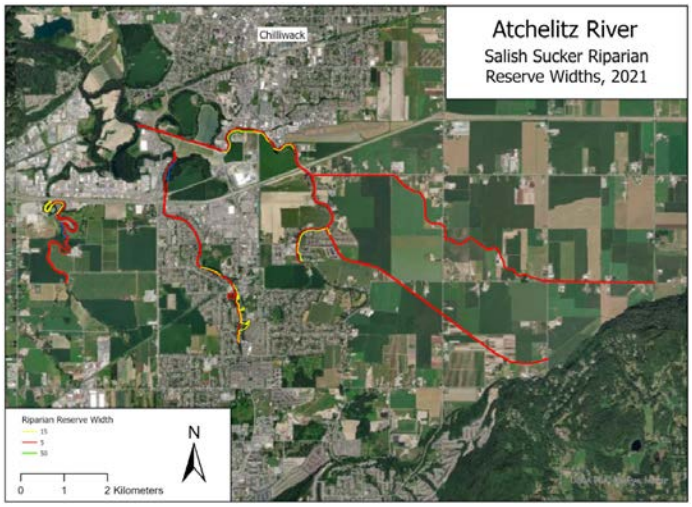


Figure 14. Map of riparian vegetation widths in Atchelitz River (G).

Table 12. Riparian vegetation widths, areas, and reason for change in the Atchelitz River (G) reach.

Reach	Length	Original	Update	Width Lost	Width Gained	Area Lost	Area Gained	Reason
ATZ 6 L	112	15	5	10	0	1120	0	Cleared farm land
ATZ 10 L	96	5	15	0	10	0	960	N/A
ATZ 33 R	241	5	30	0	25	0	6025	N/A

Atchelitz River (G) experienced both a loss and gain in riparian vegetation. It gained 7,065 m^2 and lost 1,120 m^2.

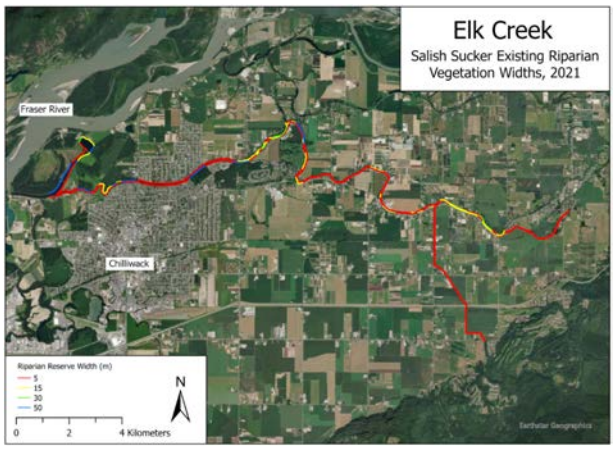


Figure 15. Map of riparian vegetation widths in Elk Creek (H).

Table 13. Riparian vegetation widths, areas, and reason for change in the Elk Creek (H) reach.

Reach	Length	Original	Update	Width Lost	Width Gained	Area Lost	Area Gained	Reason
ELK 24 R	81	15	5	10	0	810	0	Grass lawn
ELK 7 L	568	5	30	0	25	0	14200	N/A
ELK 2	1316	5	15	0	10	0	13160	N/A

Elk Creek (H) experienced both a loss and gain in riparian vegetation. It experienced the second most gains in riparian vegetation. 27,360 m² were gained and 810 m² were lost. Both of the gains were in long (>500 m) strips and were an increase in width of 25 m of vegetation.

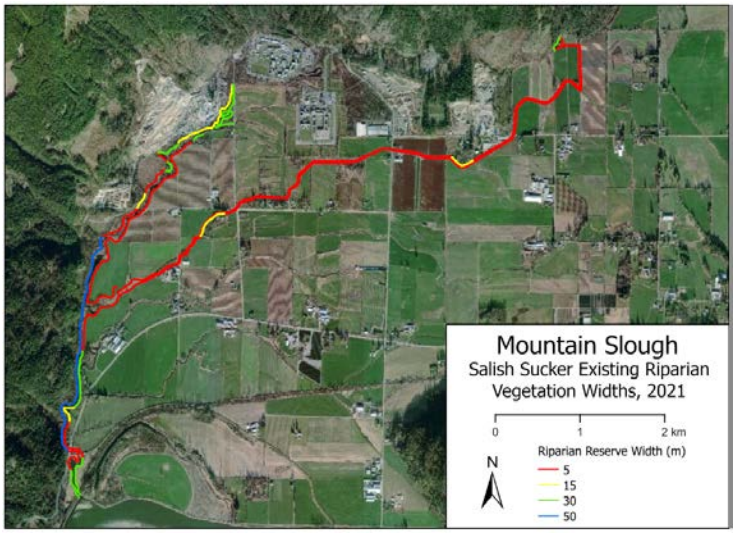


Figure 16. Map of riparian vegetation widths in Mountain Slough (I) reach.

Table 14. Riparian vegetation widths, areas, and reason for change in the Mountain Slough (I) reach

Reach	Length	Original	Update	Width Lost	Area Lost	Reason
MTN 5 L	217	50	30	20	4340	Cleared Lot
MTN 2 R	191	15	5	10	1910	House

Mountain Slough (I) experienced a loss in riparian vegetation of 6,250 m². The land was converted into a cleared lot and a house.

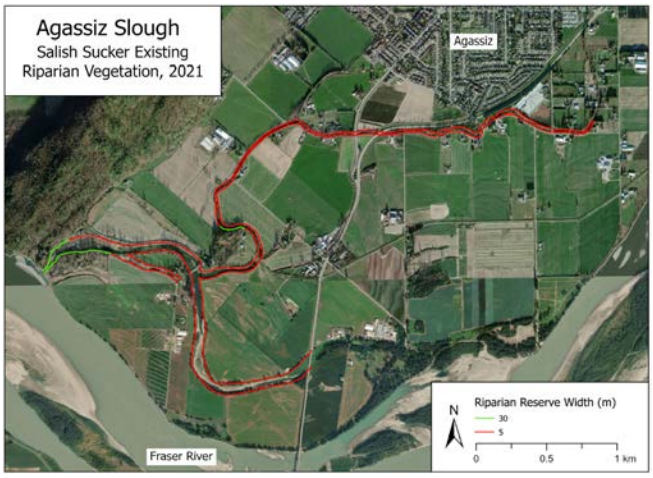


Figure 17. Map of riparian vegetation widths in Agassiz Slough Reach

Aggasiz Slough (J) did not experience any changes in widths of riparian reserves.

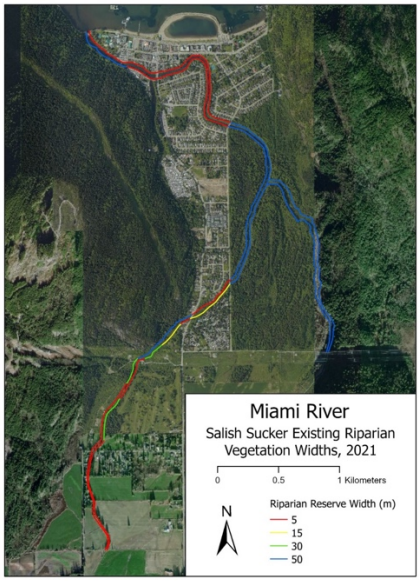


Figure 18. Map of riparian vegetation widths in the Miami River (K) reach.

Table 15. Riparian vegetation widths, areas, and reason for change in the Miami River (K) reach

Reach	Length	Original	Update	Width Gained	Area Gained
MIA 4 L	224	5	15	10	2240
MIA 4 L	193	5	30	25	4825

Miami River (K) experienced a gain of 7,065 m². The riparian widths increased.

Discussion

The results show the quantity and location of changes in riparian vegetation within Salish Sucker critical habitat. The quantity of riparian vegetation in critical habitat that was lost between the years 2007-2021 is concerning for the survival of the threatened Salish Sucker and the other organisms that exist in these areas.

There was a greater loss in riparian vegetation than gain. The majority of the loss in riparian vegetation within critical habitat was West of Chilliwack, British Columbia. All the increases in riparian vegetation were located in Chilliwack or East of Chilliwack. Even so, certain areas within Chilliwack and East of Chilliwack, Atchietz River, Elk Creek (H), and Miami River (K) experienced losses. Additionally, eight watershed reaches lost riparian vegetation while only three experienced gains which indicates that riparian vegetation is being lost in the majority of watersheds, but restoration is focused in a few watershed reaches.

The quantity of loss or gain does not indicate the health of the riparian vegetation in a watershed. To identify the health of the riparian vegetation in a watershed, the proportion of watersheds in each riparian width category should be observed. Some reaches had so little riparian vegetation < 5 m that there was little riparian vegetation that could have been lost. This is the case for the Aggasiz Slough (J), which originally had the smallest proportion of riparian reserve widths < 5 m.Therefore, it had little to lose. As a result, there was no change in riparian vegetation between these years.

One of the biggest causes for the clearing of riparian vegetation was due to the land being converted into grass fields or lawns. Since most of this was likely done on homeowners' private property, more homeowner education on the importance of riparian vegetation for the survival of the Salish Sucker and other aquatic species that inhabit the streams would be a good step.

One of the biggest causes for a gain in riparian vegetation was due to land adjacent to or within agricultural land use being returned to riparian vegetation. One of the biggest reasons for increases in riparian vegetation is land being returned to vegetation from farmland.

Comparison with Predictions

Table 2 shows the degree of concern for riparian vegetation removal in each watershed as estimated in 2007, before the implementation of SARA (Pearson, 2007). The watersheds that had a major concern of riparian vegetation removal were Fishtrap Creek (E), Salwein/Hopedale Slough (F), Atchelitz/Chilliwack/Semmihault Creeks (G), Miami River (K), and Mountain Slough (I). In this group, Salwein River/Hopedale Slough (F) experienced no loss and the greatest gain in area of riparian vegetation of 40,650 m². Atchelitz/Chilliwack/Semmihault Creeks, Mountain Slough (I), and Miami River (K) all experienced a greater gain in area of riparian vegetation then loss.

The watersheds that had a moderate concern of riparian vegetation removal were Bertrand Creek (C), Upper Salmon River, Aggasiz Slough (J), and Elk Creek (H)/Hope River. Bertrand Creek (C), Upper Salmon River, and Elk Creek (H) experienced a loss riparian vegetation. Bertrand Creek (C) experienced the biggest loss of those listed with a loss of 27,180 m². The watershed with a minor concern of riparian vegetation removal was Pepin Brook (D). Pepin Brook (D) had the third greatest loss.

It is difficult to predict the future changes in riparian vegetation in Salish Sucker critical habitat because developers, landowners, and planners in the different municipalities have different interests. The watersheds with the most riparian vegetation are also the ones that have the most to lose. The Salwein/Hopedale Slough (F), the Miami River (K), and Pepin Brook (D) have the most riparian vegetation.

Limitations

A limitation of this research is that ground truthing was not completed due to border restrictions. In the future, ground truthing may be completed in some of the areas that experienced change. Another limitation of this research is that there was not an assessment of the quality of the riparian reserve. A future study could look the location of riparian reserve degradation to identify conservation work priorities.

Conclusion

The Salish Sucker is a threatened species that exists in 11 watersheds in Canada. Riparian vegetation an essential part of Salish Sucker habitat. The widths of riparian vegetation within Salish Sucker critical habitat were mapped in 2007 before SARA for the Salish Sucker was implemented. In this research, the widths of riparian vegetation were reassessed, and it was found that there has been a loss of total 102,045 m^2 and a total gain of 82,060 m^2. Thus, the net effect is an overall loss of 19,985 m^2. The majority of the loss in riparian vegetation within critical habitat was west of Chilliwack, British Columbia. All of the increases in riparian vegetation were located in Chilliwack or east of Chilliwack. Preservation efforts should be focused on reaches that are most at risk of future development. These are likely to be the reaches that experienced the greatest loss of riparian reserves identified in this report. Additionally, restoration efforts should be focused in areas with riparian reserve widths of <5 meters widths since these areas that are most likely uninhabitable to the Salish Sucker and fragment habitats.

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Research Note: Large-Scale Complexity Trends in the North American Continental Divide Trace

Scott Rice-Snow, Department of Geological Sciences, Ball State University, Muncie IN, USA

Abstract: *Partitioning of the North American Continental Divide trace among four distinctive geologic and topographic zones shows a broad trend of increasing trace complexity from south to north. A low degree of trace irregularity (quantified by fractal dimension,* D *= 1.04) appears at all inspected scales in the continental arc terrain of Central America and southern Mexico. Moderate to high complexity of the trace (*D *= 1.08-1.12) occurs only at resolutions below a few hundred km in extensional Basin and Range terrain as well the Rocky Mountains, while this higher trace complexity appears at all scales in the discontinuous compressional range areas of northern Canada and Alaska. Inhomogeneous geometry in the entire Continental Divide trace is most similar to that appearing regionally in the Rocky Mountain and Basin and Range zones.*

Keywords: watershed boundaries; geomorphology; morphometry; fractal models.

Introduction

Plan-view complexity of watershed boundaries has been assessed on regional scales in a variety of studies (Breyer and Snow, 1992; Rice-Snow, 1998; Bárdossy and Schmidt, 2002; Fehr et al., 2009; Rice-Snow, 2016). That prior work, however, has not addressed geometric variability in a major drainage divide trace on continental scale. This study presents an initial review of such variation in the North American Continental Divide trace, characterizing multi-scaled watershed boundary irregularity for four topographically and geologically distinct segments of the trace.

Methods

The digitized Continental Divide trace dividing Atlantic/Arctic and Pacific/Interior watersheds has 15 km point spacing. It is partitioned into four contiguous segments identified to be where the Divide traverses the following regions:

A. Central America and the Sierra Madre del Sur area of southern Mexico. The linearly linked highland divides of this continental arc region continue to be built by crustal compression and volcanic accumulation associated with oceanic plate subduction to the southwest.
B. Sierra Madre Occidental and Oriental areas of central and northern Mexico, continuing into the Basin and Range province of the southwestern United States. The Divide traverses numerous fault-

block mountain ranges here that result from east-west crustal extension that, while still occurring, was most active in the late Tertiary Era, millions of years ago.

C. Rocky Mountains of the western United States and southwestern Canada. While offset and interrupted in some places, the range crests of the Rockies are more continuous than those of the Basin and Range, resulting from major continent-interior crustal compression in late Cretaceous and Tertiary time.

D. MacKenzie Mountains, Brooks range, and Arctic lowlands of northern Canada and Alaska. These discontinuous range areas of varying orientation, significantly separated by lowlands and interior plateaus, were built by crustal compression in times similar to the Rockies (Bally and Palmer, 1989).

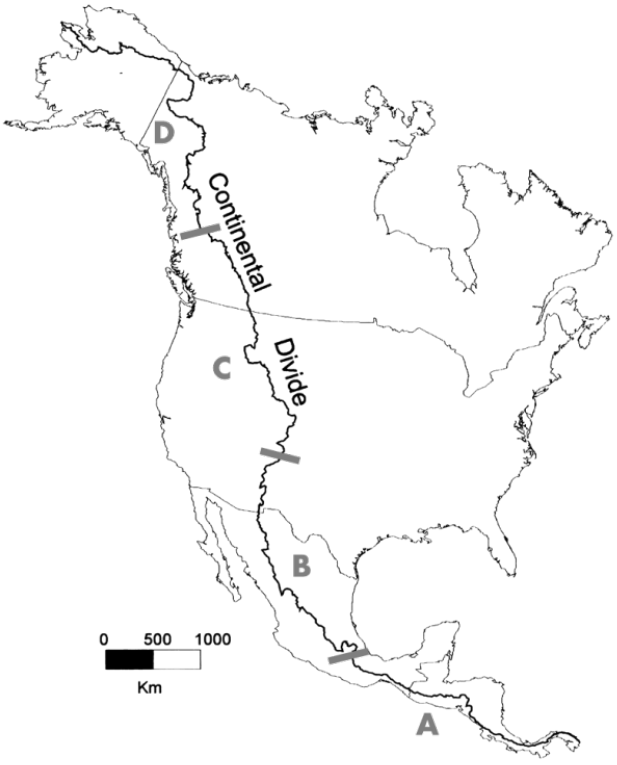

Figure 1. Segments of the North American Continental Divide trace. A: Central America and the Sierra Madre del Sur area of southern Mexico. B: Sierra Madre Occidental and Oriental areas of central and northern Mexico, and the U.S. Basin and Range province. C: Rocky Mountains of

the United States and Canada. D: MacKenzie Mountains, Brooks range, and Arctic lowlands of northern Canada and Alaska.

Multi-scaled irregularity of the Continental Divide trace in each segment is assessed by divider method (Richardson, 1961; Mandelbrot, 1983), using a digital multi-walk routine (Boyajian and Lutz, 1992). The spatial resolution range of this study is approximately 40 to 3000 km. Where justified by approximate linear form of Richardson plot sections, degree of trace complexity can be usefully quantified by *D*, fractal dimension value. The prior work cited in Introduction indicates the most typical range of D values for watershed boundaries to be 1.05-1.12, with extremes approaching 1.00 and 1.20, with greater D values corresponding to higher degrees of overall trace complexity.

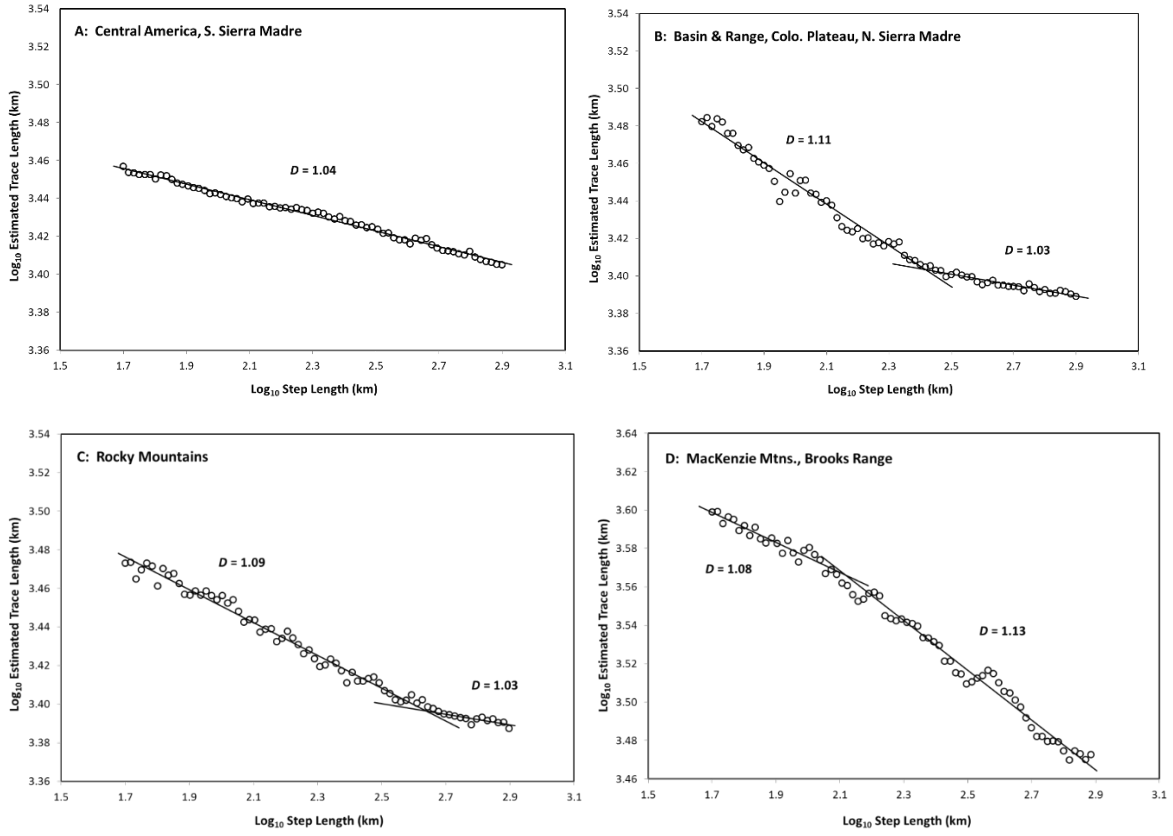

Figure 2. Richardson plots (divider analysis results) plot for four segments of the Continental Divide Trace.

Results

Richardson plots indicate that the Continental Divide trace segments well approximate inhomogeneous fractal curves, with most plots showing two portions of distinct plot trend, corresponding to different fractal dimension values for curve geometries in different scale ranges. The exception is the Divide trace Segment A in Central America and southern Mexico, with linear Richardson plot form expressing a consistently low degree of trace irregularity (D = 1.04) at all scales. Divider analysis of Segment B in northern Mexico and the Basin and Range yields a broken-trend plot with higher degree of trace complexity appearing at scales below a few hundred kilometers, and broadly similar behavior appears in results for Segment C in the Rocky Mountains. These higher fractal dimension values are in the range 1.08-1.12. While the Richardson plot for Segment D in northern Canada and Alaska, also displays broken-trend form, relatively high D values in all parts of the plot indicate high degrees of Divide trace complexity at all scales examined.

The study also provides opportunity to assess geometry of the full Continental Divide trace. For the full Divide trace, moderate degrees of map-view complexity (D = 1.08) appear at scales less than about 500 km, but less trace complexity (D = 1.05) appears at larger scales. This geometric character is most similar to that appearing regionally in the Rocky Mountain and Basin and Range zones.

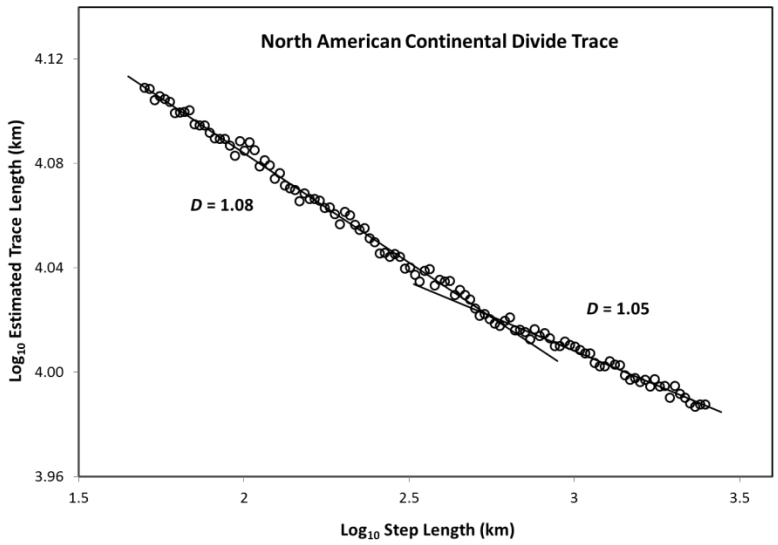

Figure 3. Richarson plot (divider analysis results) plot for entire North American Continental Divide trace.

Conclusion

Geometric complexity of the North American Continental Divide trace notably increases from south to north. This increase in complexity is expressed first (Segment B) by appearance of higher degrees of irregularity at finer scales in the trace, and once the northern part of the trace (Segment D) is reached, high complexity appears at all scales.

These trends may relate to varying tectonic environments and uplift histories of portions of the continent traversed by the Divide. Possibly longer post-uplift histories allow surface erosional processes to add further complexity to watershed divides than is initially established by tectonics, producing larger-scale geometric effects as time of erosion lengthens – this might be regarded as a hypothesis for further testing in other continental settings.

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