Social-ecological Change in Gwich'in Territory: Cumulative Impacts in the Cultural Landscape, and Determinants of Access to Fish

by

Tracey Angela Proverbs
Bachelor of Arts & Science, McGill University, 2014

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Supervisory Committee

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Abstract

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In the territory of the Gwich'in First Nation, in Canada's Northwest Territories, environmental, sociocultural, and economic changes are affecting relationships between communities and the land and water. In this thesis, I used two research projects to explore the impacts of social-ecological change in Gwich'in territory by examining cumulative impacts in the cultural landscape, and determinants of access to fish and well-being. In the first part of my MA, I used spatial overlay analysis to quantify and map: 1) cultural feature intensity, 2) cumulative environmental disturbance, and 3) overlap between disturbances and cultural features. I also interviewed four regional cultural heritage experts, who contributed critical insights into representing Gwich'in cultural features. The first two analyses indicated that overlay methods can facilitate understandings of land use and cumulative impacts, illustrating Gwich'in territory as a cultural landscape encompassing widespread, dense cultural features and diffuse, lower intensity cumulative environmental impacts. The third analysis showed that overlaying cultural feature and disturbance data is a novel, straightforward step to better incorporating cultural impacts in cumulative impact assessments. Many of the changes I mapped are affecting fishing practices central to Gwich'in livelihoods. To better understand these changes, in the second part of my MA I explored the relationship between drivers of access to fish and well-being amidst social-ecological change, by interviewing 29 Gwich'in individuals. My interviews showed that socioeconomic and environmental barriers have decreased access to fish. However, access to fish remains critical and related to well-being, driven by various socioeconomic factors. Many of these factors are reflected in sharing networks and adaptive practices that are encompassed in ecological monitoring and land-based education. These factors may strengthen Gwich'in fishing livelihoods, and highlight the importance of programs like the Rat River Char Monitoring program, and land-based education like the *Ganahghootr'onatan* – Teetł'it Land Based Learning Project.

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Dedication

This thesis is for the ones who came before me.

Including all of my grandparents - whether I met you or not.

Chapter 1 - Introduction

The effects of climate change and human development are changing ecosystems around the world (IPCC, 2014b; Lu et al., 2018; The Alberta Biodiversity Monitoring Institute, 2017; Venter et al., 2016). These effects are impacting environmental factors like animal habitat, water quality, and ecosystem structure and function (Alberti, 2005; Forister et al., 2010; Grimm et al., 2013; Nitschke, 2008). Many Indigenous communities are more exposed to environmental changes like these than non-Indigenous populations, because their livelihoods and cultural traditions are deeply connected with the land (Ford, 2012; IPCC, 2014a). Additionally, many Indigenous communities have experienced concurrent social, political, and economic changes (McMillen et al., 2017; Truth and Reconciliation Commission of Canada, 2015). Globally, the combined effects of social and ecological changes have had significant negative impacts on Indigenous livelihoods, subsistence harvesting, and important cultural areas (Manorom et al., 2017; Smith & Rhiney, 2016; Willow, 2017).

Environmental change is proceeding especially rapidly across the circumpolar north, where temperatures are increasing faster than the global average, and human footprint is expanding (AMAP, 2019; Pithan & Mauritsen, 2014; Raynolds et al., 2014; Vincent et al., 2015). The landscape in northwestern Canada has experienced disturbance from developments like oil and gas exploration and transportation infrastructure (Cameron & Lantz, 2016; Gill et al., 2014b; Kanigan & Kokelj, 2010), and warming temperatures are increasing the frequency of disturbances like wildfires and retrogressive thaw slumps (Kochtubajda et al., 2019; Kokelj et al., 2015; Lewkowicz & Way, 2019; Segal et al., 2016; Tan et al., 2019). These changes could pose significant challenges to the land-based culture of the Gwich'in First Nation, who have also experienced changes in livelihood, settlement patterns, spiritual practices, and diet due to colonial policies over the past 200 years (Alexie, 2015; Andre, 2006; Kuhnlein et al., 2009; Turner et al., 2018). While many northern communities have been characterized as having a high adaptive capacity (Berkes & Jolly, 2001; Ford et al., 2016), compounding social-ecological changes can have detrimental effects on community resilience, quality of life, and way of life (Abel et al., 2006; Tenza et al., 2017). It is vital to examine ongoing social-ecological

changes, to share information with community members, inform land use and co-management decisions, and contribute to continued adaptive capacities and strategies.

The accumulation of ecological disturbances over time can be defined as cumulative impacts (Hegmann et al., 1999; Johnston, 1994). Cumulative impact assessments examine compounding disturbances in a particular area, and are often conducted as part of Environmental Impact Assessments (Contant & Wiggins, 1991; Hegmann et al., 1999; Jones, 2016). Several authors have identified common gaps in cumulative impact studies, including a need for broader scopes extending beyond single projects (Duinker & Greig, 2006; Gunn & Noble, 2011), and an increased focus on cultural cumulative impacts that could potentially be addressed through increased inclusion of traditional ecological knowledge and a wider recognition of important cultural areas (Ehrlich, 2010; Ehrlich & Sian, 2004; Parlee et al., 2012; Willow, 2017). There is a clear need for cumulative impact assessments to explore impacts to ecological and cultural components of the landscape, especially in areas like Gwich'in territory, where significant concentrations of cultural features comprise a cultural landscape (Andrews, 2004; Andrews et al., 2016).

It is also critical to explore the impacts of environmental change to specific cultural traditions. A wide body of literature continues to examine the relationship between access to traditional foods, physical health (Kuhnlein et al., 2009; Schuster et al., 2011), and overall well-being (Lambden et al., 2007; Wesche et al., 2011). There is also a growing focus on the impacts of social-ecological change on Indigenous communities that are closely linked to the land (Forbes et al., 2009; Turner & Turner, 2008). In Gwich'in territory, impacts to community members' access to fish are particularly important to understand, because the harvesting, preparation, consumption, and distribution of fish contributes significantly to health and broader cultural well-being (GRRB & Gwich'in Elders, 2001; Gwich'in Renewable Resources Board, 2008; Wishart, 2014). As such, additional research is needed to further our understanding of the determinants of access to fish, their relationship with well-being, and how social-ecological change may be affecting access to fish and well-being.

My MA thesis seeks to address gaps in research about cumulative impacts in cultural landscapes, and changing access to traditional food. My overarching goal is to

further understandings of the multi-scalar impacts of social-ecological change to Gwich'in territory and communities. This thesis consists of two unique but complimentary projects written as stand-alone manuscripts (Chapters 2 and 3). Partnership and collaboration with Gwich'in organizations was key to these projects. My research was partnered with the Gwich'in Renewable Resources Board (GRRB) through the Tracking Change project. Tracking Change is funded by the Social Sciences and Humanities Research Council of Canada, and is engaging with local and Indigenous communities and many organizations (including the GRRB) in the Mackenzie, Lower Amazon, and Lower Mekong River basins to understand social-ecological change through traditional knowledge and other locally relevant methods (Michell et al., 2018; Parlee & Maloney, 2017). I was also fortunate to collaborate with the Gwich'in Tribal Council Department of Cultural Heritage, and Renewable Resource Councils in each community, building on the work of past graduate students in my supervisor's research group (Gill et al., 2014a; Turner et al., 2018).

In Chapter 2, I used spatial overlay analysis of the overlap between cultural features and environmental disturbances to explore the following research question: *What are current impacts of environmental disturbances in the Gwich'in cultural landscape?* To answer this question, I conducted three spatial overlay analyses, which quantified and mapped: a) the intensity of use of four categories of cultural features, b) the magnitude of cumulative impacts from seven environmental disturbances, and c) the overlap between cultural features and disturbances in the Gwich'in Settlement Region. I also interviewed four cultural heritage experts to gain their perspectives on the appropriateness and applicability of these methods.

In Chapter 3, I explored determinants of access to fish and the relationship between access to fish and well-being, and how social-ecological changes may be affecting this relationship. To explore *how access to fish affects Gwich'in well-being*, I interviewed 29 Gwich'in individuals in Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic, Northwest Territories. Interviews focused on participants' personal fishing history, access to fish, and environmental change. I also visited four fish camps, worked with local youth, and attended or hosted meetings to discuss my projects in all four communities.

In Chapter 4, I synthesized the results of both projects, discussed the benefits and challenges associated with each study, and discussed potential future applications of this work. The remainder of this chapter provides contextual information that is not provided in detail in Chapters 2 and 3. Topics covered include: Indigenous methodologies, Gwich'in territory, Gwich'in fishing practices, Indigenous well-being, social-ecological change in Gwich'in territory, cumulative impacts, and Indigenous mapping projects.

Personal location and Indigenous methodologies

My name is Tracey Proverbs. I grew up in Victoria, British Columbia on the territories of the Lekwungen and SENĆOŦEN speaking peoples, but my biological maternal grandmother was Kaska-Dena, from Liard First Nation. While my ancestors are Canadian, English, Bajan, Swiss and Kaska, the spatial closeness and temporal relevancy of my grandmother's journey through life draws me towards that aspect of my history. My grandmother was forced to attend Lejac Residential School as a child, in Fraser Lake/Carrier territory (Nadleh Whut'en First Nation, 2016), and my mother was adopted into a (wonderful) non-Indigenous family in British Columbia. Thus, my family has limited Kaska language and cultural knowledge (see Proverbs, 2014 for more family background). Engaging in northern environmental research with Indigenous communities is one way that I try to connect with the society and ecology closer to my family's traditional territory.

This research was informed by an Indigenous methodological framework that I created in an Indigenous Methodologies class at the University of Victoria. There is no formula for the creation of Indigenous methodologies (Absolon, 2011), but they often encompass tribal epistemologies and metaphors, aim to be w/holistic, and emphasize cultural revival, self-determination, and social justice (Absolon, 2011; Edosdi, 2008; Kovach, 2009; Smith, 1999). Indigenous methodologies can blend methodological frameworks with Indigenous practices (Smith, 1999).

My personal framework, like other Indigenous methodologies, utilizes a physical object as a metaphor for research (Absolon, 2011). In my case, it is a drum (Figure 1.1). The different aspects of this drum represent different parts of my research. The projects I work on are represented by the face of this drum (i.e. my thesis), the support networks for

this research are represented by the wooden frame (i.e. Gwich'in communities, University of Victoria, family), and different research methods are represented by the strings which, intertwined, hold the drum (and these projects) together (i.e. interviews, spatial analysis, youth involvement). I am a Kaska-Dena woman who has always lived away from my traditional territory. As such, while this is a take on an Indigenous methodological framework, I do not yet know enough about Kaska culture to truly embody Kaska epistemology in this framework. I realize the conundrum this presents, as the centrality of tribal epistemologies is a key tenet of Indigenous methodologies. At the same time, I recognize that my work is not strictly Western oriented. Instead, the drum methodology strives to reflect Gwich'in worldviews (without claiming to speak for the Gwich'in), while embodying an approach based on teachings of relationship, reciprocity, and respect.

By experiencing different viewpoints and ways of knowing as an Indigenous woman raised away from Kaska communities, the idea of using multiple methods in research resonated with me. There is a wide body of literature discussing multimethod and mixed methods research (Johnson & Onwuegbuzie, 2004; Johnson et al., 2007; Stange et al., 2006). Examples of utilizing multiple and mixed methods are common in Gwich'in territory and the surrounding area, from both former graduate students in my supervisor's research group and local organizations. Directly influencing my work, several past students worked with regional communities to understand and monitor ecological change through both traditional knowledge and scientific methods (Bennett & Lantz, 2014; Gill et al., 2014a; Turner et al., 2018; Tyson, 2015). Gwich'in organizations also utilize multiple and mixed research methods, including the Gwich'in science camps that were run by the Gwich'in Social and Cultural Institute (now the Gwich'in Tribal Council Department of Cultural Heritage). In these camps, high school students earned credits while living on the land and learning from Gwich'in elders, biologists, geographers, and anthropologists about Gwich'in traditional knowledge and western science (Gwich'in Social and Cultural Institute, 2016; Kritsch & Andre, 1997). For another example, the Gwich'in Renewable Resources Board makes decisions about fish, wildlife, and forests in Gwich'in territory by taking into account both traditional and scientific knowledge (Cott et al., 2018; Gwich'in Renewable Resources Board, n.d.-a).

Figure 1.1: The face and back (including strings) of my drum that represents my methodological framework.

Gwich’in territory

I have been fortunate to conduct my research in Gwich’in territory. In modern political terms, Gwich’in territory in the Northwest Territories can be referred to as the Gwich’in Settlement Region (GSR), located in northwestern Canada (Figure 1.2). The GSR was delineated in the 1992 Gwich’in Comprehensive Land Claim Agreement (Gwich'in Tribal Council & Indian and Northern Affairs Canada, 1992). This 90,379km^2 area is divided into three sub-regions (Gwich'in Land Use Planning Board, 2018). The 56,935km^2 Gwich’in Settlement Area is in the Northwest Territories, with land use planning and administration conducted by Gwich’in organizations and municipalities (Gwich'in Land Use Planning Board, 2018). There are different Gwich’in cultural groups in the four main GSA communities: the Ehdiitat Gwich’in in Aklavik, the Teetł’it Gwich’in in Teetł’it Zheh/Fort McPherson, the Nihtat Gwich’in in Inuvik, and the Gwichya Gwich’in in Tsiigehtchic (Gwich'in Land Use Planning Board, 2018). The 21,988km^2 Primary Use Area and 11,456km^2 Secondary Use Area, located in Yukon Territory, overlap with the territories of the Tr’ondëk Hwëch’in, Vuntut Gwitchin, and Na-Cho Nyäk Dun First Nations (Gwich'in Land Use Planning Board, 2018). Several Gwich’in organizations were established through the land claim, including the Gwich’in Renewable Resources Board, community Renewable Resource Councils, the Gwich’in Land Use Planning Board, and the Gwich’in Land and Water Board (Gwich'in Land and Water Board, 2018; Gwich'in Land Use Planning Board, 2017; Gwich'in Renewable

Resources Board, n.d.-a). The Gwich'in Social and Cultural Institute was established by the Gwich'in Tribal Council following the land claim agreement (Gwich'in Tribal Council Department of Cultural Heritage, 2016a).

Gwich'in territory supports diverse ecological communities (Andre, 2006; Gwich'in Land Use Planning Board, 2018), and this subarctic area experiences average daily temperatures ranging from -26˚C in January to 14˚C in August (Environment Canada, 2018). The GSR is a mosaic of forest, tundra and wetland habitats that includes mountainous areas, uplands terrain, and low-lying environments characterized by thousands of rivers and lakes (Ecological Stratification Working Group, 1995; Gwich'in Land Use Planning Board, 2018). This landscape supported traditional Gwich'in subsistence harvesting livelihoods that involved extensive travel to capitalize on seasonal harvesting patterns (GRRB & Gwich'in Elders, 2001; Gwich'in Land Use Planning Board, 2018; Slobodin, 1962). While many people now participate in the wage economy, land-use traditions remain vital to Gwich'in identity and culture (Alexie, 2015; Andrews et al., 2016; Parlee et al., 2005).

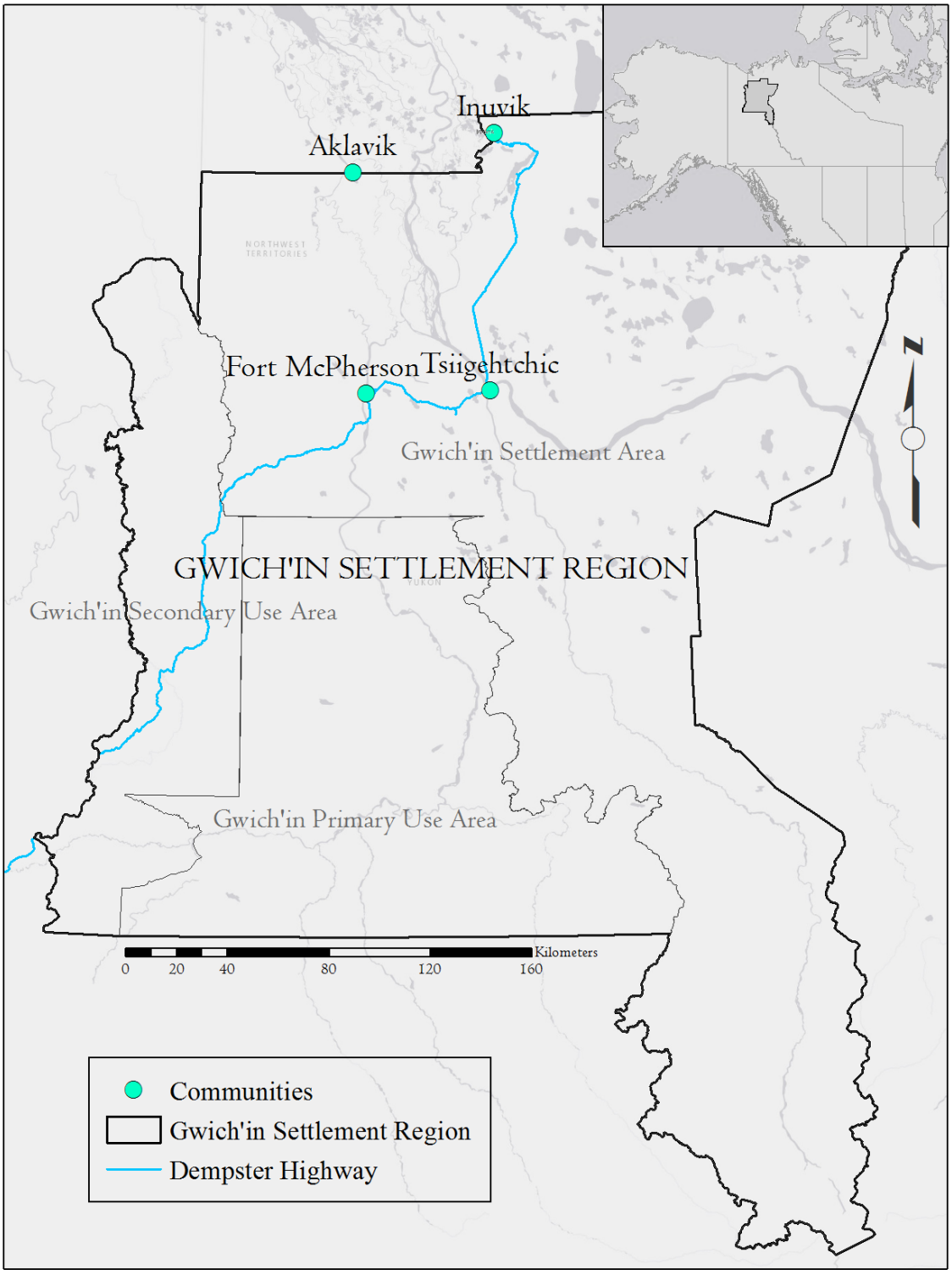

Figure 1.2: Map of the Gwich'in Settlement Region, showing the Gwich'in Settlement Area, Primary Use Area, Secondary Use Area, and communities of Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic.

Gwich'in fishing practices

One of the land use traditions that is important to the Gwich'in, and central to my thesis, is fishing (Alexie, 2015). Despite their importance, local fishing practices have received relatively little attention in scientific and popular literature, and have been considered a secondary activity to hunting (Slobodin, 1963; Wishart, 2014). Waterways in Gwich'in territory were historically important travel corridors, but also a reliable and significant food source (Berger, 1977; Wishart, 2014). Fishing often provided a base for other harvesting activities, and one of the first things that families would do before hunting and trapping was set their nets (Wishart, 2014). Gwich'in elders have described fish as a very dependable food source: "We ate lots of fish back then. It was like our store," and "Growing up we were real fish eaters, it was what we had. Fish was like going to the bank" (Wishart, 2014, p. 344). Today, this dependable food source has become somewhat eclipsed by grocery stores (Gwich'in Land Use Planning Board, 2018; Kuhnlein et al., 2009). However, fish still account for a large portion of the Gwich'in diet, with an annual average of 46,777 fish caught between 1995 and 2004 (Gwich'in Renewable Resources Board, 2008).

Seasonal fish camps remain an important fixture in Gwich'in culture (Alexie, 2015; Andre, 2006; Slobodin, 1962; Thompson & Millar, 2007). Traditionally, fish were caught with willow bark nets, fish traps, fish wheels, and spears made of caribou or moose bone (Greenland & Walker-Larsen, 2001). Today, most participants set nets at fish camps following river ice breakup, and under the ice in the fall and early winter (Wishart, 2014). Many people grew up spending summers and autumns at fish camps, steadily harvesting, consuming, preparing, and distributing fish (Wishart, 2014). Fish camps continue to provide a gathering place to dry fish, eat traditional food, share knowledge, connect with the land, and generally make people feel good (Alexie, 2015; Wishart, 2014). Many fish are harvested in Gwich'in territory. The most popular fish to eat in Gwich'in communities is ***Łuk digaii*** (broad whitefish or *Coregonus nasus*), but several other species are also harvested, including: ***sruh*** (coney or *Stenodus leucichthyes*), and ***dalts'an*** (crookedback or *Coregonus clupeaformis*), ***chehluk*** (loche or *Lota lota*), and ***dhik'ii*** (Dolly Varden char or *Salvelinus malma*) (Greenland & Walker-Larsen, 2001; Gwich'in Renewable Resources Board, n.d.-b; Thompson & Millar, 2007;

Wishart, 2014). Preparing and eating dry fish is one of the most popular ways to eat fish in Gwich'in communities (Kuhnlein et al., 2009; Thompson & Millar, 2007). Ultimately, fishing practices continue to provide a reliable food source that is integrated with other land-based activities, and Gwich'in health, economy, diet, and culture (Wishart, 2014).

Indigenous well-being and well-being frameworks

One way to examine the importance of fish to Gwich'in communities is through the contributions of fish to Gwich'in well-being. Well-being can be defined in many ways, but generally refers to quality of life (Kent, 2014; Parlee & Furgal, 2012). Various groups have expressed the need for health and well-being studies of Indigenous populations to utilize definitions of wellness from Indigenous perspectives (First Nations Information Governance Committee, 2005; Reading et al., 2007). Stemming from this, "well-being" is defined to include community, other animate and inanimate parts of the environment (such as fish), mind, body, and spirit (Mignone & O'Neil, 2005; Panelli & Tipa, 2007; Reading et al., 2007; Royal Commission on Aboriginal Peoples, 1996; Turner, 2006). In this project, I define well-being as "a diverse and interrelated set of social, cultural, economic, political and ecological factors that contribute to the quality of life of individuals, families and communities" (Parlee & Furgal, 2012, p. 5).

Indicators and frameworks are often used to understand or measure well-being (Gilani et al., 2018; Kent, 2014). Well-being frameworks can be large scale, global indices like the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005), national or regional indices like Bhutan's Gross National Happiness Index (Ura et al., 2012), or small scale, local frameworks like the central and north coast of British Columbia human well-being indicators (Rubus EcoScience Alliance, 2007).
Because all cultures experience well-being differently (Kent, 2014; Mathews & Izquierdo, 2009), some frameworks are more applicable to certain populations than others. In this thesis, I utilize the Assembly of First Nations Wholistic Policy and Planning Model (Reading et al., 2007). This conceptual framework consists of six rings centred on a circle that represents community. Community is surrounded by the medicine wheel, representing emotional, spiritual, mental, and physical health, as well as environmental, social, economic, and cultural health. In the next ring, four stages of life

are included: child, youth, adult, and elder. The next ring signifies self-government, which was not included in this analysis due to the specificity of those themes. The next circle contains 13 social determinants of First Nations health, including: environmental stewardship, social services, justice, gender, life-long learning, languages/heritage/culture, urban/rural, lands/resources, economic development, employment, health care, on/away from reserve, housing, and self-determination. This ring is surrounded by the final ring, representing relations within communities, with other communities, and with formal institutions (Reading et al., 2007). This outer ring was not included in this analysis, because my focus was on Gwich'in communities. Ultimately, my analysis in Chapter 2 included 22 themes representing community, the eight health conceptualizations in the medicine wheel, and 13 determinants of health (economic development and employment were combined).

Social-ecological change in Gwich'in territory

It is important to understand some of the causes of social and environmental change in Gwich'in territory, since I focus extensively on social-ecological change in this thesis. The Gwich'in have always lived in a changing landscape, where humans and animals interacted and transformed in early history, and have continued cultivating a dynamic relationship prior to and through European contact (Andre, 2006; Gwich'in Tribal Council, n.d.). In modern times, the Gwich'in began experiencing a number of sociocultural and economic changes in the mid-1800s with the arrival of European explorers, traders, and missionaries (Alexie, 2015; Krech, 1976). These settlers ushered in a period of great change for the Gwich'in, with the establishment of fur trading posts, and Christian churches and religion (Alexie, 2015; Andre, 2006; Krech, 1976). Following the decline of the fur trade after World War II, infrastructure like schools and nursing stations, and social service programs were created to entice people to live in towns (Alexie, 2015). Like many Indigenous groups in Canada, the Gwich'in continue to experience negative impacts from these changes, but also have many strategies to continue enhancing their culture (Andre, 2006; Kuhnlein et al., 2009).

With a growing economic focus on resource development in the north during the post-war period, the Gwich'in landscape began to experience disturbances associated

with oil and gas exploration, transportation infrastructure, and expanding community infrastructure (Alexie, 2015; Cameron & Lantz, 2016; Gill et al., 2014b; Kanigan & Kokelj, 2010). Today, cumulative impacts have slowly magnified in Gwich'in territory, with increased disturbances and shifting environmental conditions associated with climate change (AMAP, 2019; Kanigan & Kokelj, 2010; Segal et al., 2016; Stantec Consulting Ltd., 2014; Vincent et al., 2015).

Cumulative impacts

Examining cumulative impacts has become an important way to understand environmental changes, like the impacts from development and climate change occurring in Gwich'in territory. Cumulative impacts, or effects, studies emerged following the legislation of Environmental Impact Assessments (EIAs) in the United States in 1969, and became mandatory in Canadian EIAs in 1995 (Duinker & Greig, 2006; Jones, 2016). These assessments aim to investigate changes to valued aspects of the land over large temporal and spatial scales (Ehrlich & Sian, 2004; Hegmann et al., 1999; Jones, 2016). Cumulative impacts and effects have various definitions, but in a general sense, cumulative impacts are compounding and incremental impacts that result directly from environmental disturbances (often anthropogenic development projects) that can invoke ecological change, whereas cumulative effects are subsequent changes that occur as a result of these impacts (Johnston, 1994; Walker et al., 1987). In this thesis, I focused on cumulative impacts.

Cumulative impact assessments have been described as under-developed (Morgan, 2012), unclear (Gunn & Noble, 2011; Sinclair et al., 2017), and in need of a revolution (Duinker & Greig, 2006). Key issues include the need for a regional approach, and better accounting of future disturbances (Duinker & Greig, 2006; Foley et al., 2017; Jones, 2016). While the majority of cumulative impact assessments still occur on a project-by-project basis in EIAs, several research projects have incorporated some of the aforementioned feedback to continue advancing practices in cumulative impact assessments (Ehrlich, 2010; Mantyka-Pringle et al., 2017; Noble, 2008; Parlee et al., 2012; Tyson et al., 2016). While they are continually evolving, cumulative impact assessments still need improved ways to account for cumulative impacts in important

cultural areas. For instance, several authors have discussed the need to include broad culturally important areas, traditional knowledge, and social-ecological systems thinking in cumulative impact assessments (Gunn & Noble, 2011; Parlee et al., 2012; Tyson et al., 2016; Willow, 2017).

Indigenous mapping projects

One set of tools that can be used to examine both Indigenous land use and cumulative impacts are Indigenous mapping projects. Indigenous mapping is continually evolving. Printed mapping conducted by and for Indigenous peoples increased in the 1950s, ‘60s, and ‘70s, where projects largely focused on land use and occupancy studies to inform resource and sovereignty protection, land claim negotiations, and resource management (Asch et al., 1986; Chapin et al., 2005; Pearce & Louis, 2008). Since then, the field has evolved to encompass participatory approaches, and create atlases and guides to Indigenous mapping (Carlson, 2001; Chapin et al., 2005; Robinson et al., 2016; Tobias, 2000). Beginning in the 1990s, a lot of Indigenous mapping shifted towards technological mapping and spatial analysis (Chapin et al., 2005), examples of which include the Dene Mapping Project, the Inupiaq web GIS, and the Gwich’in Place Names Atlas (Aporta et al., 2014; Asch & Tychon, 1993; Eisner et al., 2012).

There are challenges associated with mapping Indigenous knowledge, such as adequately representing place-based knowledge on static maps, issues of intellectual property rights, differences in epistemology, and the potentially assimilatory nature of mapping (Chambers et al., 2004; Chapin et al., 2005; Pearce & Louis, 2008; Rundstrom, 1995). There are also challenges with spatial or web-based mapping, including the somewhat elitist nature of spatial technology (Carver, 2001; Chapin et al., 2005), and challenges with technological infrastructure in remote communities (Chapin et al., 2005; Eisner et al., 2012; Gill et al., 2014a). Many authors have explored these challenges, but also discussed the benefits of acknowledging them and working with communities to create appropriate mapping methods, because mapping is a powerful way to convey knowledge (Chambers et al., 2004; Chapin et al., 2005; Pearce & Louis, 2008).

The Gwich’in have engaged in a number of mapping projects, beginning with the Dene traditional land use and occupancy study in the 1970s (Asch et al., 1986).

Following the digitization of these data in the 1980s and 1990s (Asch & Tychon, 1993), the Gwich'in Social and Cultural Institute was involved in several projects, including: the Gwich'in Place Names Atlas, a Community Knowledge Keeper website containing observations of environmental change, and other projects that have been compiled into databases of Gwich'in place names, and traditional land use and knowledge (Gill et al., 2014a; Gwich'in Tribal Council Department of Cultural Heritage, 2016b, 2016c, n.d.).

Connecting introductory concepts

My thesis ties together the concepts that I outlined in this introductory chapter through two case studies conducted with members of the Gwich'in First Nation, guided by an Indigenous methodology and focused on cumulative impacts in cultural landscapes and determinants of access to fish. It is my hope that these understandings can be of use to Gwich'in organizations, while also contributing insights to specific disciplines. By tying together methods and insights about Gwich'in land use and social-ecological change, while building on ongoing Gwich'in cultural mapping, the methods in Chapter 2 provide an additional option to investigate cumulative impacts in cultural landscapes. Focusing on specific cultural features related to fishing practices, the discussions about relationships between ongoing change, determinants of access to fish, and well-being illustrated in Chapter 3 build on our understandings of the connections between traditional foods, identity, and well-being. Ultimately, through these two case studies I have sought to contribute to our understanding of ongoing social-ecological change in Gwich'in territory, and potential pathways to help manage or mitigate these changes that may be of use in Gwich'in communities and others experiencing similar changes.

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Chapter 2 - Cumulative environmental impacts in the Gwich'in cultural landscape

Tracey A. Proverbs [1], Trevor C. Lantz [1,3], Gwich'in Tribal Council Department of Cultural Heritage[2], Natalie C. Ban[1]

1. School of Environmental Studies, University of Victoria, PO Box 1700 STN CSC, Victoria, British Columbia, V8W 2Y2
2. PO Box 30, Fort McPherson, Northwest Territories, Canada, X0E 0J0
3. Corresponding author: tlantz@uvic.ca

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Introduction

The combined effects of intensified natural and anthropogenic disturbances are altering the structure and function of global ecosystems (Alberti, 2005; Foley *et al.*, 2017; Nitschke, 2008), with the potential to significantly impact the land-based livelihoods of many Indigenous groups (Inman *et al.*, 2018; Manorom *et al.*, 2017; Smith & Rhiney, 2016). In the Arctic and subarctic, where the climate is warming more rapidly than anywhere else on earth (AMAP, 2019; Duarte *et al.*, 2012; Pithan & Mauritsen, 2014) and industrial development is expanding (Dabros *et al.*, 2018; Forbes, 2013; McCauley *et al.*, 2016), changes to local livelihoods may be particularly severe (Huntington *et al.*, 2017; Parlee *et al.*, 2018). Alongside the impacts of climate change to permafrost, vegetation, and hydrological conditions (Hassol, 2004; Hinzman *et al.*, 2005; IPCC, 2014b; Kokelj *et al.*, 2017; Myers-Smith *et al.*, 2011; Ye *et al.*, 2011), northern regions are also experiencing development projects like oil and gas exploration and extraction, mining, and road construction (Cameron & Lantz, 2016; Harper & Kershaw, 1996; Holroyd & Retzer, 2005; Raynolds *et al.*, 2014).

Incremental, compounding disturbances that can cause landscape and ecosystem change are often defined as cumulative impacts (Hegmann *et al.*, 1999; Johnston, 1994). Over the past few decades, considerable effort has been devoted to assessing the cumulative impacts of natural and anthropogenic disturbances (Hegmann *et al.*, 1999; Hemond & Benoit, 1988; Morgan, 2012; Ross, 1998). These studies frequently examine the existing or potential impacts of a specific development project within an Environmental Impact Assessment (BC Hydro, 2013; Franks *et al.*, 2010; Joint Review Panel for the Mackenzie Gas Project, 2009; Raynolds *et al.*, 2014), or the broad scale impacts of multiple stressors on regional ecosystems (Clarke Murray *et al.*, 2015; Nitschke, 2008; Tyson *et al.*, 2016). Accounting for cumulative environmental impacts is important because they can severely impair environmental health, water quality, terrain stability, and animal habitat and interact in unexpected ways (Brown *et al.*, 2014; Johnson *et al.*, 2005; Jones, 2016; Kelly *et al.*, 2010; Kokelj *et al.*, 2015; Parlee *et al.*, 2018; Sandlos & Keeling, 2016; Segal *et al.*, 2016b).

In northern ecosystems, cultural features and activities are so widespread that most regions are best described as cultural landscapes (Andrews *et al.*, 2016; Cuerrier *et*

al., 2015; Ehrlich, 2010). Indigenous cultures across the circumpolar north rely on foods harvested from the land, and maintain strong connections with local landscapes through cultural features (Klubnikin *et al.*, 2000; Parlee & Furgal, 2012; Shannon, 2006; Wall-Reinius, 2012). In this paper, we define cultural features as tangible and intangible landscape features that are important for subsistence harvesting (i.e. hunting, trapping, fishing, gathering) and well-being, and/or that are culturally important for land management and political, spiritual, religious, or educational reasons. Since the early 1990s, authors have advocated for environmental assessments and cumulative impact studies to include impacts to the land use, livelihoods and cultural traditions of Indigenous peoples (Sallenave, 1994). However, to date, cumulative impacts research has focused primarily on ecological changes following disturbance (Gunn *et al.*, 2011; Johnson *et al.*, 2005; Johnston, 1994; Myers-Smith *et al.*, 2006; Nellemann & Cameron, 1998; Nitschke, 2008; Raynolds *et al.*, 2014; Willow, 2017).

Several studies have pointed to this gap in cumulative impacts research and called for the increased inclusion and recognition of cultural areas and subsistence resources in cumulative impact assessments (Ehrlich, 2010; Mantyka-Pringle *et al.*, 2017; Mitchell & Parkins, 2011; Parlee *et al.*, 2012; Willow, 2017). Some studies have worked to address these gaps through collaborative approaches and methods that recognize cultural locations as valued ecosystem components (Andrews *et al.*, 2016; Atkinson & Canter, 2011; Parlee *et al.*, 2012; Tyson *et al.*, 2016). Despite these efforts, there are limited quantitative, data-driven, regional analyses examining cumulative impacts affecting a variety of cultural features alongside ecological landscape components (Mitchell & Parkins, 2011; Tyson *et al.*, 2016).

In this study, we explore the potential of spatial overlay analysis to quantify and map the overlap between environmental disturbances and cultural features in Gwich'in territory. These areas of overlap can potentially damage, destroy, or alter cultural features, impacting cultural practices like subsistence harvesting and travel. We seek to provide a snapshot of regional cumulative environmental impacts occurring in the Gwich'in cultural landscape, and detail a planning tool that can be used by cultural and natural resource managers in the midst of rapid, regional changes.

Gwich'in territory

The territory of the Gwich'in First Nation is located in the northwestern portion of Canada's Northwest Territories, and the eastern reaches of Yukon Territory (Gwich'in Land Use Planning Board, 2018). Gwich'in territory was formally delineated as the Gwich'in Settlement Region in the 1992 Gwich'in Comprehensive Land Claim Agreement (Gwich'in Tribal Council & Indian and Northern Affairs Canada, 1992). This 90,379km^2 region is divided into three sub-regions: the 56,935km^2 Gwich'in Settlement Area (GSA) in the Northwest Territories, and the 21,988km^2 Primary Use Area and 11,456km^2 Secondary Use Area in Yukon Territory (Figure 2.1) (Gwich'in Land Use Planning Board, 2018). The Primary and Secondary Use Areas overlap with the traditional territories of the Tr'ondëk Hwëch'in, Vuntut Gwitchin, and Na-Cho Nyäk Dun First Nations (Gwich'in Land Use Planning Board, 2018). In total, there are 11 Gwich'in communities throughout Alaska, Yukon Territory, and the Northwest Territories (Gwich'in Council International, 2015). The four Gwich'in cultural groups in the GSR include the Ehdiitat Gwich'in of Aklavik, the Nihtat Gwich'in in Inuvik, the Teetł'it Gwich'in of Teetł'it Zheh/Fort McPherson, and the Gwichya Gwich'in in Tsiigehtchic (Gwich'in Land Use Planning Board, 2018).

Physically, this interior subarctic area lies near the tree line, supporting forest and woodland, alongside thousands of rivers and lakes, wetlands, upland tundra, and barren alpine areas (Ecological Stratification Working Group, 1995; Gwich'in Land Use Planning Board, 2018). The ecosystems in the GSR support diverse plant and animal communities (Andre, 2006; Gwich'in Land Use Planning Board, 2018), and are interconnected by river systems including the Mackenzie, Peel, and Arctic Red. The Gwich'in continue to travel by land and water throughout these territories, maintaining traditions of fishing, hunting, trapping, and gathering food and medicines from the land (Andre, 2006; Wishart, 2014). The land and water are vital to Gwich'in culture, and individual and community well-being (Andre, 2006; Parlee *et al.*, 2005; Wray & Parlee, 2013). Connections between people and place in Gwich'in territory have been well-documented by projects such as the Dene Mapping Project (Asch *et al.*, 1986), and various initiatives led by the Gwich'in Tribal Council Department of Cultural Heritage

(formerly the Gwich'in Social & Cultural Institute) (Gwich'in Social and Cultural Institute, 2018).

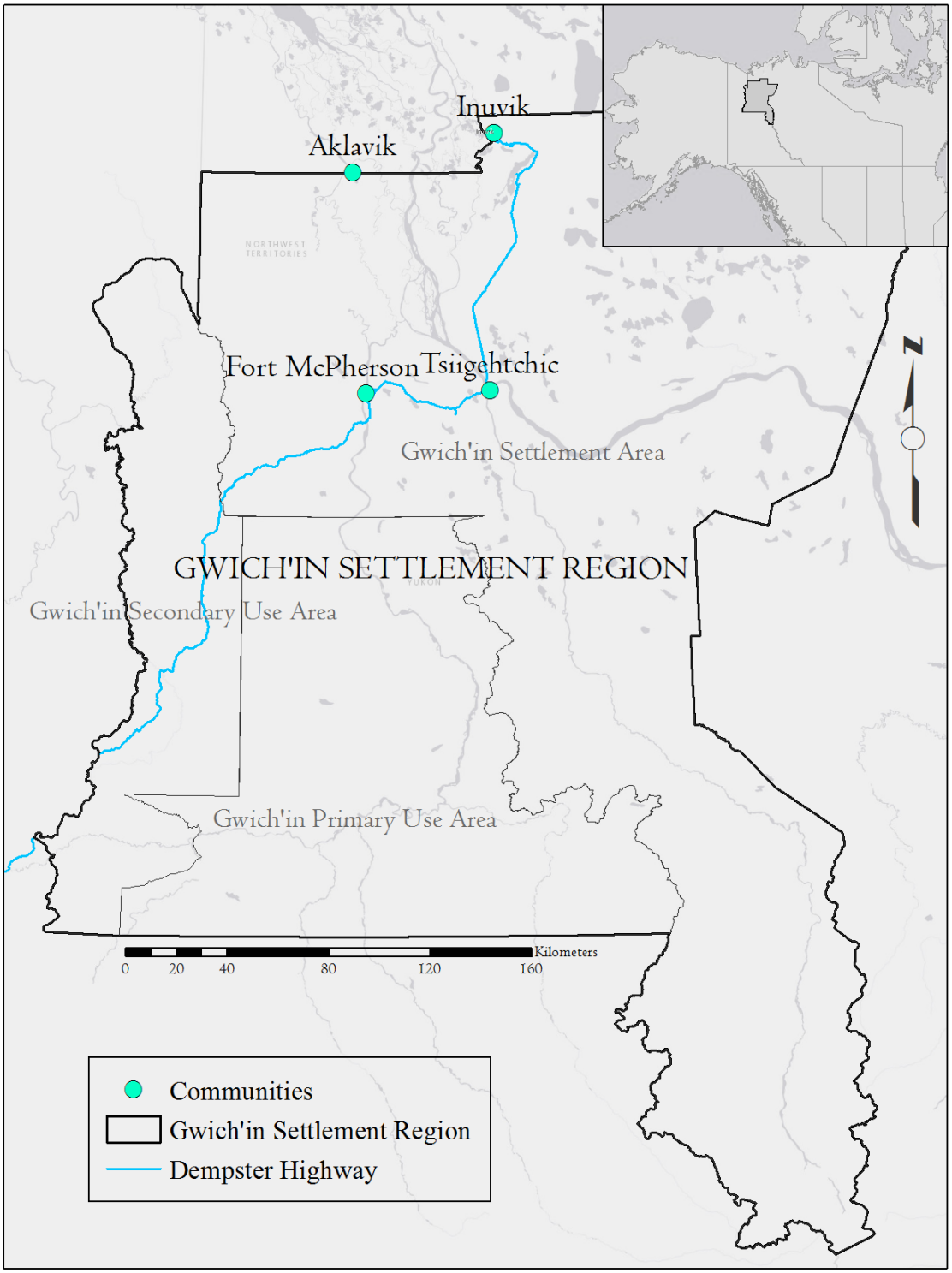

Figure 2.1: Map of the Gwich'in Settlement Region, showing the Gwich'in Settlement Area, Primary Use Area, Secondary Use Area, and communities of Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic.

Methods

This research explored the potential of regional scale spatial overlay analysis to assess the cumulative impacts of environmental disturbances in the Gwich'in cultural landscape. To accomplish this, we conducted three spatial overlay analyses in the GSR using ArcGIS software (version 10.3.1). We quantified and mapped: a) the density of use of four categories of cultural features, b) the magnitude of cumulative impacts from seven types of environmental disturbance, and c) the overlap between cultural features and environmental disturbances. Cultural features and cumulative impacts were quantified by dividing the GSR into a grid of 3,810 planning units (PUs) (Figure 2.2). The majority of PUs are 25km^2, but a number of smaller PUs were located along the edges of the GSR.

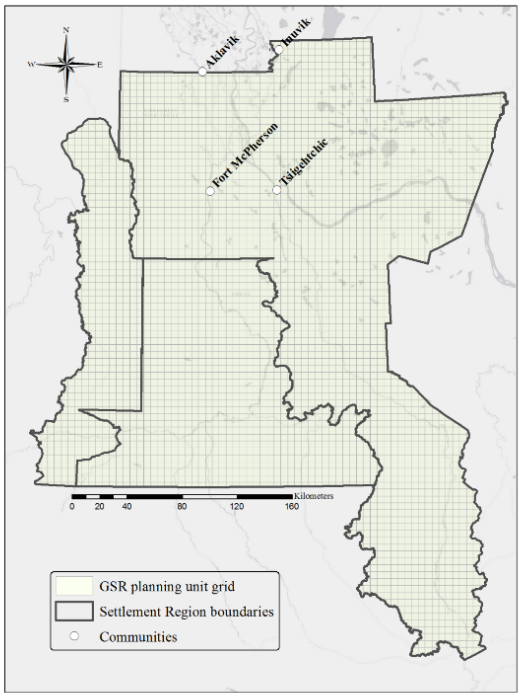

Figure 2.2: The grid of 3,810 planning units in the Gwich'in Settlement Region used to assess documented cultural feature intensity, cumulative weighted environmental disturbance, and potential overlap between environmental disturbances and documented cultural features.

Documented cultural feature density

To quantify the density and distribution of cultural features in the GSR, we created an index of cultural feature intensity (CFI) (Figure 2.3). This index is based on the assumption that the density of tangible and intangible cultural features indicates the intensity of cultural use in a given landscape unit. Data on four categories of cultural

features (historic harvesting trails, named places, traditional land use areas, and archaeological sites) were obtained from several sources (Table 2.1).

To ensure that point, polygon, and polyline data had a similar influence on the CFI, we used the procedures outlined below. Planning units that did not contain documented cultural features received a score of 0. Despite a lack of recorded features within them, these PUs are assumed to have a baseline of cultural activity, evidenced by oral and written histories that describe the importance of the entire landscape for Gwich'in cultural use (Alexie, 2015; Andre, 2006; Andrews *et al*., 2016). Each cultural feature mapped as a point in a PU received a score of 1. Each polygon that completely or partially covered a PU also received a score of 1. For example, if a PU contained 10 polygons, it would have a CFI of 10. The cultural feature intensity for polyline data was determined by dividing the total length of polylines within each PU by the length of one side of a PU (5,000m). To determine the total CFI in each PU, the CFIs of all point, polygon, and polyline data within the PU were summed (Figure 2.3). To visualize the distribution and density of cultural features across the GSR, we mapped the CFI in each PU in the GSR grid. After a CFI was calculated in each PU, we used the ArcGIS geometric interval classification (Esri, 2016; Frye, 2007) to group CFIs into 6 classes: baseline – no data (CFI = 0), light (CFI >0 – 5), moderate (CFI 5 – 14), high (CFI 14 – 40), very high (CFI 40 – 108), and extreme (CFI 108 – 286).

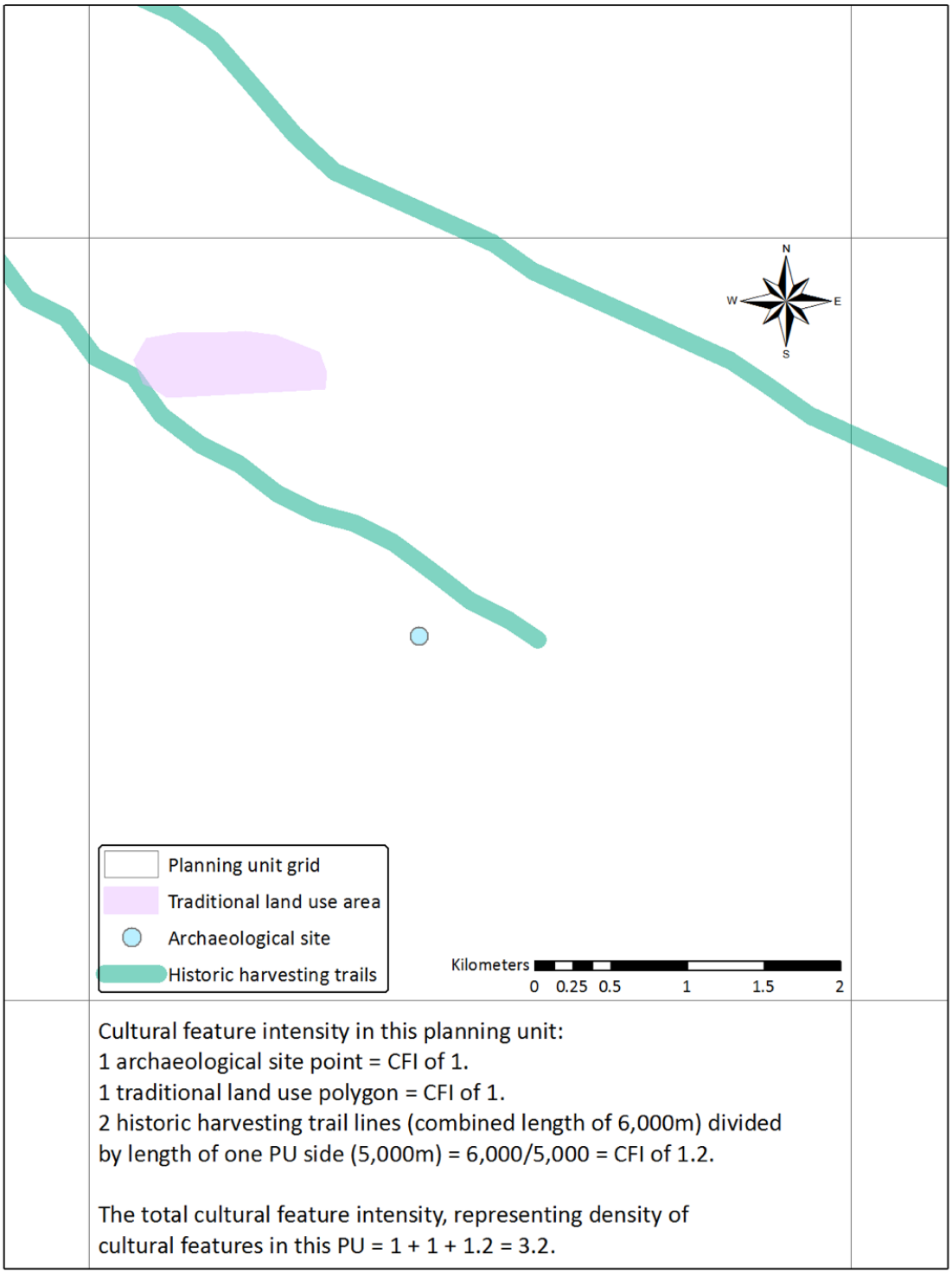

Figure 2.3: Example of the method used to calculate the cultural feature intensity in each planning unit. The planning unit in this example was modified from a planning unit in the analysis for illustrative purposes by omitting some cultural features. The planning unit above contains one cultural feature point, one polygon, and two lines of combined length 6,000m. The summed cultural feature intensity for the planning unit is 3.2 [1 (archaeological site point) + 1 (traditional land use area polygon) + 1.2 (historic harvesting trail polylines; 6,000m line divided by 5,000m planning unit side length)].

Cumulative weighted environmental disturbance

The cumulative impact of disturbances on the terrestrial environment in the GSR was estimated by compiling spatial data on seven types of environmental disturbance. Most of these disturbances are the result of anthropogenic activity, but one disturbance (retrogressive thaw slumps) is a form of permafrost degradation that is intensifying in response to climate change (Lantz & Kokelj, 2008; Segal *et al.*, 2016b).

Environmental disturbance data were acquired from various sources (Table 2.2). Drilling mud sumps (pits holding buried drilling fluids and waste from mining exploration) were represented as point data. The area of sumps in each PU was estimated by multiplying the number of sumps by the average area of sumps (2.2ha) estimated using aerial imagery in the Inuvialuit Settlement Region (NWT Geomatics, 2004; Tyson *et al.*, 2016). Polyline data on seismic cut lines were buffered to create polygons extending 3.5m on each side of the line, based on the average width of seismic lines in the Inuvialuit Settlement Region (NWT Geomatics, 2004; Tyson *et al.*, 2016). Polyline data for the Dempster Highway right of way were buffered 10m on each side to represent the average width of the highway. Community infrastructure in Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic was represented by polygon data. Gravel quarries were represented as polygon data in the Northwest Territories, and point data in Yukon Territory. The spatial extent of Yukon quarries was estimated using the average size of quarries in the Northwest Territories (7.2ha). Data on the right of way for the Mackenzie Valley Fibre Link (MVFL) (a fibre optic cable running through the Mackenzie Valley) were buffered by 3m per side to reflect the area of land cleared (Hagen, 2014; Stantec Consulting Ltd., 2014). The area of retrogressive thaw slumps per PU was estimated using a map of slump density across northwestern Canada (Segal *et al.*, 2016a). In this dataset, the density of slumps is represented categorically (low (1-5), medium (6-14), or high ($\geq$ 15)) across a grid of 225km^2 cells (Segal *et al.*, 2016a). Following Tyson et al. (2016), we assumed that low density cells contained 3 slumps, medium density contained 10, and high density contained 20. We estimated the average area of slumps within each 225km^2 cell by multiplying the average number of slumps per cell by the average slump area (3.02ha) reported by Segal et al. (2016). We then intersected the 225km^2 cells with our grid to calculate the average area of slump within each 25km^2 PU.

To quantify the impacts of these disturbances, we calculated a disturbance score for each PU that integrated estimates of disturbance severity, recovery, and area (Table 2.2). Although there is no unilateral approach to weighted analyses, they can be utilized in cumulative impacts research to account for differing effects and magnitudes of disturbance (Clarke Murray *et al.*, 2015; Tyson *et al.*, 2016). In our analysis, we used the weighting approach outlined by Tyson et al. (2016), where disturbance weights are obtained by multiplying a severity score by a recovery score for each type of disturbance. Severity scores characterize a disturbance's impact on vegetation structure, soils, and ground temperature, and range from 1 (minimal ecological alteration) to 10 (complete land transformation). Ecosystem recovery scores range from 0 to 1, and denote the length of time a disturbance is likely to persist on the land. Disturbances persisting for over 50 years received a score of 1 (i.e. community infrastructure), whereas disturbances that were likely to experience significant recovery of vegetation structure and ecological processes over 50 years received a score ranging from 0.1 to 0.9 (i.e. seismic lines) (Tyson *et al.*, 2016). Disturbance weights range from 1.2 (low severity and faster recovery, i.e. seismic lines) to 10 (high severity and limited recovery, i.e. community infrastructure). With the exception of the MVFL and gravel quarries, we used the weights created for the Inuvialuit Settlement Region by Tyson et al. (2016).

Following Tyson et al. (2016), we used the disturbance weights to calculate and map a disturbance score in each PU. This was achieved by summing the weighted areas of each disturbance (the percentage of PU affected by each disturbance, multiplied by the disturbance weight) using the following formula:

$$\text{Disturbance Score} = \sum_{Dist=1}^{n} \left(\frac{Disturbance\ Area}{Planning\ Unit\ Area} * 100 \right) \times Disturbance\ Weight$$

After this index was calculated in each PU, values were classified into ranges representing planning units without recorded disturbances (scores = 0), low (scores >0 – 0.03), moderately low (scores 0.03 – 0.3), moderate (scores 0.3 – 3), high (scores 3 – 30), and very high (scores 30 – 301) cumulative disturbance per PU. This was accomplished using the ArcGIS geometric interval classification.

Potential overlap between cultural features and disturbances

To quantify and map areas of overlap and potential impact between environmental disturbances and cultural features, we multiplied the disturbance score by the cultural feature intensity in each PU. This score is a relative measure of overlap between disturbances and culturally significant landscape features, which can be used to identify areas of potential impacts of disturbance (damage, destruction, alteration) to the ecological and cultural landscape. Throughout this paper we refer to this value as the overlap score. Overlap scores were classified into 6 categories using the ArcGIS geometric interval classification scheme: baseline – none recorded (scores = 0), low (scores >0 – 2), moderately low (scores 2 – 17), moderate (scores 17 – 173), high (scores 173 – 1727), and very high (scores 1727 – 17274).

We then assessed the relative influence of disturbance types and cultural feature categories on overlap scores in each overlap score range. To do this, we first grouped our data into the five overlap score ranges, and calculated the total disturbance score and CFI from all of the PUs in each range. Then, to understand the influence of each disturbance type or cultural feature category to the overlap score in each range, we calculated the percentage contribution of each disturbance type and cultural feature category to the total disturbance score or CFI in each overlap score range

Consultation interviews and community meetings

To gain informed guidance about this project, we conducted semi-structured interviews with four individuals knowledgeable about Gwich'in cultural features. The participants (Amy Amos, Sharon Snowshoe, Ingrid Kritsch, and Thomas Andrews) were a mix of Gwich'in and non-Gwich'in professionals who were chosen because of their employment experience and recommendations from the GTC DCH. Each audio-recorded interview was about one hour long, and took place in Fort McPherson, Inuvik, or Yellowknife, Northwest Territories, in February 2018. Our interview questions (Appendix A) were organized around four themes: 1) cultural feature management and use, 2) applications of these methods, 3) cultural feature conceptualization, and 4) communicating results. All transcripts were shared with interview participants via email to review and keep for their records. To share project results with community members

and elicit feedback, we held community meetings in Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic in February, 2019.

Table 2.1: Cultural features data, sources, and information about the contents of each data layer.

Data layer	Data type	Layer contents	Data sources
Historic harvesting trails	Polyline	Harvesting trails used by Dene and Metis trappers in the 1970s in the GSR area. Documented in the 1970s on physical maps with one third of active harvesters, and digitized in the 1980s.	GTC DCH, 2016a
Named places	Point, polygon, polyline	Place names (approximately 1000) in the GSR area. Documented from projects conducted by GTC DCH and others.	GTC DCH, 2016b
Traditional land use locations	Point, polygon, polyline	Oral history and traditional land use information about wildlife, vegetation, climate, water, trails, and camps. Documented from projects by GTC DCH and others.	GTC DCH, 2016c
Archaeological sites	Point	Documented archaeological sites in the GSR (likely only a fraction of existing sites). Includes features such as camp locations, burial grounds, portages, trading posts, traplines, and lookouts. Documented from multiple projects.	Prince of Wales Northern Heritage Centre, 2016; Yukon Archaeology Program, 2017

Table 2.2: Environmental disturbance data, weights, disturbance information and data sources. Table modified from Tyson et al. (2016).

Data layer	Recovery score	Severity score	Weight	Data source	Impacts of disturbance	Literature on Disturbance impacts
Thaw slumps	0.5	7	3.5	Segal *et al.*, 2016a	Alters soil, lake, and river chemistry; changes vegetation structure and permafrost conditions	Kokelj *et al.*, 2013; Lantz & Kokelj, 2008; Thienpont *et al.*, 2013
Seismic lines	0.4	3	1.2	World Wildlife Fund, 2002a; Yukon Highways and Public Works, 2014	Changes vegetation structure and permafrost conditions; decreases lichen cover	Kemper & Macdonald, 2009; Williams *et al.*, 2013
Dempster Highway	1	10	10	World Wildlife Fund, 2002c	Permanent right of way; changes vegetation, soil, and permafrost conditions	Gill *et al.*, 2014b; Myers-Smith *et al.*, 2006
Drilling mud sumps	0.5	10	5	World Wildlife Fund, 2002b; Yukon Government, 2014	Changes vegetation structure and composition, topography, and permafrost conditions	Johnstone & Kokelj, 2008; Kokelj *et al.*, 2010
Mackenzie Valley Fibre Link	1	3	3	GNWT Department of Finance, 2014	Permanent right of way; changes vegetation structure, permafrost conditions, and soil conditions; decreases lichen cover	Stantec Consulting Ltd., 2014
Gravel quarries	0.8	10	8	Geomatics Yukon, 2014; NWT Cumulative Impacts Monitoring Program, 2015b	Changes vegetation composition and structure, changes soil conditions and lichen cover	Forbes, 2009; Harper & Kershaw, 1996; Koronatova & Milyaeva, 2011
Community infrastructure	1	10	10	NWT Cumulative Impacts Monitoring Program, 2015a	Permanent settlement	NWT Cumulative Impacts Monitoring Program, 2015a

Results

Documented cultural feature density

The intensity of cultural features displayed in Figure 2.4 shows that the majority of Gwich'in territory is highly culturally salient. The vast majority of PUs (88%) contained cultural features (Table 2.3). Of these, 32% contained one category of cultural feature, while the majority (68%) contained overlap between two to four cultural feature categories (Table 2.3). Most PUs had moderate to high CFIs. Planning units with very high and extreme CFI values accounted for 10% of the PUs containing cultural features. The average CFI score in these PUs was 60.02 and 152.77 per PU (Table 2.4). These PUs were located along rivers like the Peel, Mackenzie, and Rat (Figure 2.4). Planning units with CFI values in the moderate and high categories made up 47% of PUs containing cultural features, and had average CFIs of 8.72 and 24.29 per PU (Table 2.4). Most of these PUs occurred adjacent to water bodies (Figure 2.4). 36% of the PUs with cultural features were in the light CFI class and had an average CFI of 2.51 per PU (Table 2.4). The highest concentrations of these PUs were located in the Great Bear Lake and Fort McPherson Plains, and the Peel Plateau ecoregions (Figure 2.4). 12% of PUs did not contain any mapped cultural features (Table 2.4). These PUs were located primarily along the southeastern edges of the GSR (Figure 2.4).

Table 2.3: The number and percentage of planning units containing different densities of cultural feature categories across planning units in the Gwich'in Settlement Region.

Number of cultural feature categories per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of PUs containing cultural features
0	450	11.81	-
1	1075	28.22	31.99
2	1246	32.70	37.08
3	898	23.57	26.73
4	141	3.70	4.20

Table 2.4: Average cultural feature intensity per planning unit and the number and percentage of planning units in each cultural feature intensity range.

Cultural feature intensity (range)	Average cultural feature intensity per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of PUs containing cultural features
Baseline – no data (0)	-	450	11.81	-
Light (>0 – 5)	2.51	1208	31.71	35.95
Moderate (5 – 14)	8.72	1020	26.77	30.36
High (14 – 40)	24.29	781	20.50	23.24
Very high (40 – 108)	60.02	316	8.29	9.41
Extreme (108 – 286)	152.77	35	0.92	1.04

The four categories of cultural features were present in different densities across the GSR. The most common cultural feature category was historic harvesting trails. These trails were present in 90% of the PUs containing cultural features, which had an average CFI of 13.97 (Table 2.5). Archaeological sites were the least common cultural feature category and were present in 5% of PUs containing cultural features. PUs with archaeological sites had an average CFI of 2.09 per PU (Table 2.5).

Table 2.5: Average cultural feature intensity per planning unit and the number and percentage of planning units containing cultural features stratified by cultural feature category.

Cultural feature category	Average cultural feature intensity per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of PUs containing cultural features
Historic harvesting trails	13.97	3026	79.42	90.06
Named places	2.58	2083	54.67	61.99
Traditional land use locations	4.73	1511	39.66	44.97
Archaeological sites	2.09	205	5.38	5.38

Cumulative weighted environmental disturbance

Our analysis shows that relatively low levels of disturbance are present across the GSR (Figure 2.5). Approximately half (54.5%) of the PUs contained recorded disturbances, but the majority of these contained one disturbance type (76% of disturbed PUs) (Table 2.6). A smaller number of PUs contained two or more disturbance types, and no PUs included all seven of the disturbance types that we examined (Table 2.6).

Table 2.6: The number and percentage of planning units containing different densities of disturbance types across planning units in the Gwich'in Settlement Region.

Number of disturbance types per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of disturbed PUs
0	1734	45.51	-
1	1584	41.58	76.30
2	437	11.47	21.05
3	43	1.13	2.07
4	8	0.21	0.39
5	3	0.08	0.15
6	1	0.03	0.05
7	0	0	0

PUs with no recorded disturbances were common in most ecoregions (Figure 2.5), and the low and moderately low disturbance score ranges contained the majority of disturbed PUs (63%) (Table 2.7). PUs with low, or moderately low disturbance levels had average disturbance scores of 0.01 and 0.15 per PU (Table 2.7), and were found in all of the ecoregions in the study area (Figure 2.5). Moderately disturbed PUs comprised 33% of disturbed PUs and had an average disturbance score of 0.64 per PU (Table 2.7). These PUs were located primarily in the Richardson Mountains, Peel Plateau and Eagle Plains (Figure 2.5). 70 PUs had high disturbance scores and were clustered close to the Dempster Highway, where gravel quarries, thaw slumps, and seismic lines frequently overlapped (Figure 2.5). These PUs had an average disturbance score of 7.08 (Table 2.7), and were present in 3% of disturbed PUs. 10 PUs with very high disturbance levels were located near Fort McPherson, Inuvik, and Tsiigehtchic (Figure 2.5). These PUs had average disturbance scores of 98.80, and were present in 0.5% of PUs containing recorded disturbances (Table 2.7).

Table 2.7: Average disturbance score per planning unit and the number and percentage of planning units in each disturbance score range.

Disturbance score (range)	Average disturbance score per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of disturbed PUs
None recorded (0)	-	1734	45.51	-
Low (>0 – 0.03)	0.01	210	5.51	10.12
Moderately low (0.03 – 0.3)	0.15	1099	28.85	52.94
Moderate (0.3 – 3)	0.64	687	18.03	33.09
High (3 – 30)	7.08	70	1.84	3.37
Very high (30 – 301)	98.80	10	0.26	0.48

The impact and density of each disturbance type varied considerably in the GSR. The most widespread disturbance types were thaw slumps and seismic lines, which were present in 63% and 51% of disturbed PUs respectively (Table 2.8). Although slumps and seismic lines were present in the most PUs, their average disturbance scores were relatively low (0.21-0.24; Table 2.8). The least common disturbance type, community infrastructure, was present in 0.6% of disturbed PUs (Table 2.8), but had the highest average disturbance score (76.70; Table 2.8).

Table 2.8: Average disturbance score per planning unit and the number and percentage of planning units containing disturbances stratified by disturbance type.

Disturbance type	Average disturbance score per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of disturbed PUs
Thaw slumps	0.24	1301	34.15	62.67
Seismic lines	0.21	1051	27.59	50.63
Dempster Highway	3.59	109	2.86	5.25
Drilling mud sumps	0.51	63	1.65	3.03
Mackenzie Valley Fibre Link	0.30	52	1.37	2.51
Gravel quarries	3.74	52	1.37	2.51
Community infrastructure	76.70	12	0.32	0.58

Potential overlap between cultural features and disturbances

The map shown in Figure 2.6 indicates that there is a moderate amount of potential overlap between environmental disturbances and cultural features in the GSR. Overall, 51% of PUs contained both disturbances and cultural features (Table 2.9). Most PUs had low to moderate overlap scores, and only a few had high or very high scores (Table 2.9). PUs with potential overlap between disturbances and cultural features were located throughout the GSR, with moderate to very high overlap score ranges located near the Peel River, Dempster Highway, Fort McPherson, Inuvik, and Tsiigehtchic (Figure 2.6).

Table 2.9: Average overlap score per planning unit and the number and percentage of planning units in each overlap score range.

Overlap score (range)	Average overlap score per planning unit (PU)	Number of PUs	Percentage of all PUs	Percentage of PUs with overlap
Baseline - none recorded (0)	-	1865	48.95	-
Low (>0 – 2)	0.59	961	25.22	49.41
Moderately low (2 – 17)	5.79	746	19.58	38.36
Moderate (17 – 173)	42.12	200	5.25	10.28
High (173 – 1727)	414.16	33	0.87	1.70
Very high (1727 – 17274)	10591.58	5	0.13	0.26

Decomposing overlap scores shows that some disturbances and cultural features had a larger impact on overlap scores than others. Thaw slumps and seismic lines were responsible for over 80% of the impact in the low and moderately low overlap score ranges, the Dempster highway was responsible for 47% of the impact in the moderate range, and community infrastructure caused 50% and 91% of the impact in the high and very high overlap score ranges (Table 2.10). Historic harvesting trails accounted for over 70% of the cultural feature intensity in overlap score ranges (Table 2.11).

Table 2.10: Contribution of environmental disturbance types to the total disturbance score across the five overlap score ranges. Values represent the percentage of the total disturbance score per overlap score range attributed to each disturbance type.

	Overlap score range					
	Low	Moderately low	Moderate	High	Very high	Total
Disturbance type	Percentage of the total disturbance score in each overlap score range					
Thaw slumps	31.41	54.96	19.49	0.72	0	14.57
Seismic lines	57.71	28.77	5.53	0.57	0.17	10.12
Dempster Highway	6.35	8.79	47.28	28.41	4.86	19.03
Drilling mud sumps	3.29	4.07	2.64	0.19	0.34	1.53
Mackenzie Valley Fibre Link	1.25	2.67	0.48	0.31	0.13	0.70
Gravel quarries	0	0.75	17.12	20.08	3.41	9.18
Community infrastructure	0	0	7.46	49.71	91.08	44.86

Table 2.11: Contribution of cultural feature categories to the total cultural feature intensity across the five overlap score ranges. Values represent the percentage of the total cultural feature intensity per overlap score range attributed to each cultural feature category.

	Overlap score range					
	Low	Moderately low	Moderate	High	Very high	Total
Cultural feature category	Percentage of the total cultural feature intensity in each overlap score range					
Historic harvesting trails	71.22	74.82	83.75	79.53	78.18	76.88
Named places	12.63	8.40	7.47	6.56	15.03	9.00
Traditional land use locations	15.70	15.66	8.31	11.14	6.39	13.24
Archaeological sites	0.46	1.12	0.47	2.76	0.39	0.88

Interviews

One of the main goals of interviewing cultural heritage experts was to explore whether or not it is appropriate to weight the cultural importance of cultural features across Gwich'in territory. Interview participants discussed the nature of different cultural features, and considered the challenges of weighting cultural features:

> I think everything is important, when people are talking about things I don't know how you would say "that's more important than something else." . . . Everybody has different views too, so, what I think is important might be different than what another Gwich'in [person] thinks is most important . . . . How would you say "this place name is more important than that place name?" (Amy Amos, Inuvik).

Because the community consultation required to effectively weight Gwich'in cultural features was beyond the scope of this project, we decided to represent the intensity of Gwich'in cultural use based on the density of features, not importance.

Interviews also helped us understand potential applications of this analysis for decision makers:

> In my former career as a government archaeologist who was responsible for trying to protect all those [cultural] resources, I really needed to know where the specific impacts were happening. It's a vast landscape and it's hard to do everything at once, so any kind of tools that help you focus the few resources that you have to rescue

> [archaeological sites are valuable] (Thomas Andrews, Yellowknife).

Participants also underscored the importance of this type of analysis by discussing impacts they are witnessing, and emphasizing the importance of sharing this information with community members interested in what is occurring on the land:

> I find so many differences now, like where there used to be a camp, it's just like where we used to live down the river at Mouth of the Peel, there used to be a camp across the river, but now it's not there because it fell in.
>
> People are interested and you know they'll look at it [maps] and see what's happening. Because sometimes you can't get to these places . . .
>
> The work that you're doing with this, I think it's really important. And, it's interesting but also, it's good to share with the people what's happening (Sharon Snowshoe, Fort McPherson).

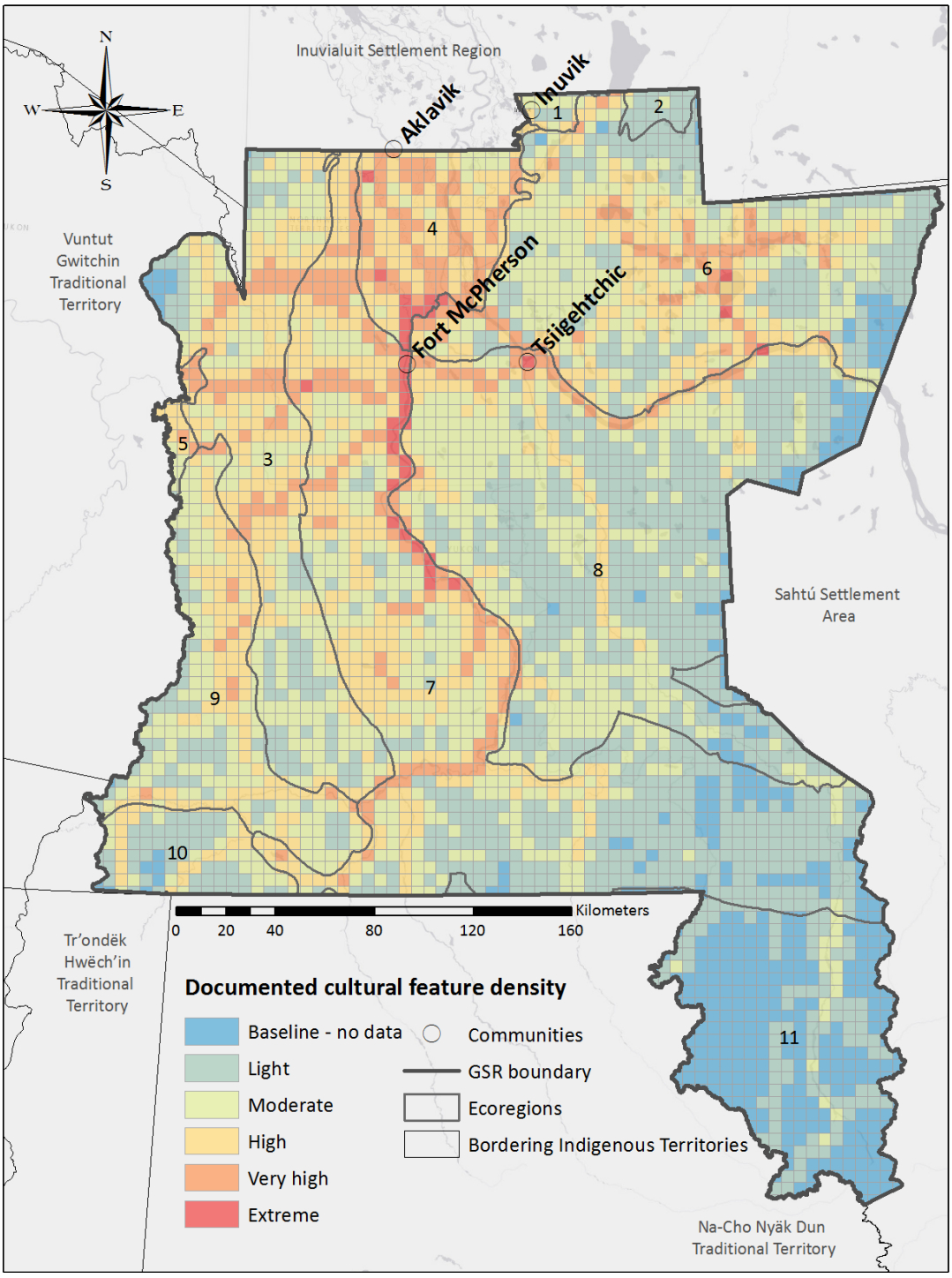

Figure 2.4: Map of the density of documented cultural features per planning unit across ecoregions in the Gwich'in Settlement Region: 1. Tuktoyaktuk Coastal Plain, 2. Dease Arm Plain, 3. British-Richardson Mountains, 4. Mackenzie Delta, 5. Old Crow Basin, 6. Great Bear Lake Plain, 7. Peel River Plateau, 8. Fort McPherson Plain, 9. Eagle Plains, 10. North Ogilvie Mountains, 11. Mackenzie Mountains. Baseline planning units did not contain data representing the categories of cultural features that we examined. Despite this, these planning units are considered to be culturally important, because oral and written histories describe the importance of the entire landscape for Gwich'in cultural use.

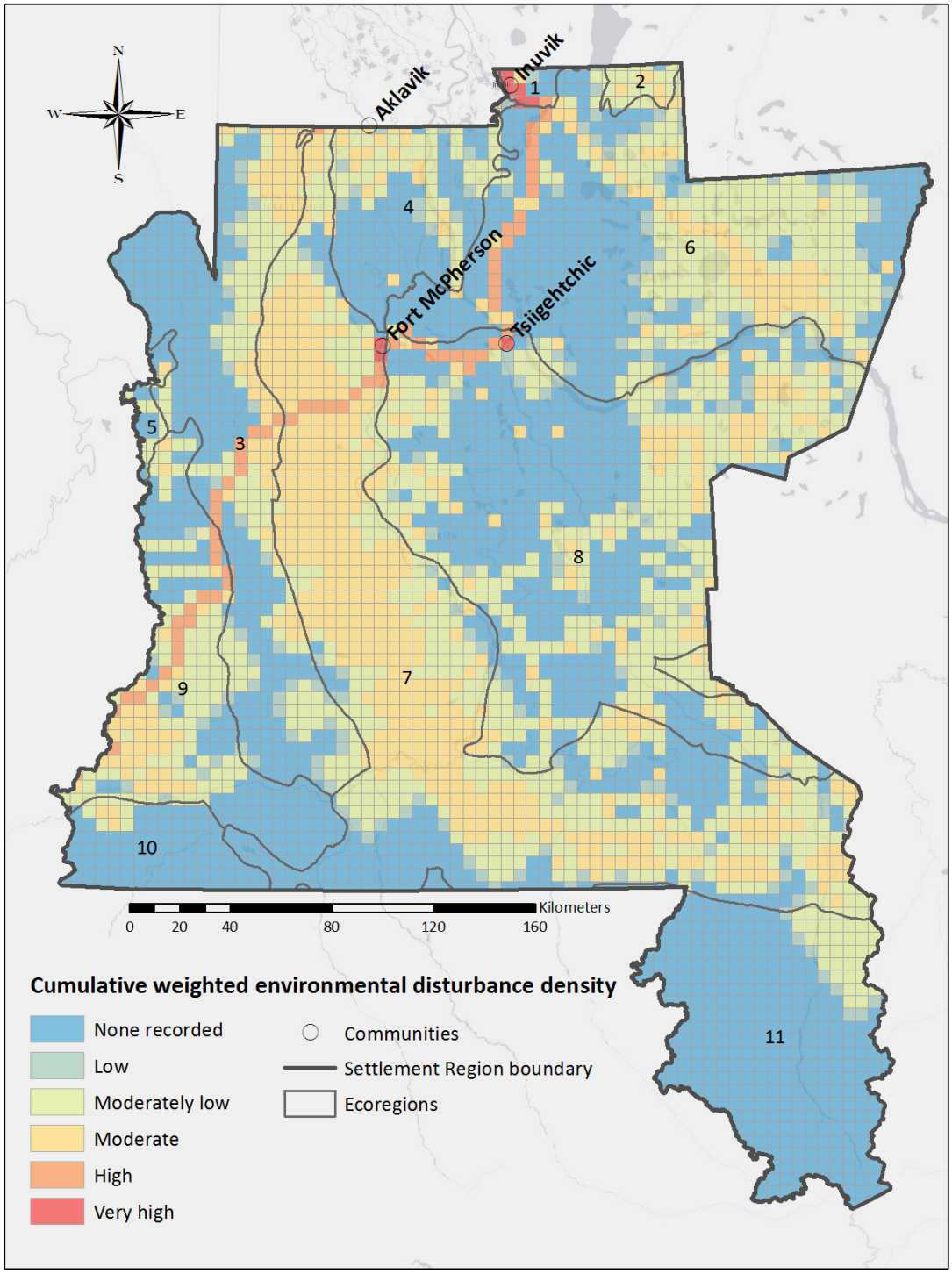

Figure 2.5: Map of weighted environmental disturbance scores per planning unit across ecoregions in the Gwich'in Settlement Region: 1. Tuktoyaktuk Coastal Plain, 2. Dease Arm Plain, 3. British-Richardson Mountains, 4. Mackenzie Delta, 5. Old Crow Basin, 6. Great Bear Lake Plain, 7. Peel River Plateau, 8. Fort McPherson Plain, 9. Eagle Plains, 10. North Ogilvie Mountains, 11. Mackenzie Mountains. Planning units with no recorded disturbances did not contain data representing any of the environmental disturbances that we examined.

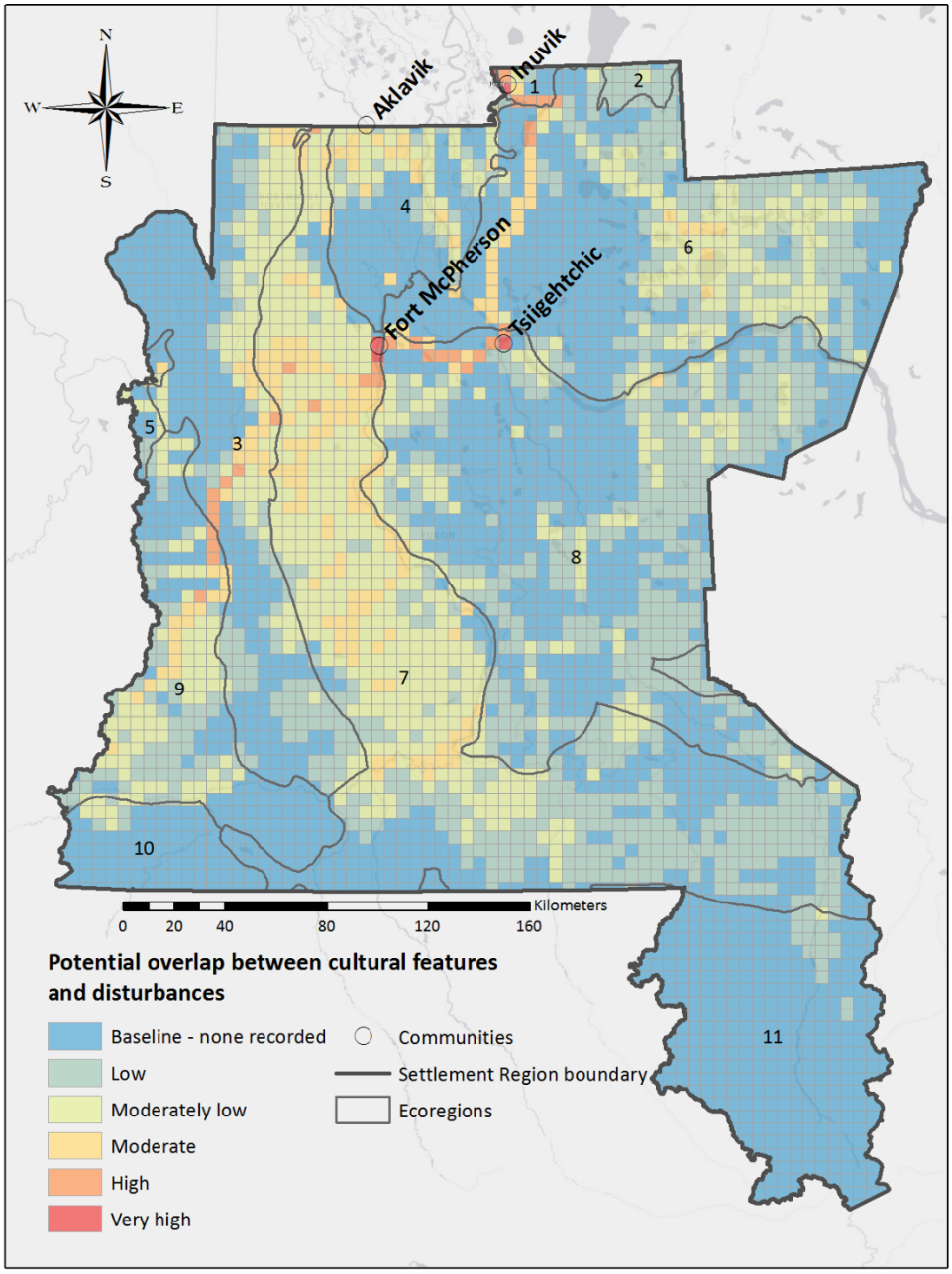

Figure 2.6: Map of the overlap score conveying the degree of potential overlap among cultural features and environmental disturbances across ecoregions in the Gwich'in Settlement Region: 1. Tuktoyaktuk Coastal Plain, 2. Dease Arm Plain, 3. British-Richardson Mountains, 4. Mackenzie Delta, 5. Old Crow Basin, 6. Great Bear Lake Plain, 7. Peel River Plateau, 8. Fort McPherson Plain, 9. Eagle Plains, 10. North Ogilvie Mountains, 11. Mackenzie Mountains. Planning units with no recorded overlap do not contain both environmental disturbances and cultural features. Planning units with low overlap represent lower severity ecological impacts and potential damage to cultural features, whereas planning units with very high overlap represent higher severity ecological and potential cultural impacts. Planning units with a baseline potential impact represent areas without documented cultural features, but which may still have a cultural impact, because the entire landscape holds cultural importance for Gwich'in community members.

Discussion

Cultural landscapes have been described as areas that are characterized by intricate relationships between humans and the land, including longstanding land use and spiritual connections (Andrews & Buggey, 2008; Andrews & Buggey, 2012; Cuerrier *et al.*, 2015; UNESCO, n.d.). Our analysis shows that Gwich'in territory represents a cultural landscape characterized by features linked to oral traditions and multigenerational land use (Andrews *et al.*, 2016). In this region, relationships between people and place are essential aspects of Gwich'in well-being, livelihood, and identity that are embedded in the cultural features that define this landscape (Kuhnlein *et al.*, 2009; Turner *et al.*, 2018; Wishart, 2014). We found that we could discern broad-scale patterns that characterize cultural landscapes by overlaying cultural features data. Figure 2.4 shows that the most intensive cultural use in the GSR occurs near waterways like the Peel River, Mackenzie River, and Travaillant Lake, demonstrating the importance of these features to Gwich'in livelihoods. This finding is consistent with the ethnographic literature which highlights the importance of rivers for travel, harvesting, identity, and language in Gwich'in culture, and for Indigenous peoples around the world (Aporta *et al.*, 2014; Inman *et al.*, 2018; Klubnikin *et al.*, 2000; Kritsch *et al.*, 1994; Manorom *et al.*, 2017; Wishart, 2014).

Social and cultural components are included in cumulative impact assessments in some regions, to inform decision-making related to land uses and development (Ehrlich & Sian, 2004; Hegmann *et al.*, 1999; US Council on Environmental Quality, 2007; Walker & Johnston, 1999). However, these features are often less prevalent in the available literature and cumulative impact assessments than biological components (Mitchell & Parkins, 2011; Willow, 2017). Because of this, additional tools are needed for cumulative impact assessments to include a wide array of cultural features that point to the intimate relationships between people and place in Indigenous communities (Baker & Westman, 2018; Willow, 2017). Such tools are important, because omitting certain cultural features underrepresents the extent of the cultural landscape, running the risk that decisions will be made with incomplete information that misrepresents the magnitude of impacts (Ehrlich, 2010; McCormack, 2017; Willow, 2017). The widespread density of cultural features in Gwich'in territory, combined with the pace of environmental change,

highlights the need for methods to assess the cumulative impacts of disturbance on the cultural and ecological landscape.

The methods for overlaying cultural features and disturbances outlined in this paper provide a unique and straightforward approach that can be used as a first step to more comprehensively include the cultural landscape in cumulative impact assessments. Overlay analysis has previously been used to assess the risks from specific environmental disturbances to socio-culturally important locations around the world (Alcaraz Tarragüel *et al.*, 2012; Andrews *et al.*, 2016; Szlafsztein & Sterr, 2007; Wang, 2015). Map overlays have also been described as a tool to examine cultural impacts in environmental impact assessments, or to analyze cumulative environmental impacts (Hegmann *et al.*, 1999; Mackenzie Valley Environmental Impact Review Board, 2007; US Council on Environmental Quality, 1997). Our approach builds on, yet is distinct from, these efforts because it is driven by both detailed ecological data and local knowledge of relationships between people, land, and water.

Our overlay analysis illustrates general, regional scale patterns of cumulative impacts in the cultural landscape that would not be evident by focusing on a single disturbance type or cultural feature category (Duinker & Greig, 2006; Foley *et al.*, 2017; Gunn & Noble, 2011; Jones, 2016; Parkes *et al.*, 2016). The map displayed in Figure 2.6 shows that, in the GSR, the highest amounts of overlap and potential impact between cultural features and disturbances occur along sections of the Dempster Highway that intersect with community infrastructure, areas of the Peel Plateau containing slumps and seismic lines, and along the Peel River, which contains dense concentrations of cultural features. Of note, the majority of planning units in the Peel Plateau ecoregion contain potential overlap between various cultural features, and disturbances such as thaw slumps and seismic lines. This reiterates the fact that this region is experiencing intensive, rapid geomorphological change in a culturally important area (Gill *et al*., 2014; Kokelj *et al*., 2015; Segal *et al*., 2016). Proposed developments or new disturbances could easily be included in this analysis by creating a disturbance weight and adding them to the disturbance and overlap analyses. Our maps also show some areas of the GSR, including the Mackenzie Mountains and the headwaters of the Arctic Red River, with no cultural features recorded in the spatial data we utilized. This is likely because the data used to

create this map has both known and probable gaps, as these areas would have experienced more widespread use prior to European contact in the mid-1800s that isn't fully reflected in the spatial data (Andrews *et al.*, 2016). Difficult travel conditions in some of these areas may have also limited their use (Benson, 2008). These areas also border the territory of Indigenous groups like the Sahtú Dene, who have highlighted place names, trails, and harvesting areas near the headwaters of the Arctic Red River (Aurora Research Institute, 2019; Sahtu Heritage Places and Sites Joint Working Group, 2000).

The overlay methods described here have the potential to inform the work of organizations involved in cultural heritage and land use management and protection. For example, broad-scale overlay analysis can be used to determine where to conduct fieldwork for cultural heritage managers who make management decisions about large cultural landscapes impacted by environmental disturbances (Andrews *et al.*, 2016). Examining overlap between cultural features and disturbances could also be used to assess impacts to valued ecosystem components (Hegmann *et al.*, 1999; Mackenzie Valley Environmental Impact Review Board, 2004). In northern regions, for example, these methods could contribute to co-management decision making by tracking disturbances that could impact a culturally important species like caribou. Caribou have a specific range, numerous associated cultural features, and are sensitive to anthropogenic disturbance (Cameron *et al.*, 1995; Nellemann & Cameron, 1998; Wolfe *et al.*, 2000). Focused information would be required to address objectives like this, such as data on caribou harvesting areas (Berkes *et al.*, 2009), and relevant disturbance data like roads (Nellemann & Cameron, 1998).

The approach to cumulative impact assessment outlined in this paper could also contribute to regional environmental monitoring. Tracking increased disturbance from climate change and development (AMAP, 2019; CBC News, 2018; Government of Northwest Territories, n.d.; Kokelj *et al.*, 2015; Segal *et al.*, 2016b) is critical to inform regional decision making and adaptation. Significant efforts are being directed at land-based monitoring which utilizes traditional knowledge or scientific methods to document changes of interest to community members and researchers (Armitage *et al.*, 2011; Johnson *et al.*, 2015; Kouril *et al.*, 2015; Russell *et al.*, 2013). The methods described here could augment these initiatives by identifying areas where rapid environmental

change may impact cultural features, which should be prioritized for monitoring (Andrews *et al.*, 2016; IPCC, 2014a; Kokelj *et al.*, 2015; Lewkowicz & Way, 2019).

Alongside potential applications of these methods, there are challenges associated with mapping cultural landscapes. For instance, demarcating cultural locations on a map may fail to fully represent the knowledge, relationships, and collective memories associated with tangible and intangible cultural features (Chambers *et al.*, 2004; Darvill & Lindo, 2015; Plieninger *et al.*, 2013). Maps are a powerful way to convey information (Chambers *et al.*, 2004; Chapin *et al.*, 2005). However, to ensure that knowledge is not misrepresented or distorted in the mapping process, it is vital that if cultural mapping projects are warranted in an area, that they are conducted in a culturally appropriate manner. For example, certain locations (sacred sites, harvesting locations) may be confidential (Honda-McNeil & Parsons, 2003; Laituri, 2011; Tobias, 2000). While maps from this analysis do not display discernible cultural feature locations, there may be concerns about releasing cultural feature location data to individuals outside the community to conduct the analysis. In these cases, funding and training (if necessary) should be provided to the interested communities to conduct the analyses. In this project, local collaboration, expert consultation, and community visits provided vital direction. The Gwich'in have a long history of engaging in mapping projects (Aporta *et al.*, 2014; Asch *et al.*, 1986; Gill *et al.*, 2014a; Gwich'in Social and Cultural Institute, 2018), and their collaboration ensured that their knowledge and data were used appropriately and that mapping was undertaken respectfully.

Expert consultation is an important aspect of cumulative impact assessment (Hegmann *et al.*, 1999; Smit & Spaling, 1995; Weber *et al.*, 2012), and our experience indicates it is particularly important when examining cumulative impacts in cultural landscapes. Interviewing community members and professionals invested in the region shaped the way that we conceptualized and represented cultural features. For instance, our interviewees were clear that creating a rigorous weighting scheme for cultural features would be challenging and could not be completed by a small number of people. Frequent community visits also ensured that we could update organizations and community members to gain feedback and share results.

An additional challenge associated with these methods relates to data availability. Acquiring high quality, up to date data is a well-documented challenge (Sipe & Dale, 2003; Szlafsztein & Sterr, 2007; Walker *et al.*, 2001). Although there is a wealth of spatial data about cultural features in the GSR, limited data may be a significant constraint in other regions. This obstacle is magnified by the pace of ecological change in some regions (Post *et al.*, 2009; Segal *et al.*, 2016b; Séjourné *et al.*, 2015), which can quickly make spatial data outdated.

Another drawback of our overlay method is that it highlights potential, rather than known, impacts. As such, we recommend it is deployed as an initial step in the assessment of cumulative impacts in cultural landscapes, which is followed up with more detailed analysis and ground truthing. Finer-scale spatial analysis and ground truthing should be used to examine areas of interest in more detail than is provided in the broad scale planning units in our analysis. Future analyses should also include disturbances and environmental changes that are not mapped, such as community members' observations of increased air temperatures (see Chapter 3). While increased air temperatures do not physically manifest on the land, they impact disturbances like thaw slumps (Lewkowicz & Way, 2019; Segal *et al.*, 2016b) and cultural activities like drying fish (see Chapter 3). Finer scale analyses could also more effectively include both positive and negative impacts of disturbances. In our broad-scale analysis, we made the simplifying assumption that disturbances causing ecological damage and overlapping with cultural features led to negative outcomes. However, most disturbances also include positive aspects. Community infrastructure has obvious positive attributes, and attendees at our community meetings discussed benefits like economic gain and travel corridors associated with seismic lines. Related to this, it is important to include cultural impacts of disturbances beyond overlap. For example, future analyses should include the social impacts of development that often accompany industrial camps and housing created for temporary workers (Komarek, 2018; National Inquiry into Missing and Murdered Indigenous Women and Girls, 2019).

Conclusion

This paper outlines a method of spatial overlay analysis designed to quantify and map cultural features, cumulative environmental disturbance, and the overlap between these landscape features. When combined, these methods provide a means to recognize regional scale patterns of cultural use and characterize environmental impacts in the cultural landscape. Our analysis shows that Gwich'in territory is fundamentally a cultural landscape containing expansive cultural features, impacted by widespread, but low-intensity disturbances. Overlaying cultural feature and disturbance data revealed low to moderate overlap between disturbances and cultural features. To understand the implications of ongoing environmental change, cultural features must be included in cumulative impact assessments. The methods described here provide a straightforward first step to addressing the exclusion of the cultural landscape in most cumulative impact assessments. Our analysis focuses on the cultural landscape at the regional scale, but with appropriate data and local consultation, our methods could be deployed across a range of scales relevant to land use and cultural heritage managers.

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Appendix A: Cultural features interview questions

Note: At the time of the interviews, cultural features were referred to as cultural resources.

- What is your name, and where do you live?
- What are your experiences working with cultural resources?
- For this project, we are thinking of cultural resources as landscape features or areas that contain significance for spiritual, cultural, religious, and educational reasons. Does this line up with what you think of cultural resources as?
- In your opinion, why are cultural resources important for the Gwich'in?
- Do you think it is important to recognize both tangible and intangible cultural resources?
    - Why or why not?

- Are there particular types of cultural resources that you think should be focused on in a secondary analysis?
    - If so, why are these cultural resources so important? (e.g. Use by multiple groups of people, use over a large temporal period, use over a wide geographical area, frequently visited, used for multiple reasons, important spiritually, important economically, important educationally, important for food, important for medicine).

- Are there particular types of cultural resources that you think are under threat by particular disturbances? If so, which disturbances?
- Are there particular environmental disturbances that you think should be focused on in a secondary analysis
    - Why should these particular disturbances be focused on? (e.g. Appear to be affecting a certain cultural resource, large scale of influence, recent disturbance, disturbance over a long time period, etc.).

- Are there particular environmental disturbances that you think are having significant impacts upon the cultural landscape? If so, what are the impacts? Upon which resources?
- Are there certain geographic areas where cultural resources are at risk?
- Jumping off of that last questions, are there particular areas within the GSR that you think should be investigated further?

- How do you think that the information we find through this analysis can be best communicated with local organizations?
- Do you think that maps like this are helpful for decision makers/organizations?
    - If not, do you have suggestions of better map visualizations?
    - (ideas: showing actual footprints of disturbances/cultural resources, include subset maps of high importance/impacted/whatever the focus is areas)
- Our environmental disturbance data was weighted based on the amount of time a disturbance persisted on the landscape, the size of the disturbance, and the severity of landscape transformation it caused. Therefore, in this analysis, a disturbance that does not occur often or has a small area can still be considered to have a high impact (i.e. community footprints). What do you think about a weighting scheme being created for cultural resources?
- Would this be useful?
- What issues do you see with this?
- We have thought about doing it as a way to get at certain resources or areas that should be focused on. However, there could be better ways to do this.
- If you think it's a good idea, what do you think weights should be based on?
- How should those criteria be determined or verified?
- What factors do you think would necessitate a higher weight for a cultural resource? (multiple use area, multiple groups using area, used over a long period of time, spiritual, medicinal, educational, harvesting?

- In your ideal world, what would management or protection of Gwich'in cultural resources look like?
- If you had a magic wand, and were working in your career fields, what would you want from a project like this? What data do you need, how do you need it, how should it be presented and communicated, who should be given that data?
- Is there anything else you think we should know or that you would like to tell us?

Chapter 3 - Determinants of access to fish and well-being in four Gwich'in communities amidst rapid social-ecological changes

Tracey A. Proverbs[1], Trevor C. Lantz[1,4], Sarah Lord[2], Amy Amos[2], Gwich'in Tribal Council Department of Cultural Heritage[3], Natalie C. Ban[1]

1. School of Environmental Studies, University of Victoria, PO Box 1700 STN CSC, Victoria, British Columbia V8W 2Y2
2. Gwich'in Renewable Resources Board, PO Box 2240, Inuvik, Northwest Territories, Canada, X0E 0T0
3. PO Box 30, Fort McPherson, Northwest Territories, Canada, X0E 0J0
4. Corresponding author: tlantz@uvic.ca

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Introduction

River systems around the world are being physically and culturally changed by industrial development and climate change (Baird et al., 2015; Holmes et al., 2013; Kelly et al., 2010; Prowse et al., 2009; RAISG, 2012; Yang et al., 2002). The impacts of these changes are significant, because rivers play critical roles in the global water budget, and support diverse human and ecological communities (Gummer et al., 2006; Klubnikin et al., 2000; Silvano & Valbo-Jørgensen, 2008). Impacts to river systems include: decreased water quality and animal habitat, and altered or destroyed fishing areas, community infrastructure, and cultural and spiritual sites (Baird et al., 2015; Loo, 2007; Michell et al., 2018; Sandlos & Keeling, 2016; Yakovleva, 2011). These impacts can negatively affect fishing and hunting livelihoods for many local and Indigenous peoples (Ford & Pearce, 2010; Middleton et al., 2009).

For the Gwich'in First Nation, fishing practices are an important component of livelihoods (GRRB & Gwich'in Elders, 2001; Gwich'in Land Use Planning Board, 2018; Gwich'in Renewable Resources Board, 2008). Gwich'in fishing livelihoods are part of a complex social-ecological system, based on reciprocal interactions between traditional foods, cultural practices, and the environment (Alexie, 2015; Andre, 2006; Berkes & Folke, 1998; Gwich'in Land Use Planning Board, 2018; Parlee et al., 2005). Many community members grew up spending summers and autumns at fish camps, harvesting, preparing, consuming, and storing traditional foods (Alexie, 2015; Andre, 2006; Slobodin, 1962; Wishart, 2014). Gwich'in land use practices have changed through time (Parlee, 2006; Parlee et al., 2018; Turner et al., 2018; Wray & Parlee, 2013), but the Mackenzie River system continues to support a large subsistence harvest of fish (Gwich'in Renewable Resources Board, 2009; Wishart, 2014). However, ongoing environmental changes including increased air temperatures, more frequent natural disturbances, hydrological changes, shifts in vegetation, and development projects like oil and gas exploration and highway construction (Gill et al., 2014b; Gwich'in Land Use Planning Board, 2018; Holmes et al., 2013; Lantz et al., 2010; Parlee et al., 2018; Scott, 2011; Segal et al., 2016; Stantec Consulting Ltd., 2014; Vincent et al., 2015) are raising concerns about the impacts of environmental changes on traditional foods (Greenland & Walker-Larsen, 2001; Parlee et al., 2018; Turner et al., 2018). Concurrent changes to

Gwich'in cultural, spiritual, educational, political, and economic systems over the last 200 years have also altered local livelihoods, and access to traditional foods (Alexie, 2015; Andre, 2006; Gwich'in Land Use Planning Board, 2018; Kuhnlein et al., 2009).

Traditional foods like fish are strongly linked with physical health and well-being in Indigenous communities (Gwich'in Renewable Resources Board, 2009; Kuhnlein et al., 2009; Receveur et al., 1997; Schuster et al., 2011; Turner, 2006a; Wein et al., 1991). Cultural activities associated with traditional foods connect Indigenous people with the land, maintain social networks, facilitate knowledge transmission, and influence physical health and overall well-being (Alexie, 2015; Guerin et al., 2011; Kuhnlein et al., 2009; Lambden et al., 2007; Parlee & Furgal, 2012; Petrasek MacDonald et al., 2015; Schultz et al., 2018; Schuster et al., 2011; Wishart, 2014). Detailed analysis of the factors influencing access to traditional foods is needed to build a more complete understanding of the ways that traditional foods benefit Indigenous well-being. Understanding these drivers could also shed light on the impacts of social-ecological change on access to fish and well-being, as well as ways to manage these impacts. In the north, the majority of recent well-being literature has related to impacts of environmental change on well-being (Cunsolo Willox et al., 2015; Parlee & Furgal, 2012; Petrasek MacDonald et al., 2015; Tobias & Richmond, 2014). To build on these critical insights, research focusing on aspects of well-being extending beyond impacts of environmental change alone is also needed (Parlee & Furgal, 2012).

We conducted this research project with members of the Gwich'in First Nation to examine socioeconomic and environmental determinants of access to fish, and their relationship with well-being amidst social-ecological changes. To do this, we worked with Gwich'in community members to: 1) document observations of environmental change, 2) explore factors preventing or helping people get fish (determinants of access to fish), and 3) examine relationships between access to fish and well-being. To frame well-being in a way that is locally relevant, we drew on Indigenous conceptualizations of well-being (First Nations Health Authority, 2018; Parlee & O'Neil, 2007; Petrasek MacDonald et al., 2015; Reading et al., 2007; Robertson & Ljubicic, 2019; Sangha et al., 2015; Schultz et al., 2018), and defined well-being as: "a diverse and interrelated set of social, cultural, economic, political and ecological factors that contribute to the quality of

life of individuals, families and communities" (Parlee & Furgal, 2012, p. 5). Ultimately, it is our hope that this research provides insights into the impacts of social-ecological change on Gwich'in fishing livelihoods and well-being, which can help inform local and regional decisions about land use and traditional foods.

Gwich'in territory

The four Gwich'in communities involved in this study are in the Gwich'in Settlement Area (GSA) (Figure 3.1), which was delineated in 1992 through the Gwich'in Comprehensive Land Claim Agreement (Gwich'in Land Use Planning Board, 2018). Figure 3.1 illustrates that the GSA is in the Northwest Territories, and a part of the larger Gwich'in Settlement Region, which also includes areas of overlapping land use in Yukon Territory (the Primary and Secondary Use Areas) (Gwich'in Land Use Planning Board, 2018). Gwich'in territory has a subarctic climate, with average daily temperatures ranging between -26˚C in January to 14˚C in August (Environment Canada, 2018). There are approximately 3,400 Gwich'in residents living in four communities in the GSA: the Ehdiitat Gwich'in of Aklavik, the Teetł'it Gwich'in of Teetł'it Zheh/Fort McPherson, the Nihtat Gwich'in in Inuvik, and the Gwichya Gwich'in in Tsiigehtchic (Gwich'in Land Use Planning Board, 2018). There are also other Gwich'in communities in Yukon Territory and Alaska (Gwich'in Council International, 2015).

The Gwich'in way of life was traditionally based on subsistence harvesting, involving extensive travel on the land and water to hunt, trap, fish, and gather food and medicines (Asch & Tychon, 1993; GRRB & Gwich'in Elders, 2001; Gwich'in Land Use Planning Board, 2018; Slobodin, 1962). The modern economy is a mix of subsistence harvesting and wage labour (Alexie, 2015; Andre, 2006; Gwich'in Land Use Planning Board, 2018; Parlee *et al.*, 2005). The Gwich'in continue to travel throughout their territory, and ties to the land and water remain critical to cultural identity and harvesting activities including fishing (Alexie, 2015; Andrews *et al.*, 2016; Gill *et al.*, 2014a; Parlee *et al.*, 2005). Gwich'in fishers have used different methods throughout time, including nets, hooks, and fish traps (Andre, 1994; GRRB & Gwich'in Elders, 2001; Wishart, 2014). Today, most fish are harvested with nets in open water through the summer and fall, and under ice in early winter (Wishart, 2014). Fish harvested in significant quantity for consumption in Gwich'in communities include: ***Łuk digaii*** (broad whitefish or

Coregonus nasus), ***sruh*** (coney or *Stenodus leucichthyes*), ***dalts'an*** (crookedback or *Coregonus clupeaformis*), ***chehluk*** (loche or *Lota lota)*, and ***dhik'ii*** (Dolly Varden char or *Salvelinus malma*) (Greenland & Walker-Larsen, 2001; Gwich'in Renewable Resources Board, n.d.; Thompson & Millar, 2007; Wishart, 2014).

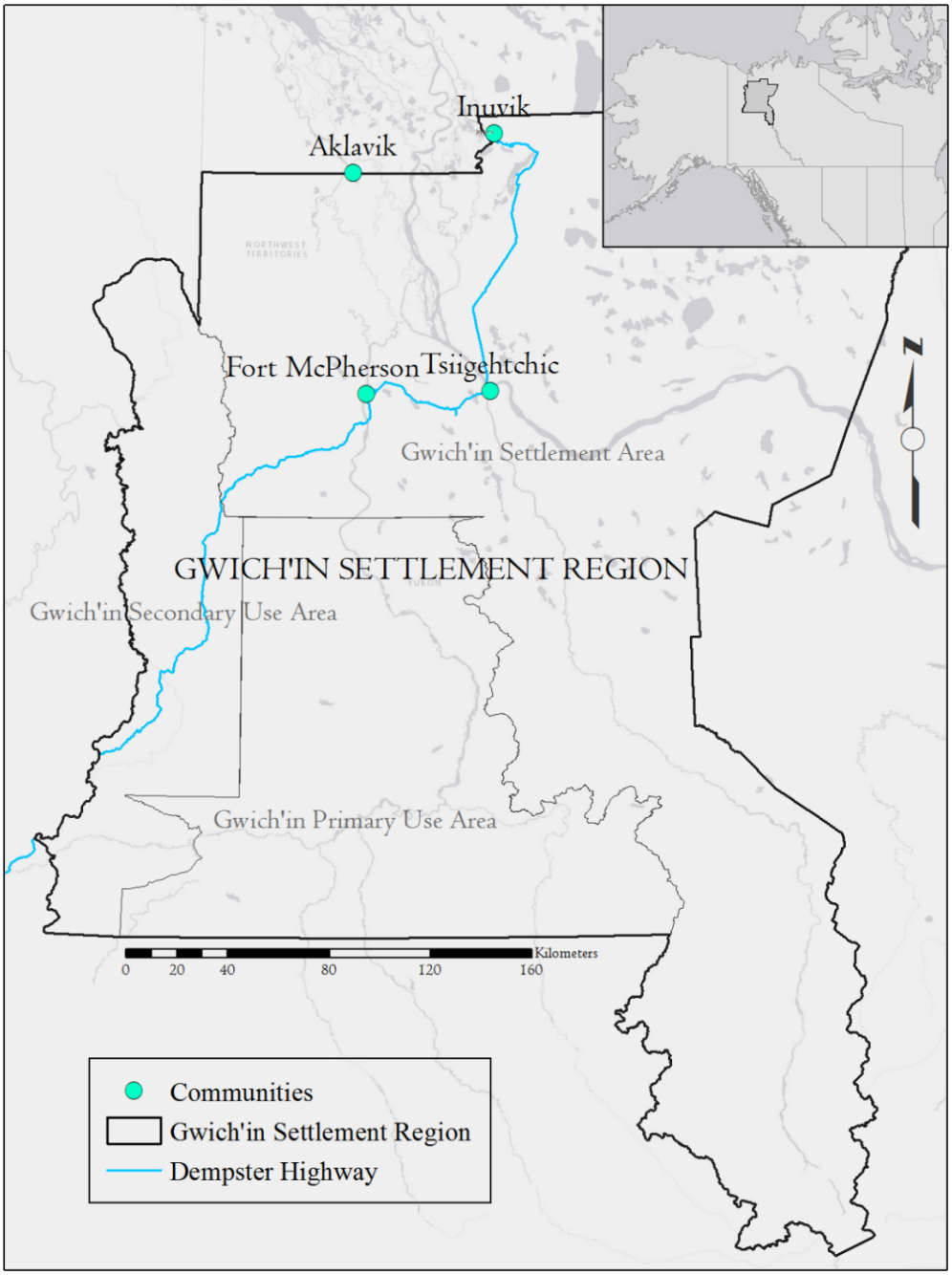

Figure 3.1: Map of the Gwich'in Settlement Region, showing the Gwich'in Settlement Area, Primary Use Area, Secondary Use Area, and communities of Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic.

Methods

Background

This research was guided by principles central to several Indigenous methodologies, including: centralizing local values and priorities, valuing and cultivating relationships, and recognizing the critical nature of the land for community members and research (Absolon, 2011; Edosdi, 2008; Kovach, 2009; Smith, 1999). Our work emerged from previous collaborations between the University of Victoria (UVIC), the Gwich'in Renewable Resources Board (GRRB), and the Gwich'in Tribal Council Department of Cultural Heritage (GTC DCH) (Gill *et al.*, 2014a; Parlee & Maloney, 2017; Turner *et al.*, 2018). UVIC researchers took the lead conceptualizing the research project, and the GRRB and GTC DCH provided key guidance regarding project objectives, interview questions, and logistics. To ensure that the questions explored in this project were consistent with the concerns and priorities of Gwich'in fishers, we conducted six pilot interviews in 2016. Our research focus emerged from our analysis of these interviews, which highlighted the relationship between fishing and well-being, and widespread observations of barriers to accessing fish. To explore determinants of access to fish, and the relationship between access and well-being, we utilized interviews and thematic coding analysis, while prioritizing local youth engagement and knowledge sharing activities.

Interviews

We interviewed 29 Gwich'in community members between July and September, 2017. Interviews lasted about one hour. Most participants were interviewed individually, but six participants were interviewed in groups of two. Participants were recruited with the help of Renewable Resource Council Coordinators and word of mouth in each community, as well as the GTC DCH in Fort McPherson, and the Ehdiitat Gwich'in band office in Aklavik. To include a variety of perspectives, we interviewed 17 individuals who fished regularly, and 12 individuals who did not fish or fished irregularly. Most participants were interviewed in communities (25 total: six in Aklavik, eight in Fort McPherson, five in Inuvik, and six in Tsiigehtchic), and four were interviewed at fish

camps. 16 interviewees were women, and 13 were men. Although we did not ask for participant ages, we estimate that participants ranged in age from 30 to 80 years old.

Interviews followed a semi-structured format to allow for open-ended discussions. Conversations were guided by pre-determined questions, but participants often steered the discussion. This flexibility and fluidity is important within many Indigenous methodologies (Brayboy & Deyhle, 2000; Kovach, 2009). Interview questions focused on participants' personal fishing history, access to fish, and observations of environmental change (Appendix A). Although well-being was central to our research question, we did not refer to this topic explicitly during interviews, but let it emerge where and when it was relevant. Interviews were recorded with a digital audio recorder (Zoom Handy Recorder H2), and/or video camera (Nikon D7000 camera) and transcribed. Each participant was offered a copy of their interview transcript to review for accuracy, and to keep for their records. The majority of participants requested copies, which were delivered during community visits in February, 2018.

Thematic coding analysis

To analyze interviews, we coded them for themes using NVivo software (Version 10). In a first round of coding, the text of each interview was systematically reviewed to identify various themes, including environmental change, factors influencing access to fish, family, place names, animals, land-use activities, and well-being. In subsequent rounds of coding, themes were refined, and organized into three topics relevant to our research: 1) environmental change, 2) access to fish, and 3) well-being.

To track participant observations of environmental change, we coded changes that participants had observed or were concerned about occurring in the future. To organize participant observations about access to fish, we coded portions of each interview that mentioned factors that impede or enhance the ability of Gwich'in individuals to harvest, prepare, consume, and/or distribute fish. This coding focused on socioeconomic barriers and facilitators of access, and environmental barriers to access. Environmental factors facilitating access were not coded, because while participants made it clear that a healthy environment is critical in facilitating access to fish, they typically did not discuss this in enough detail to be coded. To assess if fishing effort was stable or changing, we coded instances where participants described changes in access to fish through time.

To identify aspects of well-being discussed by participants, we coded instances where well-being indicators included in the Assembly of First Nations 'Wholistic Policy and Planning Model' framework were mentioned, based on emergent general criteria (Appendix B) (Reading *et al.*, 2007). To explore the relationship between access to fish and well-being, we used NVivo to identify the sections of each interview where the themes of socioeconomic and environmental determinants of access overlapped with well-being themes.

Knowledge sharing and youth involvement

During this research project, we maintained regular contact with partner organizations, and visited Gwich'in territory a total of five times, for periods of two weeks to two months. We visited the region for initial scoping interviews, for the main interviews and fish camp visits, to deliver newsletters and transcripts, to touch base with participants and partner organizations, to help organize a high school visit in Fort McPherson, to attend Renewable Resource Council or GRRB meetings, and to hold community meetings to discuss results. Throughout data collection in August 2017, we visited three established fish camps near Fort McPherson, and one near Aklavik (Figure 3.2). These visits brought together researchers, youth, and land users to discuss this research project, and provide a land-based context to this work that increased experiential understandings of fishing in Gwich'in territory. These trips also provided the opportunity to briefly employ six young adults (two from Fort McPherson and four from Aklavik). These youth participants received training in digital SLR cameras and audio recorders, and were given the opportunity to photo and video-document fish camp activities and assist with interviews. Fish camps also provided youth with opportunities to spend time on the land with elders and helped facilitate knowledge sharing between generations, the importance of which has been well documented in the region (Aporta *et al.*, 2014; Bennett & Lantz, 2014; Gill *et al.*, 2014a; Turner *et al.*, 2018).

Figure 3.2: Photos from fish camp visits in Gwich'in territory: A) Aerial view of a camp near Aklavik (*Photo - Kiyo Campbell*), B) Abe Stewart (Fort McPherson interview participant/fish camp owner) checking his net on the Peel River (*Photo - 2017 Peel fish* camp *participant)*, C) William Tyrrell (Aklavik youth participant) cutting a fish to make dry fish *(Photo - Tracey Proverbs)*, D) Fish drying for consumption at Mary Effie Snowshoe's fish camp on the Peel River *(Photo - Tracey Proverbs)*.

Results

"It is Gwich'in:" the importance of access to fish

Our interviews highlighted the fundamental role of harvesting, preparing, consuming, and distributing fish for community members in Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic. All participants described fish as an important food and a central aspect of Gwich'in culture. One anonymous interview participant illustrated the innate connection between fish and Gwich'in identity by simply saying: "It [fishing] is Gwich'in." Elizabeth Vittrekwa (Fort McPherson) also described the broader spiritual, cultural, social, and dietary importance of fish:

> [Not having fish would be] like, killing part of our spirit I guess, because . . . the majority of the community rely on fish. And, when you have cook outs here you're going to see fish. And that's good because some people may not

> have that access to fish too so . . . if we didn't have access that's, again killing us I guess.

Participants also described the importance of respecting fish. Practices like frequently checking nets and keeping a clean camp were emphasized, as well as a general conservation ethic described by David Thompson (Fort McPherson): "Well people always say take only what you need. It works for me! I just take what I need and then leave it."

"They just enjoy being out there:" fish and well-being

Throughout our interviews, it became clear that accessing fish is important for well-being for Gwich'in individuals. Participant responses indicated that access to fish influences 19 of the 22 well-being indicators that we examined from the Assembly of First Nations framework (Table 3.1) (Reading *et al.*, 2007). Participants mostly noted instances where sustained access positively influenced indicators, and cases where limited access negatively influenced indicators.

Some of the most frequently cited well-being indicators related to physical health benefits of fish, as well as knowledge transmission. The importance of fish for physical health often emerged in a roundabout way, when participants discussed the possibility of *not* being able to access fish:

> I think we'll starve [if we couldn't get fish]. We'll go hungry for sure for a few days out of a month, because the store food, you could eat it for maybe two weeks and then you'll just, you can't eat it anymore. You just don't want it. It sort of makes you sick. So, really eating our wild food [is better] (Anonymous participant).

Knowledge transmission was regularly discussed in relation to life-long learning about fishing practices, or teaching others. Learning to fish as a child was often attributed to continued enjoyment of fishing:

> I was wee little [when I learned to fish]! Annie B. used to take me jiggling when I was one, would put me between the sled and take me across the river . . . [I would] sit there with a hook. I guess that's why I still enjoy it nowadays (Anonymous participant).

Table 3.1: Well-being indicators from the Assembly of First Nations Wholistic Policy and Planning Model discussed in interviews. The positive columns display instances where participants discussed the indicator being positively influenced by access to fish, and the negative columns display instances where participants discussed the indicator being negatively influenced by decreased access to fish.

Well-being indicator	No. of participants who discussed		No. of times discussed	
	Positive	Negative	Positive	Negative
Life-long learning	29	17	119	29
Community	29	7	120	9
Lands and resources	28	26	200	203
Environmental stewardship	27	8	48	10
Employment & economic development	27	5	83	8
Physical health	26	17	71	40
Economic health	26	4	71	8
Languages, heritage, and culture	25	13	79	24
Social health	25	4	54	5
Housing	18	3	32	3
Self determination	18	2	27	2
Cultural health	16	6	36	16
Environmental health	14	19	20	28
Urban and rural	13	8	19	8
Health care	9	—	10	—
Emotional health	6	1	7	2
Mental health	6	1	6	2
Social services	6	—	6	—
Spiritual health	2	—	2	—

"Now nobody goes out:" changes in access through time

Most interview participants described changes in fishing practices through time (Table 3.2). 28 of 29 participants noted decreased access to fish, which they related to catching fewer fish and/or going on the land less:

> The first two weeks in July. There was hardly anything. Like I told you we had the one net out. Usually we have only one [net], and there's enough fish. But we had four [nets] in. And sometimes you only get like four or five fish . . . . we experienced this twice now [in 2016 and 2017] (Anonymous participant).

Participants also made it clear that reduced access to fish negatively influences well-being. In 92% of the instances where participants discussed decreased access to fish,

they also mentioned the negative impact it had on well-being. Mary Effie Snowshoe (Fort McPherson) linked decreased access to traditional foods with decreased physical health:

> Those days, people ate a lot of fish and, ate a lot of berries off the land. Everything was off the land. And, we never heard of cancer. Nobody was sick. Even old people would be out there on the land. And, never hear of anybody being sick. But now, nobody's out on the Peel [River] fishing, and, a lot of people are sick. So I think, our traditional food is very healthy.

Table 3.2: Changes to fish access through time.

Changes in access through time	No. of participants who discussed	No. of times discussed
Decreased access	28	154
Increased access	24	35
Altered access (direction not specified)	23	59

"If I can't get fish, I'm not going to be too happy about it:" factors influencing access

Our interviews showed that both socioeconomic and environmental factors influence access to fish, with implications for well-being. Participants' observations of decreased access were linked to 16 socioeconomic barriers, and 13 environmental barriers (Table 3.4). However, interviewees also discussed 16 socioeconomic factors that facilitated access to fish (Table 3.4).

Access Barriers

Participants mentioned many barriers to accessing fish that negatively influenced well-being. A wide variety of observations of environmental change and concerns about future change were discussed (Table 3.3). Many of these changes manifested as environmental access barriers, the most frequently cited of which included concerns about fish health, river morphology change, and irregular water levels (Table 3.4). Several of these changes were described as unprecedented disruptions to a cycle of land use synchronized to the seasons that Dwayne Semple (Aklavik) described as "just like clockwork" until recently. A number of participants also expressed concerns about the

impacts of environmental change on aspects of well-being like environmental and physical health:

> You don't know how, like… when fish are going to be turned bad . . . we go to Yellowknife and around there and we see a lot of people. Like I know a lot of people from way back there. And now they can't even fish around their community. The fish is… full of that mercury (Anonymous participant).

Participants also discussed several socioeconomic factors making it harder to get fish. Socioeconomic barriers like cultural change, limited fishing knowledge, and high cost (Table 3.4) had a negative influence on well-being indicators like lands and resources, physical health, and environmental health (Table 3.1). For example, Archie Norbert (Tsiigehtchic) discussed cultural change altering aspects of well-being like traditional land use:

> It's not like the old days. The old days everybody was raised on fishing in the fall and all summer. Hunting in the fall. Moose, caribou, whatever. So you know, we were raised that [way], but nowadays we're not. Now it's [formal] education. And, we're losing our language, we're losing, the old traditional ways.

Access Facilitators

Ultimately, our participants' observations demonstrated the continued importance of access to fish for well-being. While all participants described barriers that can make it challenging to get on the land, they also emphasized that they can still access fish: "No, no, no. It doesn't matter what it cost me, I'll still try to make it out there [to my fish camp]" (Mary Effie Snowshoe, Fort McPherson). Multiple factors help Gwich'in individuals get fish, including family, sharing networks, and several other socioeconomic facilitators (Table 3.4). These factors ensure continued access to fish, while positively influencing well-being indicators like lands and resources, community, and life-long learning (Table 3.1):

> My mother-in-law goes out fishing, on her holiday, like her camp is set up down the river and she does fish, so that's an opportunity for us to go down and, you know, share the knowledge with us. So that's really good (Jamie Benoit-Cardinal, Tsiigehtchic).

Many of the access facilitators described by participants were traditionally important, such as sharing fish:

> It's the Gwich'in way, if you have enough and that, you should be sharing . . . because a long time ago, that's what they did, and I think those are kind of the things that need to be carried on (Margaret Gordon, Inuvik).

While embracing traditional ways of getting fish, participants also discussed more contemporary access facilitators, such as modern equipment, and selling or buying fish. While selling fish was widely acknowledged as a recent practice that was not part of the traditional Gwich'in economy, it was generally accepted:

> I don't see that, there's nothing wrong with that [selling fish] because, it's their way of getting income and helping out . . . and people are willing to pay for it. Like, we have a hard time getting a fish, so I know, I have to go and buy a fish and you know, I don't mind that. It's helping out and they're helping me too (Anonymous participant).

Participants also discussed efforts to monitor fish populations in the face of environmental changes and barriers. Our participants generally expressed happiness that Gwich'in community members and organizations were involved in organizing these efforts: "We're doing this [community-based whitefish monitoring] study, which is really good, really important" (Alice Vittrekwa, Fort McPherson).

Table 3.3: Environmental changes and concerns observed by interview participants.

Environmental change theme	Environmental change sub-theme	No. of participants who discussed	No. of times discussed
River & lake	River morphology*	24	46
	Water levels*	23	40
	Water quality	19	40
	Eddies and current*	11	11
	Ice dynamics	11	18
	Water temperature	10	10
Climate and weather*	Air temperature	20	39
	Climate & seasonal change	17	28
	Storm and wind	10	11
	Precipitation	7	9
Fish health*	Soft fish	13	18
	Amount of fish	12	21
	Internal physical issues	11	12
	External physical issues	10	20
	Fish migration*	8	12
	Spawning*	5	7
Landscape change	-	13	18
Anthropogenic development	Transportation	10	15
	Oil, gas & mining development	7	9
	Other anthropogenic development	6	8
	Garbage & pollution	5	4
Vegetation	-	7	8

* These themes were asked about explicitly in interview questions.

Table 3.4: Facilitators and barriers to accessing fish mentioned by participants. Access facilitators are determinants that increase access to fish, and access barriers are determinants that impede access to fish. Most of the access barriers represent a lack of the determinant, for example, a fishing knowledge barrier represents limited knowledge of aspects of fishing. However, the barriers of cultural change, technology, fear, and personal tragedy directly limit access. Many of these factors positively or negatively influenced indicators of well-being.

Theme	No. of participants who discussed		No. of times discussed	
	Facilitators	Barriers	Facilitators	Barriers
Socioeconomic determinants of access				
Fishing knowledge*	29	18	150	46
Access through others*	28	—	141	—
Equipment*	26	18	66	43
Place to fish on the land*	29	13	71	15
Monetary wealth/cost*	12	22	13	42
Cultural change	1	19	1	55
Time to get on the land*	14	13	18	26
Organizations*†	20	—	34	—
People to fish with	12	5	14	6
Regulations and licensing*	11	5	10	10
Fish storage	8	2	16	2
Health	—	10	—	17
Like fish/working with fish	3	6	7	10
Open access~	8	—	11	—
Older age	—	6	—	10
Necessity	1	4	4	5
Self-motivation	3	—	5	—
Technology	2	2	1	2
Fear	—	2	—	2
Personal tragedy	—	2	—	2
Environmental determinants of access				
Fish health*	—	22	—	58
River morphology change*	—	20	—	30
Water levels*	—	18	—	30
Water quality	—	13	—	26
Anthropogenic development	—	12	—	19
Weather conditions*	—	11	—	15
Air temperature	—	10	—	15
Eddies change*	—	7	—	7
Water temperature	—	6	—	5
Vegetation change	—	5	—	6
Ice dynamics	—	5	—	5
Permafrost thaw	—	3	—	4
Wildlife	—	3	—	3

* These themes were asked about explicitly in interview questions.
† The organizations determinant of access represents Gwich'in and other governmental organizations. For example, several participants spoke about Renewable Resource Council programs helping them access fish.
~ The open access determinant of access represents observations that everyone in Gwich'in communities is encouraged and able to access fish.

Discussion

The importance of fish for well-being

Fishing practices are a central component of the Gwich'in social-ecological system. Our interviews showed that fishing practices contribute to well-being by influencing multiple aspects of health, sustaining connections with the land, and facilitating knowledge transmission. Participants stressed the positive influence of fish on physical health (Bersamin *et al.*, 2007; Blanchet *et al.*, 2000; Kuhnlein *et al.*, 2009), but more frequently cited aspects of well-being connected with Gwich'in cultural traditions: travelling and harvesting on sacred lands and waters (Alexie, 2015; Andre, 2006; Slobodin, 1962), learning and teaching between generations (Andre, 2006), and building and maintaining community through resource sharing (Parlee *et al.*, 2005; Wray & Parlee, 2013). By providing an important food source while promoting land use, community connections, and knowledge sharing, the benefits of access to fish include, but also transcend, nutrition values to incorporate broader benefits. These findings align with past research highlighting the importance of traditional food systems for well-being as well as food security (Collings *et al.*, 2016; Lambden *et al.*, 2007; Searles, 2002).

Barriers to accessing fish

Our interviews showed that environmental change is creating barriers to accessing fish that negatively influence well-being, as has been described in other regions (Cunsolo Willox *et al.*, 2015; Parlee & Furgal, 2012; Petrasek MacDonald *et al.*, 2015; Tobias & Richmond, 2014). Changes described included processes related to anthropogenic development and climate change (Cameron & Lantz, 2016; Gill *et al.*, 2014a; Segal *et al.*, 2016), which manifested as impacts that can make it harder to get fish, like changes in water quality, water levels, or river morphology. These barriers can directly affect fish health and abundance (Roe, 2003; Walker & Simmons, 2018), but can also decrease community members' abilities to harvest on the land, and consume or prepare fish (Guyot *et al.*, 2006; Lawrence, 2009). Uncertainty about future environmental conditions expressed by many participants may also intensify negative influences on well-being by impacting mental and emotional health (Cunsolo & Ellis, 2018; Cunsolo Willox *et al.*, 2015; Hayes *et al.*, 2018).

In addition to environmental change, our analysis showed that social, cultural, and economic factors can result in barriers to accessing fish, with implications for well-being. Cultural changes that make it difficult to access fish were frequently described, such as eroded knowledge of fishing practices like setting nets, preparing fish, and choosing camp locations. Many participants discussed these barriers in relation to changes stemming from colonial policies, including residential schools, and lifestyle changes associated with introduction to the wage economy and permanent settlements. Interviews also showed that, by affecting livelihoods, diet, and cultural traditions central to Gwich'in identity, reduced access to fish negatively influences well-being (Alexie, 2015; Andre, 2006; Slobodin, 1962). These findings echo previous research showing that changes in livelihood and land-based knowledge, and decreased language use negatively impact well-being in other Indigenous communities (Biddle & Swee, 2012; Kuhnlein & Receveur, 1996; Turner, 2006b). Overall, the combination of social and ecological changes was described as creating barriers to accessing fish, culminating in fewer people out on the land and negative effects on well-being.

Cultural institutions that sustain Gwich'in fishing practices

Despite reduced access, fishing remains integral in Gwich'in communities. Our analysis suggests that multiple social, economic, and cultural processes related to sharing networks and adaptive practices are sustaining access to fish in the face of social-ecological stressors. Sustained access fosters many of the well-being benefits linked to accessing fish. The most prominent facilitators discussed in our interviews related to sharing networks, such as gifting fish, learning with a mentor, borrowing equipment, or utilizing a relative's fish camp. Participants often described benefits of these facilitators for aspects of well-being like physical health, heritage, and culture. Local food sharing networks, without imposition by external elements, can be described as self-organizing processes (Biggs *et al.*, 2015), which are important in resilient land use activities (Abel *et al.*, 2006; Berkes & Turner, 2006; Biggs *et al.*, 2015) and have been shown to contribute to well-being across Indigenous communities in North America (Baggio *et al.*, 2016; Collings *et al.*, 2016; Natcher, 2009). Additionally, the use of both traditional and modern fishing practices in Gwich'in communities represents adaptation that likely contributes to the continued importance of accessing fish. Participants frequently discussed traditional

land use values and fishing practices like sharing, while also incorporating modern facilitators like newer equipment. This response to change likely plays a role in the evolution of fishing practices and continuing ability to access fish.

Gwich'in communities are engaged in co-management and education programs that encompass sharing networks and adaptations that are likely to continue strengthening fishing systems. These efforts include fish monitoring programs such as the Rat River Char Monitoring program and a recently started community-based whitefish monitoring program (Armitage *et al.*, 2011; Harwood *et al.*, 2009; Scott, 2018), as well as land-based education like the new *Ganahghootr'onatan* – Teetł'it Land Based Learning Project and past land-based science camps (Ganah Khoonatan - Teetl'it Land Based Learning Project, 2018; Kritsch & Andre, 1997). Both ecological monitoring and land-based education centre social and sharing networks and adaptation by disseminating scientific and traditional knowledge about fish populations and traditional and modern land-use practices (Armitage *et al.*, 2011; Berkes *et al.*, 2009). The pace of ongoing social and environmental change underscores the importance of existing programs to monitor fish and facilitate intentional, intergenerational knowledge transfer.

Taken together, our results suggest that social, economic, and cultural factors facilitate access to fish and bolster aspects of Gwich'in well-being. Sustained access to fish in spite of increased barriers can be described as resilience, "the natural, human capacity to navigate life well" (HeavyRunner & Marshall, 2003), "to be ready" or "to never give up" (Inuvialuit elders in Rawluk, 2012, p. 69), or "to be strong" (Gwich'in elders in Rawluk, 2012, p. 69). While uncertain future changes in Gwich'in territory have the potential to push the factors enabling Gwich'in fishing practices outside of their typical ranges of variation, the combination of positive feedbacks between access to fish and well-being, and a diversity of processes that sustain access indicate that Gwich'in fishing livelihoods will continue to be strong.

The importance of understanding determinants of access to traditional foods and well-being

Examining socioeconomic and environmental drivers of access to fish, and their relationships with well-being that were documented in our case study, builds on previous work illustrating relevant, contextual indicators of well-being for northern communities

(Parlee & Furgal, 2012; Parlee & O'Neil, 2007; Petrasek MacDonald *et al.*, 2015; Robertson & Ljubicic, 2019). Highlighting common and intersecting barriers to accessing fish, like limited fishing knowledge and concerns about fish health, and common facilitators of accessing fish like learning from other people, is an important step in enhancing fishing practices that could guide programs aiming to strengthen connections with the land and well-being. As discussed above, several programs in Gwich'in territory are working to overcome barriers to accessing fish like limited fishing knowledge, by promoting learning through others and providing a camp and necessary land use equipment through land-based education (Ganah Khoonatan - Teetl'it Land Based Learning Project, 2018), while others are addressing barriers like concerns about fish health through ongoing fish monitoring programs (Armitage *et al.*, 2011; Scott, 2018). Continued evaluation of determinants of access to traditional foods could contribute to these efforts if new barriers or facilitators arise, and similar examination of determinants of access to traditional foods and their relationship with well-being could guide programming in other regions.

The link between access to traditional foods and well-being also makes it clear that land use decisions must consider the role of access to traditional foods in enhancing well-being (Parlee *et al.*, 2005; Sangha *et al.*, 2015; Tobias & Richmond, 2014). Some planning processes are working to incorporate local well-being indicators into decision making (Gilani *et al.*, 2018; Marine Plan Partnership for the North Pacific Coast, 2017; Rubus EcoScience Alliance, 2007), but many land use decisions prioritize resource developments that limit access to traditional foods (Baird *et al.*, 2015; LaDuke, 2005; Parlee *et al.*, 2018). The Gwich'in continue to collaborate with neighbouring Indigenous groups to limit development in the upper Peel Watershed, which could cause barriers to accessing traditional foods like fish and caribou (Parlee *et al.*, 2018; Stantec Consulting, 2019; Staples *et al.*, 2013). Our research indicates that, because access to fish is intimately intertwined with well-being for Gwich'in community members, changes in access caused by resource development have consequences that extend beyond the need to find a different food, and include severe impacts to identity and culture.

Similar to northern Canada, river systems around the world are experiencing changes related to environmental pollution, dams, and industrial activities like oil and gas

developments (McCreary & Milligan, 2014; Molle et al., 2009; Walker & Simmons, 2018), which can affect access to traditional foods like fish (Finley-Brook & Thomas, 2010; Roe, 2003; Sarkkula et al., 2009; Yakovleva, 2011). Our study suggests that local consultation and engagement can identify social-ecological factors that influence the ability of people to access fish or other traditional foods, and gain well-being benefits from this access. While there are broad similarities between Gwich'in territory and other watersheds experiencing change, regional or local analysis is critical to understand local determinants of access to fish or other traditional foods, and how they relate to well-being. Like our research in Gwich'in communities suggests, insights into the influence of access to traditional foods on well-being could contribute to activities like land use planning that enhance multiple aspects of well-being by conserving areas that provide access to traditional foods, or guiding the focus or creation of land-based programs that seek to overcome common barriers to accessing traditional foods.

Conclusion

The interviews and analysis presented here show that access to fish makes a vital contribution to well-being in Gwich'in communities in spite of ongoing social-ecological changes. Despite declines in access to fish resulting from socioeconomic and environmental barriers, everyone that we spoke with continues to value, utilize, and/or share fishing practices in ways that foster well-being, and Gwich'in culture and identity. Access to fish is sustained through a variety of social, cultural, and economic factors related to social networks and adaptive practices, which are embodied in ecological monitoring and land-based education. These processes are likely to foster access to Gwich'in fishing practices in the face of future changes by facilitating knowledge transmission about fishing practices and fish health. Illustrating socioeconomic and environmental drivers of access to fish as well as the relationship between access to fish and well-being builds on understandings of well-being relevant for Indigenous communities, with the potential to guide programming efforts and inform land use decision making in Gwich'in territory and other global river systems.

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Appendix A: Fishing livelihoods interview questions

Changes to fish and fishing livelihoods

Icebreaker questions and questions about personal fishing history

- What is your name, and where do you live?
- Are fish and fishing important to you? Do you think fishing is an important part of being Gwich'in?
    - Why or why not?
- Do you go fishing regularly?
    - How many days a month have you fished in the last year (in spring, summer, fall, winter)?
    - How old were you when you started fishing?
    - Who taught you how to fish?
    - What type of fish do you catch (in spring, summer, fall, winter)? Which fish do you primarily target?
    - How many days a month do you eat fish?
- If not, did you fish regularly in the past?
    - How many days a month would you fish in the year that you did the most fishing (in spring, summer, fall, winter)? When was this?
    - How old were you when you started fishing? How old were you when you stopped?
    - Who taught you how to fish?
    - Do you now get fish to eat from other people? What types of fish (in spring, summer fall, winter)?
    - How many days a month do you eat fish?
- If you have never fished regularly, do you get fish to eat from other people? How?
    - How many days a month do you eat fish?
    - What types of fish do you eat (in spring, summer, fall, winter)?
    - Do you want to go fishing?
- Do you fish (or eat fish) the same amount, less, or more than you did when you were ten years old? 20? 30? 40? (or other ages, depending how old the person is).

- Do you catch the same amount and same species that you did 10 years ago? 20? Etc. Same amount in different seasons? The same amount of each target species?
    - If it's different, why do you think this might be? Any changes that could be affecting fish?
- Do you use the same equipment that you used 10 years ago? 20? Etc.
- Do you hunt and/or trap other animals?
    - If so, what kinds and how many days per month in the past year (in spring, summer, fall, winter)?
- Do you eat fish more than other meat, less, or the same amount? Has this changed over time (past x number of years)?
- Do you think that fishing and eating fish is more important, less important, or has just the same importance as hunting/trapping and eating other animals?

Questions about access to fish and fishing

General questions about access to fish and fishing

- Are you able to go fishing or get fish to eat if you want to?
    - Why? Why not?
- What do you need in order to access fish to eat, and/or to go fishing?
- Are there any barriers preventing you from fishing and/or getting fish to eat? If so, what are they?
- Has access to fish to eat and/or to fishing changed for you over your lifetime?
        - If something has changed, when did this change occur?
        - If so, what do these changes mean for you (i.e., food, well-being, way of life, passing of knowledge, etc.)?
- What would it mean for you if you could not get fish to eat and/or go fishing anymore?
- If you could change anything about fishing or food fish in your community, what would you change?

Questions addressing specific barriers to accessing food fish and fishing

- If you wanted to go fishing, do you have a place on the land to fish (i.e. fish camp)?
    - If so, how long have you fished there?
    - If not, did you used to? When did you stop going there?
- If you wanted to go fishing, do you have the equipment you need to fish? (i.e. you own it, share it, borrow it - nets, boats)
    - If so, have you always had access to the equipment you need?
    - If not, have you ever had access to this equipment? When did you stop?
- If you wanted to go fishing, do you know people who would fish with you?
    - If so, have you always had people to fish with you?
    - If not, did you ever have people to fish with you? When did this stop?
- If you wanted to go fishing, do you have time to get out on the land and fish?
    - If so, have there been times where you haven't had time?
    - If not, did you used to have more time? What is taking up your time in town or a city so that you don't have time to get on the land?
- If you don't fish regularly, do you have the knowledge to go fishing (how to set net, where to go, etc.)?
    - Do you think that knowledge of how to fish is being passed down to younger generations?
- If you want to go fishing, would the cost of fishing affect how much and when you go fishing? (I.e. cost of gas, cost of purchasing and maintaining equipment).
    - If not, has this ever been a factor?
    - If so, has this always been a factor? When did it start?
- Are there organizations that regulate how much people fish, where, how, and when people fish?
    - Do you think this is important? Why or why not?
    - If so, when did this start?

- Do you know about the Rat River char working group? And their voluntary harvest allocations?
- Is anyone in your community allowed to fish?
    - Has this always been the case (if yes or if no)?
- Do you think that who you know or are related to makes a difference in whether or not you can fish out on the land, or get fish to eat?
- Do you think that there are opportunities for people of all ages (kids, youth, adults, and elders) to access fish to eat or to go fishing?
    - Do you think it's important for people of different ages to go fishing and to get fish to eat?
- Do you think that sharing fish with others is an important part of fishing?
- Do you think that selling fish to others is an important part of fishing?
- If you do not fish or eat fish, and are not interested in fishing or eating fish, why is this? (i.e. are there specific barriers? Preference? Cultural shift? Don't enjoy being on the land?).

Questions about changes in fish, rivers, aquatic health

- Are there any environmental changes you've noticed, that you think are affecting fish?
    - Are there environmental changes affecting the way people fish (or where/when they fish)?
- Are there any big changes that have happened in your community over the past 5 years? 10? Etc.
    - If so, do you think these changes affect fish? Do these changes affect the way people fish?
- Have you noticed any changes in the weather that are affecting when and how you can fish?
    - If so, what changes have you noticed? When?
- Have you noticed any changes in areas of the river system where people can travel?
    - If so, what kinds of changes have you observed? When (years/seasons)?

- Can you navigate rivers the same way you used to? If not, what sorts of changes have occurred (i.e. erosion, sand bars)? When?
- Are there some areas that have changed a lot? (Can you show us on a map?) When?
    - Have some of these areas that have changed a lot affected
        - Fish migration/travel
        - Fish access to food
        - Fish spawning
- Do you remember these fishing locations changing seasonally, from year to year or over time?
- If people have stopped fishing in some areas, why did people stop fishing in these areas? When?
- Have you noticed anything about the health of the fish you are catching that is concerning to you? (Are you very concerned, somewhat concerned, not concerned, don't know)? Why? When?
    - **Which fish** are affected?
- Are there places where people never fish now where the fish are considered unhealthy? When?
- Have you noticed any changes in water levels? If so, what have you noticed? When did you notice (years/seasons)?
- Have you noticed any changes in the eddies that people fish in? When?
- Why do you think fish conditions may have changed?
- How should fishing areas be cared for in the future?

- Are there any questions you have about fish that you'd like us to pass on to researchers?
- Is there anything else you think we should know or that you would like to tell us?

Appendix B: Well-being indicators and general well-being coding criteria.

Table A3.5: Criteria that were used to code interviews for well-being indicators. If participants discussed criteria in the "positive influence" column, those observations were coded as positive influences on well-being. If participants discussed criteria in the "negative influence" column, those observations were coded as negative influences.

Well-being indicator	Coding criteria	
	Positive influence	Negative influence
Life-long learning	1. Learning on the land as a child/youth 2. Continual land-based learning 3. Importance of elders as teachers 4. Teaching others land-based knowledge 5. Wanting more opportunities for diverse learning (fish art/cooking) 6. Challenges and opportunities for youth learning on the land 7. Importance of observation in learning 8. Importance of both formal and land-based education	1. Fewer youth learning on the land 2. Lacking fishing knowledge 3. Fishing in incorrect areas 4. Regulations/criminal record checks making it hard to teach on the land 5. Intergenerational impacts of residential schools
Lands and resources	1. Importance of eating fish 2. Importance of hunting and trapping 3. Importance of maintaining the land/trails 4. Socioeconomic facilitators getting people on the land 5. Growing up on the land/living on the land 6. Importance of both formal education and land-based education 7. Importance of being on the land 8. Healing camp	1. Fewer people fishing/living off the land 2. Elders predicting changes to the land 3. Fewer young people getting on the land or eating fish 4. Socioeconomic barriers to getting people on the land 5. Ecological barriers to getting people on the land 6. Challenges in fishing for non-Gwich'in

	9. Importance of elders on the land 10. Land-based rights 11. Enjoying being on the land 12. Land-based knowledge 13. Sharing or trading fish 14. Selling or buying fish 15. Importance of fish to Gwich'in identity 16. Ways of travelling on the land (i.e. dogs, snow machines) 17. Gwich'in land-based values (i.e. respecting fish, checking net) 18. Social events on the land (i.e. fishing derby) 19. The idea that any Gwich'in person can go on the land	
Environmental stewardship	1. Listening to elders 2. Enforcing regulations 3. Protecting the land/concern about development projects 4. Hiring qualified people to do monitoring and research 5. The land is in charge; humans do not control the land 6. Teaching others land-based values 7. Value: Respecting fish (i.e. don't waste, check net often) 8. Value: Looking after places you fish (i.e. keep a clean camp) 9. Value: Take what you need and use all that you can	1. Disrespecting fish (i.e. wasting) 2. Development concerns (i.e. ferries) 3. Lacking fishing knowledge 4. Dirtier environment 5. Fishing in incorrect areas

Employment/economic development/economic health	1. Selling fish to make a living 2. Making time to fish around in-town employment schedule 3. Employment from taking people on the land 4. Fishing important in the past for livelihoods 5. Transition to the wage economy 6. Employment as a monitor 7. Local office helping fishers economically	1. Lack of employment 2. Cost barrier to getting on the land if unemployed 3. Challenges in starting courses getting people on the land 4. Challenges in selling fish from regulations 5. Challenges in keeping fish fresh to sell
Languages, heritage & culture	1. Importance of fish to Gwich'in identity 2. Importance of hunting and trapping 3. Relationship between dog teams and fish 4. Cultural and land-based learning and programs 5. Sharing or trading fish 6. Selling or buying fish 7. “Open door” cabin policy 8. Speaking Gwich’in 9. Importance of fish to Gwich'in values 10. Gwich'in traditional feasts and food 11. Growing up living on the land	1. Fewer elders left 2. Fewer people speaking Gwich'in 3. Fewer people getting on the land, especially young people 4. Lacking fishing and cooking fish knowledge 5. Selling fish (some think fish shouldn't be sold) 6. Intergenerational impacts of residential schools 7. Challenges in getting on the land to practice culture because of cost 8. Regulations/criminal record checks making it hard to teach on the land
Self determination	1. Getting on the land without a fuss 2. Idea that no barriers can stop them (age, cost, time)	1. Rules limiting who can fish 2. Decreased opportunities to just go fish compared to past

	3. Do it yourself attitude (take the opportunity that exists) 4. Learning land-based skills in case of famine or scarcity in future 5. Continual evolution and learning	
Housing	1. Importance of spending time on or living on the land 2. Living on the land as a part of Gwich'in culture 3. Modern housing - different than on the land 4. Passing bush camps down to children 5. Growing up living on the land	1. Erosion threatening/destroying houses on the land 2. Fewer camps being passed down between generations
Urban and rural	1. Important to have access to urban centres for cheaper equipment 2. Splitting time between land and town	1. High cost of land can keep people in town 2. Sickness can keep people in town 3. Younger people staying in town 4. More people in general staying in town 5. Family emergencies keeping people away from fish camp
Health care	1. Traditional medicine 2. Fish as healthy food 3. Healthy lifestyle on the land	None discussed
Social services	1. Funding for youth to study environmental issues 2. Having counselling at fish camp 3. Ability to harvest on land (important because store food is expensive)	None discussed
Gender	None discussed	None discussed
Justice	None discussed	None discussed
On/away from reserve	None discussed	None discussed
Physical health	1. Fish and traditional foods are nutritious	1. Health problems keeping people off the land

	2. Importance of knowledge about the land and fish 3. Fish critical for survival in the past 4. "Not being able to live" without fish 5. Healthy lifestyle on the land 6. Physical safety for kids at camps 7. Spiritual importance of fish 8. Land-based medicines 9. Sharing and trading fish 10. Storing food for winter 11. Enjoying eating fish 12. Gwich'in traditional feasts and food	2. Correlation between eating less traditional food and health problems 3. Older age keeping people off the land 4. Overly smoked fish can make people have heartburn 5. Sand bars can be dangerous 6. "Modern living" can make people lazy 7. Concerns about fish health 8. Getting sick after eating fish 9. Risks to being on the land 10. Young people eating less fish
Economic health	1. Selling fish to make a living 2. Employment 3. Local office helping fishers economically 4. Fishing important in the past for livelihoods 5. Concerns about fish health from industrial activity 6. Making time to fish around work schedule 7. Getting paid to take people on the land 8. Transition to the wage economy	1. Expensive to get on the land today 2. Challenges in securing employment 3. Challenges in selling fish because of regulations 4. Challenges in keeping your fish fresh to sell 5. Challenges in starting courses getting people on the land
Social health	1. Meeting with other fishers and discussing fish 2. Church services on the land in the past 3. Looking out for each other on the land 4. Importance of fish to Gwich'in identity	1. Challenges in bringing people on the land 2. Challenges in getting fish for a feast due to decreased catch

	5. Selling or buying fish 6. Sharing and trading fish 7. Gwich'in traditional feasts and food 8. People helping each other get on the land to practice culture & values 9. Cultural and land-based learning and programs 10. Visiting with lots of people on the land in the past 11. Having (access to) a camp to gather and practice culture	
Cultural health	1. Importance of fish to Gwich'in identity 2. Importance of fish to Gwich'in values 3. Gwich'in traditional feasts and food 4. Recognizing elders who teach Gwich'in culture 5. Having (access to) a camp to gather and practice culture 6. Cultural and land-based learning and programs 7. Importance of kids knowing Gwich'in traditions 8. Knowing your culture can get you on the land 9. People helping each other get on the land to practice culture & values 10. Programs teaching people to cook traditional foods 11. Bartering system a part of the culture 12. Sticking to fishing traditions 13. Growing up living on the land	1. Lacking fishing knowledge 2. Cultural change 3. Fishing in incorrect areas 4. Intergenerational impacts of residential schools 5. Fewer young people learning cultural skills on the land 6. Selling fish (some think fish shouldn't be sold) 7. Regulations/criminal record checks making it hard to teach on the land

Environmental health	1. Value: Respecting fish (i.e. don't waste, check net often) 2. Value: Looking after places you fish (i.e. keep a clean camp)	1. Concern about roads, erosion and pollution getting into rivers 2. Throwing away soft fish instead of giving it to dogs 3. Concern about fish health 4. Lacking fishing knowledge 5. Observations of "dirtier" environment 6. Concern about sediment from ferries 7. Concern about upstream development
Emotional health	1. Sharing fish with elders making them happy 2. People feeling good at fish camps 3. Kids like going to fish camp 4. Idea to have counselling at fish camp	1. Family emergencies keeping people away from fish camp 2. Health problems keeping people off the land
Mental health	1. Strong mental health of ancestors 2. Less stress at fish camp 3. People feeling good at fish camps	1. Family emergencies keeping people away from fish camp 2. Health problems keeping people off the land
Spiritual health	1. Spiritual importance of fish 2. Church services on the land in the past	None discussed
Community	1. Helping each other get on the land to practice culture & values 2. Meeting with other fishers and discussing fish 3. The idea that any Gwich'in person can go on the land 4. Communities adapting to changes they observe	1. Challenges in getting on the land to practice culture because of cost 2. Challenges in getting fish for a feast due to decreased catch 3. Throwing away fish instead of giving it to people who would use it 4. Regulations/criminal record checks making it hard to teach on the land

	5. Having (access to) a camp to gather and practice culture 6. Cultural and land-based learning and programs 7. Fishing derbies 8. Sharing and trading fish 9. Selling or buying fish 10. Gwich'in traditional feasts and food 11. Sharing values together 12. Borrowing equipment 13. Fishing with friends and family 14. Educational training for young people	5. Lacking interest in land-based programming 6. Fewer young people listening and learning 7. Cabins eroding away

Chapter 4 - Conclusion

Summary

The combined effects of environmental and socioeconomic changes are impacting subsistence livelihoods globally (Baird et al., 2015; Tenza et al., 2017; Walker & Simmons, 2018; Willow, 2017). In northern environments, paired social-ecological change is occurring in ecologically and culturally significant landscapes (Andrews et al., 2016; Pearce et al., 2011; Walker et al., 2011). For example, in the territory of the Gwich'in First Nation in northwestern Canada, rapidly increasing air temperatures, thawing permafrost, and increasing layers of anthropogenic development are happening in conjunction with social, economic, political, and cultural changes that have been occurring since the arrival of European missionaries, traders, and settlers in the mid-1800s (Alexie, 2015; Andre, 2006; Gill et al., 2014; Segal et al., 2016; Turner et al., 2018). Although Gwich'in identity remains deeply connected with the land through harvesting practices like fishing and widespread cultural features, linked social-ecological changes have affected aspects of Gwich'in livelihoods (Parlee et al., 2018; Turner et al., 2018; Wishart, 2014). With the accelerated pace of change in the north (AMAP, 2019; Lewkowicz & Way, 2019; Porter et al., 2019), it is important to examine the cumulative impacts of social-ecological changes on Indigenous culture and livelihoods, as well as ways to manage or mitigate them.

The overall goal of my MA research was to increase our understanding of the impacts of social-ecological changes in Gwich'in territory. To do this, I used a suite of methods to conduct two independent, but linked, projects that examined social-ecological change and land use at different temporal and spatial scales. In one project, I explored the potential of spatial overlay analysis to quantify and map: a) cultural feature intensity, b) cumulative environmental disturbance, and c) overlap between disturbances and cultural features (Chapter 2). In the second project, I conducted semi-structured interviews with 29 Gwich'in community members to document and discuss social and environmental determinants of access to fish, the relationship between access to fish and well-being, and observations of environmental change (Chapter 3). In this chapter, I provide a summary of the overall findings of my research, highlight insights from the combination of

Chapters 2 and 3, and discuss challenges and future research opportunities associated with my research.

The research presented in Chapter 2 examined the question: What are current impacts of environmental disturbances in the Gwich'in cultural landscape? and demonstrated that spatial overlay is a straightforward and effective means to assess cumulative environmental impacts in a cultural landscape. This method to assess the overlap between disturbances and cultural features provides one step to more comprehensively include cultural features in cumulative impact assessments, responding to calls for greater inclusion of cultural components in cumulative impacts research. Exploring the density of cultural features as an initial step in this analysis helped me understand the cultural landscape by providing insight into patterns of cultural use and illustrating that Gwich'in territory is a fundamentally cultural landscape. The next step illustrated disturbances in the GSR, and showed that current environmental disturbances are diffuse and largely low intensity, with small pockets of higher intensity impacts concentrated around permanent settlements. Overlaying cultural feature and environmental disturbance data in the final step helped me tie the first two steps together to answer my question, and revealed that cumulative environmental impacts in Gwich'in territory are causing low to moderate levels of overlap and potential cultural impact between cultural features and disturbances, with large areas containing no overlap.

The interviews and fish camp visits discussed in Chapter 3 helped me examine one of the land uses associated with cultural features in Chapter 2, fishing practices, by exploring how access to fish affects Gwich'in well-being. Interview participants provided insights into determinants of access to traditional foods and well-being by sharing that access to fish is central to Gwich'in identity, and is strongly linked to diverse aspects of well-being. Participants also made it clear that access to fish is decreasing, and identified numerous socioeconomic and environmental barriers to accessing fish which can negatively influence well-being. Despite these changes, everyone that we interviewed can still access fish. Continued access to fish was widely linked to socioeconomic factors, including sharing networks and adaptive practices, which are key aspects of local environmental monitoring and land-based education. The continued access to fish despite barriers discussed by our participants suggests that these factors represent cultural

institutions that enhance the continuation of Gwich'in fishing practices. Insights into drivers of access to traditional foods and well-being not only increase our understanding of wellness in Indigenous communities, but can also provide guidance for land-based programming and land use decisions in communities where social-ecological change is affecting access to traditional foods.

Using multiple methods to understand social-ecological change

My research demonstrates the value of using multiple approaches to examine social-ecological change. Both of my projects were guided by an Indigenous methodology, emerged from regional research priorities, and involved collaboration with local organizations. However, they also differed in their utilization of qualitative or quantitative methods, and their spatiotemporal scale. Because of these differences, insights stemming from solely one of these projects may miss some of the details provided by the other type. When utilized in tandem, the individual strengths and outcomes of each of these projects provide a fuller picture of social-ecological change in Gwich'in territory, which can contribute to informed decision-making.

My MA research shows that utilizing both quantitative and qualitative methods that incorporate scientific indicators and traditional knowledge can provide insights into social-ecological change at multiple scales. My spatial analyses relied on scientific methods that quantified data to illustrate cumulative environmental impacts in the cultural landscape. This approach allowed me to observe patterns of land use and impacts across the entire GSR. By utilizing data representing anthropogenic disturbances and cultural features that span multiple generations, these methods offer insights into broad patterns of land use and cumulative impacts that are relevant to cultural heritage and land use managers. These methods also included disturbances that were not mentioned in our interviews, including the recently constructed Mackenzie Valley Fibre Link. Gwich'in knowledge was also central to both of my projects, forming the basis of the cultural feature data I analyzed quantitatively In Chapter 2, and the backbone of the interviews discussed in Chapter 3. The interviews highlighted in Chapter 3 were designed to qualitatively explore observations of social-ecological change and knowledge about fishing practices at a finer scale. These discussions provided the opportunity for

participants to share observations that they deemed relevant. Participants described various areas of Gwich'in territory and periods of history, but typically focused on finer scales (specific locations, changes, and recent time periods). The detailed information shared through observations and stories in interviews also reiterated that, though they were presented quantitatively, the cultural feature data in Chapter 2 embody dynamic connections between communities and the land. Interview participants also shared observations of environmental change that were not included in our spatial analysis, including impacts of climate change on fishing practices and concerns about upstream contaminants. Both of these projects also illustrated that change in Gwich'in territory is likely to continue.

Incorporating both traditional knowledge and Western science was important in my thesis, and is increasingly important in other communities and disciplines. Indigenous communities have long stressed the value, validity, and imperative of highlighting traditional knowledge in education and research with Indigenous communities (Bishop, 1998; Kirkness & Barnhardt, 1991; Smith, 1999). The generation, transmission, and protection of traditional knowledge is increasingly recognized and celebrated in the wider scholarly community (Berkes, 2009; Parlee et al., 2018), utilized in decision making in many regions including the GSR (Armitage et al., 2011; Berkes et al., 2009), and was the theme of the 2019 United Nations Permanent Forum on Indigenous Issues (United Nations, 2019). Many Indigenous people also advocate for a "best of both worlds" approach to research and education, where different knowledge systems contribute valuable information. This idea was evident in conversations with two of my interview participants, Alice and Ernest Vittrekwa, who described their hopes for Gwich'in youth to learn both traditional fishing practices and scientific fish biology, and is also seen in examples of combining Western and Indigenous knowledge in healing and therapy (Reeves & Stewart, 2015) and biology education (Kimmerer, 2002).

My research also highlights the many ways that Gwich'in communities continue to strengthen their culture and steward their territory, while experiencing significant changes. Chapter 2 highlights information about the Gwich'in cultural landscape that the Gwich'in Tribal Council Department of Cultural Heritage continues to gather and share (Aporta et al., 2014; Gwich'in Social and Cultural Institute, 2016). Sharing information

about harvesting traditions, place names, and history is particularly important for strengthening Gwich'in culture in the wake of negative impacts from colonial policies, and has been described as a counter strategy to negative change (Andre, 2006). Similarly, Chapter 3 mentioned the importance of ongoing monitoring programs that document information about important species and changes on the land (Armitage et al., 2011; Berkes et al., 2009), and land-based education programs that share both traditional harvesting practices and contemporary research opportunities (Ganah Khoonatan - Teetl'it Land Based Learning Project, 2018; Kritsch & Andre, 1997). Monitoring and land-based education programs in Gwich'in territory embody many factors that enhance the sustainability of Gwich'in fishing practices, and taken together, these examples contribute to learning, environmental stewardship, community building, and many other aspects of well-being. By sharing these insights, my research reiterates the value and critical importance of continuing of these initiatives.

Limitations and future directions

Chapter 2

One of the challenges with the research presented in Chapter 2 relates to simplifying complex cultural features to static map data so they can be portrayed across Gwich'in territory. As discussed in Chapter 2, following discussion with cultural heritage experts, we decided to map cultural features based only on their unweighted density on the landscape. While the resulting maps are useful, there is inevitably something lost in the act of plotting locations representing memories, values, and a fundamental relationship between people and place on static maps (Chambers et al., 2004; Chapin et al., 2005; Pearce & Louis, 2008). Additionally, in mapping cumulative impacts, we utilized disturbance weights to attempt to provide a more nuanced representation of the severity and persistence of disturbances. However, like the cultural feature intensity index, the disturbance index is an oversimplification. If the analysis focused on a particular area or landscape component it would be appropriate to modify the disturbance weights to reflect the situation of interest (Tyson, 2015). Additionally, the fast pace of change in northern cultural landscapes (Guyot et al., 2006; Huntington et al., 2017; Michell et al., 2018) suggests that this type of analysis should be repeated semi-regularly.

In doing this, continued consultation with cultural feature experts should occur in Gwich'in territory, to reflect the dynamic nature of cultural knowledge and avoid static representations. Similarly, disturbance weights could be determined with experts (scientists and traditional knowledge holders) to reflect unique impacts in specific regions, or to tailor weights focused on specific ecosystem components.

To provide a basis for comparison, disturbance and cultural feature data should be overlaid in other regions. Since traditional knowledge and conceptualizations of cultural features differ between Indigenous groups (Corsiglia & Snively, 1997; Turner et al., 2000), similar analyses in other regions should include consultation with community members, and local cultural feature experts or heritage organizations. Our experience suggests that consultation with cultural feature experts is critical. Similarly, disturbance weights should be adapted to represent the disturbance impacts specific to different regions or ecosystems, based on the literature, expert consultation, or a combination of those approaches.

Another limitation in Chapter 2 relates to the fact that we did not measure the impact of disturbances on cultural features directly, but assumed that greater potential impacts occurred in PUs with more disturbances and higher densities of cultural features. This approach to overlap analysis provides a regional-scale indicator of potential impacts to the Gwich'in cultural landscape, but not a direct measure of impact. Because of this, I recommend that this research should be followed up with ground-based field work to assess impacts in PUs with high overlap scores. This could be accomplished by combining fine-scale mapping using high resolution imagery with visual inspections (Andrews, 2017; Andrews et al., 2016). As discussed in Chapter 2, these methods should also be used in conjunction with analysis of impacts of environmental changes that do not manifest as disturbances on the landscape (such as increased air temperatures), as well as cultural impacts of disturbances extending beyond impacts of overlapping areas, like social impacts from influxes of temporary workers for development projects (Komarek, 2018; National Inquiry into Missing and Murdered Indigenous Women and Girls, 2019).

Chapter 3

One of the limitations of the analysis presented in Chapter 3 relates to participant sample size and selection. To gain a fuller perspective of the role of fish in Gwich'in

communities, I interviewed people who fish regularly, and those who do not. One consequence of this sampling design is that I may have captured less detailed ecological knowledge than I would have if I had interviewed only experienced fishers. Focusing exclusively on fish may have also limited the breadth of the knowledge included in my interviews. Although interview questions focused primarily on fish, many participants also mentioned land and waters and made it clear that one animal or land use practice cannot be separated from all others. This is similar to many other Indigenous groups that emphasize the interconnectedness of all landscape components (Turner & Berkes, 2006; Turner et al., 2000).

Future research should continue to focus on documenting the relationship between social-ecological change, access to fish, and well-being, but could also be expanded to include multiple subsistence species and cultural traditions. A broader focus would provide more room for participants with a variety of experiences and knowledge to participate, and help to document a wider range of impacts with implications for well-being. Future efforts should continue engaging local youth, organizations, and elders, as including both elders and youth in these sorts of projects is important for intergenerational knowledge transmission and capacity building (Aporta et al., 2014; Turner et al., 2018).

If this research was expanded to explore multiple land uses, identifying common barriers to accessing the land could help monitoring and land-based education programs prioritize their efforts. The connection between access to fish and well-being that our participants discussed demonstrates the continued need for the ecological monitoring and land-based educational programming that the Gwich'in are engaged in. Much, if not all, of this programming in Gwich'in territory already works to overcome many of the access barriers our participants discussed, like high cost, a lack of access to fishing sites, or uncertainty about fish health. These programs also capitalize on factors that strengthen Gwich'in fishing practices, including social networks and adaptive practices. A broader focus on access to multiple subsistence resources would provide insight into whether or not the processes that are both negatively and positively influencing access to Gwich'in fishing practices and well-being are unique, or if they apply to other components of the

Gwich'in social-ecological system. This understanding could spur new focus areas of monitoring or land-based programming, or reinforce the efforts already underway.

Another potential future direction of this sort of work would be to develop a Gwich'in-specific well-being framework which could be incorporated into ongoing land-use planning and management processes. While my research was not aimed at specific land-management goals, different groups are utilizing well-being frameworks in land and resource management. For example, specific well-being indicators and frameworks have been developed with the intention of being incorporated into ecosystem-based management and marine management on the British Columbia coast, to account for the well-being of local communities in land use decision making (Gilani et al., 2018; Marine Plan Partnership for the North Pacific Coast, 2017; Rubus EcoScience Alliance, 2007).

Overall

One overall limitation of my thesis is that it provides snapshots of particular focus areas and periods of time. While Chapters 2 and 3 provide perspectives on social-ecological change through different methods and questions, they do not tell the entire story of change in Gwich'in territory. This in itself may be impossible, however, a more complete picture of the impacts of social-ecological change could be gained by compiling these projects alongside other studies examining change through different methods and questions, particularly emphasizing research and stories from Gwich'in community members. A more complete picture of change could also be gained by continuing to conduct these sorts of analyses. Chapters 2 and 3 each focus on particular periods of time that, together, increase our understanding of current social-ecological changes. This is important, but it is crucial to continue examining impacts of change in the future, given that ecological change is projected to become more intense (AMAP, 2012; IPCC, 2014). To do this, these projects could continue, or potentially contribute questions to ongoing monitoring programs like the Arctic Borderlands Ecological Knowledge Society (https://www.arcticborderlands.org/).

Conclusion

The overall goal of my MA research was to increase our understanding of ongoing change in Gwich'in territory by exploring the effects of social-ecological change

on the cultural landscape, and access to fish, an important traditional food. My thesis illustrates that Gwich'in territory is a cultural landscape that is undergoing change, but remains the home to a cultural group with strong traditions that enhance the continuation of land use practices. Chapter 2 of this thesis described a GIS approach that can help to include cultural features in cumulative impact assessments. These methods show that Gwich'in territory is fundamentally a cultural landscape, experiencing diffuse, low-intensity disturbances that have a moderate amount of overlap with important cultural areas. Chapter 3 of this thesis focused on the relationships between drivers of access to fish and well-being amidst regional social-ecological change. This analysis showed that several socioeconomic factors ensure continued access to fish, which bolsters many aspects of well-being. These factors are likely important in maintaining and strengthening access to fish into the future. Conducting projects that include different spatiotemporal scales and knowledge systems provides significant insight into the regional impacts of change. Future work should be undertaken that updates these analyses and expands them into other areas, while continuing to engage with community members and organizations.

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