The Geospatial Web, Geospatial Ontologies, and Eastern Cree Conceptualizations of Space and Time

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April 2019

This thesis is submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy

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Abstract

Maps and mapping technologies have been criticized for contributing to Indigenous assimilation. For example, explorers and colonizers represented Indigenous lands as unoccupied and free, ignoring traditional place names and existing communities. In recent years, a large body of research has developed to decolonize maps; today, Indigenous communities across the world are using maps and mapping technologies to support their causes. However, the underlying architecture of mapping technologies can still be at odds with Indigenous ways of knowing and conceptualizing the world. For example, GIS and spatial data structure mostly consider time as linear, whereas Indigenous conceptualizations often view time as cyclical.

Advances in mapping technologies over recent years with the geospatial web (geoweb) have marked dramatic changes in traditional cartographic practices and conventional geographic information systems (GIS). This dissertation asks whether the underlying architecture of the geoweb is effective in considering Indigenous ontologies and epistemologies. The aim of this research is to inform next generations of mapping technologies that will assist Indigenous peoples in the expression of their knowledge and of visions of their territory within their own epistemological and ontological frameworks.

In this dissertation, I first address the benefits and challenges of the geoweb in considering Indigenous epistemologies. I review the literature on the critiques of existing Indigenous GIS technologies, and compare these critiques with new components in the architecture of the geoweb to evaluate the changes. I argue that, in many ways, the geoweb is not adequately addressing the shortcomings identified in GIS technologies. After, I address the question of ontological benefits and challenges of geospatial technologies. I review the literature on conventional geospatial ontologies and look at assumptions of universality. I show that Indigenous ontologies prove universal assumptions embedded in existing technologies to be wrong.

These literature reviews point to the need to develop Indigenous geospatial technologies that are place-based instead of universal. My research addresses this need by focusing on developing a spatio-temporal ontology based on Eastern Cree concepts. The case study takes place in the Cree Nation of Wemindji in Norther Quebec. I present the methodological approach used in this research and discuss my positionality. I then present the results of the research and propose an alternate ontology to that found in conventional geospatial technologies to better consider Indigenous concepts of time and space.

Résumé

Les cartes et les technologies cartographiques ont été critiquées pour contribuer à l'assimilation des populations autochtones. Par exemple, les explorateurs et colonisateurs représentaient les territoires autochtones non-occupés, ce faisant, ils ignoraient les toponymes traditionnels et les communautés existantes. Un vaste corpus de la littérature a été développé portant sur décoloniser les cartes et les technologies cartographiques pour que celles-ci soient utilisées par les communautés autochtones elles-mêmes afin de supporter leurs propres causes. Par contre, l'architecture qui sous-tend les technologies cartographiques peut tout de même être incompatible avec les façons de développer les savoirs ancestraux et les façons de concevoir le monde. Par exemple, les systèmes d'information géographiques (SIG) et les structures de données géographiques considèrent le temps linéaire, alors que les conceptualisations autochtones mettent l'emphase sur le temps circulaire.

Dans les dernières années, les avancements des technologies cartographiques avec le web géospatial (géoweb) ont marquées des changements drastiques pour les pratiques conventionnelles de cartographie et pour les SIG. Cette thèse pose la question à savoir si l'architecture qui sous-tend le géoweb est efficace pour considérer les épistémologies et ontologies autochtones. L'objectif de cette recherche est d'informer la prochaine génération de technologies cartographique qui assisterait les peuples autochtones dans l'expression de leurs savoirs et de leurs visions de leur territoire en fonction de leurs propres prémisses épistémologiques et ontologiques.

Dans cette thèse, j'adresse d'abord la question des bénéfices et des défis du géoweb pour concidérer les épistémologies autochtones. Je procède à une revue de la littérature sur les critiques des technologies SIG avec les autochtones. Je compare également ces critiques avec les nouvelles composantes de l'architecture du géoweb pour évaluer les changements. J'argumente que dans plusieurs sens, le géoweb n'adresse pas nécessairement les critiques qui avaient été identifiées avec les SIG. Ensuite, j'adresse la question des bénéfices et des défis ontologiques des technologies géospatiales. Je revoie la littérature sur les ontologies géospatiales conventionnelles et me penche sur les postulats d'universalité. Je démontre que de plusieurs façons, les ontologies autochtones prouvent que ces postulats d'universalité sont faux.

Ces revues de la littérature point vers le besoin de développer des technologies géospatiales qui seraient basées sur les spécificités locales plutôt que sur l'universalité. Ma recherche adresse cette brèche en développant une ontologie spatio-temporelle basées sur les concepts des Cris de l'est. L'étude de cas porte sur la Nation Crie de Wemindji au nord du Québec. Je présente l'approche méthodologique développée dans cette recherche et j'offre une réflexion sur ma position en tant que chercheure non-autochtone. Je présente ensuite les résultats de la recherche et propose une ontologie alternative aux approches conventionnelles pour mieux considérer les concepts Cris de temps et d'espace.

Acknowledgements

First, I would like to express my deep gratitude to my supervisor, Dr. Renee Sieber. Dr. Sieber accommodated my unpredictable schedule associated with the multiple fieldwork visits in Wemindji, and with my unique needs based on the challenges that life has thrown at me. In times of crisis, she kept me from quitting, and provided support and compassion. At the same time, Dr. Sieber showed me tough love when I needed it and pushed me to go beyond my limits to become an independent critical thinker with an aspiring career in academia. She has impacted my life in many ways, and I am forever grateful for her support that went well beyond the role of a supervisor.

I also owe many thanks to the members of my committee for their comments at various stages of this PhD: Colin Scott, George Wenzel, and Werner Kuhn. I would like to thank George Wenzel for his support during difficult times. Beyond providing feedback on this dissertation, I would also like to thank Colin Scott for giving me opportunities to be involved in research projects with the Cree, and for supervising and guiding me in those projects. I also thank him for supporting and mentoring me in my career.

This research would not have been possible without collaboration with the Cree community of Wemindji. I want to thank everyone who participated in interviews and focus group for this research. I am also forever grateful to all the people in Wemindji who welcomed me into their community and who were patient with me in the bush! I cannot name everyone, but many community members contributed to making Wemindji my second home. I want to acknowledge the support from the Cree Nation of Wemindji, the Chief and Council, the administration, and the department of Culture and Wellness, as well as thank all the staff there. Many thanks also to Chief Rodney Mark who met me in Montreal and invited me to the community. I am grateful to Rod Mamianskum, my boss during my first visit, who initiated me into the GIS department in Wemindji. I owe many thanks to Sammy Blackned, Katherine Scott, and Anthony Georgekish for making the work on mapping projects in Wemindji such a pleasant and enriching experience. I want to thank every colleague in Wemindji working for the mapping project. Thanks to Linda Stewart, Angela Stewart, and Audrey-Rose Otter for their constant patience and support.

I would like to thank other colleagues working on research projects in James Bay. I also thank all my colleagues and friends who shared our work environment in lab 428. I am grateful to friends and professionals who edited early drafts and sections of the dissertation.

Because of tragic circumstances in my life, the completion of this dissertation would not have been possible without spiritual and emotional support from many people. My PhD was interrupted by the sudden death of my beloved life partner, Sean Hill. In grieving and overcoming post-traumatic stress, many compassionate people accompanied me in my healing process.

I owe an infinite gratitude to everyone in my family, my friends, roommates, and neighbors in Wemindji, in Montreal, in Glen Sutton, at Lac Beauchamp, and elsewhere. So many people were there for me in many different ways, and sometimes something as simple as sharing

a laugh or a story had an extremely positive impact on my day. I am grateful for their understanding when I was not available, their compassion, and their moral support. I would like to especially thank my parents, Lise St-Aubin Reid and Jean Reid, for their infinite generosity and love. I am also grateful for the memory of my loving grandparents who passed along strong values to live by and the importance of education. I want to express my deep gratitude to Elisa Hill for helping me see the blessings in life and find light in the darkest places. I thank the persons who were there for part of the journey in India and the people Elisa and I encountered during this pilgrimage in memory of Sean. I also wish to thank all the teachers, therapists, and healers who crossed my path.

Finally, I would like to dedicate this dissertation in loving memory of Sean Hill (1983-2011). Sean, I am grateful that you were there when the first seeds of this research were planted. After your sudden passing, I couldn't see life at all, but what we shared together saved me and brought me back to pursue my research. Even though my PhD became entangled with the process of grieving your physical presence, I could feel that somehow, you guided me through it all. I am still learning every day from your philosophy of life. You will always be my greatest teacher.

Geneviève Reid
Wemindji, December 2018

Contribution to Original Knowledge

This dissertation contains original scholarship in the field of geography. Four of the six Chapters each contain a manuscript with a distinct contribution to the advancement of knowledge with regards to GIScience, the geospatial web, critical GIS, Indigenous ontologies, spatio-temporal ontologies, and positionality. Three of the manuscripts have been submitted for publication, and the other one is being prepared for a peer-reviewed journal in the field of geography.

The manuscripts in Chapters Two and Three constitute the literature review of this research. Chapter two is a review of the critiques of GIS in Indigenous contexts. It presents a unique argument demonstrating that advances in the architecture of the geoweb are not necessarily addressing the critiques identified with early desktop GIS. The second literature review also presents a unique argument by demonstrating that conventional geospatial ontology approaches fail to consider Indigenous conceptualizations of time and space. These reviews point to the need to develop Indigenous geospatial technologies. This research addresses this need by developing a spatio-temporal ontology that considers Indigenous concepts of space and time with the Eastern Cree in northern Quebec. The manuscript in Chapter Four presents an innovative methodological approach to ontology development that is designed to engage deeply with community members' articulation of concepts of space and time. It also discusses the positionality of an outside researcher with technological expertise in an Indigenous community. In the last manuscript, I present original findings on Eastern Cree conceptualizations of space and time and ways to model those in spatio-temporal ontologies.

Contribution of Authors

All four manuscripts contained in this dissertation are co-authored with my supervisor, Dr. Renee Sieber. I am the primary author of all the manuscripts. I undertook the literature review, conducted fieldwork, analyzed all the research material, crafted the arguments, and wrote each manuscript. Dr. Sieber provided supervision, guidance, and oversight concerning the structure of the manuscripts, the framing of the arguments, and the discussion of the implications of the arguments. Dr. Sieber also edited the manuscripts and revisions intended for publication.

The manuscript in Chapter Five is also co-authored with Sammy Blackned from the Cree Nation of Wemindji. Sammy Blackned was the director of the Community Services Department, including the Wellness and Culture Department when the research was conducted. Sammy Blackned provided inspiration and guidance on conducting fieldwork in Wemindji, discussing the implications of the research, and choosing examples to illustrate the arguments contained in the manuscript.

Chapter 1: Introduction

Over the past 25 years, geospatial technologies — mapping, Geographic Information Systems (GIS), geospatial web 2.0 (geoweb), Global Positioning System (GPS) — have been widely used in Indigenous contexts, and studied under different terminology.[1] Geospatial technologies have served a number of purposes, including the documentation of traditional cultural sites, place names, and use and occupation of the land for the preservation and transmission of knowledge and language (Aporta, 2003; Eades, 2010; Tobias, 2009). The use of geospatial technologies has also become crucial for the defense of community land rights and management of resources against government agencies, development corporations, and resource extraction companies (Hoole and Berkes, 2010; McCall and Minang, 2005; Nietschmann, 1995; Offen, 2003; Peluso, 1995; Poole, 1995; J. J. Taylor, 2008; Tripathi and Bhattarya, 2004; Wainwright and Bryan, 2009).

Despite the use of mapping practices and mapping technologies in Indigenous communities, a number of critiques have been developed about the application of these approaches in Indigenous contexts, including many that focus on important epistemological and ontological issues (Nadasdy, 1999; Rundstrom, 1995; Turnbull, 2007). Simply put, epistemologies are the ways in which knowledge is developed. Ontologies are about defining the nature of reality or how the world is conceptualized. For instance, GIS have been depicted as failing to take into consideration Indigenous conceptualizations of both space and time

[1] Chapin et al. (2005) present an overview of the different terms : traditional land use studies, traditional knowledge and land use, traditional land use and occupancy studies (TLUOS), land use and occupancy studies, traditional use studies), aboriginal land use and occupancy studies, participatory rural appraisal (PRA), rapid rural appraisal (RRA), participatory mapping, participatory land use mapping, participatory resource mapping, community mapping, community-based mapping, ethnocartography, counter-mapping, self-demarcation, ancestral domain delimitation, participatory GIS, public participation GIS (PPGIS), community-integrated GIS, mobile interactive GIS, participatory 3-D modeling, participatory photomapping, critical mapping, critical GIS.

(Rundstrom, 1995). Indeed, GIS and mapping projects in Indigenous contexts face major challenges in doing justice to Indigenous peoples' relationships with the land that include finding means to represent space and time in non-Cartesian methods, avoiding a new kind of assimilation, and acknowledging traditional ways of preserving and transmitting knowledge (Chambers, et al., 2004; Crampton, 2010; Gerlach, 2010). Indigenous knowledge has been defined as ''a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission'' (Berkes, 2012, p. 7). It includes: relationships with local land, animals, and plants; rules and norms about interacting with the environment; and worldviews shaping the way people make observations, make sense of their observations, and learn (Berkes, 2012; Turner, 2012). GIS have been criticized for failing to take into consideration such Indigenous epistemologies (Rundstrom, 1995).

While there is constant innovation in mapping technologies (including the geoweb and tools like Google Maps and Mapbox), there is little to suggest 'new' technologies will ameliorate the numerous ontological and epistemological critiques identified with GIS (c.f., Elwood 2010; Leszczynski 2012). Indeed, there is significant scholarly debate about whether the geoweb allows for non-Western representations of time and space, or merely continues to impose Western ways of thinking about geography and temporality onto Indigenous territory (Crampton, 2010; Gerlach, 2010). The ideologies that underpin web 2.0— extreme openness, neoliberalism and sharing, and disdain for experts (elders)— might be incompatible with how Indigenous knowledge is traditionally kept and transferred.

When GIS technologies are criticized as failing to consider human conceptions and experience of place, Schuurman (2006) suggests engaging with the materialization of geospatial technologies. To design geospatial technologies that better integrate Indigenous

conceptualizations, we must look at how the technology is built, its codes, and its ontologies – the ways that geographic entities are organized into distinct categories with relationships. However, most of the research in the field of geospatial ontologies in recent years, including by the World Wide Web Consortium (W3C)[2], focuses on data standards; this research is largely concerned with achieving interoperability between geospatial data on the web to allow for search and analysis of a huge amount of data (Agarwal, 2005). This research development assumes a universality in concepts of space, and it remains to be seen if and how alternate ways of conceptualizing space (such as those held by Indigenous peoples) can be included in models being proposed. This issue is crucial as excluding Indigenous ways of knowing might compromise Indigenous peoples' access to geospatial technologies that can help them defend their rights and promote their interests.

Indigenous communities are increasingly relying on geospatial technologies. Whereas geospatial technologies have typically been used to study the past (e.g., integration of traditional knowledge), they are now being used by Indigenous communities who are developing their own future-oriented projects. Thinking about the future, and developing alternate visions and life projects is of great importance for Indigenous communities to withstand changes brought about by development and globalization, whether wanted or not (Blaser, et al., 2004; Feit, 2004). This context highlights the issue of integrating Indigenous concepts of time in geospatial ontologies and in geospatial technologies. Even in non-indigenous GIScience research, integrating the conceptualization of time and temporal referencing of geographic concepts in data models is a very complex task that is by no means "solved" (Agarwal 2005: 520; O'Sullivan 2005).

[2] The W3C is an international organization that creates standards for the World Wide Web (www.w3.org).

In the Cree Nation of Wemindji along the coast of Eastern James Bay in Northern Quebec, where this research takes place, geospatial technologies are used to support culture and language revitalization (Bishop, 2018; Blackned et al., 2016). Geospatial technologies are also essential in the expression of Eastern Cree communities' rights when dealing with external agencies. I further discuss the Eastern Cree use of geospatial technologies below (Section 1.2.3).

1.1 Research Question

The geoweb represents recent developments in geospatial technologies. It combines geographic information with web-based content and often emphasizes interactive capabilities and user generated content (Elwood and Leszczynski, 2011). My research aims to evaluate if the geoweb can be an effective and appropriate tool to record Indigenous knowledge and Indigenous ways of knowing, as well as how it could be improved to do so.

1.1.1 First Contacts with the Cree Nation of Wemindji and Defining the Research Question

As a white female researcher engaged in research with an Indigenous community, creating connections is a vital part of each step of this research, from the first contacts established and throughout the many fieldtrips conducted in the community. My first personal encounter with the community occurred prior to the development of my research proposal. Being invited in a community and asking permission before proceeding is very important as the first contact and the first opportunity to demonstrate respect (Koster et al., 2012). As an independent researcher, I had to do the first contacts by myself, instead of joining a research project where the first contacts are already established. I sent a gift in a handmade box and a letter to the Chief of the Cree Nation of Wemindji at the time, Rodney Mark. I wrote about my personal journey, mentioned my research interest, and presented the idea of a possible visit in Wemindji to discover the community and to meet community members prior to starting any research process.

The Chief replied to me with an invitation to meet in Montreal during one of his stays. Over breakfast at a hotel restaurant in downtown Montreal, the Chief examined my CV and proposed that I could come to Wemindji to work as a GIS technician during my first visit. Following our meeting, I was in touch with the director of environment at the time, Rod Mamianskum, and he invited me to work in his department during my first visit in the community. A first visit prior to the development of research is important because it establishes a first personal connection with the community and community members.

Building connections during a first visit is also a great opportunity to (re)define research questions and methodology for conducting research that is aligned to the community's situation, needs, and aspirations (Castleden et al., 2012). My initial research idea was to develop a geoweb plateform to record aspirations of community members as a tool to support collective discussions in planning processes. However, upon my arrival in the community, I was disappointed by two geoweb plateforms that had been developed by non-Indigenous geographers and consultants: whereas the tools were supposed to be easy to use with "user friendly interfaces", no one was using them or even knew how to use them. No matter how 'easy' to use the plateforms were, they still failed to be accessible to community members. This lack of use made me realize that the problem of accessibility lay somewhere else than in the interface design, and I started to question other parts of the design of geoweb technologies, such as the way these technologies define and organize geographic entities and their abilities to integrate Cree conceptualizations of their environment. This is when I reoriented my research question toward geospatial ontologies.

During subsequent visits, I was invited to collaborate on a few GIS/mapping research projects with the Cree Nation of Wemindji and the Cree Nation Government. These mapping projects support the community and the regional government's priorities such as preserving

culture and language, transferring Cree knowledge to younger generations, developing a network of protected areas on Cree territory, and supporting land claims. In all of these projects, the information gathered is protected and kept offline, which brought me to question the role of the geoweb in supporting Indigenous causes.

1.1.2 Research Objectives

My research evaluates if the geoweb can be an effective and appropriate tool to record Indigenous knowledge and Indigenous ways of knowing, as well as how it could be improved to do so. To answer this research question, I take two different approaches: 1) epistemological; and 2) ontological.

For the epistemological approach, my theoretical contribution pertains to Indigenous contexts. My objective is to review the challenges of 'old' GIS in integrating Indigenous knowledge and in considering Indigenous ways of knowing. For example, Indigenous knowledge is collectively acquired, passed between generations, and can be encoded and transferred through non-material or non-inscriptive performance practices such as storytelling, chant, and dance (Berkes, 2012, Pearce, 2009). Such practices represent a challenge for integration in any form of inscriptive medium including geospatial technologies. In the 1990s, critical GIS literature has identified problems with the early desktop GIS in Indigenous contexts. I review these critiques to provide a framework to evaluate whether the 'new' geoweb can better consider Indigenous epistemologies. Based on the early critiques, I analyze the new components of the geoweb such as new content forms (i.e., volunteered geographic information–VGI), new data practices (i.e., crowdsourcing, mash-ups) and new technological devices (i.e., GPS-enabled smartphones) and informational artefacts (i.e., Google Earth, OpenLayers, crowdsourcing platforms like OpenStreetMap {OSM}) (Elwood and Leszczynski, 2011).

For the ontological approach, my research objective is to compare conventional geospatial ontologies to Indigenous ontologies. Indigenous ways of categorizing geographic features might be different than conventional categories in geospatial ontologies (Wellen and Sieber, 2013). For example, Indigenous and geospatial ontologies might differ in the way they define and categorize geographic entities. Relationships between geographic entities might also be different. The objective of my research is to evaluate whether geospatial ontologies are inclusive of Indigenous concepts, and how geospatial ontologies could be improved to better consider Indigenous ontologies. To meet this objective, I review the literature on the development of geospatial ontologies and specifically look at the quests to achieve universality. I highlight the failings of these universal approaches by presenting fundamental differences with Indigenous ontologies.

My research also focuses on spatio-temporal ontologies by comparing assumptions about time in conventional spatio-temporal ontologies with Indigenous notions of time. I use the case study of the Cree in Northern Quebec, where I conduct extensive fieldwork (more than three visits per year in eight Cree communities between 2012 and 2018). Another research question is about ways to engage in research with an Indigenous community as a non-Indigenous researcher. To address this question, I engage in a reflexive process about positionality in Indigenous geospatial ontology development and propose a methodology to conduct my ethnographic work with the Cree in Northern Quebec about concepts of time. My methodology includes conventional ethnographic methods such as individual interviews, focus groups, and participant observation. Furthermore, the methodological approach developed in the research goes beyond merely relying on conventional ethnography to include approaches that move away from research *on*, toward research *for* and *with* Indigenous people (Frantz and Howitt, 2012; Koster et

al., 2012). The objective is to develop an alternate spatio-temporal ontology based on Cree concepts in a culturally sensitive way.

1.2 Case Study: The Cree Nation of Wemindji, Qc

The research case study takes place within the Cree Nation of Wemindji in Northern Quebec. Wemindji— formerly called Paint Hills— is one of the eleven Eastern James Bay Cree communities. It is located around 900 km north of Montreal, at the mouth of the Maquatua River on the coast of James Bay. The population in 2012 was 1413 people.[3] Wemindji is a relatively new settlement; it was founded in 1959 when families were relocated from their original settlement at the trading post called Old Factory about 45 km south. The community was accessible only by air until 1995, when the Access Road was built from the James Bay Highway. The Cree Nation of Wemindji is one of eleven communities, collectively called the Eastern Cree, or Eeyou. Their territory is governed by the Grand Council of the Crees (Eeyou Istchee), the elected body, and its administrative structure, the Cree Nation Government.

1.2.1 The Eastern Cree Territory: Eeyou Istchee

The Eastern Cree call their territory Eeyou Istchee, which means "the People's Land," although the meaning would be misinterpreted if understood from a Western perspective of possessing land as a form of private property. Cree modes of land tenure do not presuppose the existence of private property rights (Feit, 1991; Preston, 2011). The customary system of tenure is to subdivide the land to form family hunting grounds, called traplines in English, that are managed by tallymen (Scott, 2018). The boundaries of traplines are flexible and altered by tallymen so as to allow or deny access to other trappers and hunters depending on the season. For example, a

[3] Aboriginal Affairs and Northern Development Canada, Indian Register, 2012

tenure arrangement with the tallyman may give a hunter and his family access to another person's trapline during a hunting season while his own trapline is 'resting' from the pressure of the hunt, thereby allowing an animal's population to recover (Preston, 2011). Rather than private property rights, diffusion of harvesting pressure, resting the land, cyclicity, and seasonality act as guiding principles for the management of tenure systems (Sayles and Mulrennan, 2010).

Cree ways of managing the land also stand in contrast to Western notions of controlling nature. This is exemplified in the Eastern Cree's ongoing relationship with the land, including their hunting practices and belief systems (Feit, 1991; Scott, 1983; Tanner, 1979). Feit (1991) explains that, in the Cree worldview, "people are born and die while the land continues. The land is passed on from previous generations, and will be transmitted to future generations and no one can create it, dispose of it or control it in any absolute sense" (p.228). Instead of a relationship of control over nature, Cree adhere to a concept of reciprocity between human and nature (Feit, 1991; Scott, 2006). In hunting practices, the actions of humans and animals are both based on learning from the habits of the other. Hunters observe the habits of the animals to better hunt them, but the animals also learn habits of humans and come to understand humans' needs (Feit, 1991, 2001). Cree interact with other agents such as animals, spirits, the weather, and some geophysical agents– winds, water, and land– who are conceptualized as beings, or 'other-than-human-persons' (Feit, 1991; Preston, 2002; Scott, 1996). For example, hunters have a relationship of love, sacrifice, and respect with animals, and often interact with them through their dreams, which can help them foresee possible futures (Preston, 2002; Scott, 2006; Scott, 1983). In opposition to the notion of control over nature, notions of reciprocity and agency are the foundations of the Eastern Cree relationship with the land. These differences between Eastern

Cree and Western conceptualizations of the land speak to the ontological problems of categorizing spatial arrangements.

1.2.2 Eastern Cree Use of Geospatial Technologies

Benefits

Cree use of geospatial technologies and maps has been and still is immensely beneficial (even crucial) to the Eastern Cree for the advancement of their causes. For a number of decades, the Eastern Cree have been forced to develop strategies to defend their land and to maintain their ways of living against outside pressure on their territory (Nasr and Scott, 2010). Since the 1970s, large-scale hydroelectric development has had significant impacts on the natural environment, as well as on the lives and livelihoods of community members (Feit, 2004; Morantz, 2002; Niezen, 1993; Scott, 2001; Warner, 1999; Whiteman, 2004). Beyond hydroelectric projects, government agencies have promoted development in the North in other ways (Desbiens, 2013), for instance by producing maps of the province with major blank spaces in the North, ignoring Cree settlements and Cree use of the land (Desbiens, 2013; Forest and Forest, 2012). This was a strategy to depict the territory as unused and free for development. In response, since the 1970s, Cree communities have effectively used their own mapping to counter hegemonic maps produced by government agencies, to express their resistance, and to negotiate with the government (Atkinson and Mulrennan, 2009; Desbiens, 2004a, 2004b; Mulrennan and Scott, 2005; Tanner, 1999).

More recently, there have been increased pressures on Cree territory posed by climate change, sport hunting (Scott and Webber, 2001), natural resource extraction (mining, forestry, hydroelectricity), and provincial economic development plans. For example, the provincial

government of Quebec in 2011 launched an ambitious development and resources exploitation program called 'Plan Nord,' or the Northern Plan. During the next twenty-five years, $80 billion in private and public investments will be brought into the region for development projects including mining, roads, airports, tourism, and hydroelectricity (Desbiens, 2013; Desbiens and Rivard, 2014). In response, Cree communities have expressed their own visions of development involving co-management strategies, as well as cultural and social development rather than merely economic development (Rodon et al., 2017). Geospatial technologies play an important role in developing, expressing, and implementing Eastern Cree visions and strategies to respond to resource extractive corporations and provincial government agencies.

In the context of protected areas, geospatial technologies also serve to express Cree communities' aspirations for protecting their land. At both the regional and local level, Cree communities are organizing to actively develop their own plans that ensure protection of the land according to their way of life. The Cree Nation of Wemindji, for example, has begun to implement a strategy for creating a network of marine and terrestrial protected areas (Mulrennan et al., forthcoming). From a regional perspective, the Cree Nation Government is currently creating a network of protected areas across its entire territory (Eeyou Protected Areas Committee, 2014). These initiatives, based on mapping processes, are protecting land and ways of life in the face of development, and are being used as manifestations of Cree sovereignty and self-determination (Blaser, et al., 2004; Feit, 2004; Eeyou Protected Areas Committee, 2014; Niezen, 2003, 2016).

Challenges

Notwithstanding the many benefits that they bring, current geospatial technologies and planning processes have forced the Cree to translate their views and conceptualizations into "Western

language" to explain and legitimize their claims to the Western world (Feit 2004, McGregor, 2004; Nadasdy, 2002). Based on western ontologies, Indigenous conceptualizations have been translated into (and reduced to) concepts of 'place attachment', or 'strong and complex relationships with the land' to claim "rights" and "ownership" of the land. Nadasdy (1999) has a very illustrative term for this kind of process that reduces Indigenous knowledge and Indigenous worldviews to fit into western science: "distillation."

With this reduction of Indigenous conceptualizations, a crucial concern arises: what is lost in translation? For example, what is being discarded when participatory planning processes ignore Cree beliefs that the whole land is sacred (Ball, 2002; Feit 2004), and claim that the entirety of Cree territory cannot be legally recognized as protected area in the eyes of the government? These kinds of questions are inevitable when geospatial technologies, which in some contexts can be used in support of Indigenous causes, are also the same tools that are being used to control and exclude Indigenous communities (Lorde, 1984; Veland et al., 2014).

1.3 Purpose of the Research

Whereas geospatial technologies have been used in asserting power such as colonialism, my research aims to inform the design of these tools and how they can be transformed. To achieve this, my research identifies where existing geospatial technologies fail to take Indigenous ontologies and epistemologies into consideration, while seeking to find ways to integrate them. Thus, this research will highlight challenges of the GIS in considering Indigenous knowledge and ways of knowing, offer a theoretical argument to evaluate whether the geoweb has improved over GIS, and propose solutions for a geoweb that eliminates issues identified with 'old' GIS technologies.

This research will also point to the challenges of geospatial ontologies in integrating Indigenous ontologies. My research focuses on Eastern Cree conceptualizations, and aims at finding ways to be inclusive of Cree concepts of time. The purpose of the research is also to engage in a reflexive process about the researcher's positionality in the development of Indigenous geospatial ontologies. The goal of this research is to eventually provide grounds to develop geospatial technologies that allow for the expression of Indigenous knowledge based on the ontological premises of Indigenous peoples. This research will advance research in two fields: Indigenous knowledge, and GIScience and spatio-temporal ontologies.

The purpose of this research is also to benefit the Cree in Northern Quebec. In the context of a rapid development of the North, the Cree will continuously need to express their own aspirations for their territory. Instead of translating their visions and their knowledge to fit into existing geospatial technologies, my research aims to evaluate ways to integrate their concepts of space and time into the geoweb. This would allow them to use the next generation of geospatial technologies to advance their causes within their own epistemological and ontological frameworks.

1.4 Outline of the Dissertation

In this Chapter, I have introduced the research question: can the geoweb be an effective and appropriate tool to record ways that Indigenous peoples conceptualize their territory and their ways of knowing? I have explained the purpose of my research. I have also provided background information about the case study of the Cree Nation of Wemindji in Northern Quebec.

The remaining chapters are organized as follows. In Chapter 2, I review the literature on Indigenous mapping. I focus on the critiques made in the 1990s of the early desktop GIS in failing to consider Indigenous epistemologies. I provide a theoretical analysis to review whether

new geoweb technologies are an improvement. In Chapter 3, I review the literature on geospatial ontologies and focus on challenges of integrating Indigenous conceptualizations into existing technology. In Chapter 4, I present the methodological approach designed to conduct fieldwork for this research, and the reflexive engagement about my positionality as a non-Indigenous expert. In Chapter 5, I present the results of the research by pointing at differences between conventional geospatial ontologies and Cree concepts of time. I also present an alternate spatio-temporal ontology that would better integrate Cree concepts of time. Chapter 6 provides a discussion of the results and concludes with the implication of the research and future work.

Chapter 2: Preface

My research is based on two literature reviews. The first literature review, presented in this chapter, focuses on the benefits and challenges of the geoweb in considering Indigenous epistemologies. We use the criteria identified in Critical Indigenous GIS to assess ways in which various components of the geoweb are improving on GIS or perpetuating the misrepresentation, distortion, assimilation, exclusion, and exploitation of Indigenous knowledge and Indigenous ways of transmitting knowledge.

This chapter consists of a manuscript co-authored with my supervisor, Dr. Renee Sieber. The manuscript has been submitted to *Environment and Planning D: Society and Space*. Based on initial reader reports, the editor of the journal asked us to revise and resubmit. We are currently working on the revisions. I am the primary author of the manuscript. I conducted the literature review, crafted the arguments, and wrote the content. Dr. Sieber provided guidance and feedback on the structure of the manuscript, the framing of the arguments, and the discussion of the implications of the arguments. Dr. Sieber also edited the manuscript prior to its submission.

Chapter 2: Is the Geoweb better than GIS for Indigenous Communities?

Geneviève Reid and Renee Sieber

2.1 Abstract

Advances in geospatial technologies over recent years have marked dramatic changes in traditional cartographic practices and conventional geographic information systems (GIS). Scholars in GIScience and digital geographies commonly argue that, compared to GIS, the geospatial web (geoweb) offers improved opportunities for marginalized communities to make their own maps, contribute their own place-based content, and tell their own stories. Critical GIS has informed issues of GIS in Indigenous contexts that which we synthesize into three themes: 1. compartmentalizing and distilling Indigenous knowledge; 2. undermining Indigenous ways of knowing and of transferring knowledge, and 3. exploiting and assimilating Indigenous knowledge. In this paper, we use these three criteria to evaluate whether the geoweb is better than GIS for Indigenous peoples with regard to issues of data ownership, access, sharing, and appropriation. We assess ways in which various components of the geoweb often do not substantially improve on GIS and can further exacerbate the misrepresentation, distortion, assimilation, exclusion, and exploitation of Indigenous knowledge and Indigenous ways of transmitting knowledge.

2.2 Introduction

Over the years, geographic information systems (GIS) have been confronted with significant social critiques. Among these, Warren (2004) and others contend that GIS further a positivist way of knowing the world. GIS reinforce a particular epistemology in part because GIS representation is based on Descartes's mathematical system of coordinates and geometries of points, lines, and polygons (Pickles, 2004). Lake (1993: 405) explains that this positivist view in

GIS derives from "assumptions of objectivity, value-neutrality, and the ontological separation of subject and object". Curry (1995) deepens the critique of neutrality in the way that GIS enable a panoptic and detached 'view from nowhere' in its representation: we do not know who uses the GIS but rationalists argue that it should not matter who views the output. Goals of efficiency and optimization are prioritized with GIS, while crucial ethical issues are ignored (Schuurman, 2000). Critical feminist GIScientists challenge an emphasis in GIS on quantitative data and methods over the qualitative (Kwan, 2002; McLafferty, 2005). Spatial data, especially highly organized and numerous layers have become a replacement for knowledge (Sieber et al. 2016); nuances become less important than how well-structured, big or analyzed the data are. GIS perpetuate power relationships in politics, economy, and society (Pickles, 1995; Wood, et al., 2010). Most applications of early GIS supported surveillance, corporate, government, and military powers (Crampton and Krygier, 2006; Pickles, 1995, 2004). GIS thus combine the representational and the political in a positivist but not a positive way.

Mainstream critical GIS literature sporadically engages with Indigenous scholars. However, Indigenous peoples are one of, if not the most, affected by the negativities of GIS because of their history of colonialism and western assimilation. The single strongest critic of the use of GIS in Indigenous contexts has been Robert Rundstrom (1995), who focused on ways that GIS, down to the level of the software architecture, distort Indigenous epistemologies (i.e., ways of knowing), and of transferring knowledge. He also condemned GIS for forcing a western ontology (i.e., rigid and explicitly defined categories) on Indigenous knowledge. His position on the fundamental incommensurability of western and Indigenous knowledge systems has compelled us to question whether geospatial technologies could ever suit Indigenous peoples.

Since then, many have found that the benefits of integrating Indigenous knowledge into GIS exceed the downsides and are worth seeking a balance (Caquard et al., 2009; Palmer, 2012). Indigenous GIS have been used to document traditional cultural sites, place names, and use of the land for the preservation and transmission of culture, knowledge, and language (Pearce and Louis, 2008). Indigenous GIS and mapping projects aim to deconstruct Western notions of geography, to encourage the (re)emergence of traditional mapping practices, and to react against uses of maps that assert power (i.e., colonialism, property ownership, national identity, race, military power, bureaucracy and gender) (Johnson et. al, 2006; Peluso, 1995). Palmer (2012) argues for an 'Indigital geographic information network', which combines Indigenous geographic knowledge with scientific knowledge into GIS to advance Indigenous causes such as language revitalization. Indigenous GIS have also been used to defend community land rights and resources against government agencies and resource extraction companies (Taylor, 2008; Wainwright and Bryan, 2009). Rundstrom himself has moved from an incommensurability position towards balancing the use of GIS by government agencies and Indigenous bands to support resource management (Palmer and Rundstrom, 2013). Despite many efforts and benefits in putting GIS at their best use to serve Indigenous peoples' agenda, Rundstrom's early critiques continue to guide interrogations in Indigenous GIS (cf., Chambers et al. 2004; Chapin et al. 2005; Dunn 2007; Pearce and Louis, 2008).

Early desktop GIS have often been represented in critical GIS literature as the 'bad guy' or a "theoretically corrupt weapon" (Warren, 2004). Newer technologies have been considered as sort of a 'hero', the killer application for the 21st Century (Junglas and Watson, 2008). Called the geoweb, it includes new content (i.e., volunteered geographic information–VGI), new data practices (e.g., crowdsourcing, mash-ups), new technological devices (e.g., GPS-enabled

smartphones) and software platforms (e.g., digital earths like Google Earth and OpenLayers, and crowdsourcing platforms like OpenStreetMap {OSM} and Ushahidi) (Elwood and Leszczynski, 2011, 2012). Simply put, the geoweb refers to "the merging of geographic information with web-based content, often with an implied emphasis on Web 2.0–based frameworks and services, especially those that emphasize user interactivity and user generation of content" (Elwood and Leszczynski, 2011: 6). To create a better comparison with GIS technologies, we characterise the geoweb as having an explicit mapping component or allowing one to excerpt information based on a defined geographic boundary.

The definition and characterization still miss the hagiography of the geoweb. It is variously considered to be tool of democratization (Goodchild, 2007; Warf and Sui, 2010) and decentralization of political power (Wilson and Graham, 2013a, 2013b). Many call it a form of "neogeography", because it supports activities of non-experts new to geography (Haklay, 2013; Haklay et al. 2008; Warf and Sui 2010; Wilson and Graham, 2013a, 2013b). It is an 'open' technology facilitated by crowdsourced data and open-sourced platforms (Budhathoki and Haythornthwaite, 2013). The geoweb is also depicted as an opportunity for public participation in society (Sieber et al. 2016). The geoweb allows for "multimedia narratives" (Elwood and Leszczynski, 2013) via different media (video, short posts) and platforms. The hope is these new narratives can bridge the qualitative/quantitative divide (Caquard, 2013; Kwan, 2004; Sui and DeLyser, 2012). Some claim the geoweb offers a 'liberation technology' because of its possibilities to improve governance, empower marginalized communities, defend human rights, promote economic development, and expand social benefits (Sui, 2015). The above authors do not remove the geoweb from criticism but they also stress the geoweb's qualities of being user-friendly, interactive, and enabling a greater diversity of contributions. The geoweb is even

labelled ‘the beast’ in the literature (Boulton, 2010; Schuurman, 2009) because it encompasses a larger and more complex collection of interactions between society and technology, compared to conventional desktop GIS.

Whereas the geoweb, as presented, appears to address the original flaws of GIS, Indigenous communities in our research express their reluctance to adopt it. Over the last ten years we have been collaborating in research projects with the Eastern Cree in Canada. Our investigations of GIScience issues with Cree Nations are conducted in contexts of culture and language revitalization, land claims litigation processes, elaboration of protected areas strategies, and documentation of traditional knowledge about ecological changes around areas affected by resource extractive activities. Geospatial technologies are important in these projects, but the role of the geoweb is unsettled.

Given the tensions between liberating claims of the geoweb in GIScience and the uncertain positions of the Indigenous communities we are working with, our question is: has the geoweb ameliorated the critiques leveled against Indigenous GIS? To answer the question, we look back at Rundstrom and other Indigenous applications of GIS and synthesize these critiques around Indigenous GIS into three themes. First, critics pointed out that desktop GIS have served to compartmentalize and distill Indigenous knowledge. Second, desktop GIS has undermined Indigenous ways of knowing and transferring knowledge. Third, it has exploited and assimilated Indigenous knowledge. We use these three critiques of desktop GIS in Indigenous contexts to argue that the exalted features of the geoweb do not markedly improve upon desktop GIS. Many critiques of desktop GIS are still valid critiques of desktop GIS mainly because of the intrinsic way these technologies handle geospatial information. In his chapter about “traditional technology”, the Indigenous scholar Vine Deloria Jr. (1999) highlights that the main difference

between Indigenous knowledge and western science systems is what happens with knowledge after it is obtained. Similar to Deloria's point with science, we show that the geoweb can put Indigenous knowledge at risk of being separated into parts and detached from the context in which it came from. Given such problematic nature of the geoweb, we propose solutions and strategies for Indigenous communities to engage with the geoweb as well as for ways to ameliorate the technology.

2.3 Indigenous critical GIS

Although many Indigenous communities have reported benefits from GIS, those who write on Indigenous critical GIS have depicted GIS as a double-edged sword because Indigenous peoples are encouraged to engage with the same technology that has been used for their domination and exclusion (Veland et al. 2014). It is important to remember that GIS are hardware and software but also a set of practices of data structuring, handling, analysis and visualization. It is argued that GIS need to integrate Indigenous epistemologies and ontologies, that is, their ways of knowing and of conceptualizing the world (Laituri, 2011; Veland et al. 2014). GIS face major challenges to being an Indigenous technology because they can perpetuate a western conceptualization of the world (Laituri, 2011; Rundstrom, 1995). We summarize the critiques of GIS as pertains to Indigenous peoples in the three following sections.

2.3.1 Compartmentalization and Distillation of Indigenous Knowledge

One of the most trenchant critiques of GIS is in their handling of Indigenous knowledge. Nadasdy (1999) criticizes western science efforts to integrate Indigenous Knowledge because those efforts can create a false compartmentalization of Indigenous concepts. Similarly, Runstrom (1995) is concerned that GIS force Indigenous concepts to fit into predefined categories of spatial phenomena. This is accomplished in part with the relational database model

(RDBM), which serves as the foundation for almost all GIS databases. Of necessity, the RDBM enforces a rigid structure on content. By contrast, Rundstrom (1995) argues that many Indigenous cultures see knowledge discovery as a refutation of patterns and categories. In an RDBM these are identified as "outliers" which would be eliminated since they cannot slot into the fields and records as well as the keys that link the data. The same rigidity is seen in the layers of GIS. Sieber and Wellen (2011) show that Cree hydrographic concepts do not fit GIS conventional layer categorization. Whereas GIS layers divide land features from hydrographic features, the authors found that the Cree recognize portions of land around rapids where one needs to portage a canoe, as an integral part of a river. In addition to a lack of fit, Indigenous knowledge often avoids precise categorizations and embraces an ambiguity of deliberately vague meanings of geographical phenomena contingent on social and natural factors (Berkes, 2012). The failure of GIS to capture ambiguity is observed in static objects and in a geometry of points, lines, and polygons. Mapping initiatives have revealed that Indigenous boundaries of land and resource use are often fluid, flexible, and overlapping (Sletto, 2009a). Fixing boundaries in a GIS can actually create conflicts within and between communities (Peluso, 1995; Sletto, 2009a; Thom, 2009; Turnbull, 2005).

Nadasdy (1999) contends that interactions between western scientific and Indigenous traditions invariably result in a distillation of Indigenous knowledge. Distillation represents a process of dismissing what is identified as irrelevant parts of knowledge that cannot easily be integrated into western systems. For example, when scientists and government agencies set hunting quotas on fully grown male bighorn sheep, they are only interested in monitoring the number of sheep sighted by Indigenous community members (with location and year). Officials distill out any other kind of information such as the social structure of the sheep population in

which elder sheep are considered essential guides for younger sheep (Nadasdy, 1999). Accurately representing language is important for cultural sustainability. GIS also impose specific character encodings and labels onto spatial entities by restricting the type and number of characters in their data entries. For example, Indigenous place names become truncated to fit the limited number of characters allowed by the system (Rundstrom, 1995). Even if new subsets of UTF-8 character encodings offer Inuktitut and Cree characters, that does not mean the database supports them.

The logics underlying compartmentalization and distillation reduce Indigenous views and privilege specific conceptualizations of the world over others (Veland et al., 2014). GIS utilize established coordinate systems. These can fail to consider Indigenous spatial representations such as coordinate systems composed of radiating lines from a localised center point (e.g., in Incan maps) instead of the conventional meridian and parallel grid; representations that integrate multiple directions of orientation and multiple perspectives to emphasize important places; representations that connect the celestial and terrestrial; or representations that vary in scalar granularity within a spatial extent (Pearce, 2009; Orlove, 1993). GIS also disregard Indigenous concepts of time such as cyclical (e.g., seasonal) or branching (e.g., multiple pasts and futures) concepts of change. This disregard forces Indigenous knowledge to fit into a static, linear, progressive, and evolutionary sense of time (Rundstrom, 1995). Overall, desktop GIS emphasize quantitative methods and data, and as a consequence, can lose the complex web of practices, values, social relations, and agency of geographic entities on the land (Rundstrom, 1995).

2.3.2 Failure to Consider Traditional Ways of Transmitting Knowledge

Researchers have criticized GIS for ignoring traditional ways of transmitting Indigenous knowledge (Laituri, 2011; Palmer, 2009; Rundstrom, 1995). Indigenous ways of knowing are

based on experiences of directly living and traveling on the land (Poirier, 2005; Berkes, 2012). Place anchors identity, spirituality, and well-being (Basso, 1996). GIS are location-based but in many ways they are place-less. The technology encourages the idea that place and people no longer need be visited (Rundstrom, 1995). Curry (1995) argues that GIS enable a view from nowhere in which the world is perceived from a vantage point, which is from nowhere in particular and in a way that is detached from experience and interest. Aporta and Higgs (2005: 743) explain that with the adoption of GPS devices in Inuit communities, geospatial technologies "have the potential to transform local geographies into standardized and measurable space" and thus could "encourage disengagement from experience of the land, people, and culture". Driving their snowmobiles in straight lines and with perpendicular turns replaced following patterns in the ice (Aporta and Higgs, 2005). Geospatial technologies eliminate traditional processes associated with acquiring knowledge and instead emphasize the insights or products themselves (Rundstrom, 1995; Aporta, 2003).

GIS also dismiss Indigenous ways of transmitting geographic knowledge. Rundstrom (1995) explains that in Indigenous communities, elders are traditionally the holders of geographic knowledge who carefully choose the recipients of that knowledge. This practice of knowledge transfer contradicts the inscription of knowledge in GIS. Information that is made machine readable, such as in databases or GIS, emphasizes the artifact (i.e., data, maps) rather than the act of transmission and assumes that anyone with a training in GIS can be a recipient of geographic knowledge. Indigenous knowledge is collectively acquired and passed between generations in face-to-face interactions and community gatherings (Berkes, 2012). The knowledge also can be encoded and transferred through other non-material or non-inscriptive performance practices such as storytelling, chant, and dance (Pearce, 2009; Woodward and

Lewis, 1998). GIS discard performance-based forms of transmitting knowledge in favor of the database (Rundstrom, 1995). When information is removed from its context, it can create a separation in time and space between knowledge holders and recipients, and encourage a loss of morality and responsibility associated with receiving knowledge. Altering traditional processes of knowledge transfer can be disastrous because of their importance in sustaining culture in Indigenous communities.

2.3.3 Exploitation of Indigenous Knowledge and Assimilation of Indigenous Systems

Traditional knowledge has been exploited throughout history with significant consequences for Indigenous communities. Notwithstanding many projects in participatory GIS (PGIS) and public participatory GIS (PPGIS) that focus on democratizing GIS and empowering local marginalized communities (i.e., Sieber, 2006; Elwood and Ghose, 2000; Laituri, 2011; Rambaldi et al., 2006), GIS are criticized for continuing a practice of exclusion and assimilation. Rundstrom (1995) argues that GIS put Indigenous knowledge at risk of being used in service of interests of external governments, agencies or researchers; even worse GIS can be used against the communities themselves. Because the communities do not necessarily control the GIS or the maps (even if they are the producers), external agencies can use the information to harm the communities (Fox et al., 2006). Impacts of GIS include allowing privatization of land, enabling non-traditional titling practices, and regulating traditional resource management and conservation practices (Fox et al., 2006).

Limited and unequal access to the software of GIS furthers the exploitation of Indigenous knowledge. Early desktop GIS were restricted to an elite of experts (e.g., academics, scientists, state, military) because they required powerful systems hardware and software (Pickles, 1995). In addition to the cost of hardware and software, for Indigenous peoples, it necessitates

expensive training that is not easily available particularly in remote regions (Laituri, 2002). Furthermore, GIS represent a kind of knowledge production that can create internal divisions if not everyone in the Indigenous community is knowledgeable in the scientific systems and technologies (Rundstrom, 1995). This divisiveness has been noted elsewhere (Sieber 2006) but community cohesiveness is especially critical for an Indigenous populace already threatened by colonialism, globalisation, and resource development on their territories (AIPP, 2010).

GIS can add to existing movements towards cultural assimilation. By assimilation, we mean that GIS disregard complexities of traditional authority systems and subordinate them to Western systems of data ownership. Ownership of Indigenous knowledge is complex because Indigenous communities are not homogenous. Harrison (1992: 235) questions the common assumption that Indigenous knowledge, such as a ritual, is owned by local communities, "specific groups or individuals may own the exclusive right to perform or organize it, to enact the leading roles in it, or to teach or transmit it authoritatively". The requirement of identifying who should have the right to control the access and who should benefit vary as different groups even from within the community hold different perspectives and interests. Beyond intra-community differences, western legal systems can prevent Indigenous people from being recognized as authors of the knowledge used in GIS and place ownership through copyright to others outside of the community (Engler, Scassa, and Taylor, 2013). This distanciation from ownership, as complex as it might be, furthers potential exploitation of Indigenous knowledge.

2.4 Early Critiques of GIS in Indigenous Contexts Still Valid with the Geoweb

The geoweb differs from GIS, at least in software, data, and hardware. In addition to new content like VGI, the geoweb has transformed from an elite of expert producers and users of geographic information to an "anyone" and "everyone can use it" suite of technologies. Our question is

whether these new components of the geoweb remedy the three Indigenous critiques of GIS summarized above.

2.4.1 The Geoweb Can Continue to Perpetuate Compartmentalization and Distillation

Certain characteristics of the geoweb ameliorate GIS critiques of compartmentalizing Indigenous knowledge. The geoweb breaks from a conventional GIS database model and enables considerable ambiguity (i.e., flexibility). The geoweb tends not to be expressed as a database but, as with KML or GeoJSON format, involves either tags or lists of data, where the formats themselves could be extensible for different groups of people.

Enthusiasm must be tempered. Geosocial media, when mapped with existing geoweb platforms, remain bound to a coordinate system and exclude Indigenous spatial representations containing alternate coordinate systems. The geoweb still emphasizes a linear conceptualization of time. This is exacerbated with streaming data, which emphasize the most current information. Geoweb research primarily focuses on distributing time-sensitive spatial information to the public as well as rapidly gathering information directly from the public such as in crisis management or disaster relief situations (Roche et al., 2013). Instead of data being based on short time periods and covering a large area, Indigenous knowledge of the land is based on a long time-series tied to a specific place (Berkes, 2012). Where speed and currency of linear temporal flows drive the geoweb, it does no better than GIS in accounting for alternate conceptions like cyclical time.

Ameliorations exist in the geoweb with its capacities to handle data. The geoweb allows high levels of ambiguity in the contributions but not necessarily in the underlying structure. Indigenous peoples can insert their own basemaps, which remedy the problem in remote areas

where the spatial resolutions might be quite coarse. They could include labels with placenames in their own language. This is important because the raster map tiles in the digital earths can "flatten" the underlying base content, including labels, into a single layer at any one resolution. One would think the VGI platforms would support heterogeneity, for example in language. Despite its openness, the OSM platform still has in its predominant tiles, labels hard-coded in official national languages. This precludes easy label replacement.

The geoweb is valued for its ability to include everyone and via numerous multimedia. It becomes harder to argue that, relative to GIS, the geoweb results in a distillation or loss of information. When everyone can contribute this creates a cacophony of voices and a signal to noise problem. In Web 2.0, large amounts of contributions on the geoweb refine the accuracy of content with the "many eyeballs" of precision. The problem is that big data drown out small sample sizes, where "statistical patterns that apply to the majority might be invalid within a minority group" (Hardt, 2014). Because of the computational intensity of big data, they cannot easily accommodate cultural differences. For Indigenous peoples, big data and the quantity of instances do not necessarily denote the importance of places. Janz (2011: 114) shows that for Indigenous people, the frequency of toponomic use does not correlate with the importance or centrality of the particular place: "an infrequently used term could designate sacredness or uniqueness rather than lack of importance. In some cases, cultural and spiritual topics may be inappropriate to discuss with outsiders, or may be limited to one gender group, ceremonial situation, time of day or year". The tyranny of big data on the geoweb may bury important local Indigenous knowledge.

Spatial data for GIS historically have largely come from authoritative sources like government. By contrast, the geoweb is based on data that is asserted by 'amateur mappers'

(Haklay, 2010). This change has prompted a surge of innovation in assessing spatial data quality (Goodchild and Li, 2012). In geoweb applications, rating systems are often used to infer the quality of data, which could be incompatible with Indigenous systems. Corbett (2013) shows with a case study in the Northern Vancouver Island region that the use of "open judgment" rating systems has deterred some community members from even participating in Indigenous mapping projects. Corbett (2013: 236) found that community members are concerned that their story on the geoweb "might be construed as being authoritative and/or definitive, and thus in conflict with other views". New data quality methods created for the geoweb can deter the contribution of new data by Indigenous peoples. Open rating systems also have potential political negative implications for Indigenous peoples' control over resources and territory if the quality of their data is publicly put into question or assessed with inappropriate criteria. Olson et al. (2016) expand on Tobias's (2009) Indigenous-led indicators for data quality about land-use (who, what, when, where) to include data related to kinship, ecology, Indigenous knowledge transfer, and relationships between places. Their argument is that Indigenous beliefs and ethics constitute a more appropriate assessment of data quality.

2.4.2 The Geoweb Undermines Traditional Ways of Transmitting Knowledge

The geoweb improves on GIS for transmitting Indigenous knowledge. Palmer (2012) defines the neologism Indigital Geographic Information Networks (iGIN) to encourage geoweb practices that move beyond the duality of Indigenous knowledge and western science. The Indigenous scholar demonstrates the use of geospatial technologies that depict the emotions in narrative in storytelling practices integrated in geospatial technologies. Another example is via narrated 3D views of places, such as with the Google street-views of the sacred Australian mountains Uluru and Kata Tjuta (https://storyspheres.com/uluru/), the geoweb can allow users to navigate space

through stories about the land. Google worked with aboriginal elders to present their stories and songs. Google respected elders' decisions to eliminate certain sites from filming the "streetview" because the sites were sacred (Campbell, 2017). The geoweb has potential not only to create a different interpretation of the land, but also to rekindle Indigenous peoples' engagement with the land, for example in Indigenous communities that have been displaced (Corbett, 2013). The geoweb can also improve transfer of performance-based knowledge (Thom et al., 2016). The use of comments, tags, likes, and multimedia (images, sound, and video) to produce Indigenous atlases can represent oral traditions through recorded narratives about the land, display items of material and visual cultural heritage, and also store historical documentation about the communities (Caquard et al., 2009; Taylor, 2014). Compared to GIS, the geoweb ameliorates, to some degree, tools to capture dynamic aspects of Indigenous ways of transmitting knowledge (e.g., related to religious ceremonies).

The transmission of knowledge within Indigenous communities is critically important because traditional knowledge is threatened in many communities as younger generations lose their cultural roots, notably due to changes brought by globalization (Laituri, 2002). Having grown up with technology, youth are considered to be more receptive to information offered on interactive and multimedia technologies (Prensky, 2001). Responding to requests from a remote Canadian Indigenous community, Isogai et al. (2013) used GPS and geotagged photos to connect youth with elder knowledge. Fienup-Riordan (2014) found that elders are not always amenable to a technologically-augmented transfer of knowledge in her research with Yup'ik elders in Alaska. The author observed problems with the translation and interpretations added in English to share elders' stories with younger generations. The elders reported that stories should only be told in Indigenous language while out on the land. The geoweb can still lose the specific context

of knowledge transfer and, dependent on the application, can fail to account for the appropriate setting of a particular story (e.g., a ceremony that can only be conducted and viewed at a specific time of the year).

Like GIS, the geoweb potentially creates distancing between people. The geoweb might be even worse than GIS because of its pervasiveness in interpersonal interactions and with the natural environment (Leszczynski and Elwood, 2015; Leszczynski and Wilson, 2013). Turkle (2011) found that, as engaging as they are purported to be, technologies like smartphones discourage social engagement because they isolate people from their surroundings and create fleeting weak ties among people. Despite its alignment with youth culture, the geoweb might be inappropriate for Indigenous ways of sharing knowledge. As mentioned above, Corbett (2013) has shown that the geoweb can expose discord among Indigenous community members when they share their stories via a geoweb platform. Conflicts are exacerbated because the geoweb fails to oblige community members to meet in person to "talk one's way through disagreements and misunderstandings" (Corbett, 2013: 13). Embrace of this form of geospatial data handling offers an uneasy trade-off. The elders see the geoweb as a way to connect youth to the land but are placed in an untenable position of welcoming the enabling tools of globalization as solution to the intergenerational connection to a specific locality.

When anyone can openly add and share information, the geoweb diminishes the role of knowledge holders in the community. Geoweb platforms such as OSM support the idea that all data should be free, accessible, and shared (Budhathoki and Haythornthwaite, 2013). For the Eastern Cree, a customary system of stewardship of family hunting grounds gives responsibility to the stewards for managing productivity and sustainability of the land (Scott, 1986). Contrast this with sports hunters who intrude on Cree territories (Scott and Webber, 2001) and can

contribute information on Indigenous territory merely because they have a GPS-enabled fitness tracker and an app such as Strava on which to publish the information. Haklay (2013) argues that information in the geoweb is mostly contributed by only an affluent, educated and powerful part of the society. Because of the volume of data and the ease in conveying it, the geoweb increases the indiscriminate exposure of Indigenous knowledge and thus furthers de-privileging practices of transmission of knowledge.

Platforms that profess to allow anyone to openly add and share VGI can still fail to live up to those goals. Critics of the geoweb demonstrate that, despite OSM's goal of crowdsourcing local knowledge and sharing it democratically with the world, a gender division prevails (Leszczynski and Elwood, 2015) that results in "men serving as the gatekeepers of local knowledge" (Stephens, 2013: 982). The introduction of information in OSM is based on consensus: new features proposed by contributors are open for discussion, subjected to a vote, and then approved or rejected by OSM editors. Stephens (2013) shows how the seemingly democratic nature of the platform hides the exclusion of women's views because men contribute geographic information at almost twice the rate of women, and they occupy important roles in the decision-making hierarchy of OSM. Consequently, categories of information contributed by men are integrated (e.g., a detailed sub-categorization to distinguish sites for the consumption of sex and alcohol); whereas information contributed by women can be dismissed (e.g., subcategories for childcare facilities).

A reproduction of gender divisions for women has already been demonstrated in Indigenous mapping projects. Women have often been excluded from mapping processes because elder men are often granted authority for geographical knowledge (Altamirano-Jiménez and Parker, 2016). Under-representing women's stories jeopardizes categories of knowledge

only known by women (e.g., traditional medicine plants; Voeks, 2007), and can depict large parts of the territory (e.g., areas where women gather) as unused or merely sporadically used (Altamirano-Jiménez and Parker, 2016).

2.4.3 The Geoweb is More Prone to Create Exploitation of Traditional Knowledge and Assimilation of Indigenous Systems than GIS

Desktop GIS have been criticized for benefiting the privileged few in positions of state, military, and corporate power (Pickles, 2004; Wood, et al., 2010). By contrast, the geoweb should provide novel ways for citizens and nonprofit organizations to assert their influence with governmental agencies on social and environmental issues (Sieber et al. 2016). Through user-friendly interfaces for contributing VGI and interacting with maps online, the geoweb has potential to strengthen an Indigenous nation's claims vis-a-vis the state and create global networks of Indigenous nations. This mirrors the literature on social media, information technologies, and digital activism (Landzelius, 2006). The geoweb should remedy the critiques of GIS with regard to putting Indigenous knowledge in service of interests of external governments, agencies or researchers.

Like GIS companies before them, geoweb corporations are directly involved with Indigenous communities in mapping projects or simply to transfer their tools. Google developed a branch called Google Earth Outreach to partner with Indigenous groups to advance their causes. Google's most famous example is the protection of land against deforestation for the Surui tribe in Brazil (Clendenning, 2007; Ustinova, 2008). Google Earth Outreach also hosts mapping workshops to promote and train Indigenous participants to use their toolkit (www.indigenousmaps.com). Involvement with Indigenous peoples functions as an instance of Google's corporate philanthropy "to democratize tools like satellite data and software for

storytelling for Indigenous peoples to use" (Rebecca Moore, personal communication, 22 May 2014, in Thom et al., 2016: 17). Corporations promote this enthusiastic description of the geoweb in "changing power relationships and empowering previously marginalized groups" (Tulloch, 2007: para 1).

With the geoweb, the business model of geospatial data handling has shifted from a privatization of software towards a privatization of geographic information (Leszczynski, 2012), all within a complex interlinked network of multiple software providers, some of which are open source. One example was Google Map Maker, which was openly accessible (but not open source) (Google Map Maker closed in 2017). Via Google Map Maker, Google appealed to the VGI community to expand its mapping base in areas poorly served by Google Maps (Stephens, 2013). Terms of service with Google MapMaker showed that ownership of those contributions transferred to Google. These were the ghettos, the favelas, and the Indigenous places in the world, precisely the areas that are vulnerable to having their data misused. Despite the potential for more voices on the geoweb and exhortations of empowerment, Zook and Graham (2007) argue that the increasing corporatization and privatization has had the opposite effect. This "Google governance" creates a form of governance that represents the corporate managers rather than representing well-informed citizens and is unaccountable should data be misused (Zook and Graham, 2007: 1334). Issues of privatization of data also play out in the context of big data where large amounts of data are computationally analyzed to reveal patterns. Thatcher et al. (2016) explain how big geospatial data "mask the asymmetrical power relations between users of technology and the almost exclusively corporate entities which algorithmically collect, link, and analyze the data points of many users" (2016: 9). Indeed, the case of VGI has led some scholars to call attention an imposition of a kind of volunteered (geo)slavery (Obermeyer, 2007) and to

data colonialism (Thatcher et al., 2016) where people are dispossessed of private information about their daily lives, which is accumulated by corporations to support their economic growth or by government agencies to support geosurveillance. With the business model of privatization of information, the geoweb may exacerbate issues of exploitation of Indigenous peoples and their knowledge.

An open and freely shareable medium contrasts with Indigenous peoples' need to protect their cultural property (Eisner et al., 2012; Engler et al., 2013; Scassa and Taylor, 2017). Young and Gilmore (2014) argue that Indigenous empowerment in the geoweb is about privacy rather that openness. The authors show that Indigenous communities must engage with issues of control and restriction of their knowledge when choosing to use geoweb technologies. Indigenous digital archives illustrate the problems of conventional copyright systems in protecting Indigenous ownership of Indigenous knowledge (Callison et al., 2016). Christen (2012: 2887) challenges the idea that "information wanted to or should be open, free, and available" and shows how Aboriginal knowledge archive systems in Australia are designed to restrict certain access to certain information depending on the user profile (i.e., community member or outsider, age, sex). Even if an application restricts access and possesses a license agreement that limits the use of information, there is still a risk that in being online, audio, video, or text may be copied, altered, mashed up, and reproduced elsewhere without the permission from these communities (Engler et al., 2013; Scassa et. al 2015). Informed consent is also crucial when gathering Indigenous knowledge in the geoweb. For example, Wainwright (2013) relates disastrous political and economic problems caused by the breach of ethics by the researchers of the Bowman Expedition by the American Geographical Society in Oaxaca, Mexico. The Indigenous community involved in the research was uninformed of sources of funding and contexts of use of collected data by the

Foreign Military Study Office (FMSO) of the Army of the United States. The community engaged in procedures to limit the detrimental effect of the study and forced the organization to destroy their data. In cases of breach of licensing agreements on the geoweb, Indigenous communities may choose to engage in litigation. However, any compensation for the misuse of traditional knowledge likely is far less than the cost of the litigation process (Franklin, 2016).

With the geoweb, data is stored in the cloud, which is a boon to state surveillance. One such example pertains to the ease with which Canada's First Nations Idle No More movement could be surveilled by the Canadian Security Intelligence Service (Ling, 2014). Surveillance was greatly assisted by the movement's online presence. The federal government was "concerned by the decentralized, leaderless nature of the protests" (Ling, 2014: para 5). If the state is concerned about the structure of Idle No More, then they will likely be averse to crowdsourcing, which is an open, leaderless call for collaboration by known and unknown contributors. In researching the Itelmen Indigenous community in Russia, Thom et al. (2016) caution that communities must carefully consider which data are hosted in the cloud and must balance the tradeoffs of utility with potential privacy violations. Finally, cloud storage defies jurisdictions. US cloud service providers such as Google and Amazon are regulated under US legislation. Usage of a US company's cloud services can be subjected to US scrutiny, irrespective of the origin of the contribution and the location of the servers (Adams and Thom, 2016).

The so-called openness of the geoweb could also exacerbate negative impacts on community cohesiveness that were identified with GIS with regard to unequal GIS skills. The geoweb offers opportunities to address this issue. Thom et al. (2016) suggest that the transfer of geoweb technologies can improve the skills of local community members in the processes of data collection, mapping, and representation of Indigenous knowledge. Some problems remain.

Viewing or contributing multimedia information to the geoweb by posting pictures and audio recordings remains a superficial engagement with the technology, in contrast to the advantages of those few who possess the skills and abilities to "hack" the technology and adapt it to their specific needs (Haklay, 2013). Brandusescu and Sieber (2017) have pointed out that skill requirements for geoweb application development may be easier with the advent of mashups but they remain predominantly designed by a small portion of the population possessing deep technical skills (software engineering, system administration) as well as different skills from those traditionally held by GIS professionals. Like GIS, the lack of technical expertise in Indigenous communities remains an issue with the geoweb. Geoweb applications are still built by outsiders and training is required to use them within the communities (Isogai et al., 2013; Gardner-Youden et al., 2015). It is curious that while the geoweb ecosystem of numerous apps, platforms, and software libraries offers a multitude of opportunities to design apps that align with Indigenous needs for display and data handling, there is very little desire (or a business model) to support that development. The libertarian do-it-yourself view of mapping technology development assumes that all the technology is equally available and ignores differential access to resources and technical expertise within Indigenous communities.

2.5 Ameliorations to the Geoweb

A comparison of the geoweb to the Indigenous critical GIS criteria suggests that many of the challenges of the geoweb resemble those in GIS. They lie in the digitizing and quantifying of data and exposing that content to a larger public unaware of the context or intent. These issues are generic to all software, quantitative studies, and online work. In many instances, the geoweb is no better or worse than GIS. For these reasons, the geoweb fails to live up to its democratizing and liberation goals. By highlighting the challenges of the geoweb, we hope that this area of

research will alarm technology developers to engage with a geoweb 4.0 that is inclusive of Indigenous peoples, of their knowledge, and ways of knowing, mirroring web 4.0 where "technology and human become one." (See the blog post Web 4.0 Era Is Upon Us for an overview of a brief web 1.0, web 2.0, web 3.0 and web 4.0; http://www.pcworld.com/article/143110/article.html). We propose ameliorations for the geoweb 4.0.

There are also many place-based solutions for the geoweb 4.0 depending on Indigenous context. We have discussed challenges of GIS and the geoweb in the context of Indigenous knowledge and Indigenous peoples collectively. Different Indigenous Nations have their own place-based knowledge and culture. Duarte (2017), an Indigenous scholar researching uses of information and communication technologies (ICTs) in Indigenous communities in the United States, explains that there exist as many ways of engaging with ICTs as there are Indigenous communities. Each Indigenous community can engage in the geoweb with different objectives and ways to address the challenges identified such as reducing the compartmentalization and distillation of Indigenous knowledge. For example, an Indigenous community could construct alternate basemaps to account for Indigenous spatial representations and conceptualizations. To do that, we propose that Indigenous communities use open layers instead of Google Earth where they would have to add on top of the already existing layers. Other solutions for Indigenous communities include building their own geospatial apps and creating their own social networks.

Technical expertise to achieve these alternatives is often lacking in Indigenous communities so emphasis must be placed on building capacity within Indigenous communities, and/or engaging with researchers and practitioners. Duarte (2017) points to the importance of long term technical training in Indigenous communities to safeguard the appropriation of long

term benefits and sustainability of technologies. In efforts to support Indigenous network sovereignty (Duarte, 2017) or Indigenous geoweb sovereignty, Indigenous-to-Indigenous capacity building has potential to strengthen the transfer of technological skills within Indigenous epistemological and ontological frameworks. We also believe that community discussions offer potential to engage in decisions about ways to mitigate challenges of the geoweb. Young and Gilmore (2014) explain the need to develop common understandings of technical issues with community members. Community conversations about technological challenges of the geoweb are necessary to develop the geoweb according to the specific needs and contexts of each communities.

Many ameliorations could be done with the geoweb to safeguard Indigenous knowledge from exploitation. We believe that the recent area of study of Indigenous data sovereignty should be an integral part of the geoweb 4.0. Indigenous data sovereignty is concerned with Indigenous peoples' authority over data about them, their territories, and ways of life (Kukutai and Taylor, 2016). Here, data sovereignty recognizes that data ought to be subject to the laws of the Indigenous nation from which they are collected. Data should remain under that nation's governance at all stages of the process: choice of data to be collected, data collection, organization of data, storage, development of data infrastructure, development of security and protection systems, and control of dissemination (Davis, 2016). In Canada, Indigenous data sovereignty has been developed with the use of First Nations' principles and practices of ownership, control, access and possession (OCAP) in relation to data (First Nations Information Governance Centre, 2016; Gardner-Youden et al. 2011). Development of a geoweb that integrates Indigenous data sovereignty into its systems would help Indigenous communities to

determine the processes of gathering, management, maintenance, distribution, and use of their knowledge, and directly address issues of exploitation and assimilation.

For example, to reduce risks of sharing Indigenous data, Sieber and Haklay (2015) suggest that geoweb developers should anticipate potential locational privacy violations and integrate techniques to obscure location when necessary. Geographic masking (or geomasking) refers to techniques to shift the exact location of points and has been used to ensure confidentiality of Indigenous data (Olson, 2017). There has been significant development in geographic masking techniques and GIS (Cottrill, 2011; Kwan et al., 2004). However, geoweb technologies have yet to incorporate them. Indigenous communities would need to control masking decisions to ensure that location privacy is defined and managed by Indigenous nations. Another solution is that Indigenous communities create forums on OSM to manage contributions of information on their territory and prevent outsiders to add data without their consent. The design of user interface in the geoweb could also include restricted logins based on characteristics such as age and gender to consider privileged ways of transferring knowledge.

2.6 Conclusion

Our proposed ameliorations are promising for the development of geospatial technologies by Indigenous peoples based on their epistemological and ontological frameworks. Overall, our critiques show that currently, the geoweb can perpetuate issues identified with desktop GIS and thus fails to liberate Indigenous peoples from compartmentalization, distillation, reduction, loss, exploitation, and assimilation of Indigenous knowledge, and Indigenous ways of transmitting knowledge. It is interesting to speculate on reasons why these critiques remain. One possibility would be that the critiques are durable. As new geospatial technologies are developed, similar problems are replicated over again. Another possibility would be that GIScience researchers are

stuck in a rut of constantly referencing Foucault and others to criticize the technology based on its ability to deeply and almost invisibly embed power. There is also a possibility that researchers are extolling the liberation because it offers a willful forgetting of the past sins of technology. The new technology is disruptive--it represents a break from the past. We have to be wary of this lens on the geoweb and consider that the technologies may be replicating the same challenges under a different guise.

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Chapter 3: Preface

Chapter Two presented a literature review focused on the epistemological benefits and challenges of the geoweb. The literature review in this chapter, by contrast, focuses on ontologies that are part of the underlying architecture of geospatial technologies. Specifically, I review the literature on geospatial ontologies and uncover assumptions of universality that fail to consider Indigenous concepts.

This chapter consists a manuscript co-authored with my supervisor, Dr. Renee Sieber. The manuscript has been accepted for publication in *Progress in Human Geography*. I am the primary author of the manuscript. I conducted the literature review, crafted the arguments, and wrote the content. Dr. Sieber provided guidance and feedback on the structure of the manuscript, the framing of the arguments, and the discussion of the implications of the arguments. Dr. Sieber also edited the manuscript prior to its submission.

Chapter 3: Do Geospatial Ontologies Perpetuate Indigenous Assimilation?

Genevieve Reid and Renee Sieber

3.1 Abstract

Research on geospatial ontologies focuses on achieving interoperability by creating universal standards applied to data. We argue that universality through ontologies can potentially perpetuate homogenization of concepts, thus contributing to assimilation of Indigenous peoples. We cover the ways the conventional geospatial ontologies enable dichotomies between mental and physical concepts, reduce concepts during the classification process, attribute agency, and privilege ontological class over relationships. We further argue that the geospatial web and natural language processing should be inclusive of Indigenous peoples to ensure future access to geospatial technologies and to prevent further loss of Indigenous knowledge. We explore alternate approaches to universality such as hermeneutics and heuristics. These offer the potential for Indigenous geospatial ontologies considered as equal, instead of being reduced to fit within western concepts.

3.2 Introduction

Geospatial ontology is a key subfield within Geographic Information Science (GIScience) (Agarwal, 2005). A working definition has ontologies characterized as the nature of the real world, usually operationalized as categories of logically distinguished features and deployed in "axiomatic language frameworks" (Harvey, 2006). For a period in the 2000s, the field of Geographic Information Science (GIScience) was dominated by research on geospatial ontology (Schuurman and Leszczynski, 2006). After a brief downturn, ontologies saw a resurgence with increases in available information on the web and aspirations of connecting massive amounts of data on the web with best practices to achieve goals like linked data (Bizer et al., 2009). This re-

emergence of ontologies was due in part to the creation of platial science, which moves away from authoritative data and seeks to integrate crowdsourced and social media data (Quesnot and Roche, 2015). This represents a more bottom up and yet computational approach to ontologies. In computer science ontologies are defined as a method to explicate the underlying meaning of data because ontologies organize, classify, and make geospatial concepts interoperable by way of properties, relationships, and hierarchies. Interoperability and the semantic web – an extension of the current web in which information is given well-defined meaning through standards developed by bodies like the World Wide Web Consortium (W3C) – are conventional areas in ontology research (Agarwal, 2005; Li et al., 2017). The quest to standardize information into an overarching universal ontology also is a priority because standardization attempts to identify concepts independent of culture and language. This would enable interoperability among different data sets across domains of knowledge or within a domain of knowledge such as the geographic domain (Tomaž and Ceh, 2012).

Interoperability among different data sets is desired by many, including marginalized populations like Indigenous peoples. Integrating Indigenous knowledge, whether via universal standards or other means, is claimed as a priority throughout academic disciplines. Examples include joint resource management projects (Berkes 2009; Pearce et al. 2015), as a way to assert Indigenous values and establish appropriate methods to manage resources. Indigenous communities view integration of their knowledge with scientific data, in particular, as a mechanism to gain skills on ecological decline or data management (Edwards and Heinrich, 2006). Indigenous groups also report benefits from mapping technologies to gather, document, store, and communicate Indigenous spatial data and advance their causes in the face of external pressures (e.g., land claims and natural resource management, see Olson et al., 2016; Tripathi

and Bhattarya, 2004; Corbett et al., 2015; Thom et al., 2016). A motivation for prioritizing Indigenous knowledge in ontology research is to support revitalization of Indigenous peoples' language and culture and inter-generational transmission of knowledge (Holton, 2011; Louis, 2011; Murton, 2011; Sieber and Wellen, 2011).

Technically, integration of data proves quite challenging (Bohensky and Maru, 2011). Such research and projects face barriers of diverging modes of data collection, management, control, sharing, and ownership between science and Indigenous systems (Pearce et al., 2009). But geospatial ontology research is not merely an instrumental exercise; it is inscribed in broader contexts of power such as the history of reinforcing colonization and domination over Indigenous territories in geography (Bryan, 2009; Palmer 2009). Technologies associated with mapping have been blamed for supporting colonization, supremacy of the state, and neoliberal agendas of market-oriented governance (Pickles, 2004; Wood, et al., 2010). Mapping technologies can potentially be detrimental for Indigenous peoples because of the challenges, as will be described, of diverging epistemologies (Rundstrom, 1995). Attempts at integration can reduce Indigenous knowledge, disregard Indigenous ways of knowing and of transmitting knowledge, put Indigenous knowledge at risk of being exploited, and assimilate Indigenous systems. Integration can potentially effect dispossession, decrease access to the land and resources, and create conflicts between and within Indigenous communities (Fox et al., 2006; Peluso, 1995; Rundstrom, 1995; Sletto, 2009). To mitigate negative impacts and engage in decolonization, Indigenous scholars argue for a reinvention of mapping technologies and mapping practices that focus on the process and allow to counter-map territories for the benefits of Indigenous communities (i.e., Pearce and Louis, 2008; Louis et al. 2012). We argue this includes a reinvention of geospatial ontologies that considers Indigenous ontologies.

Reinventing conventional ontologies is challenging. Approaches to ontology research in GIScience presume that organizing and linking information in ontologies will achieve the ultimate goal of universally integrating data. However, Schuurman (2008) claims that "we cannot contextualize the data for current and future users" without nuancing "contextual information about the objects" (Schuurman, 2008: 1540). Numerous problems arise when attempting to construct a universal ontology that bridges cultural and semantic boundaries. Different users and producers of information often assign different meanings for the same digital data products. Because universality is such an important focus in GIScience and geospatial ontology research, the concern is that non-dominant ontologies, like those from Indigenous cultures, will be excluded.

In this paper, we inquire whether standardizing information into a universal ontology as the standard operating procedure for geospatial ontologies perpetuates the assimilation of Indigenous concepts. We define universality in ontologies in four ways: the mainstream development of ontologies by a dominant class who decides how the world should be ordered, and accordingly designs the software for building ontologies; a formalized product that eliminates ambiguity, embraces objectivity and neutrality, and is driven by efficiencies; an assumption that primitives (core concepts) exist in the world that can be discovered; and a supposed agreed upon common sense way of discretizing the world and of establishing relationships between classes of entities. To address the impact of universality, we first uncover assumptions of universality embedded in ontology research in computer science and GIScience. We then point to problems of claims of universality that can effect an erasure of Indigenous knowledge. We examine differences between Indigenous ontologies and conventional ontologies and show how they represent fundamental breaks with conventional development of geospatial

ontologies that strive for universality. We conclude with alternatives that could bring together Indigenous ontologies and conventional ontologies.

3.3 Universality Expressed in Geospatial Ontologies

Computational and GIScience literature use the term ontology to describe a system of definitions and relationships between objects in-the-world and as they are represented in-the data. Originally, the word 'ontology' comes from the Greek words 'Onto' meaning being and 'logos' meaning study or science. Briefly, a philosophical approach to ontology examines what is reality and what is the nature of what exists. Contemporary texts in the philosophy sub discipline of ontology use mathematical logic to define the nature of reality (Kavouras and Kokla, 2007). Within computer science and GIScience, the common ontological approach creates a model for connecting and defining entities common to a domain of knowledge with classes, properties, instances, and rules (Guarino and Giaretta 1995). Arguably, geospatial ontology research borrows more (in terms of tone and technique) from the discipline of philosophy than from human geography. Behind conventional geospatial ontology development, the philosophical assumptions are primarily from a realist perspective: a reality exists across time and space as being independent from cultural interpretation or distortion (Smith, 2003).

Universality is a core goal in ontologies. Definitionally, universality refers to a common or shared understanding of reality as it exists and is represented. Aspects of universalism are at the foundation of defining the term ontology in computer science as well as in GIScience (c.f., Agarwal, 2005). Gruber (1993: 199), a leading computer scientist in Artificial Intelligence was the first to borrow the classical philosophical definition used in metaphysics and stated that an ontology is an "explicit specification of a conceptualization". Borst (1997: 12) defines ontology as a "formal specification of a shared conceptualization". Studer et al. (1998: 184) combine these

two definitions to state that: “An ontology is a formal, explicit specification of a shared conceptualization”. This combination of descriptions affirms the universalizing notion of capturing and mathematically expressing a consensual knowledge that is shared by several groups. The concept ontology is perhaps best captured by Agarwal (2005, 504) as being “the manifestation of a shared understanding of a domain that is agreed between a number of agents, and such agreement facilitates accurate and effective communications of meaning, which in turn leads to other benefits such as interoperability, reuse and sharing”.

The widespread motivation at the center of GIscience and computer science is to make data interoperable across different sources of information. Here interoperability is “a standardization procedure through which easier translation between different information sources can be achieved” (Agarwal, 2005, 501). Research in interoperability aims at reducing the Tower of Babel problem, which focuses on data integration of different systems and on data exchange between computer systems and users (Smith, 2003). Achieving these objectives requires more than a lexical solution with dictionary definitions of terms. Addressing the Tower of Babel entails resolving divergences in semantics, which is in the underlying meaning of data. Semantic interoperability creates correspondences between languages and users. The benefit of interoperability is the integration of data from multiple sources, aided by tools like Geographic Information Systems (GIS) (Fonseca et al., 2000, 2002, 2003; Harvey et al., 1999; Kuhn, 2002, 2005).

A major part of mainstream research to resolve the cacophony of the Tower of Babel is the development of top-level ontologies. Ontologies are hierarchical; top-level ontologies (also called upper level ontologies or foundation ontologies) aim to establish universality across domains of knowledge (e.g., across transport experts and poverty researchers) through

formalizing concepts called primitives that sit atop domain ontologies (e.g., public transit). Geography overlaps numerous knowledge domains so top-level ontologies function to unify different conceptualizations of the geographic world (Bittner et al., 2009; Kokla and Kavouras, 2001; Tomaž and Ceh, 2012). One set of primitives of a top-level geographic ontology is feature geometry: all features are either represented as points/pixels, lines, or areas. Top-level ontologies include most general categories of existence, or, as Smith (2012) explains are 'concerned only with what exists' (Smith, 2012: 1). These ontologies serve as foundations that subsume or encapsulate domain specific ontologies, which define categories and their relations within a specific application like land use (Bittner et al., 2009). Concretely, ontologies define collections of things in classes. A class can subsume or be subsumed by other classes; a class subsumed by another is called a subclass (or child) of the subsuming class called superclass (or parent). Figure 1 shows the superclass *Ecoregion*, which subsumes the subclass *Polar* (Bittner et al., 2009). The subsumption relation is used to create a hierarchy of classes. Anything that is necessarily true of a parent class is also necessarily true of all of its subsumed child classes. Similarly, top-level ontologies include top-level categories of things that subsume domain specific classes.

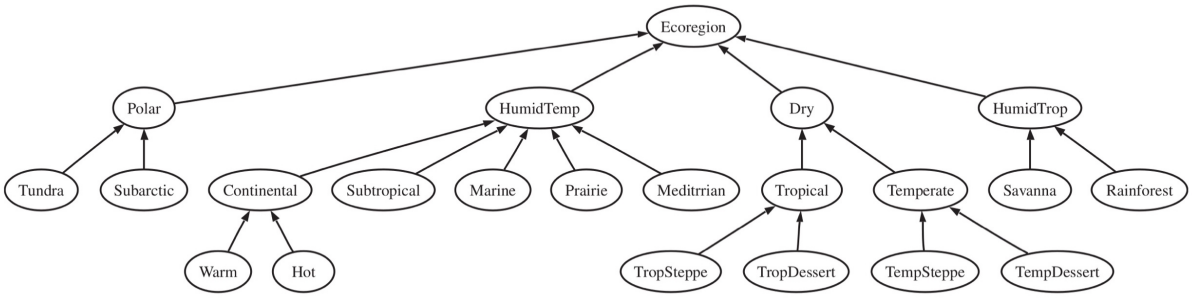

Figure 1: Subsumption of classes (Source: Bailey 1983 in Bittner et al. 2009: 779)

Examples of top-level ontologies from computer science include Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) (Bateman et al., 2007) and Basic Formal

Ontology (BFO) (Smith, 2012); an example in geography is the Open Geospatial Consortium (Lupp, 2008). Because of all the benefits of interoperability, efforts to develop top-level ontologies ambitiously strive to define categories that would be universal across all contexts, for example a superordinate category ‘watercourse’ that includes categories ‘stream’ and ‘channel’ in three different geospatial ontologies (Kokla and Kavouras, 2001).

Notwithstanding the focus on top-level ontologies, semantics and benefits of interoperability, disadvantages can be overlooked by computer scientists and GIScientists. Top-level ontologies are top-down, singular, and a priori (Bittner, 2007; Grenon and Smith, 2004). They are top-down as they are determined by an elite of experts who define general classes of entities, as opposed to domain ontologies, determined by domain experts, which for example could concern rivers but not necessarily include all waterbodies. Top-level ontologies oblige a singular conceptualization on the world. A top-level ontology may be designed to remedy the problem of integrating multiple conceptualizations, for example from different sources of information, different scales, or multiple geospatial disciplines such as hydrology, environmental science, forestry, and geology. Additionally, top-level ontologies are developed a priori. Definitionally, they are developed independent of the context they are describing. Figure 2 illustrates this framework of using top-level ontologies a priori and extending it with specific concepts of the domain. These solutions unavoidably deny the diversity of conceptualization in an attempt to create a “common neutral backbone” (Smith 2003: xx).

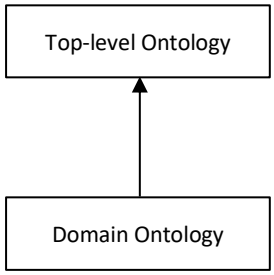

Figure 2: A domain ontology subsumed to a top-level ontology

Top-level ontologies produce controlled vocabularies and increase simplicity. When designers of these systems conform to an existing ontology, they are limited in their expression of different perspectives. These kinds of homogenizing solution have been called 'Newspeak solutions' by GIScientists Fonseca and Martin (2005) inspired by the 'Newspeak' English in George Orwell's novel 1984. 'Newspeak' refers to a technological language, a controlled vocabulary that is simpler than a natural language and its concepts and therefore does not allow the expression of complex points of view. Promises of top-level ontologies that amalgamate different conceptualizations can effectively reduce the complexity and subsume different cultural ontologies (Schuurman, 2005). Global efforts to achieve semantic interoperability exacerbate universalizing tendencies in geospatial ontology research because they require all to use the same simplified language.

Ultimately, representing a singular reality through a unified ontology rests on the question of "whether there are general truths or commonality in reality and whether universal knowledge of individual entities is feasible" (Kavouras and Kokla, 2008: 60). Most geospatial ontological approaches are based on the assumption that Smith (2003) calls "The Ontologist's Credo" (Smith, 2003: 154), that there are real truths and that one can categorize the world. In search for universal knowledge, ontologists also assume that every culture "ontologizes" the world, in other words, conceptualizes the world in categories. Geospatial ontologists often brush

aside these critiques because they maintain the belief in a reality completely independent from culture and contexts (Smith and Mark, 2001).

Like computer science, the achievement of a shared conceptualization in GIScience assumes that a 'common sense' of the geographic world exists across cultures, and across individuals at every age (Smith and Mark, 2001). This 'common sense' knowledge forms a universal theory 'on what there is' (Quine, 1980), which is called 'primary theory' (Smith and Mark, 2001). According to Smith and Mark (2001), primary theory defines the foundation for all human action and perception in the real geographic world and is independent of context. In this approach to geospatial ontology, universality is imperative to ensure accessibility, maintainability, and integrity of a 'good' ontology (Smith and Mark, 2001; Guarino, 1998). Converse to good ontologies, "Bad conceptualizations (rooted in error, myth- making, astrological prophecy, or in antiquated information systems based on dubious foundations) deal only with created (pseudo-)domains, and not with any transcendent reality beyond" (Smith and Mark, 2001: 594). The authors link goodness to universality, especially a universality grounded in scientific realism:

> focusing on good conceptualizations in the geographical domain will bring the advantage that it is more likely to render the results of work in geospatial ontology compatible with the results of ontological investigations of neighbouring domains. It will have advantages also in more immediate ways, above all in yielding robust and tractable standardizations of geographical terms and concepts (Smith and Mark, 2001: 595).

This dualist and normative perspective in ontology development, that there are right and wrong ontologies, that one can discern good ontologies, and that there are falsely grounded

ontologies (e.g., in myth), informs most geospatial ontology research. The use of normative terms like neutral, good, common understanding, “everyone does it”, and general truth demonstrates a faith in objectivity and realism. This ubiquitous attitude in the computational and GIScience fields is a major problem for other cultures and contexts, such as Indigenous peoples who are not represented in mainstream development. As we increasingly rely on technologies like search engines as a window to access to the world's information, we argue that ontologies are still important to achieve some common understanding.

Agreement is not universal on the universality of concepts in geospatial ontologies (Agarwal, 2005; Schuurman, 2005). The idea that there are universalities is an epistemology, a way of knowing the world. Thomas Kuhn (2012), in his treatise on knowledge epistemes, argues that a neutral classification is impossible and explains that scientists see things differently depending on the paradigm to which they adhere. Geography has a substantial literature on the problems of adopting dominant epistemologies. The literature on positionality (i.e., England, 1994; Merriam et al. 2001; Rose, 1997) demonstrates that factors such as race, nationality, age, gender, social and economic status, and sexuality influence scientists in their adherence to specific paradigms. Bowker and Star (2000) suggest that any classification system reveals political or ethical issues associated with the classification, or imposes normative behavior for peoples involved in the classification. Quite opposite to being neutral or universal, ontologies are subject to specific contexts of culture, and of their uses.

3.4 Indigenous Ontologies versus Geospatial Ontologies

We argue that Indigenous ontologies differ from conventional geospatial ontologies and top-level universal ontologies in fundamental ways. Indigenous concepts explicate how western concepts can break a continuum between physical and mental entities, deny the role of agency in

geographic entities and natural phenomena, view the environment as discretizable, and prioritize class over relationship. These differences can be so fundamental that a blind adherence to conventional geospatial ontologies development and a desire to seek universality risk assimilating Indigenous ontologies. In these instances, the "good intentions" of ontologists break down and instead force an epistemology of ontologies that can deracinate peoples' cultures.

3.4.1 Continuum between physical and mental entities

Geospatial ontologies are rooted in western science and geography. Gregory (1994) links western science and geography to Descartes's views on Enlightenment thinking. Descartes theorizes that thinking and vision are the sole foundations of knowledge; by comparison, the senses other than vision are inherently deceptive and can lead to errors in perceptions and representations. Descartes' reality is defined by objects that can be thought about and observed with the eyes. Within this objective and rational view, a duality exists between nature and culture, conceiving the world as a set of objects over which cultural significance is discretely added on top (Creese, 2011). This perspective follows Searle's (1995) realist theory of "brute facts". Physical entities such as mountains, rivers, and trees, are objective and distinct from "mental facts" or "social facts", such as ideas, interpretations, and beliefs. Geospatial ontologies perpetuate such a view by distinguishing physical objects from mental objects.

Such distinctions are found in DOLCE ontology, where physical entities such as 'river' are separate from non-physical mental and social concepts such as 'theory'. DOLCE offers the possibility to model non-physical mental and social concepts (Brodaric et al., 2008); however, theories are still separate from the objects themselves. BFO ontology does not allow for representation of human mental concepts at all. As Wood and Galton (2008, 11) explain: "BFO has been designed to represent entities and relations that exist in a so called 'mind-independent'

world. Bateson (1972, 1979) condemns western science because of a false duality between mind and nature. The Cartesian duality is a simplification of the world at best.

At worst, the duality between mind and nature contradicts Indigenous ontologies that may not distinguish between inanimate geographical objects and cognitive processes (Berkes and Berkes, 2009; Creese, 2011; Ingold, 2000; Johnson and Murton, 2007). As opposed to a dualist ontology, Indigenous peoples are said to possess a monist conceptualization of the world where physical entities and the mind are one (Aikenhead and Ogawa 2007). Irwin (1996) provides an example:

> Among Plains Indian visionaries, there is a strong sense of the continuum between human perception, the natural world, and the mysterious appearance of visionary events—a sense that allows features of the lived world to blend, transform, or suddenly reveal new dimensions of meaning and power. A stone might speak, an animal change into another creature, a star fall to earth as a beautiful woman. The individual's experience of the world is not limited to ordinary motor action or to the five physical senses. (Irwin, 1996: 27)

The continuum between mental processes and the physical has been considered 'Indigenous place-thought' (Watts, 2013). Basso (1996) shows in his ethnography *Wisdom Sits in Places* that Apache people's relation to the land, attachment to place and place names are linked to their sense of spirituality, sacredness, wisdom, morality, and wellbeing. For Indigenous communities, natural features are often inseparable from what could be called 'spirituality' (Mark and Turk, 2003). For the Maninka farmers in southwestern Mali, the physical environment is inseparable from the bio-spiritual environment that is comprised of all beings such as humans, spirits, animals, plants, and their possessions (physical things) (Duvall, 2011). For Indigenous

conceptualizations, actions performed by humans such as storytelling, naming places, music, and dance, are also often inseparable from the land itself and geographic entities (Louis, 2004; Turnbull, 2007). Indigenous lands are not merely canvases onto which memories are located in space and over which meanings are ascribed (Ball, 2002). Geospatial ontologies that categorize Indigenous concepts as beliefs about the land rather than what the land is, interrupt a continuous Indigenous conceptualization of the world.

This dichotomy can further the long history of assimilation and displacement of Indigenous peoples, as well as domination over their territories (Johnson and Murton, 2007). Explorers and researchers described Indigenous peoples as objects of ethnographies, those stories and dances, which could be detached from the land. The land could then be characterized as empty, 'pristine nature' (Johnson and Murton, 2007: 123), which eased the relocation of Indigenous peoples. These days ontologies may aid in the exploitation of Indigenous territories because there is no intrinsic cultural significance to the land.

3.4.2 Holism of physical concepts in the environment

We noted above that the duality between mental and physical entities fundamentally differs from Indigenous conceptualizations; however, even the ways that the physical entities are categorized in geospatial ontologies are problematic. Scientific practices tend to adopt a reductionist perspective of the world dividing everything into a set of parts with the assumption that the knowledge of parts of a system generates knowledge of the whole environmental system (Berkes, 2010; Shiva, 1988). In GIScience, geospatial ontology development focuses on classifying into smaller parts and into kinds (e.g., has-part/is-part-of, is-a/kind-of relationships) (Casati et al., 1998; Tomai and Kavouras, 2004). Partonomies use part-of relationships and

create sub-divisions to define concept and categories. Formalization of ontologies necessitate axioms to clearly define rules of membership and demarcate classes.

Classification in conventional ontologies, where an entity that belongs to one category cannot be in another one, contrasts with the holistic perspective in Indigenous conceptualizations where geographic entities on the land do not map to distinct categories. In Cree language, one word for the land *eshiwiinaahtammakak* means "the way in which the (E)arth is dressed or clothed" (Preston, 2014: 203). According to the Eastern Cree, the word encompasses trees, rivers, animals and everything that covers the land. This example shows how the Eastern Cree (and other Indigenous groups) often see and talk about the entirety of the land as sacred (Ball, 2002: 467), and how this kind of conceptualization challenges geospatial ontologies that are built to organize and categorize entities and then place them into well-separated boxes.

Holism describes the notion of inclusivity of all entities and beings comprising the land (Aikenhead and Ogawa, 2007; Berkes, 2012; Berkes and Berkes, 2009; Kohn, 2013; Little Bear, 2000). As opposed to a reductionist separation of entities into parts, Berkes and Berkes (2009) show that Indigenous conceptualizations often resemble fuzzy logic, where entities are classified with a gradual (rather than abrupt) transition from membership to non-membership. Rather than clear cut boundaries of entities and categories such as in geospatial ontologies, Indigenous ontologies exhibit an unbounding between classes of entities, where entities might be part of multiple classes. For the Eastern Cree, a river affords a critical source of transportation. In areas where there are rapids, canoes must be portaged (carried) on the bank next to the river. To the Eastern Cree, that portion of the bank is the river. Therefore, a river can sometimes be part of the class waterbody and sometimes be part of the class land feature (i.e., the portage section)

(Wellen and Sieber, 2013). Conventional ontologies force a reduction and conformance of physical entities rather than allowing holism.

3.4.3 Agency of geographic entities and natural phenomena

In certain Indigenous cultures, the land and elements constituting the land (i.e., geographic entities like mountains, rivers, islands, trees; natural phenomena like wind, thunder; sun, moon) have agency. Land and elements are conceptualized as living beings. Non-human entities can be filled with spiritual powers and can all be considered as 'persons' (Bastien, 1978; Bawaka Country et al., 2016; Cruikshank, 2010; Hallowell, 2002; Ingold, 2000; Nadasdy, 2007; Scott, 2006). Cruikshank (2012, 245) explains that "From this [Indigenous] framework, animals, humans and even features of landscape have points of view, exhibit agency, and engage in reciprocal responses" and, like above, exhibit no dual distinction between inert objects and alive beings.

Numerous examples of this form of agency occur in Indigenous cultures. Hallowell (2002) has used the term other-than-human persons in his ethnography of Ojibwa people, to refer to the category of beings possessing their own agency and potentially charged with spiritual powers. For Ojibwa elders, stones can speak, move, and interact with people (Hallowell, 2002: 24). The Eastern Cree in Northern Quebec conceptualize the land, waters, topographic features, climate, animals, spirits, and humans with status of 'persons' (Feit, 2001, 2004; Preston, 2005). In Eastern Cree narratives, hills, mountains, and rivers often have the role of conductors for powers (Preston, 1999). For example, the "North Wind" is a powerful person (Feit, 2004). Feit (2004) found that it was inappropriate to talk about the "North Wind" during warm weather because "he" could interpret it as "talking behind his back" and be offended (Feit 2004: 104).

For some Indigenous peoples, a non-physical entity with agency might be inextricably attached to a geographic entity. Mark and Turk (2003) show that the desert-based Yindjibarndi Australian aboriginal communities view seasonal pools of water as possessing spirits who determine how much water is allowed to be removed. This agency challenges integration into mainstream geospatial ontologies because a spirit would be categorized as a mental process or a belief about the pool of water, separate from the non-agentive geographic entity. The spirit might be eliminated entirely because it is not real.

The agency of certain geographic entities and natural phenomena in Indigenous conceptualization greatly differs from western systems of thought. In particular, top-level and geospatial ontologies make clear distinctions between fixed geographic objects, agents (humans), and processes happening in time. These categorizations assume that geographic features and agents possess distinct kinds of properties and discount Indigenous notions of agency of geographic kinds. Because many top-level ontologies do not include concepts related to humans or agents such as in the BFO (Wood and Galton, 2008), they are ill equipped to integrate agency of geographic entities.

3.4.4 Predominance of Relationships

The predominance of relationships in Indigenous ontologies differs from conventional ontologies. Ontology development focuses on defining classes of entities and hierarchies of entities. Entities are connected via relations. The following are the most commonly used relationships in geography: mereology (has-part/is-part-of relationships), location (relation between a geographic entity and region of space in which it is located), and topology or the connections between entities or of a piece (is-a/kind-of relationships) (Casati et al., 1998; Tomai and Kavouras, 2004). The relationships between concepts define a hierarchy of concepts and

classes. They also can fail to completely capture the ways that human beings conceptualize geographic features.

To support more complex human conceptualizations, geospatial ontology developers have adopted the concept of affordance. This concept is based on the theory of perceptions developed by the ecological psychologist, James J. Gibson (1986). Gibson considered that "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1986: 127). For example, an affordance could be the 'ability to sit on' relation between a chair (or the object) and a person (or the agent). In geospatial ontology, the concept of affordance is used with the assumption that geographical objects support actions, for example, 'mountain' supports the affordance 'hiking'. Affordance aims to better represent human conceptualization because "things that human beings distinguish in the world depend on the actions they afford" (Kuhn, 2001: 617). In Kuhn's (2001) classification, actions predominate; whereas the identification of objects affording those actions is made afterwards. Actions and objects are linked by an affordance table. Affordances and the predominance of actions in classifications differ from other geospatial ontologies that merely consider function and action as secondary and modeled as property of an entity. Sen (2007) also considers an action ill-represented as a property of an entity. The author claims that actions should be distinguished and developed in parallel with entities hierarchies to give equal importance to both activity and objects. The author links the two hierarchies (actions and entities) with the role-holder concept. For example, the action concept 'hike' would be linked with the entity 'mountain' using a role-holder concept 'Areas for hiking'. These advancements in geospatial ontologies aim at capturing human conceptualization but do not necessarily correspond to Indigenous ontologies.

Indigenous ontologies predominantly focus on relationships. They do so without establishing a hierarchy and in a more complex way than the concept of affordance. In Indigenous conceptualizations, entities are defined, not so much with their physical properties nor in terms of membership in super classes or subclasses, but in terms of their relationships. Thus, Indigenous conceptualizations are often referred to as relational ontologies, where everything is defined by its relationships with humans, animals, more-than-human agents, and physical entities (Bawaka Country et al., 2016; Cajete, 2000, 2004). Australian Aboriginals conceptualize "a world of relationships where each person defines himself or herself in relation to others and to the environment" (Poirier, 2005: 112). The Runa of Ecuador's Upper Amazon see themselves and the environment as part of complex webs of relations with spirits of the forest as well as with "many powerful human beings who have left their traces on the landscape" (Kohn, 2013: 19). The Cree in Northern Quebec view the concept of landscape as embedded in a relational cosmology and defined in relational terms among entities. There, animals, humans, spirits, the weather and 'some geophysical agents' (Scott, 1996) form part of the landscape and mutually interact with one another (e.g., through dreams) based on socially interconnected processes of engagement (Preston, 2002; Scott, 2006). For the Athapaskan and Tlingit people in the Yukon, glaciers respond to human actions and misconduct (Cruikshank, 2010). Whereas the concept of affordance assumes that objects support human actions, Indigenous conceptualizations can have humans influencing and triggering actions of animals, geographic entities, spirits, the weather and geophysical agents. A focus on affordances, which have been adopted in mainstream ontology research, can still miss and diminish important kinds of reciprocal relationships.

The gap between mainstream geospatial ontology development and Indigenous ontologies is considered incommensurable by some critical scholars (Agrawal, 2002; Rundstrom, 1995). These authors claim that any attempt to formalize Indigenous knowledge inevitably leads to alterations and represents a form of assimilation. Notwithstanding issues of appropriateness in formalizing Indigenous knowledge, omitting Indigenous conceptualizations and Indigenous peoples from ontology development efforts may be just as detrimental.

Whereas the quest for universals can associate mainstream geospatial ontologists with Indigenous communities to satisfy the curiosity of comparing which definitions and concepts of geographic entities remain constant in the geographic domain across multiple culture and contexts (Mark et al., 2012), this kind of research might be problematic. A search for primitives runs the risk of objectifying Indigenous peoples, similar to the search for the 'noble savage'. It could continue the romanticizing of Indigenous peoples as authentic and free of civilization (Krech, 2000). This picture would paint the ideal place for the discovery of fundamental and universal concepts that are free of artifice, but might fail to engage deeply with what Indigenous communities define as reality.

3.5 Alternate Approaches to Addressing Universality in Ontologies

Here we explore alternatives to the quest for universals that could engage Indigenous peoples in the development of ontologies. At minimum we need to expand the concept of expert. Any ontology research requires the engagement of domain experts (Mizen et al., 2005). If one wishes to "dissect" mountains then one would talk to geomorphologists (among experts from related scientific domains). The geospatial ontologies literature has numerous instances of involving Indigenous experts. Indeed it generated a new subfield, ethnophysiography—the study of the conceptualizations of landscape across culture and language that are developed with Indigenous

communities (Holton, 2011; Louis, 2011; Mark and Turk, 2003; Murton, 2011; Sieber and Wellen, 2011; Wellen and Sieber, 2013). The field recognizes that Indigenous peoples serve as important sources of information about the land.

A deeper engagement with Indigenous peoples requires that GIScientists look to Indigenous peoples as more than conduits and involve them in the co-creation of their ontologies. Indigenous methodologies (i.e., Kovach, 2015; Louis, 2007; Smith, 2012) offer guidance to approaches of deep engagement. In efforts to decolonize research in geography, Sundberg (2014) coins collaboration as a process of *walking with* (Sundberg, 2014: 40). This method demands the researcher appreciate "the difference between learning to know the other and learning as an engagement with the other (that also may entail learning from the other)" (Sundberg, 2014: 40, also see Kuokkanen 2011). In information science, a participatory approach called 'fluid ontologies' can be employed with Indigenous communities to co-create information systems (e.g., computerized database systems) that are sensitive to the culture and their conceptualization of knowledge (Becvar and Srinivasan, 2009; Srinivasan, 2007; Srinivasan and Huang, 2005). Rambaldi (2005) integrates ontological discussions in participatory design of map legends as part of on-the-ground mapping techniques and skills training. Participatory approaches to ontology development offer opportunities to engage and reflect Indigenous conceptualizations and to limit infusing Indigenous conceptualizations within western misconceptions. Admittedly mapping, delineating, and discretizing indigenous territories "walks a fine line" between effectiveness in addressing Indigenous needs and overcoming negative outcomes in mapping projects (Bryan, 2011: 40). Collaboration invariably downloads responsibility of skills development to the Indigenous person. Multicultural approaches to

participatory mapping can represent a form of bounded self-determination, where people have control over knowledge production within limits.

Beyond participation, alternate solutions to mainstream ontology development can emphasize the engagement of Indigenous people in directly shaping technologies themselves (Lameman and Lewis, 2011; Lewis and Fragnito, 2012). This approach moves beyond considering Indigenous people merely as technology consumers or Indigenous knowledge as another data source (Boast et al., 2007). For example, Indigenous youth are crafting technologies such as video games to represent their stories and conceptualizations (Lameman and Lewis, 2011). To move in that direction, authors of academic papers on ontology development could engage with Indigenous scholars that are already engaged in defining aspects of the world such as natural and physical entities (i.e., Cajete, 2000; Cruikshank, 2010; Kohn 2013; Little Bear, 2000). Even though the term ontology differs between domains including Indigenous studies, anthropology, language, geography, computer science, and GIScience, we argue for a dialogue that includes multiple disciplines and cultures to ensure inclusivity of perspectives.

Location, context, and place are fundamental for indigeneity (Escobar, 2001; Sundberg, 2014; Watts, 2013). Place-based approaches to ontology development represent opportunities where other approaches of ontology, specifically those with a focus on universality, have failed (Veland et al., 2014). Alessa et al. (2011) call for development of GIS that are specific to context and denote the local views of the world. An example is found in the development of digital libraries that use tags to classify knowledge, where users annotate pieces of information with descriptions or keywords (Bénel et al., 2001, 2010; Boast et al., 2007). Tags, annotations, and tag clusters are subsequently used to categorize information in dynamic ways and to reveal users conceptualizations in their own language. Such approaches have the potential to offer an

alternative to universal static ontologies and to consider multiple Indigenous place-based ontologies that might evolve over time. For example, different generations may have different geospatial ontologies (Wellen and Sieber, 2013). Another example of technical implementation of a place-based approach would be rethinking ontology development software, such as the software Protégé OWL, to allow for more elaborate ways of deploying relationships than topology and mereology.

A hermeneutic approach also holds potential for a place-based Indigenous ontology that could partner with western ontology instead of being subsumed by it. The definition of hermeneutics in information science as described by Fonseca and Martin (2005: 52) emphasizes interpretation as the foundation of the information process: "a hermeneutic contextualization of ontology construction and use can make room for communication among users who hold different ontologies". Hermeneutics is the study of interpreting knowledge including methods of analysis, synthesis, and application--the bounding of how we understand the underlying meaning (Schwandt, 2007). But hermeneutics also "is ontological because 'understanding' is our very mode of being in the world...Understanding is always open and anticipatory; one never achieves a final, complete interpretation. This is so because we are always interpreting in light of 'prejudice' (or prejudgement, preconception) that comes from the tradition of which we are a part" (Schwandt, 2007: 227). Historically, the role of communicating ontology information has been given to the Indigenous peoples and the role of interpreting what is meant has largely been accorded to western researchers. In GIScience, the objective of hermeneutics would be to establish: "a place where users may come to learn from one another in a way much more fundamental than merely exchanging information within a mutually accepted paradigm" (Fonseca and Martin, 2005: 52). Hermeneutics in GIScience could begin to address the Tower of

Babel problem, semantic heterogeneity, and the incommensurability of different cultural ontologies as well as accord rights of interpretation to Indigenous peoples.

A core principle of alternate place-based Indigenous ontology development is the recognition that there is no universality and instead multiple worlds exist. This approach mirrors processes of decolonization and political ontology proposed by Blaser (2014). Blaser explains that "political ontology cannot be concerned with a supposedly external and independent reality (to be uncovered or depicted accurately); rather, it must concern itself with reality-making, including its own participation in reality-making" (Blaser, 2014: 55). This process of ontology making is a heuristic device, a tool that forces ontologists to experiment with how ontological assumptions are deployed and how they might differ across different interlocutors (Blaser, 2014: 55). The heuristic device contributes to a postcolonial paradigm, which theorizes that "hybridity in the contact zone will generate excess creative diversity, contradictions for the patronizing hierarchies of colonial discourse and, thereby, scope for subaltern agency to displace neo/colonialism" (Coombes et al., 2012: 692). It tries to move beyond multiculturalism as a way of including multiple worlds. Hale (2005) argues that multiculturalism actually represents a neoliberal project that focuses governance solely on economic reforms and political measures that limit rights and recognition for Indigenous peoples. For the Indigenous people of Central America, it: "deepened state capacity to shape and neutralize political opposition, and a remaking of racial hierarchies across the region" (Hale 2005: 10). As an alternative to the neoliberal 'multiculturalist', Blaser (2009: 11) suggests to focus on a 'multinaturalist' approach which was developed by Viveiros de Castro (1998). A multinaturalist approach recognizes not a universal world with many interpretations layered on top; but instead many worlds, many natures. Ecuador state's policies, development strategies, and constitution instantiate into law the

Indigenous notion of "*sumak kawsay*" (*buen vivir*, or living well). Actions like Ecuador's recognize the multiplicity of knowledge in a "situated engagement with ontological pluralism" (Howitt and Suchet-Pearson 2006: 331). They do not subsume Indigenous concepts to western a priori conceptualizations.

3.6 Conclusion

Conventional ontology development focuses on achieving interoperability and on bringing together ontologies from different domains and cultures. In this paper, we uncovered assumptions made in the universality promoted in geospatial ontologies such as classification and discretization. These efforts can effect loss of information and subsumption of cultural ontologies. We described how these endeavors fail to engage with Indigenous conceptualizations. Excluding the participation of Indigenous peoples risks furthering a kind of fetishizing of authenticity. Characterizing Indigenous peoples as objects from the past waiting to be discovered supports a colonizing tendency found in many contexts such as the stereotyping of the 'ecologically noble Indian' in conservation and environmental strategies (Nadasdy, 2005). This tendency could be addressed when Indigenous ontologies are considered equal with mainstream ontologies in GIScience, instead of being assimilated into western conceptions. A few approaches offer possibilities to bring Indigenous geospatial ontology in this direction.

We have presented the challenges and alternatives to considering ontology as static and universal. Place-based, and participatory approaches, as well as technical implementations of these kinds of approach prioritize co-creation, debates, communication, flexibility, fluidity and adaptability of ontologies over time. Indigenous peoples can be directly involved in the shaping and crafting of ontologies. These approaches are steps toward a 'socio-semantic web'—which focuses on a semantics dependent on human subject and on ontologies updated through

cooperation and debate, in contrast to an ontology defined by fixed standards (Bénel et al., 2010). Hopefully this can reduce 'ontological violence' (Walker, 2004) toward Indigenous peoples and instead support efforts towards 'ontological self-determination' (Holbraad et al., 2014) where Indigenous conceptualizations are taken seriously and neither assimilated nor colonized.

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Chapter 4: Preface

Chapters Two and Three presented literature reviews dealing with the challenges of considering Indigenous epistemologies and ontologies in the geoweb, in GIScience, and in geospatial ontologies. In response to this literature, our research involved working with Eastern Cree communities in Northern Quebec to develop an alternate spatio-temporal ontology that consider their conceptualizations of space and time instead of subsuming their concepts to Western views. This chapter presents a unique methodological approach that engages deeply with the community at the same time as acknowledging the expert positionality of an outsider researcher.

This chapter consists of a manuscript co-authored with my supervisor, Dr. Renee Sieber. The manuscript is currently being prepared to be submitted to *The Canadian Geographer*. I am the primary author of the manuscript. I conducted the literature review, conducted all fieldwork, crafted the arguments, and wrote the content. Dr. Sieber provided guidance and feedback on the structure of the manuscript, the framing of the arguments, and the discussion of the implications of the arguments. Dr. Sieber also edited the manuscript which is intended for publication.

Chapter 4: Unavoidable Expertise, "Technocratic Positionality", and GIScience: Eliciting an Indigenous Geospatial Ontology

Genevieve Reid and Renee Sieber

4.1 Abstract

Advancements in geospatial technologies promise a liberation from experts' knowledge in the somewhat abstruse topics of GIScience such as ontologies. We argue that, despite, these technological developments, technocratic GIScience expertise remains important in research with Indigenous communities. We found limits in approaches to Indigenous ontology development because the role of the expert is unquestioned, which effects a recolonization. Researchers must address their positionality in research with Indigenous peoples. Positionality compels the researcher to acknowledge the mantle of legitimacy accorded to, for example, their credentialled expertise, institutions, race, class, and gender. To address technocratic positionality in Indigenous geospatial ontologies, we draw on our experience with eliciting geospatial concepts with the Eastern Cree in Northern Quebec. We identified the concepts of hermeneutics and heuristics as promising approaches to avoid recolonization and increase Indigenous contribution to ontology production. A heuristic approach compels the researcher to be immersed within the community context. Hermeneutics emphasizes interpretation of knowledge alongside Indigenous community members. Immersion and greater inclusivity afforded by these two approaches allow the researcher to conduct research activities without being confined in the role of a technocrat outsider/expert. We discuss challenges that remained in reducing distance and in balancing a technocratic positionality.

4.2 Introduction

Advances in geospatial technologies like the geospatial web (geoweb) are claimed to abolish the supremacy of Geographic Information Systems (GIS) experts (Crampton, 2009). These advances

introduce user-friendly applications on easy-to-use and relatively inexpensive devices and the ability for non-experts to contribute geographic content commensurate with their lived experiences (Elwood and Leszczynski, 2011). It is a 'neogeography' in GIScience, which means that the technology is supposedly universal to these non-experts, accompanied by promotional claims that anyone can use it at anytime (Leszczynski, 2014). New geospatial technologies are also commonly praised as liberation technologies (Sui, 2015). Liberation technologies promise to improve governance, empower marginalized communities, defend human rights, promote economic development, and expand social benefits (Diamond, 2010; Sui, 2015). The rhetoric of liberation from expertise via new geospatial technologies is particularly powerful in Indigenous communities, where it could allow them to cartographically represent their voices, protect their culture (e.g., via spatial databases) and press their concerns (countermap, counterapp and counter analyze).

We argue that, despite the liberating claims of the geoweb, GIScience expertise is still needed in Indigenous communities. We see this in Indigenous geospatial ontologies. Ontologies can be defined as a method to explicate the underlying meaning of data and concepts. They are models that connect and define entities in a specific domain (e.g., water) with classes, properties, instances, and rules (Guarino and Giaretta, 1995). Building Indigenous geospatial ontologies can reveal inadequacies in current data models. Ontologies can help establish provenance over the land and can be instrumental in Indigenous language revitalization. Indigenous ontologies also can contribute to inter-generational knowledge transfer by providing means for the organization, management, and interoperability of data gathered when documenting Indigenous knowledge (Mark et al., 2011; Pulsifer et al., 2011; Wellen and Sieber, 2013). In our research we developed an Indigenous ontology that focused on different ways the community considered space and

time. Developing geospatial ontologies requires considerable GIScience skills because ontology development is a highly abstract endeavor that requires to define and categorize entities in the world, and form relationships between entities. Ontologies extract the meaning behind the semantics. Ontologies are studied by a narrow niche of experts and are hard to explain to anyone, even to other GIScientists (Schuurman, 2006). To develop ontologies, ontologists convene groups of domain experts (Mizen et al., 2005). In this case, Indigenous peoples are involved in the creation of Indigenous ontologies as domain experts. A hierarchy remains with the ontologist, often a non-Indigenous expert, inferring the underlying meaning and formalizing the ontology. There exists no widespread ontologist training that can easily be diffused to Indigenous communities. These circumstances create for the GIScientist the position of a technocrat.

As part of our methodology to conduct GIScience research in an Indigenous community, we realized the need to address our own position, particularly from a technology perspective. That meant recognizing that we came from a position of privilege and distance: we are part of a dominant class (white, middle class, highly educated, heteronormative) and we are not of the community. Acknowledging one's positionality is common in Indigenous research (Absolon and Willett, 2005) because it compels the researcher to foreground their biases and begin to redress power differentials created by their roles. Positionality is promoted in research with Indigenous communities as a step in decolonizing methodologies (Absolon and Willett, 2005; Moffat, 2016). Feminist scholars argue that positionality allows one to engage in the production of knowledge that begins a process of emancipation from patriarchal oppression (England, 1994; Rose, 1997). We wanted to acknowledge and address the situation in which we brought specialized knowledge that enabled us to adopt the mantle of expertise and institutionalized legitimacy. To that end, we used the heuristic and the hermeneutic (2H) approaches to refine what we

considered to be a technocratic positionality. Heuristics concerns the creation of knowledge based on the researcher's personal engagement with the context (DePoy and Gitlin, 2016). We involved community members in hermeneutics–the interpretation of the underlying meaning of knowledge (Schwandt, 2007). Our aim is to engage in a reflexive process that would address issues of being an outsider/expert who brings technological knowledge and is sensitive to the Indigenous context. We further argue that recognizing positionality via the 2H approach builds a better ontology, in the sense that it captures Indigenous concepts that are not necessary easily accessible to an outsider researcher.

The article is organized as follow: First, we define technocracy and explore why it is an issue in GIScience. We argue that while technocracy is not desired, expertise is inevitable in GIScience. We then look at ways in which technocratic positionality is unaddressed in Indigenous geospatial ontologies and point to issues of effecting a recolonization of knowledge production. We then explore alternatives to address technocratic positionality with the hermeneutic and the heuristic approaches in our research. We present benefits and challenges with the hermeneutic and heuristic processes in our research on developing geospatial ontologies with the Eastern Cree in Northern Quebec.

4.3 Technocracy and the Inevitable Expertise in GIScience

Since the beginning of the last century, technocracy has been part of Western thought, specifically in the fields of political science and sociology. Technocracy refers variously to the government, the control of society, or the exercise of political authority by technical experts such as scientists, technicians, and engineers (Roszak, 1969). During the industrial revolution, values of productivity, efficiency, and order were promised to a society that faced a constant increase in the complexity of problems and threats of economic crisis (Gunnell, 1982). Technocracy was

popular in the 1930s in the United States because it was praised as a response to the Great Depression (Gunnell, 1982). More recently, many saw technocracy as an appealing way to address the increasingly complex technological problems (Fischer, 2000), especially when the general public and the market-based structures seemed incapable of handling the complexities. In these circumstances, technocracy embodied in agents (experts) and institutions such as universities, and governments agencies, play an important role in society.

Despite these virtues and the utopian vision of technocracy, political scientists and sociologists criticize technocracy and identify many problems. Gunnell explains that: "Technocracy has often been associated with a utopian social vision, yet it has also been regarded as a political pathology" (1982, 392). Problems are associated with a rise of an elite of technical experts that control important spheres of society without input from citizens. Max Weber (Gerth and Mills, 2009) explains that the technocratic phenomenon represents a march towards technical rationality. What is considered rational in society is transformed from a value in the role and functions of politicians and of democracy, into an emphasis on procedural rules and bureaucracy. Fischer (1990) points to the issue of citizen participation in an age that is dominated by technologies and by decisions that are made by experts or that are exclusively based on expertise. Technocracy problematizes the relation between knowledge and power.

GIScience has been implicated in technocracy since the introduction of GIS software (Obermeyer, 1995). Early desktop GIS was expensive and difficult to learn so the systems were exclusively in the hands of an elite of experts. Spatial datasets could be huge, with file sizes that exceed storage capacities of microcomputers and require tens of thousands of polygons to process. Often expensive hardware like large format plotters were needed to support them. People began creating and adapting complex spatial analysis and modelling to aid in processing

the spatial data. A primary reason that systems were in the hands of experts was not necessarily because only elites were qualified to use them, but instead the software frequently "broke", requirely arcane insider knowledge to fix it. As admitted by the lead developer of Geographic Resource Analysis Support System (GRASS), "Yes, we did release code with known bugs and we did release code before the software was "done"" (Westervelt, 2005). This was a new concept that software definitionally is never complete; software is considered to be always evolving and requires considerable knowledge to find workarounds.

Technocracy is embedded with many levels of expertise in geospatial technologies and GIScience. At the first level, some types of usage of geospatial technologies are now increasingly accessible to many, such as map production and the contribution of geospatial local knowledge. With practices such as Public Participatory GIS (PPGIS) (Sieber, 2006) and neogeography (Goodchild, 2009), lay people, and non-governmental organizations have now increasing opportunities to use geospatial technologies and to reverse technocracy. However, a second level of expertise is still in the hand of experts. The development of geospatial technologies is very complex. For example, developing mapping API still requires coding skills that are often alien to the layperson (Haklay, 2013). Yet a third level of expertise is almost inevitably exclusive to scholars and experts. There is the underlying science behind geospatial technologies which is not merely technical but theoretical. The theory includes data accuracy, data quality, data structure, semantics, and ontologies, power dynamics in knowledge production and in the design of the technology, implications for deep citizen participation (Sieber and Haklay, 2015). These theoretical topics are not accessible to people outside of GIScience, yet necessary even for Indigenous peoples. For example, ontologies can allow to find the meaning behind semantics of toponyms and can contribute to establish that Indigenous knowledge of the

territory as authoritative by formalizing it. This demonstrates the impenetrability of geospatial technologies and the continuing dependance on experts in GIScience who continue to assert a technocratic positionality.

Developing geospatial ontologies pertains to a level of expertise in GIScience that is not yet easily penetrable. It requires a high level of abstraction to define geospatial concepts, categories, and relationships between them. For example, a water ontology must unambiguously determine what constitute a waterbody and the distinctive classes of swamp, lake, lagoon, pool, pond, reservoir, inland sea, aquifer, spring, etc. Geospatial ontologies also conventionally use mathematical logic language to formalize these already abstract conceptualizations. In these circumstances, ontologists have a technocratic positionality.

4.4 The Mantle of Expertise in Indigenous Geospatial Ontologies

Indigenous geospatial ontologies are concerned with ways that Indigenous peoples conceptualize and ascribe meaning to geographic features, that is how they define concepts, categories, and relationships (Wellen and Sieber, 2013). It is a knowledge production via classification, explication and relation. For example, Wellen and Sieber (2013) develop a geospatial ontology for hydrographic features with the Eastern Cree in Northern Quebec. Ontology of landforms with the Yindjibarndi people in Australia study the terms for landscape entities, the ways that entities are categorized (e.g., hills and water features), the structure of placenames, and the role of spirituality in defining landscape entities (Mark and Turk, 2003). Geospatial ontologies research with Indigenous communities is conducted both by Indigenous scholars and non-Indigenous scholars.

Technocratic positionality is not explicitly addressed in Indigenous ontologies. The ontology developer is meant to be a transparent medium, through which the ontology emerges

from domain experts (Uschold, 1996; Uschold and King, 1995). This is especially true in the initial stages of the ontology development which aim at capturing the content of the ontology without ascribing any a priori conceptualization (Uschold and King, 1995). Whereas the process of Indigenous ontology elicitation is extensively detailed (Janz 2011; Turk, 2011), researchers do not explicitly write about the reflexive process of conducting ontology research, their role as researchers, or the impacts of their research on the community. Hence, ontologists do not acknowledge the inevitable influence of their race, nationality, age, gender, social and economic status, sexuality, and education in their research. Certain combinations of these characteristics can lend an unearned legitimacy and a higher status of power to the researcher expert.

Nonetheless, we can look at implicit positionality in Indigenous ontology research. Ontologists working in Indigenous contexts refine some of the conventional ontology development approaches. Whereas conventional methodologies to develop geospatial ontologies usually involve a small set of experts in a setting that is often distant from the field, Indigenous ontology methods require more involvement with Indigenous communities. Methods are developed in Indigenous ontology research to engage in a more direct and substantial way in the field and in everyday activities of Indigenous communities, and mainly draw from ethnography and linguistics (Mark and Turk. 2003; Mark et al. 2007). Such methods include for example semi-directed interviews, photographic interviews, informal conversation, field walks, and participant observation. Researchers will adopt a transdisciplinary approach to acknowledge the need for collaborations between disciplines, and integration of many methods to address the complexity of problems in this field of study (Janz 2011; Turk, 2011). Transdisciplinarity implies that a common overarching paradigm is developed to allow researchers to collaborate without privileging one discipline over the other (Turk, 2011). It is implicit that the researchers

interrogate the paradigms of their fields to arrive at a common understanding. Thus, Indigenous ontologies deconstruct the conventional knowledge production approach which tends toward a silo structure of exclusive scientific fields.

Indigenous geospatial ontology researchers also inevitably need collaboration with Indigenous communities. Geospatial ontologies are developed with a group of Indigenous experts (Sieber and Wellen, 2011). Collaboration is needed to ensure 'good science', meaning here that the knowledge produced captures Indigenous concepts. Turk explains: "If … [the ontology of landforms] is to genuinely seek to understand the way that landscape is treated in languages across the world, it must do so from a perspective that is not biased towards Western (European) concepts of knowledge" (2011, 56). Researchers in this field engage in deconstructing their conceptual assumptions of the world from a scientific point of view. Researchers are also concerned with collaboration for ethical and practical concerns (i.e., ensuring that people collaborate in the research) or mention such topics in anecdotes about fieldwork (Turk, 2011; Turk and Mark, 2011).

Although engagement with Indigenous communities is a requisite of Indigenous ontology research, we argue that a deeper engagement with the Indigenous community is needed. We also argue that when researchers do not explicitly address their technocratic positionality (i.e., the influence of their expert position on the research, the relations of power at play in their research) they instead adopt the mantle of unquestioned expertise yet assume that their positionality is neutral. This is a problem because research is never neutral, it is always political.

4.5 The Mantle of Expertise Effecting a Recolonization

We argue that the mantle of expertise is effecting a recolonization in Indigenous contexts because of two main issues. First, the mantle of expertise is perpetuating power dynamics in the

production of knowledge, and second, it is exacerbating distancing. We further explain these two issues in this section.

Research in Indigenous contexts faces many challenges with regards to power relations in the production of knowledge because a continuing colonization of Indigenous peoples is often perpetuated in conventional research approaches (Castleden et al. 2012; Frantz and Howitt, 2012; Koster et al. 2012; Nadasdy 1999). For example, Nadasdy (1999, 11) argues that scientific research often "implicitly assumes that knowledge is an intellectual product which can be isolated from its social context". Such approaches can distort Indigenous knowledge and ways of knowing and accentuate risks of exploitation of Indigenous territories and resources by governments or corporations. Nadasdy (1999) shows that when scientists and governments agencies survey the numbers of sheep sighted by Indigenous community members and restrict hunting quotas to fully grown male sheep, they leave out of their model important parts of Indigenous knowledge. They ignore that elder sheep are essential to the regeneration of sheeps because they guide the younger ones (Nadasdy, 1999). This exemplifies how power is expressed in decisions about what constitute knowledge and how those decisions are made (i.e., who decides; how knowledge is categorized; how knowledge is interpreted). The mantle of expertise puts these decisions in the hands of the expert and thus effects a recolonization of Indigenous knowledge.

On the contrary, decolonizing approaches seek to elevate Indigenous people to the position of experts so they are afforded the right to constitute and contextualize knowledge (Chilisa, 2012; Smith, 2012). To decolonize knowledge production many call for research in Indigenous contexts to be conducted solely by Indigenous scholars (McGregor et al., 2010; Rigney, 1999; Steinhauer, 2002). It is hoped that exclusivity will reverse the power relationship

between the researcher and Indigenous people and allow Indigenous people to push back from a position of 'subjects' *of* research to 'subjects' *doing* research. Non-Indigenous researchers should presumably not do research with Indigenous communities because decolonization entails that non-indigenous researchers 'don't talk about what they don't know' and on the contrary make room for Indigenous stories told in the first voice (Aveling, 2013). From that point of view, non-Indigenous peoples have no role as experts in Indigenist research.

There are Indigenist scholars who allow for Indigenist research to include both Indigenous and non-Indigenous peoples (Louis, 2007; McIvor, 2010; Simpson, 2004; Wilson, 2007). Wilson explains that "an Indigenist paradigm can be used by anyone who chooses to follow its tenets" (2007, 193). Following Indigenist principles must involve committing to Indigenous ways of knowing, traditions, values, and conceptualizations of the world (Churchill 1996). Indigenist scholars find that decolonization is similar to feminist scholars' mission (Chilisa, 2012; Rigney, 1999). Rigney explains these similarities: "the struggle against oppression is a key factor for seeking and analyzing societal structures to determine whether they are liberatory or colonizing in orientation" (1999, 115). The author shows that feminists' claims to liberate the production of knowledge from the patriarchal society are mirrored in Indigenous contexts. This means that non-Indigenous experts must avoid a recolonization through the use of traditional methods and instead adopt or at minimum be sensitized to the ways Indigenous social, political, economic, and philosophical knowledge is produced. From that point of view, outsider non-Indigenous researchers should try to negate their expertise and reduce as much as possible the distance between them and Indigenous community members instead of adopting the mantle of expertise which exacerbates distance and recolonizes knowledge production.

Decolonizing approaches offer potential to remedy problems of adopting the mantle of expertise in knowledge production and reduce distancing. However, when technology plays such an important role in the research, an additional distance might be created. The researcher is not only a non-Indigenous outsider, but also an expert/technocrat widening the distance. There are also additional power dynamics associated with technologies. Rundstrom (1995) points to the dangers of GIS in distorting Indigenous ways of knowing. Conventional data selection, data collection, database creation, and data structuring approaches reduce Indigenous knowledge (Agrawal, 2002; Nadasdy, 1999). Our focus is less on the software and data structure than it is on the agent of that system--the outsider expert. Nonetheless, the prevalence of technology and of technocracy suggest that the researcher cannot reject completely their expertise. Even if the researcher is sensitive to Indigenous contexts, issues of knowledge interpretation and knowledge translation (i.e., into ontologies) remain.

4.6 Methodologically Addressing Technocratic Positionality with Indigenous Geospatial Ontologies

Our research takes place in Northern Quebec, with the Eastern Cree. For the Eastern Cree, the relationship with the land is very important but understanding the nature of those relationships for a non-Cree researcher takes time (years) and substantive engagement with the community. In our research, we look at Eastern Cree concepts of space and time and compare those concepts with space-time in conventional geospatial ontologies. We use some of the methods of Indigenous geospatial ontology such as individual interviews, focus groups, and field visits. However, because of some failings of Indigenous geospatial ontology research such as effecting recolonization and exacerbating distancing, we also need to further refine the methodology and the methodological approach. While technocracy is not desired, our research also needs to recognize the need for the researcher's expertise. However, instead of adopting the mantle of the

expert, we designed a methodological approach that would engage deeply with community members, reduce distancing, and decolonize power relations in knowledge production and knowledge interpretation.

Our methodology addresses technocratic positionality. Positionality is an acknowledgement that one's "race, nationality, age, gender, social and economic status, sexuality" inevitably influences their research (Rose, 1997, 308). Feminist scholars extensively write about positionality to reverse power in knowledge production (see England, 1994; Haraway, 1988; Nagar and Geiger, 2007; Rose, 1997). Positionality is a reaction against "pure" scientific research producing neutral knowledge conducted by an impartial researcher. Acknowledging positionality in Indigenous research is one way of reducing power because it reduces distancing between Indigenous community members and the outsider expert in knowledge production (Absolon and Willett, 2005; Moffat, 2016). Positionality in Indigenous context acknowledges the power dynamics that the expert brings to the research as well as the need to reduce distance between the outsider researcher and Indigenous community members. Our research does not focus merely on the outsider non-Indigenous positionality, but also on the expert specifically from a technology perspective. We address technocratic positionality in a reflexive way to ensure ethical standards and protocols are met, and to respect Indigenous ways of knowing and of conceptualizing the world.

Our methodology also uses the 2H approach because of the opportunities that these approaches offered to break down distinct categories such as expert/non expert; researcher/ research subject. With the 2H approach, the research considers that everyone involved are experts, emphasizes a deep engagement from the researcher, and focus on an increase collaboration with community members in knowledge production and knowledge interpretation.

Our research aims at finding ways to bring all kinds of expertises (i.e., GIScience expert researcher and local research participants' expertise) together in a fruitful way for everyone involved without effecting a recolonization. In the following sections we further describe the 2H and present ways in which we used the 2H approach and reflect on technocratic positionality in our research.

4.6.1 Heuristic Approach

To address the question of how to go about eliciting a geospatial ontology, we used a heuristic approach which is about ways of producing knowledge based on practical engagement with the context of study. The word heuristic comes from an ancient Greek word "heuriskein" which means "to find" or "to discover" (Moustakas, 1990). Practically, a heuristic approach to qualitative research implies that the inquiry of the study is not a priori based on a theory, but that the data emerge from a practical method (DePoy and Gitlin, 2016). This practical method is based on personal engagement with the phenomenon being studied and on immersion in the context (DePoy and Gitlin, 2016).

Our research uses a heuristic approach to eliciting Eastern Cree concepts of space and time and addressing technocratic positionality. Early on in the research, we identified our technocratic positionality with the community when the first author was invited to work on a few projects as a mapping/GIS expert by the Cree Nation of Wemindji and the Cree Nation Government. These mapping projects aim at preserving culture and language, at transferring Cree knowledge to younger generations, at developing a network of protected areas on Cree territory, and at supporting land claims. Being involved in these projects and conducting fieldwork activities about eliciting Eastern Cree concept of space and time were a good way to

reduce distancing. Yet simultaneously reverse effects also exacerbated the distancing of the expert role from community members. We explore these tensions in this section.

On the one hand the heuristic approach offers great potential in our research. By definition of heuristics, since our research requires understanding how community members conceptualize space and time, the researcher needs to be in the field with the domain experts. To be immersed in the context of the Eastern Cree geospatial conceptualization, the researcher needs to spend time out in remote areas (out on the land). This is to engage in discussions with community members on how they conceptualize geographic features. The point of discussing geographic features, and opportunities for being understood, are more apparent in the actual context of being on the land. Furthermore, some community members are more comfortable while they are out in the land, and are more likely open for conversations in this setting. Being immersed in the context is also a great way to address technocratic positionality. As opposed to being an impartial outsider/expert, the first author situates herself in relation with the Indigenous community and engages in building connections with community members. The researcher's expertise becomes partial rather than impartial, in the sense that it is part of a co-expertise with an Indigenous community.

On the other hand we found that participating in activities during an immersive setting was not enough to eliminate distancing. In the reflexive process, we noted that the researcher's state of mind matters for the heuristic approach to be effective. When feeling out of place, the first author found that community members were reluctant to engage in conversations or to even be around her. The researcher has to developed strategies to counter the feeling of being out of place. Larsen and Johnson (2012) suggest cultivating the feeling of 'being in place. We noted that the feelings of being honored and grateful to have the opportunity to spend time in

Wemindji, the practice of being fully present, and engaging in activities that she enjoyed doing, overcame negative feelings and opened up a space for conducting research about conceptualizations of space and time, and for reducing distancing.

While spending a long period of time in a community is commonly acknowledged as an important aspect of immersion and reducing distance, we found that this was not necessarily the case in our research. Ethnographic research stresses the importance of spending an extensive amount of time in the field to break down the cultural barriers in interpreting another culture (Wolcott, 2005). However, we found that it is not necessarily the amount of time that the researcher spent in the community that mattered so much as how many times the researcher came back. The first author noted changes in welcoming messages she was hearing and seeing each time she went back: “Hey you came back!”; “Hey you are back!”; “Hey welcome back!”; smiles; “Hi, it’s so good to see a familiar face!”; kisses; “Welcome home!”. Returning as much as possible to the community respects the process that people need to trust, open themselves, and become familiar with a new person from outside (Kovach, 2009). The trust was not necessarily in the duration but making good on the promise to come back.

With all the ups and down of reducing distancing between the researcher and the community members in our research, we found that no matter how much the researcher puts efforts into ‘being in place’ there remain situations where community members themselves seemed uncomfortable. While spending time in remote areas (out in the land) with community member was the initial primary setting to conduct research, we found that during these kinds of trips engaging in formal research activities (i.e., interviews, GPS, recording, and consent forms) was difficult. For example, during one snowshoe walk, the researcher brought along her GPS to map the trail. While we had planned to employ the researcher’s expertise to profit the community

in their mapping project, we found that it can produce the opposite effects of making people (the other walkers) uncomfortable and exacerbating distancing.

Ultimately, we found that the heuristic approach doesn't remedy all challenges of mitigating distance with community members. While the research emphasized spending time immersed in the land, as soon as the researcher came back to the community to contribute to local mapping projects, she noted that she was identified as the mapping expert. The distancing is inevitable.

4.6.2 Hermeneutic Approach

The hermeneutic approach complements heuristics because hermeneutics concern interpreting what is discovered in the research process. Hermeneutics are the theory of understanding and of interpreting (Schmidt, 2006). Historically, hermeneutics are the study of the underlying meaning of ancient sacred texts (e.g., the Bible). Later, philosophers (e.g., Heidegger, Gadamer) used hermeneutic to study the meaning of any written texts and shifted the focus on grammar to include broader considerations such as how a work is put together, and the specific context in which the work was composed (Freeman, 2008). In research methodologies, the hermeneutic approach acknowledges that interpretations are based on preconceptions coming from the researcher's tradition (Schwandt, 2007). Arriving at an understanding is never final, the interpretation is never closed, and the research process is not linear (i.e., theory, hypothesis, test, conclusion). Rather, the process is open, iterative, and constructed through dialogue. Meaning also emerges through a dialogue between the information and the researcher (Koch, 1999). This means that the researcher goes back and forth to "question" the data collected to generate understanding rather than constructing an interpretation based on their expertise.

Interpretation of knowledge in ontology research is difficult because ontologists have to be very careful not to ascribe their own characterizations to the system (Agarwal, 2005; Kuhn, 2000). In our research, hermeneutic focuses on knowledge interpretation done with community members instead of merely being in the hands of the researcher/expert. A co-production process in knowledge interpretation acknowledges Indigenous peoples as experts (Coombes et al., 2012, 2013; Coombes et al., 2014; Koster et al., 2012; MacDonald, 2017). Deep collaboration is also crucial in Indigenous ontologies due to the dangers of misrepresenting, reducing and flattening Indigenous knowledge which can be destructive for Indigenous peoples (Rundstrom, 1995). In our research, we use an hermeneutic approach to interpret the information gathered regarding Eastern Cree conceptualisations of space and time, to reduce distancing, and to avoid misinterpretation of Indigenous knowledge. Yet as with the heuristic approach we found tensions between reducing distance and creating the reverse effect of exacerbating it.

Participating in mapping projects by the Cree Nation Government and the Cree Nation of Wemindji was a great opportunity to allow an hermeneutic approach. These settings were an opportunity to have back and forth exchanges of ideas to interpret knowledge shared by community members and elders. Notwithstanding constant dialogue with community members, biases are omnipresent in the research. For example, the first author was collaborating in a participatory community mapping of dangers zones along traveling routes. Her assumptions about ways to communicate a message with maps distributed in the community clashed with Cree ways of transferring knowledge. The maps could not be shared because they could not replace the elder who is with the driver on the land explaining how to observe the environment to 'read' traveling information such as weather changes. This example shows that, even when a researcher is engaged in critical GIS research and in deconstructing their technocratic

positionality, biased technical assumptions (i.e., participatory danger zone maps are good to share with other community members) can still come up.

We also found gender issues were tied into the technocratic positionality of our research. In our research, the GIS/mapping expert role created distancing with people who felt non-responsible for knowledge associated with geography and maps. Many women expressed this discomfort which could sometimes create a distance between the researcher and women community members. For example, at social gatherings, men would often sit around maps and engage in conversations with the researcher about ways that people think about the land. However, a woman explained that she was sitting at the wrong table with the men; women sat at another table. We found in our research that the GIS/mapping technocratic expert can be associated with gender roles in the community, which complexify negotiating distancing and positionality.

We also used an hermeneutic approach in the design of interviews about Cree conceptualizations of space and time to allow participants to engage in interpreting information and reflecting on their culture. Conventional methods use 'competency questions' with domain experts to capture the content of an ontology (Uschold and King, 1995). Instead of merely asking direct general questions, we used observations from participation in mapping projects as a stepping stone. This allowed us to develop interview guides that were more culturally appropriate by giving contexts and telling stories about the community or about a specific hunting territory. This allowed us to invite participants in interpretating the stories and is in accordance with Indigenous methodologies. Chilisa (2012) points to the importance of recognizing Indigenous participants as researchers themselves and engaging them in the reflection on their culture. In our interviews, we integrated stories previously heard, and asked

participants to reflect on the stories which proved to be a fruitful way to start the conversation about geographic features, places on the land and concepts of time.

The hermeneutic approach also brought us to engage in an iterative process to continuously ask community members to engage in the interpretation of information gathered to develop a geospatial ontology. This is a common practice in the field of geospatial ontology with Indigenous peoples, where the process of doing research about landscape conceptualizations is iterative (Janz, 2011; Turk, 2011). Janz explains "(the) iterative approach that shifts from emic to etic and back to emic representations" (2011, 107). The emic approach of study from within the community is first used to gather information about the ways people conceptualize their environment. After, the etic approach from outside the community and from the researcher's point of view includes the analysis of information and the development of an initial ontology by the researcher. The switch back to the emic approach evaluates the researcher's interpretations by presenting the results to the community and opening up the discussions with community members for feedback. That new feedback information gathered is then integrated and the corrections are made by the researcher, which brings the process back to etic again.

Despite the design of interviews, the iterative process, and all the benefit that these methods had in addressing the distancing of the expert, we found that some information remains inaccessible to the researcher outsider. These aspects of Indigenous knowledge are called 'resistant data' (Holbraad, 2009). This is a kind of information that is difficult to capture and represent in conventional western systems, such as data collection methods, or database systems. Holbraad explains: "the peculiar difficulty (resistant data) present to the researcher is precisely that of determining how best to describe them, that is, how best to find concepts that distort them as little as possible " (2009, 83). In our research, we found that resistant data is not only an issue

of being difficult for the researcher to capture but it is also about acknowledging the information that community members resist sharing. Resistant data could be due to the community members' choices in not revealing information by means of the "tools" of the researcher such as interviews, maps, or mapping applications. Intellectual property of traditional knowledge and Indigenous data sovereignty—Indigenous peoples' governance over data about themselves, their territories and ways of life — play a key role in addressing resistant data and respecting limits that communities wish to establish (Kukutai and Taylor, 2016; Louis, 2007).

4.7 Conclusion

We argued that despite the decreased role of experts in GIScience with neogeography and the geweb, GIS/mapping expertise is still in high demand in Indigenous communities. Whereas a first levels of expertise is addressed with neogeography where a large number of people can contribute information on the geoweb and do basic mapping, other levels in GIScience are not accessible. This can put GIScientists in a technocratic positionality when doing research with Indigenous communities. Whereas feminist geographers and Indigenous scholars already point to the dangers of an outsider/expert positionality in the power dynamics of research with Indigenous peoples, GIScience expertise is still important to Indigenous peoples.

The issue is to bring the GIScience expertise together with Indigenous expertise. Our research in geospatial ontology development with the Eastern Cree addresses technocratic positionality by way of hermeneutic and heuristic approaches. On the one hand, we show that the mapping projects and needs for GIS/mapping skills that encourage a technocratic positionality can also be a platform to engage in a reflexive way to reverse this GIS expert savior positionality. We show that the hermeneutic and heuristic approaches allow the researcher to conduct research activities while putting their mapping expertise to the benefit of Indigenous

communities without being confined to the role of a technocrat outsider/expert. In developing Indigenous geospatial ontologies, the hermeneutic and heuristic approaches discussed also allow the researcher to deconstruct their conceptual assumptions about the world and mitigate dangers of misrepresenting Indigenous concepts. On the other hand, we found that the heuristic and hermeneutic approaches still face many challenges. Distance is inevitable in GIScience research with Indigenous communities. It brings us to conclude that ultimately, GIScience should be led by Indigenous groups to allow critical research done not only *with* and *for* but also predominantly *by* Indigenous peoples.

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Chapter 5: Preface

Chapter Four presented the methodological approach to building a spatio-temporal ontology. In this chapter, we present our results of eliciting Eastern Cree concepts of space and time. We also propose an alternate spatio-temporal ontology that responds to these concepts instead of subsuming them to Western conceptualizations.

This chapter consists of a manuscript co-authored with my supervisor, Dr. Renee Sieber, as well as with Sammy Blackned. The manuscript has been submitted to the *International Journal of Geographical Information Science*. Based on initial reader reports, the editor of the journal asked us to revise and resubmit. I am the primary author of the manuscript. I conducted the literature review, conducted all fieldwork, crafted the arguments, and wrote the content. Dr. Sieber provided guidance and feedback on the structure of the manuscript, the framing of the arguments, and the discussion of the implications of the arguments. Dr. Sieber also edited the manuscript prior to its submission. Sammy Blackned from the Cree Nation of Wemindji provided inspiration and guidance on conducting fieldwork in Wemindji, on discussing the implications of the research, and on choosing examples to illustrate the arguments.

Chapter 5: New Visions of Time in Geospatial Ontologies from Indigenous Peoples

Geneviève Reid, Renee Sieber, and Sammy Blackned

5.1 Abstract

Geography (e.g., features, topology, relationships) is relatively well-developed in ontology research. Integrating time and temporal referencing of geographic concepts in ontologies remains understudied with serious ramifications when we attempt to apply those models. The gap is heightened when considering Indigenous concepts of time where existing geospatial and temporal ontologies limit the knowledge that is acquired, modeled, and made interoperable with existing systems. Our case study with the Cree Nation of Wemindji in Northern Canada utilizes ethnography and qualitative analysis methods to compare Cree concepts of space-time with time in conventional geospatial ontologies. The study reveals that conventional ontologies make four assumptions which differ from Indigenous space-time, including: 1. Time can be a repeating cycle instead of a line; 2. The past and the future have agency which contrasts with the positioning in the present; 3. Geographic entities are dynamic processes rather than fixed physical objects; 4. Time is inseparable from a place rather than merely a fourth dimension added to a three dimensional space model. We propose an alternate spatio-temporal ontology that better integrates Indigenous concepts and improves interoperability of data.

5.2 Introduction

In Geographic Information Science (GIScience), the development of geospatial ontologies must include both space and time to account for geographic processes (Frank 2003). Most geographical phenomenon are dynamic, for example urban mobility, natural hazards, and land use change. More recent focus on temporal Geographic Information Systems (GIS) as a way to handle the volume and velocity of big data (Dijst 2013, Kwan 2013, Kwan and Neutens 2014,

O'Sullivan 2005, Richardson 2013) places further pressure on geospatial ontologies to integrate time. Compared to geographic features, time has received less attention in ontology research. Integrating concepts of time and temporal referencing with geographic concepts in data models remains challenging (Agarwal 2005, p.52, O'Sullivan 2005). GIS and spatial data models have tended to offer a "'snapshot' view of the world, where time and dynamic change are reduced to a sequence of static moments" (O'Sullivan 2005, p.750).

Remedies to the snapshot model and other challenges to explicating time in geospatial ontologies could include alternate conceptualizations of time, such as those integral to Indigenous ontologies. Alternate conceptualizations of time could expand our notions of time in conventional ontologies. Geospatial ontology research has been conducted for geophysical features derived from various Indigenous contexts (cf., Mark *et al.* 2007, Wellen and Sieber 2013). This denotes the importance of place for Indigenous peoples (Deloria 2003, Simpson 2002, Tuch and McKenzie 2014). Numerous researchers eschew cultural context and instead utilize Indigenous concepts to further the universality of ontologies (see Chapter 2). As well as supporting conventional ontologies, accounting for multiple ways of conceptualizing time across culture can allow us to challenge the necessity for universality and create more culturally-specific ontologies. Indigenous ontologies also can enhance Indigenous spatial data handling to support goals of Indigenous knowledge documentation and interoperability with scientific data (Pulsifer *et al.* 2011). Thus, Indigenous concepts of space-time can play important roles both for Indigenous communities and the advancement of GIScience.

To contribute to these goals of Indigenous knowledge documentation, of interoperability, and of advancing GIScience, our research focuses on modeling Indigenous space-time and, in that contextual modeling, improve spatio-temporal ontologies. This paper is organized as follow.

First, we briefly describe current methods of integrating time in geospatial ontologies. We then uncover assumptions underlying this integration, which we argue limit advances in conventional geospatial ontologies. Considering Indigenous notions of time could begin to address these gaps. We present our methodological approach and our results to our study of modelling Eastern Cree notions of time and of comparing these with common assumptions in spatio-temporal ontologies. Finally, based on our findings, we suggest an alternate space-time ontology to remedy gaps and to account for Eastern Cree conceptualizations.

5.3 Approaching Time in Conventional Geospatial Ontologies

Geospatial ontologies integrate time by means of formalized spatio-temporal models that define entities, relationships, and axioms. These entities, relationships, and axioms allow researchers to describe temporal characteristics of geographic phenomena as well as understand human notions of time (Galton 2011). In this section, we look at the context in which geospatial ontologies are developed, how they handle time, and the kinds of model they formalize.

Ontologies tend to function at two levels: a more general top-level and a domain level. Top-level ontologies have been developed to integrate broad categories of space and time (Bittner *et al.* 2009, Grenon and Smith 2004). One main objective to create top-level ontologies is for the semantic geospatial web – a massive effort to create interoperability across data from a wide range of sources, knowledge domains, and cultures (Egenhofer 2002, Hobbs and Pan 2004). OWL-Time ontology was developed specifically to integrate time in the geospatial web (W3C 2006). Domain-specific spatio-temporal ontologies integrate space-time phenomena in a specific thematic area, such as cadastral administration (Stock *et al.* 2015), territorial jurisdiction (Lopez-Pellicer *et al.* 2012), traffic management (Yan *et al.* 2008), and cultural heritage

(Kauppinen *et al.* 2008). Whereas top-level ontologies and domain geospatial ontologies are developed for different purposes and contexts, they often handle time in similar ways.

In both top-level and domain geospatial ontologies, mainstream developments adopt a distinction between endurant objects that are fixed through time and perdurant objects that happen in a certain time (i.e., processes or events). Agarwal (2005) further explains the distinction: "The 'endurant' is a kind of entity that endures or persists through time and is wholly present at each moment of its existence, while 'perdurant' (or occurrant) entities are never fully present at any one given moment in time, but instead 'unfold' themselves in successive phases or temporal parts" (p.57). Endurant objects are involved in perdurant processes and events. For example, a mountain can be classified as endurant while containing spatial properties that contribute to the unfolding temporal process of erosion.

Spatio-temporal ontologies are often based on spatio-temporal models developed in different fields. There have been efforts to model cognitive aspects of time in qualitative spatial and temporal reasoning (Bennett and Galton 2001 Bittner 2002) and in spatio-temporal frameworks (Allen and Hayes 1985, Hornsby and Egenhofer 2000, Peuquet 1994). In the field of temporal GIS, there is substantial development to integrate time into data models and spatial databases (Kwan 2013, O'Sullivan 2005). These efforts provide background frameworks to develop geospatial ontologies (Agrawal 2005).

For example, Hornsby and Egenhofer (2000) offer a framework for time that influences geospatial ontologies. They model different types of state changes of geographic phenomena and spatial objects by defining the processes by which changes of identity occur (e.g., state of the lake changed to overflow or dry). These dynamic aspects of time and space focus on developing a formal language of logic to define semantics, concepts and relationships that are involved in

spatio-temporal phenomena (Cohn *et al.* 1995, Bennett and Galton 2001, Bittner 2002). Using such logic language has enabled the implementation of time into formal geospatial ontologies (Galton 2001, 2015, Grenon 2003).

Allen (1983) provides another framework widely adopted in spatio-temporal ontologies. His interval algebra theory aims to model temporal aspects of the world, information, and data. Interval theory defines temporal entities as points and intervals that are measured relationally (e.g., before, meets, overlaps, starts, during, finishes, is equal to), or in relation to clock and calendar time (e.g., second, minute hour, date, month, year). Intervals are used in mainstream ontology development to handle temporal relations, specifically between events (i.e., Hobbs and Pan 2004, W3C 2006).

Formalizing time in geospatial ontologies also may come from temporal GIS research which focuses on modeling, visualizing, processing, managing, and analyzing spatio-temporal data and databases. Authors report on the numerous temporal GIS models that have been developed over the years (Goodchild 2013, Yuan *et al.* 2014). One such model is the tracking data model, which manages series of observation points from moving objects; another is the snapshot model, which can analyze time series for example for remotely sensed images. Cellular automata track the state of each cell of a set raster; agent-based models simulate reactions of autonomous entities at each time interval. Other space-time analysis models handle data structured as sequences of time-specific attributes of polygon coverages (e.g., zoning, census tracts, countries); the events and transaction model deals with records that represent an event or transaction in space-time; and some models use multidimensional data that extensively sample temporal data at specific georeferenced locations, which is often used to estimate values at other locations such as in weather applications. The main challenge in temporal GIS is to move away

from a static view of time with sequences of snapshots and timestamps because, as O'Sullivan (2005) argues, they fail to capture the dynamic human experience of geographic phenomenon in time.

Whereas spatio-temporal ontologies also have been identified as way to contribute to temporal GIS data models (Frank 2003, Galton 2015), many efforts in spatio-temporal models still need to be fully integrated with space in geospatial ontologies (Agrawal 2005). Compared to other domains, Agrawal explains that "[w]ith behavioural procedures and cognitive conceptualizations determining the categories and knowledge in the geographic domain, the task of defining temporal knowledge is made even more complicated" (Agrawal 2005, p.523). It is unsurprising that geospatial ontologies focus more on space and location than time:

> In geographic data models, ontologies for the human conceptualization of space and spatial relations are comparatively easier to define than the human conceptualization and categorization of time and temporal relations. Appropriate languages and tools have been developed to describe spatial concepts, but this is still an active area of research for temporal relations (Agrawal 2005, p.525).

Geographic phenomena are not frozen in time, yet conceptualizing time has proven challenging for GIScience. Time is dynamic, not easy to model in geospatial ontologies, and still needs further research and developments.

5.4 Gaps in Conventional Assumptions of Time

To advance the field of spatio-temporal ontologies, it is crucial to look at the underlying assumptions of time because, we argue, the assumptions are holding back the advancement. Conventional developments in geospatial ontology are based on a specific conceptualization of

the world and of time. In this section, we present some major themes and assumptions of time extant in geospatial ontologies. These assumptions reveal gaps in considering time in GIScience.

5.4.1 Considering Time as Persistence of Features

The prevailing assumption in spatio-temporal ontologies is that entities can be characterized by their persistence in space-time. Grenon and Smith (2004) propose a spatio-temporal ontology of change and processes called SNAP/SPAN that formalize endurance (Figure 3) and perdurance (Figure 4) of classes of features.

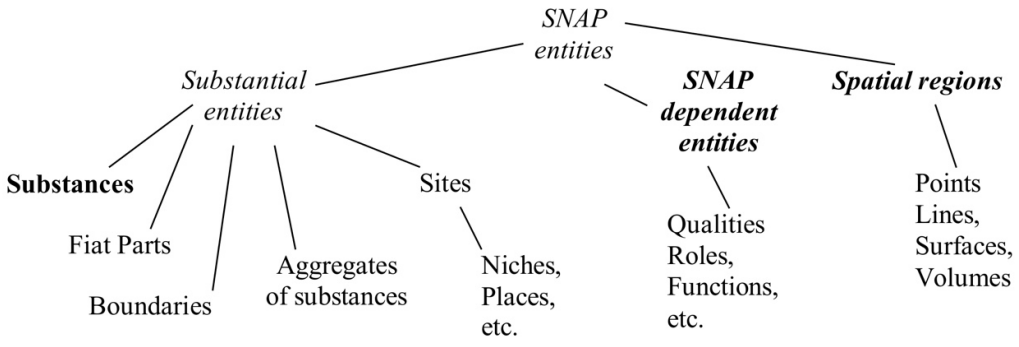

Figure 3: Categorization of SNAP (endurant) entities (Source: Grenon and Smith 2004 p.74)

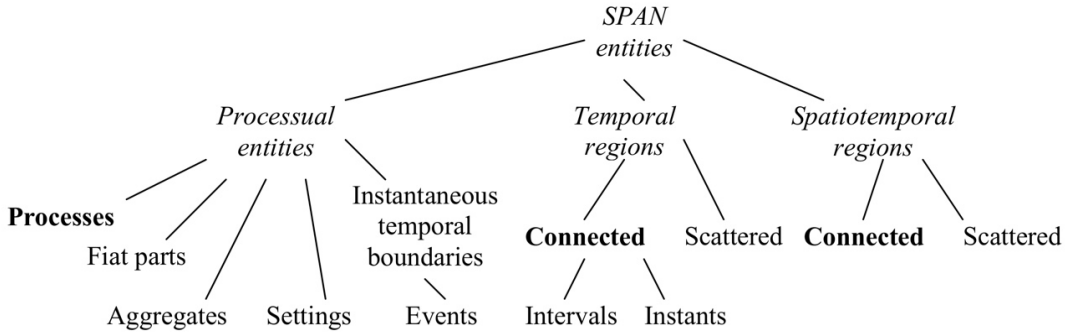

Figure 4: Categorization of SPAN (perdurant) entities (Source: Grenon and Smith 2004 p.74)

In SNAP/SPAN endurant entities have spatial properties and perdurant entities have temporal properties (i.e., processes or events). This distinction assumes there are entities that are

fixed and independent of the notion of time. There is a practical reason for the distinction--it reduces one degree of freedom--but it absolves the researcher from integrating process elements. We know that endurant entities, which describe things as wholly present at each moment, still undergo changes (e.g., even if only entropic). This assumption of temporal fixity of material objects such as mountains, is controversial in temporal ontology debates, specifically with proponents of the temporal parts theory (Hawley 2018). Temporal parts means that objects can occupy time just as they occupy space, can exist at different times, and can have different properties at different times. Just like mountains have spatial parts (e.g., top and sides), they are then conceptualized as having temporal parts as well (i.e., eroded side). Notwithstanding the divergence of opinions about temporal concepts, the SNAP/SPAN distinction is widely adopted in the field of GIScience (Agarwal 2005) without acknowledging the debate about the temporal parts of material entities.

5.4.2 Positioning Time in the Present

Geospatial ontology research borrows some concepts of time from philosophy but does not integrate many nuances already developed in philosophy. One such example is the focus on the concept of "presentism" in geospatial ontology. In philosophical treatments, presentism is defined as the theory that things exist in the present, in other words only present things exist (Deng 2018). For example, a mountain exists because it is there today. In temporal GIS and space-time data models, integrating views other than presentism is challenging because of the need to maintain a record of the past. For instance, Dragicevic *et al.* (2001) developed a fuzzy spatio-temporal interpolation method to fill in gaps between static snapshots when data was missing from historical GIS databases. Despite some advancements in temporal GIS, geospatial ontologies remain focused on the presentism perspective.

With presentism, geospatial ontologies make strong assumptions about the world that align with realism. A realist perspective on the world basically means that what exist is only what can be observed. Realism is detected in conventional spatio-temporal ontologies based on Euclidean geometry and Newtonian physics because, as explained by Frank (2003), "these are the scientific foundations for precise observations and representations of spatial phenomena" (p.1). In this view, the knowledge of the world is only derived from observations (e.g., properties of existing objects) by cognizant observer (i.e., humans, animals) in the time 'now' (Frank 2003). A realist perspective leads to an emphasis on the present and leaves past and future as describing entities that no longer or do not yet exist. Presentism is also justified because of a so called "common sense" view of time (Ingram and Tallant 2018, para 24). Szabó (2006, p.399) illustrates this claim: "Ask the man on the street whether there are dinosaurs in Montana or outposts on Mars, and learn from his answers that no one really believes in merely past or future entities". The assumptions of presentism is widely adopted in geospatial ontologies. For example, a spatio-temporal ontology based on presentism allow Grenon and Smith (2004) to model SNAP entities that exist at a present time.

Strong skepticism of presentism is raised in temporal ontology work in philosophy (Ingram and Tallant 2018, Sider 2006). Diverging from the presentism view, eternalists adopt the idea that all times and/or events exist, or that past and future things also exist (Deng 2018). The metaphysical debate between presentists and eternalists in philosophy is rarely if ever acknowledged in geospatial ontologies, and presentism sits as a *de facto* assumption. The problem with the assumption of presentism is that it over emphasizes the perspective from the present instant and ignores nuances about past and future. This perspective might explain why

time is de-emphasized in geospatial ontologies and why temporality is often reduced to change (i.e., a past state changes to present state of a spatial object) in geospatial ontology research.

5.4.3 Considering Time as Linear

Both top-level ontologies and domain specific ontologies consider time as a linear progression where events happen in succession from the past through the present to the future. However, numerous conceptions of times exist other than linearity (Adam 2002). For example, cycles accentuate a repeating sequence that exist in natural phenomena (Dahl 1995); branching time divides many timelines from a specific time point (e.g., to consider multiple possible scenarios for the future) (Ott and Swiaczny 2001); and spirals emphasize the integration of the past into a continuum of the present and the future (Murton 2011). Other meanings may be associated with temporality than the metaphor of a linear progression, such as a topographic organization of time with the past downhill and the future uphill (Núñez and Sweetser 2006). Yet, linearity dominates geospatial ontologies because of the difficulties in modeling other structures of time in computerized data models.

A major challenge is to integrate non-linear types of time into spatial data systems, such as GIS, which operate with built in timestamps (Frank, 1998). Perhaps this data structure explains disconnections between GIS and advancements in computer science . Geospatial simulation modeling allows us to break the linearity of time for example by representing multiple scenarios (branching time) or cyclical time (e.g., what the crops look like in March as opposed to September) (Goodchild 2005). This is still largely disregarded in geospatial ontologies.

5.4.4 Subsuming Time to Space

Conventional temporal models invariably subsume time to space. In temporal GIS models, a common goal is to manage temporal data within a spatial frame. This is best represented with the space-time cube that is based on the time geography framework developed by Hägerstrand (1970). The space-time cube is represented as "a collection of lattice points, for example, with semantic properties at locations and then (this representation) expand(s) the lattice orthogonally to a cube to incorporate the temporal dimension" (Yuan *et al.* 2014, p.2). The space-time cube is essentially a container that is filled independently with space–time objects. However, a lattice is a spatial construct, which essentially creates a 'spatialisation of time' (Galton 2011). The problem is that this framework subsumes time to space by constraining time to spatial qualities, which can undermine nuanced aspects of temporal concepts.

Another subsumption of time to space is treating the former as an attribute of the latter. Conventional geospatial ontologies often model time as a property of a class. For example, the SNAP ontology is indexed by a time instant and the SPAN ontology is indexed by a time interval (Grenon and Smith 2004). This is adopted in geospatial ontologies and top-level ontologies such as BFO or DOLCE, where perdurant entities are attributed temporal qualities.

5.4.5 Measuring Time as Intervals

Assumptions of time also are apparent in the measures of time, the temporal properties of entities, and in the relationships used in spatio-temporal ontologies. Most spatio-temporal ontologies research, including the SNAP/SPAN model, uses the theory of time intervals (Allen 1983) to define temporal properties. Figure 5 illustrates possible relationships between two temporal intervals.

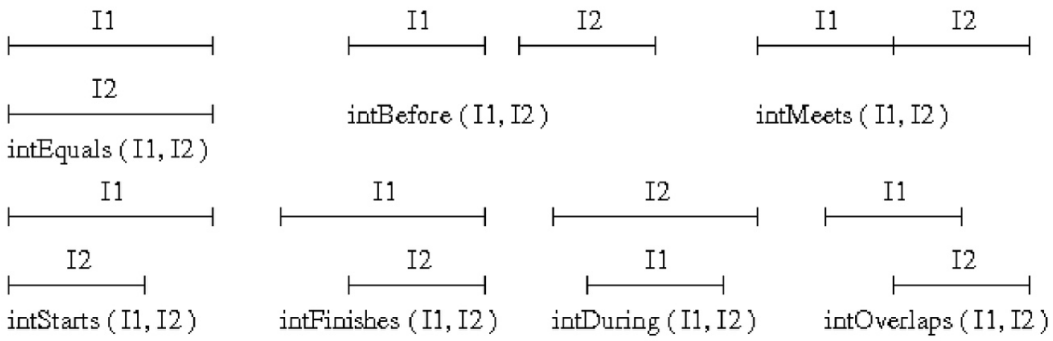

Figure 5: Relationships among intervals of time (Adapted from Allen 1983 in Petnga and Austin 2013)

Temporal intervals and relationships among them are often used in conventional spatio-temporal ontologies to define durations of perdurant entities, such as events (i.e.. Bennett and Galton 2001). Temporal intervals accentuate the problematic focus on linearity (discussed in Section 3.3) because they 'cut' events on a linear axis of time.

Geospatial ontologies also fall short in handling events because they focus on measuring temporality. Events are attributed with 'temporal regions' (parts of time), such as specific dates of beginning and ending. However, events are not necessarily attributed with specific calendar dates but are rather part of cycles of life, such as demonstrated in phenology – the study of natural phenomena in relation to climate and plant and animal life cycles events (Demarée and Rutishauser 2011). For example, an event could be attributed with the temporal measure of the time when the flowers are blooming.

Temporal interval measures of time represent a narrow conceptualisation of time in geospatial ontologies. Other gaps are found in philosophical assumptions about time embedded in spatio-temporal ontologies discussed such as the the separation between space and time, the linearity and progression of time, and the fixity of some object entities. Our position is that

GIScience may benefit and be enriched by considering other conceptualizations of time such as in Indigenous ontologies.

5.5 Conceptualizing an Indigenous Spatio-Temporal Ontology

Ontology development is challenging. It is a non-lexical task; researchers must define broad categories that encompass the underlying meaning. This is even more complicated when eliciting abstract and top-level concepts like time. It also requires identifying the appropriate experts. We conducted research with the Cree Nation in Northern Quebec (collectively called the Eastern Cree), a sub-group of the largest First Nation in Canada. We sought to uncover and define the following broad temporal concepts: past, present, and future of time; changes on the land and in the community; aspirations for the land and the community; passage of time; marks and measures of time; representations of time; connections between present, past, and future; connections between the land and time.

5.5.1 Eliciting Space-Time Concepts

Ontology elicitation has been described as a complex task due to the difficulty in capturing human understanding of the world, and is often referred to as the problem of 'grounding the ontology' (Kuhn 2000). Several methods for designing spatio-temporal ontologies have been developed (Campelo *et al.* 2012, Carstensen 2007, Krieger 2010, LemosDias *et al.* 2004). Research often focuses on domain ontologies so the methods involve deriving concepts from texts within a scientific domain, relying on previous existing ontologies and categorizations, and working with domain experts. For example, survey-based methods and spreadsheet-based methods are used with domain experts to elicit terms, definitions, categories, relationships, and specifications of meaning of concepts in ontology development (Mark and Egenhofer 1995, Mizen *et al.* 2005). Our elicitation concerns top-level concepts, which represents a more difficult

endeavor because top-level ontologies involve an additional level of abstraction in an already abstract field of computational ontologies.

Conducting research with an Indigenous community requires a methodology different from conventional approaches to ontology development. Methods have been developed to look at the ways that different cultures conceptualize their environment in the fields of ethnogeography (Blaut 1979), ethnoecology (Barrera-Bassols and Toledo 2005), folk taxonomies (Black 1969, 1977), and more recently, ethnophysiography (Mark and Turk 2003, Mark *et al.* 2007). These studies tend to use ethnographic and linguistic methods such as semi-directed interviews, photographic interviews, informal conversation, field walks, and participant observation. Whereas conventional geospatial ontology research usually consider a small set of experts and often distantiate the setting of research from the field, Indigenous ontology methods use more direct and more substantial involvement on the field and in everyday activities of Indigenous communities. This involvement with Indigenous knowledge holders and users of the land is necessary because of the nature of traditional knowledge, and of ways of transmitting knowledge, that often involve oral face-to-face storytelling, the practice of traditional activities in the bush, and a trust relationship (Berkes 2012). We also work from a critical GIS perspective, which means we acknowledge the historical connections between data collection and colonization.

We conducted research in Wemindji, Quebec, Canada. Wemindji–from *wiimin uchii*, meaning “red ochre hill”, formerly named Paint Hills. This community is one of eleven Eastern James Bay Cree communities in the Territory of Eeyou Istchee (“the People's Land”). It is located approximately 900 km north of Montreal, on the mouth of the Maquatua River, on the coast of James Bay. The population is approximately 1400 people (Aboriginal Affairs and

Northern Development Canada 2012). Whereas the Cree in Quebec have signed agreements to benefit from hydroelectric development on their territory, they continue to defend their land against increased pressures posed by climate change, sport hunting (Scott and Webber, 2001), natural resource extraction (mining, forestry, hydroelectricity), and provincial economic development plans (Desbiens and Rivard 2014). Constantly negotiating their future, the Eastern Cree strive to balance outside pressures of economic growth with their own development priorities such as environmental, social, cultural, and political well being (Cree Nations of Eeyou Istchee 2011, Rodon *et al.* 2017). These goals are also advance through collaborations with academic researchers (i.e., Mulrennan *et al.*, 2012, Peloquin and Berkes 2009, Radu *et al.* 2014). Indigenous ontologies have a prominent role for such research partnerships.

We focus our research on Eastern Cree concepts of time. Ten field trips were conducted between 2012 and 2017 with durations varying between three weeks and three months. To increase opportunities to capture potential cyclical time, fieldwork was conducted during all four seasons. The first author conducted the fieldwork during these visits. We used the following methods: participant observation, semi-directed interviews, and focus groups.

Participant observation accompanied with informal conversations are common in Indigenous ontologies. In Wemindji, participation in events included cultural gatherings, travellings, and camping out in remote areas ("in the bush") as well as sporting events, and community assemblies and meetings in the community. Instead of merely observing activities, in which the researcher watches at the "front stage", we also were in the "back stage" where the researcher is an active participant. This latter approach of increased researcher activity has been termed "observant participation" (Schmuck 2006). Observant participation allows for better elicitation of concepts that are only available to a participating member (Moeran 2009).

To conduct observant participation, our active part in activities included creating a mapping story project in Cree language with the tallymen's (stewards of family hunting territories or traplines) families to pass on Cree knowledge to younger generations. We also participated in projects initiated by the Cree Nation Government to collect Cree knowledge about the ecological health of James Bay, traditional land use of Cree territory, and protected areas (protected areas are an official government designation for conservation areas that receive protection because of their recognized natural, ecological or cultural values). Further documentation of Cree knowledge involved community consultations, and mapping interviews with tallymen and elders in Wemindji, as well as four other coastal communities. These projects also involved training youth and other community members in mapping skills. Trips to remote areas ("on the land," "in the bush") were part of the activities. Varied settings create opportunities to be in direct contact with community members and to have informal conversations about concepts of space and time. Topics included the meaning of Eastern Cree knowledge from the past transferred to the present context, and differences from ways of living in the past, in the present, and in the future.

To complement participant observation, we conducted four focus groups in the winter of 2013 with 17 participants. Focus groups offered an effective method for eliciting concepts while minimizing a priori classification. Kitzinger (1994) explains that focus groups discussion "ensures that priority is given to the respondents' hierarchy of importance, their language and concepts, their frameworks for understanding the world" (p. 108). The author further emphasizes the benefits of "encourag[ing] people to engage with one another, verbally formulate their ideas and draw out the cognitive structures which previously have been unarticulated" (Kitzinger 1994, p. 106). Focus groups are kept small to give more time to participants to discuss their

points of view. Participants were selected to have a relative homogeneity in the group according to generation, gender, and activities (e.g., hunters, arts and craft group, Council member, young mothers, members of an association, members of a committee, workplace environment). Kitzinger (1994) shows that "being with other people who share similar experiences encourages participants to express, clarify or even to develop particular perspectives" (p.112). A setting with participants who already know each other and where group dynamics previously have been 'worked out' should increase the likelihood of a productive discussion. Stories about the future came up less frequently during conversations with community members, so we used focus groups to elicit notions of future. Elicitation included questions such as: "What would you like Wemindji to look like in the future?" "What are the themes that you think about when you envision how the community/the land would look like?" "What kind of changes would you like to see?" "What kind of things you would like to stay the same?" Participants then were asked as a group to collaboratively explain and organize themes that emerged. To facilitate this, we asked questions such as: "In which category would this 'XX' theme be?" "Could you define how these two themes/categories are related?" "Could you define what does this 'XX' category/theme/relationship mean?"

We also conducted 17 individual semi-directed interviews in the summer 2014, in the winter of 2016, and in the summer 2016 with 17 other participants, including elders, tallymen, and adults. Some participants were met more than once, and some interviews included two people. We augmented conventional semi-directed interviews with a 'phased assertion' method that formulates questions as stories that are built in multiple phases (Collings 2009). With this method, the researcher uses stories that he/she previously gathered in the community to start conversations and then adds to the story he/she tells as new information is gathered. We used

stories that were told by interviewees during preliminary field trips to begin conversations and expand on the meaning of the story. This method allowed us to address the challenge of eliciting responses to abstract concepts. Research in Indigenous ontologies shows that starting with examples from the local context facilitates elicitation, for example with the use of photographs from the local environment or a list of words for geographic features (Mark and Turk 2003). We used stories because they are an important part of knowledge transmission for the Eastern Cree (Moses 2013).

Based on an ethnophysiography approach, we used stories to ask questions such as: "What do you think of time?" "What does time mean while you are in the bush/in the community?" "What is the difference between past, present and future?" "How are past, present, and future related?" "If you would have to choose a symbol to represent time, how/what would it be?" (Janz 2011) For example, in a conversation during preliminary fieldwork, a community member told us that time does not exist on the land. Later, when we used that story during formal or informal conversations, Wemindji community members explained more about what time means for Eastern Cree.

5.5.2 Analyzing Information and Modeling Eastern Cree Concepts of Time

We analyzed information gathered via our three methods by extracting concepts from the texts produced with transcripts of interviews and field notes. This method is commonly used in ontology research (Kuhn 2000). For example, a geospatial ontology of car navigation domain may be developed by deriving concepts from traffic codes (Kuhn 2000). Compared with such conventional ontology development, in our study, the challenge was to identify which concepts to extract from the texts.

Identifying concepts, and more generally analyzing information, should avoid a priori compartmentalization of Indigenous knowledge and subsumption into existing scientific knowledge (Blaut 1979). In his research about Maninka concepts of soil, Duvall (2008) shows that deriving Indigenous concepts by using concepts found in the scientific field fails to capture broad conceptualization and risks misrepresenting Indigenous knowledge. Whereas we acknowledge that it might be impossible to conduct research without a preconceived conception of the world and that ontologies are a fundamental construct of humans, we attempt as much as possible to define the broad concept of time without attaching specific a priori classifications.

To reduce bias, we relied on the "grounded theory" (Strauss and Corbin 2007). Grounded theory focuses on generating concepts directly from information gathered in research rather than applying concepts identified a priori to generate meaning. The researcher develops an iterative process between coding--identifying themes--and creating codes that emerge from the data. As the researcher learns more from the data collected, he/she creates more codes and starts the coding process over with these new codes. This process of *learning from* the data represents another effort to reduce imposing any a priori concepts *onto* the data and is crucial in spatio-temporal ontology research that would not subsume Indigenous conceptualizations to any foreign ontology.

Our analysis is based on qualitatively coding themes. Themes emerge and are manually entered. To facilitate the coding process, we used a qualitative analysis software, Nvivo. We imported texts from transcripts of interviews and field notes into the software, and we assigned themes (or codes) to excerpts of texts by using the 'nodes' tool. Example of themes that emerged from the data include past, present, future, changes on the land and in the community, aspirations for the land and the community, temporal references, measures of time, and connections between

present, past, and future. The nodes created facilitated the organization of information that was gathered and further exploration of the data with the creation of more nodes. Further sets of nodes that emerged from the analysis include cyclicity; causality; links with stages of life; links with other activities; dynamic notions of time. The last set of nodes in this qualitative analysis corresponds to our results that we represented in illustrations. We used those illustrations (see example in Figure 6) to facilitate the sharing of our results with community members, and to validate our interpretations with community members.

5.5.3 Validating Researchers' Interpretations with Community Members

Towards the end of the research, another set of interviews were conducted in the Fall of 2017 to validate interpretations of the information gathered in the community. These were conducted to evaluate the findings and obtain feedback from community members.

Six participants were interviewed. Three participants were immersed in both cultural contexts of Eastern Cree and Western culture (2 women and 1 men). This selection aimed at easing the conversation about differences in conceptualizations between Eastern Cree and other cultures. We also included three other participants immersed in Eastern Cree culture and Eastern Cree ways of living on the land. Snowball sampling allowed us to select those three people (1 elder and 2 men) based on their interest in sharing insights about Eastern Cree concepts. We included different generations (i.e., elders and younger adult generations) to gain feedback from different perspectives in the community.

During those interviews, we presented the simplified illustrations mentioned previously of conceptualisations of time in conventional geospatial ontologies and in our analysis of Eastern Cree concepts. Those illustrations proved to be a good tools to generate conversations about the

evaluation of the results because they seemed to be well understood by participants. We complemented the presentation of illustrations with stories gathered from the previous stages of research that supported the results. Portions of those stories explicate our results.

5.6 Results

Based on discussions during interviews, informal conversations, and on participant observations, we derived concepts of time in Eastern Cree culture. Readers will note that we kept participants' names and identity confidential, unless participants wanted to be identified in presentations and written documents and specifically indicated so in their consent. This is in accordance with Indigenous practices (Svalastog and Eriksson 2010). Identifying the names contributes to considering Indigenous people participating in research as experts themselves. This also guided our choice to reveal the location of the study, which was done in consultation with elders and band leaders.

5.6.1 Time is a Repeating Cycle and a Triangle

The linear passage of time from the past, to the present, and towards the future represent a failure of conventional ontologies to capture concepts of time. The Eastern Cree reveal new ways of thinking about time. Our results demonstrate that an emphasis on time as a cycle, a circle, and a triangle, as seen in Figure 6.

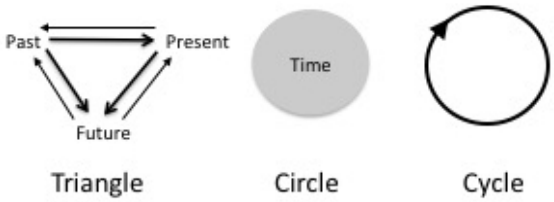

Figure 6: Illustration used with participants

Eastern Cree conceptualizations reaffirm the importance of modelling time as a cycle. Time follows cyclical patterns, including the diurnal, solar, lunar, and seasonal cycles. Events and activities are understood as part of these cycles. Eastern Cree hunting practices are tied to cycles of the return of animals, cycles of resting the land to restore animals' habitat, cycles of seasons affecting the animals' behaviors and movements across the land (Berkes 2012, Peloquin and Berkes 2009, R. J. Preston 2002). During an interview, Elizabeth Georgekish (Interview, April 19, 2016) shared a story about Eastern Cree practices of cycles of the life on the land and explained that her family was invited by friends on the next trapline for a year to let their own trapline rest and to let it move through its cycle of regrowth.

In temporal GIS, cycles often form part of a movement or a progression of time (Hornsby *et al.* 1999). This could be represented in the image of a spiral. For the Eastern Cree, time is a circle because it does not 'go' anywhere. Linear time is directive and has a destination; it starts from the past and moves through the present and towards the future. Rather than following a direction and a progression, Eastern Cree time repeats itself. Time follows repetitive patterns of recurrences such as the seasons of the year and the migration of the animals. During interviews, participants often mentioned larger recurrent patterns. For example, the elder Billy Natawapineskum (Interview, September 29, 2017) talked about Eastern Cree ancestors passing on the story about giant animals that existed in the past and disappeared for a while, but which will return in the future. George Natawapineskum mentioned that, "the past repeats itself"

(Interview, September 28, 2017). Ronnie Georgekish talked about his father who mentioned Eastern Cree ancestors passing on knowledge that, “All what happened in the past... it’s all going to come back again” (Interview, April 23, 2016).

Eastern Cree conceptualization of time as a triangle emphasizes bi-directional relationships between the past, the future, and the present. The emphasis on relationships differs from conventional spatio-temporal ontologies where time is considered as a property of a class (i.e., temporal durations as properties of events). Conventionally, people will acknowledge links between past and present; present and future. For the Eastern Cree, the future links with the past. Distinct from the notion of nostalgia, which would emphasize a longing for returning to the past, Eastern Cree past is the lens through which people look into the future. This is apparent when community members stress the importance of teaching the past to the youth. For example, during a conversation, a community member told me how her father would never make plans and would never talk about the future. When she had children, her father began telling her what she needed to show her children. She stated that, at that point, she understood that he had a notion of the future. This example shows that Eastern Cree conceptualization of the future is directly linked to the past. For Eastern Cree, time is linked to assuring that knowledge from the past is transferred so that future generations maintain connections with ancestors. Ronnie Georgekish explains that: “Today people are used to go[ing] anywhere, like by plane or skidoo, or motorboat. When I started hunting there was none of those. You know, I had to use my legs or use my hands right there. Move around all the time. That’s how we survived. When I stick to those things and I teach my children, my grandchildren, I pass it on to them. I always tell them stories that my father… stories that he told us. Pass it on to my grandchildren.” (Interview, April 23, 2016). He

shows that, even though things change, Eastern Cree knowledge of the land emphasizes a continuation and interrelation between the past and the future.

Conceptualizations of time as a repeating cycle and a triangle with interconnections between past, present, and future are present in every culture across North America. These conceptualizations of time are emphasized in other Native American cultures (cf., Deloria 2003, Fixico 2003, Hall 1983, Little Bear 2000). Indigenous peoples explicate concepts ignored in conventional geospatial ontologies because of the narrow assumptions of time as a line, a progression from the past, through the present and towards the future, and an over emphasis on classes instead of relations.

5.6.2 Geographic Entities are not Endurant but Processes with Temporal Parts

We find that the conventional distinction between SNAP (endurant) entities and SPAN (perdurant) entities is problematic for Eastern Cree concepts of time. Endurance emphasize the spatial properties of physical entities. Temporal properties are attributed to perdurant entities such as events and processes. Conversely for the Eastern Cree all things, including geographic entities, are conceptualized as perdurant.

Temporally fixing geographic feature (endurance) reduces Eastern Cree conceptualization of the land. For the Eastern Cree, as for many other Indigenous cultures, creation stories are predominant in defining what the land is (McGregor 2004). Stories define geographic features and everything that forms part of the land by how they came to exist. During an interview, Ronnie Georgekish (Interview, April 23, 2016) shared the story of his family trapline about a mountain that was formed and got its shape from a cooking pot a Giant dropped after being killed by a Shaman. An adjacent mountain was formed when the same Shaman cut

that Giant into pieces and piled them up (the mountain is shaped by rocks formations and looks like they were put one on top of each other). On another Wemindji hunting territory, a river had been formed when a Giant Otter was chasing a Hunter that had shot its baby. The interview participant explained that the shape of that river was rhythmically wider and narrower, which mimicked the otter's swim. The lake out of which the Otter emerged to swallow the hunter also was shaped like the otter's head. These examples show that everything on the land possesses temporal properties. Geographic features may have past identities, when they have been created and when they took form during specific events.

Indigenous placenames represent another way of emphasizing process over properties of features. Placenames, rather than being fixed or written down, are ephemeral and told--performed--during storytelling (Muller 2014, Verran 2004, Veland *et al.* 2014). Here, placenames are not merely properties of a location but are classes that contain their own properties. When things are not fixed in time, geographic entities become processes. Our results suggest that everything is perdurant, which contradicts conventional geospatial ontologies because endurant entities are continually "unfixed" in time.

5.6.3 Time Has Agency

We argue elsewhere that a distinguishing characteristic of Indigenous ontologies is the attribution of agency to inanimate geographical classes (see Chapter 2). The land and the elements constituting the land (geographic entities e.g., mountains, rivers, islands, trees; natural phenomena e.g., wind, thunder; sun, moon; animals and other spirits present on the land) can be considered 'persons' (Cruikshank 2010, Hallowell 2002, Ingold 2000, Nadasdy 2007, Scott 2006). Other than living natural and geographic features, the notion of agency of time has been less explored with Indigenous communities (c.f. Kohn 2013). Our research finds that time has

agency amongst the Eastern Cree. “Past” and “future” are entities into themselves and have capacity to act by influencing actions.

The Eastern Cree have often expressed the notion of a ‘living past’. A young Cree woman activist expressed in a TV interview that for the Eastern Cree people, each step you take forward, there are a thousand ancestors supporting you (Maïtée Labrecque-Saganash in Radio Canada 2016). Respondents mentioned how spirits of ancestors are part of the land and guide the Eastern Cree, for example in their hunting practices or in other traditional activities such as proper ways to care for the animals’ spirits and prepare the meat when animals are killed. People reported during interviews and conversations that their ancestors are indistinguishable from the land and are watching over them.

The future also carries a sense of living agency for the Eastern Cree. The future is alive through practices of teaching culture and passing on traditional knowledge to future generations. For, example, an elder in a community meeting mentioned the importance of teaching Cree children and showing youth how to do things in the bush. He added that this is the only way to ensure a tradition continues to live in the future. A ‘living future’ was further exemplified in stories of ancestors or elders foreseeing future events. For example, during many conversations and in interviews, Wemindji community members shared stories of elders foreseeing white men coming and hurting the land, which they later confirmed with the hydroelectric development on Eastern Cree land. Others shared the story of an elder foreseeing the site of a mine on Eastern Cree territory prior to any signs of exploration. Interpreting dreams and everyday observations to understand future events is considered a crucial skill for survival off the land (S. Preston, 1999). For example, predicting the animals’ behaviors assures a successful hunt. Hunters often interact with animals through their dreams, which can help them understand the possible future (Preston

2002, Scott 2006). Many other cultures, like immigrant communities also possess similar concepts, which that provides further impetus to view time as an agent rather than a passive attribute.

The Eastern Cree notion of future is tied to attentiveness to environmental signs, such as unusual behaviors of animals. Such conceptualizations of time are difficult to integrate in ontologies; however these observations have become important in other areas of GIScience. Goodchild (2007) stresses the importance and value of volunteer geographic information (VGI) gathered by citizen sensors who contribute observations of their environment on the geospatial web. The Eastern Cree explain that observations of the environment provide insight about the future. Irene and Sinclair Mistacheesick (Interview, April 12, 2016) told a story of an elder hunting in his snowshoes, who stopped by a tree to have a cigarette. A whisky jack bird landed on the tip of the shovel carried by the hunter. The hunter immediately recognized this as a sign that there was food nearby and asked the whisky jack to indicate the direction. The hunter followed the direction towards where the bird flew away and discovered a black bear in a bear den and killed it. This story is one of many that emphasize the relation between important messages and uncommon occurrences. Other stories about experiencing events about the future pertain to telling bad news. Elizabeth Georgekish (Interview, April 19, 2016) mentions a story about a hunter who found two otters hanging by their heads in his beaver trap. The hunter talked to the otters, knowing that they were telling him bad news before it happened, which was confirmed when he lost his son. In Eastern Cree conceptualization, the future is living and manifests itself in the present through unusual occurrences interpreted by the Eastern Cree. Even though these stories reveal knowledge that is difficult to quantify, Nadasdy (1999) stresses the

importance of considering these stories when documenting Indigenous knowledge because they are integral to the ways Indigenous peoples make sense of their environment.

5.6.4 Place (Including Humans) Depends on Time

Rather than subsuming time to space, we found that in the Eastern Cree conceptualization, geographic features cannot exist without time. One such example is seasons, which are very important in Eastern Cree conceptualizations of space and time. Features and places only exist in a certain season. Place is conditional on seasons rather than season being an attribute of places, features, and events. Traditionally focused on traveling on the land, Eastern Cree language refers to traveling routes as ‘winter trail’ or ‘summer trail’. Seasons change the surface and mode upon which one travels. Winter is on land and afforded via snowshoe or skidoo; summer is on water and via canoe. This emphasis on seasonality and temporality points to the need to expand conventional geospatial ontologies to consider broader notions of time. Time and space need equal consideration or perhaps space needs to be subsumed to time.

The Eastern Cree conceptualization also exposes the gap in conventional geospatial ontologies that focus on "natural phenomena" and largely exclude humans. The assumption that geography is a world without people contradicts Eastern Cree concepts of space and time. Geographic features cannot exist without time and without relations with other entities such as humans and animals. This is often explained with the concept of reciprocity, where everything in the natural world is dependent on mutual interactions with one another based on interconnected processes (Preston 2002, Scott 2006). In the Eastern Cree conceptualization, reciprocity emphasizes the relationships between entities of the natural world (including humans) that go both ways and that are inseparable from one another.

5.7 Discussion: Alternate Space-Time Ontology

Our results show that Eastern Cree notions of time significantly differ from conventional spatio-temporal ontologies and offer possibilities to enrich considerations of time in GIScience. To accommodate these differences we propose an alternate way to conceptualize and formalize time, which is a modification of SNAP/SPAN. We eliminate the distinction between endurant and perdurant (SNAP/SPAN), which affirms our findings that space cannot be distinct from time. SNAP/SPAN essentially either holds time constant or it holds spatial extent and relationships constant. We acknowledge Grenon and Smith (2004)'s argument that "the challenge is to build a unified framework within which we can do justice to both of these modes of being equally" (p. 72). Although they argue that SNAP and SPAN are treated equally, in practice, mainstream ontologies emphasize space and relegate time to a property (see Section 3.4). More importantly, our results show that theoretically, entities cannot be treated as endurant in time. Our findings echo back to the debate between the three-dimensionalist and the four-dimensionalist perspectives, recognized in ontology research (Sider 1997). SNAP corresponds to a three-dimensionalist perspective; SPAN corresponds to the four-dimensionalist perspective. Grenon and Smith (2004) argue that adopting either one of these mode of being and existing in time would oversimplify the world. We agree that both are needed but they cannot be separated in this fashion. The separation, while practical, is itself an oversimplification. Our findings holds that everything is perdurant as reflected in the new model (Figure 7).

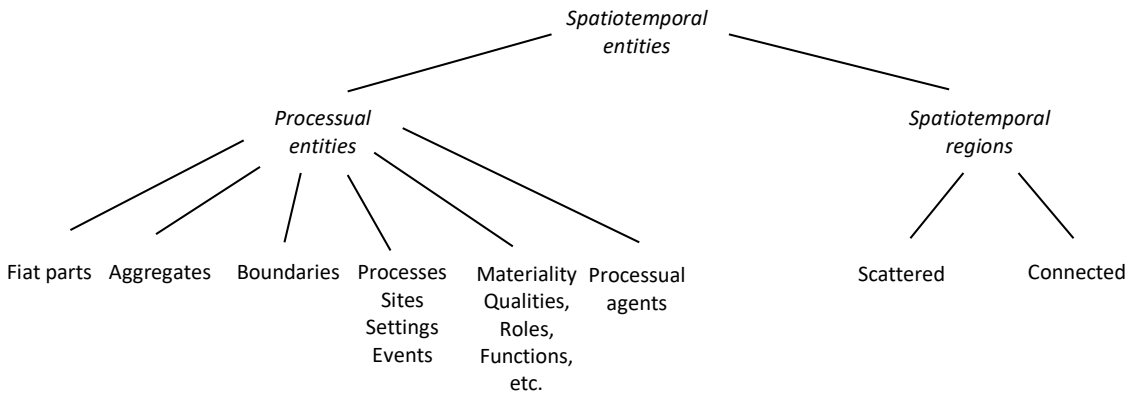

Figure 7: Alternate spatio-temporal ontology

We propose to subsume SNAP entities to the SPAN ontology, so that everything is a *Spatiotemporal entity*. We retain the conventions in SNAP/SPAN where the italicized items represent categories that are meant to be dissected into subcategories or to "cumulate" subcategories under one category. The category *Processual entities* includes *Boundaries*, *Fiat parts*, and *Aggregates* to consider parts and aggregations. The category *Processes* is defined differently from the original SNAP/SPAN ontology. Processes include entities that were already considered as processes such as erosion but now include previously endurant features like mountains, which shift over various time scales (e.g., via erosion or volcanic eruptions). Processes include events, sites, and settings, which also are located in space and time (*Spatiotemporal region)*. We erased the distinction between the spatial classes *Sites* from SNAP, and temporal classes *Settings* and *Events* from SPAN.

We eliminated the category *Substances.* We created a new category called *Materiality* because our "substances" refer to temporally contingent properties of entities. *Materiality* was added to *Qualities, Roles, Functions*. For example, water is a dynamic quality of a waterbody. Research on Indigenous geospatial ontologies has found that, in the Yindjibarndi language in Australia, water features are categorized according to the permanence and impermanence of

water (Mark and Turk 2003). The presence of water is not a fixed property of a water feature because some features contain water every year or contain water only once a decade.

To consider Eastern Cree concepts of agency of time, such as the entities 'Past' and 'Future', the category *Processual agents* is added to our ontology. This category would allow for the modeling of agents such as humans acting on entities, as well as ancestors and spirits, common in Indigenous conceptualizations. We collapsed *Spatial regions* and *Temporal regions* from the SNAP/SPAN ontology into one category *Spatiotemporal regions* to locate prosessual entities in space-time either as scattered entities (with boundaries that are not connected) or connected. This component of the ontology corresponds to our findings that space and time are inseparable (see Section 5.4).

Our spatio-temporal ontology considers Eastern Cree conceptualizations, which challenges the proposition that there are two ways of existing in time and space (endurant/perdurant). What happens when geospatial entities that are categorized as endurants, do not exist physically in the present but are still part of the present, in living memory of people? Trying to fix things in time can create a fiction of endurance. Alternately, we demonstrate that definitions of entities and the entities themselves are temporally-dependent. Whereas spatial issues in defining entities is a focus in GIScience, we point that these effort tend to ignore time. For example, in defining a mountain, much attention is given to issues of shape, slope, and spatial boundaries (Smith and Mark 2003). We show that a mountain is not fixed in time and anything that defines a mountain depends on time. A mountain top can be removed for mining purposes so a mountain shifts to the properties of a plateau. We argue that space should be subsumed to time instead of time being subsumed to space.

5.8 Conclusion

Our research reveals the assumptions in conventional ontologies about time: linearity, purely chronological measures of temporal intervals, distinction between objects fixed in time and events/ processes happening in time, and realist perspectives that things only exist by observations of agents in the present. Explicating the assumptions uncovers gaps in conventional geospatial ontologies. Our research also shows that notions of time differ across culture. Including cultural conceptualizations of time, such as with Indigenous ontologies, can remedy the gaps.

Our research finds four differences between conventional spatio-temporal ontologies and Eastern Cree notions. First, time can be a repeating cycle and a triangle instead of a line. Second, the past and the future have agency, which contrasts with positioning entities in the present. Third, geographic entities are dynamic processes rather than fixed physical objects. Fourth, time is inseparable from a place rather than being subsumed to space. To remedy gaps revealed by our research, we propose an alternate spatio-temporal ontology that is built on SNAP/SPAN.

We hope this research furthers geospatial and spatio-temporal ontology development and facilitates collaborations that will contribute to culturally appropriate ways of storing and categorizing Indigenous knowledge. Many Indigenous communities rely on geospatial technologies to advance their causes. Broadening consideration of time is crucial both for the advancement of Indigenous rights and for the advancement of the field of GIScience.

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Chapter 6: Discussion and Conclusion

6.1 Summary

This dissertation has asked whether the geoweb is effective in considering Indigenous epistemologies and ontologies, and how it could be improved. The manuscript in Chapter Two reviewed literature on critical Indigenous geospatial technologies and assessed whether new components of the geoweb remedy the critiques that were identified with older desktop GIS. I showed that, in many ways, the geoweb is not doing better than GIS technologies with regards to the three main GIS critiques: 1. compartmentalizing and distilling Indigenous knowledge; 2. undermining Indigenous ways of knowing and of transferring knowledge, and 3. exploiting and assimilating Indigenous knowledge. The second literature review, which comprised Chapter Three, focused on geospatial ontologies. I showed that conventional approaches to ontology development focus on universality and fail to consider how Indigenous peoples view time and space. I covered the ways in which conventional geospatial ontologies constrain mental and physical concepts to dichotomies, reduce concepts during the classification process, dismiss attributes of agency, and privilege ontological class over relationships. I further argued that the geoweb must be inclusive of Indigenous peoples to ensure future access to geospatial technologies and to prevent loss of Indigenous knowledge. I explored alternate approaches to universality such as place-based, hermeneutics and heuristics. Together, the two literature reviews point to the need to develop Indigenous geospatial technologies and Indigenous ontologies that engage deeply with the local contexts of Indigenous communities, and consider place-based Indigenous conceptualizations, ways of knowing, and tenets of knowledge management.

To address this need, my research with the Eastern Cree community of Wemindji in Northern Quebec focused on eliciting Cree concepts of space and time. This research adopted a place-based approach to geospatial ontology inquiry. I presented a methodological approach that deeply engaged with community members and addressed the positionality of the expert non-Indigenous researcher. I used hermeneutics and heuristics that treated community members as experts, reduced distancing, and focused on immersion, while also acknowledging that challenges remained because outside expertise and distancing were inevitable. I presented the results of Eastern Cree conceptualizations of space and time, which highlight the need to focus on processes in ontologies instead of fixing entities such as geographic features in time. I proposed an alternate spatio-temporal ontology that considers everything as a fluid process rather than conventional instead of the conventional approach of distinguishing temporal and spatial entities, or subsuming of time to space.

6.2 Major Findings and Conclusions

This research shows that the geoweb and conventional geospatial ontologies face many challenges to account for Indigenous conceptualizations, Indigenous knowledge, Indigenous ways of knowing, and Indigenous ways of transmitting knowledge. My results also suggest that the further development of geospatial technologies and ontologies needs to be done directly by Indigenous peoples. This would require training Indigenous people in GIScience as both geospatial technology developers and ontologists.

Maps and mapping technologies are crucial for the advancement of Indigenous causes, and much research and many practices focus on decolonizing maps and mapping technologies (Chapin et al. 2005; Corbett et al., 2009; Louis et al., 2012). This research and practices focus on issues of usage (i.e., the accessibility of mapping to Indigenous peoples) or issues of

representation (i.e., maps with Indigenous place names). Such work is crucial because, as the development of Northern Quebec accelerates[4], mapping will be increasingly central to court cases, deferrals, and the opposition to or negotiations with resource extractive activities. It is important to keep in mind, however, that the underlying assumptions about the world of those who design mapping technologies find their way in the architecture of such technologies (Haklay, 2013). This thesis addresses this issue by looking at the new components of the architecture of the geoweb and by looking at the underlying assumptions embedded in geospatial ontologies.

Among other conclusions, the research in this dissertation shows that common ideologies associated with the geoweb such as ubiquitousness, user-friendliness, interactivity, openness, and accessibility for everyone are often at odds with Indigenous epistemologies. Openness is not necessarily a useful concept when considering Indigenous knowledge, Indigenous ways of knowing, and Indigenous knowledge transfer. This points to the need for further research on Indigenous geospatial data sovereignty and on the design of geospatial technologies that will enable Indigenous peoples to have control over geospatial data about their territory.

My research also addresses the need to develop Indigenous geospatial ontologies that are place-based instead of subsuming and reducing Indigenous concepts to Western (allegedly "universal") conceptualizations. The Eastern Cree concepts of space and time that were explored in this research exposed gaps in geospatial ontologies. In this dissertation, I propose an alternate spatio-temporal ontology that considers Eastern Cree concepts by focusing on fluidity and processes of entities, rather than on fixing things in time. My research offers perspectives on

[4] The 25 years program of the provincial government of Quebec launched in 2011 called 'Plan Nord,' or the Northern Plan includes $80 billion in private and public investments for development and resources exploitation in the North. These projects include mining, roads, airports, tourism, and hydroelectricity (Desbiens, 2013; Desbiens and Rivard, 2014).

achieving interoperability between conventional geospatial ontologies and Eastern Cree ontologies.

The results of the thesis also imply that Cree conceptualisation of space and time are relational. My literature review of conventional geospatial ontologies suggests that within these conventional approaches relationships are underdeveloped and would be inadequate and inappropriate to handle Cree relationships. Relationships between concepts in geospatial ontology development mainly focus on partonomies and sub-divisions. Concepts classified into smaller parts and into kinds (e.g., has-part/is-part-of, is-a/kind-of relationships) (Tomai and Kavouras, 2004). Our results show that Cree conceptualizations emphasize more complex interrelationships between entities. I envision a future paper about relationships in geospatial ontologies compared with Cree ontology.

My existing and proposed work can inform ways to eventually change geospatial technologies to integrate Indigenous conceptualizations of the land and of time. Ultimately, this area of research might lead to a geospatial web 4.0 that would completely integrate Indigenous epistemologies and ontologies in the web 4.0 era where "technology and human become one."[5] My results suggest that the geospatial web 4.0 needs to include new components that facilitate face-to-face interactions and performance-based forms of transferring knowledge. Future tools also need to better integrate Indigenous geospatial data sovereignty such as capabilities for Indigenous peoples to blur, erase, or mask VGI contributions that concern their territory. The geospatial Web 4.0 would also need to consider Indigenous ontologies and concepts of space and time such as the predominance of circular time and of processes rather than fixing entities in

[5] See the blog post *Web 4.0 Era Is Upon Us* (http://www.pcworld.com/article/143110/article.html) for an overview of a brief web 1.0, web 2.0, web 3.0 and web 4.0.

time. The geospatial web 4.0 needs to be designed to assist Indigenous communities in expressing their knowledge based on their own ontological and epistemological perspectives.

The implications of this research also lay in the field of Indigenous planning. Indigenous geospatial technologies designed by Indigenous peoples themselves could benefit from the gathering of Indigenous knowledge and the use and occupancy of their territory to inform planning processes and development strategies. These expressions and visions of Indigenous territories will be based on their own concepts of space and time rather than western-centric point of views.

In terms of short-term tangible outcomes for the Cree Nation of Wemindji, the results of this research about Cree notions of time can inform Cree knowledge documentation for example within the Culture and Wellness department. I shared the research results during a community gathering in November 2018. The themes that emerged in the research about time were used to gather more stories for example about cycles, changes on the land, old stories, and how geographic features came to be on the land. Community members expressed wanting to continue having this activity, which was integrated in the department's activity program in the form of a workshop, called Cree Season, to map and record these kinds of stories. Community members and staff members of the Culture and Wellness department also requested to have a hard copy of the summary of findings. I will produce a booklet in collaboration with the mapping program within the Culture and Wellness department.

6.3 Limitations of the Research

Although the design of this research aimed at creating a culturally sensitive methodological approach to build a place-based Indigenous spatio-temporal ontology, my results still point to the need for research done by Indigenous peoples themselves. I showed that while non-Indigenous

researchers remain involved in the process of informing the design of geospatial technologies and geospatial ontologies with Indigenous peoples, the position of the outsider/expert needs to be explicitly addressed. Whereas I designed a methodology to address this position, my research demonstrates remaining challenges of balancing the need for non-Indigenous researcher's expertise with the inevitable distancing with Indigenous community members to avoid a recolonization in knowledge production. Heuristic and hermeneutics are nonetheless beneficial in developing ontologies that are place-based.

To achieve a future involving Indigenous geospatial data sovereignty and Indigenous technological sovereignty, the training of Indigenous peoples in the design of mapping technologies and of geospatial ontologies will be crucial. My research contributes to building a bridge between that future and current issues with geospatial technology developers and ontologists that are undermining Indigenous epistemologies and ontologies. By identifying problems and critiquing current geospatial technologies, this research invites solutions. Overall, my research is highly critical. This can be a limitation when Indigenous communities are trying to find best practices and to adopt technologies to address their causes in a timely manner such as in deferrals against development projects and resource extraction activities with devastating impacts on their territory. In parallel to the more practical efforts to use existing geospatial technologies, I still find that the critiques are necessary and will continue to be essential until we are on the other side of the bridge with geospatial technologies designed directly by Indigenous peoples themselves. Until then, questioning and critiquing the assumptions that underpin existing technologies will contribute to building that bridge.

6.4 Future Research Directions

This research has demonstrated the importance of looking at the underlying architecture of mapping technologies, and of interrogating ways in which the components reinforce power dynamics in society. In my future research, I will continue to study the ways in which mapping technologies can support or undermine Indigenous governance over data that is produced about their territory.

Issues of control and ownership of Indigenous data in geospatial technologies are timely. I have shown that privacy issues are important with the geoweb. Zook and Graham (2007) explain how the geoweb is subjected to corporate control and exploits information from citizen-contributors for corporate profit. Many people volunteering information on the geoweb are unaware that third parties use their data to target consumer's needs and interests and serve corporate benefits (Obermeyer, 2007). Furthermore, government agencies and Canadian cities are increasingly generating open data— data that is freely accessible and usually with minimum restriction on usage (Johnson et al., 2017). These circumstances exacerbate dangers of misuse, misinterpretation, and exploitation of Indigenous knowledge. Open data and issues of repurposing of information on the geoweb also put pressure on Indigenous governance over data produced about their territory.

Indigenous data sovereignty is an emerging area of study focused in the United States, Australia, and New Zealand in fields such as Indigenous rights and Indigenous health research (Davis, 2016; Kukutai and Taylor, 2016) which offers a unique opportunity to look at geospatial technologies. Defining the tenets of Indigenous geospatial data sovereignty in Canada offers an alternative that will push back against common assumptions that everything should be open and accessible to everyone. Ultimately, designing geospatial technologies that integrate Indigenous

geospatial data sovereignty into their systems could help Indigenous communities in Canada determine the processes of gathering, managing, and using their knowledge. Additionally, Indigenous geospatial data sovereignty aims at disrupting current corporate control in the geoweb.

My future research will continue to question the liberation claims commonly associated with geoweb technologies. I will specifically examine ways through which geospatial technologies can help Indigenous communities regain power and allow them to have ownership over their data and control over the ways in which this data is used. My future research will pursue the following objectives: 1) Identify ways in which volunteer geographic information (VGI) that is sold and repurposed is detrimental to local communities or even to the people who volunteered information in the first place; 2) Define what data sovereignty means to First Nations leaders/elders; 3) Define the 'boundaries' of data sovereignty (between Nations; with the federal and provincial governments; Is there a Metis data sovereignty, an urban Indigenous peoples data sovereignty, data sovereignty for First Nations people living off reserve?); 4) Suggest ways in which digital mapping technologies could consider issues of privacy and intellectual property. My future research will also involve cross-cultural comparisons in data sovereignty in Canada and with other countries such as the United States, Australia, and New Zealand to explore how data sovereignty might depend on political context, such as government regime changes.

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Appendices

A. Consent form

RESEARCH CONSENT FORM
McGill University

Title of Research: Aspirations of the Cree in Northern Quebec and Geospatial Ontologies
Researcher: Geneviève Reid, Ph.D. candidate, Geography department, Supervisor: Renee Sieber
Contact Information: Prof. Renee Sieber; email: renee.sieber@mcgill.ca; Tel: (514) 398-4941

Wachiya!
My name is Genevieve Reid. I'm a student in Geography at McGill University. I work with Colin Scott and Rodney Mark on a project about creating a network of protected area across the entire Cree territory. I also work here in Wemindji with Rod on his maps, and with Sammy Blackned on a Wemindji mapping project that includes placenames, and the history of traplines.

Purpose of the research: The purpose of my own research for my studies in geography at McGill is to look at different ways of thinking and seeing the land. I think that there might be important differences between how Cree see the land and how people from the south, and science describe it. Results of my research will be shared with people in Wemindji, with the Band Office, and with the Cree Regional Government. I think that my research can help to find Cree ways for mapping, protecting, and developing the land.

What is involved in participating: Interviews are about discussing how you think about the land and how you see the land. General questions will be asked. For example, what are the different ways to think about a mountain? Or about a mine? What are the boundaries of a mine? What does it include?

The time of the interview will be approximately one hour and will be tape-recorded in its entirety. I will be the only person to access the tapes and I will use them to transcribe the discussions. The audio tapes will be kept under locked conditions.

Your participation is voluntary and you may choose not to participate or withdraw at any time or refuse to answer any question you don't want to. You will receive $20 in compensation for your time.

Your name will never be revealed in written or oral presentations. Anything you say will only be attributed to you with your permission otherwise the information will not be reported in such a way as to make direct association with yourself impossible. My pledge to confidentiality also means that no other person or organization will have access to the interview materials and that they will be coded with a key numbers on a separate document. All interview materials will be kept in a locked cabinet in my locked office and I am the only person who has access to the cabinet.

You may contact Prof. Renee Sieber; email: renee.sieber@mcgill.ca; Tel: (514) 398-4941; if you have any questions or concerns.

Oral Consent: Your oral consent serves to signify that you agree to participate in this study.
Do you agree to participate in this study?
Do you agree to be tape-recorded?
Do you agree to be identified in public presentations and reports?

Written consent:
I have read the above information and I agree to participate in this study ____YES _____NO
I agree to be tape-recorded ____YES _____NO
I agree to be identified in public presentations and reports ____YES _____NO

Participant's printed name _____ Researcher's signature_____

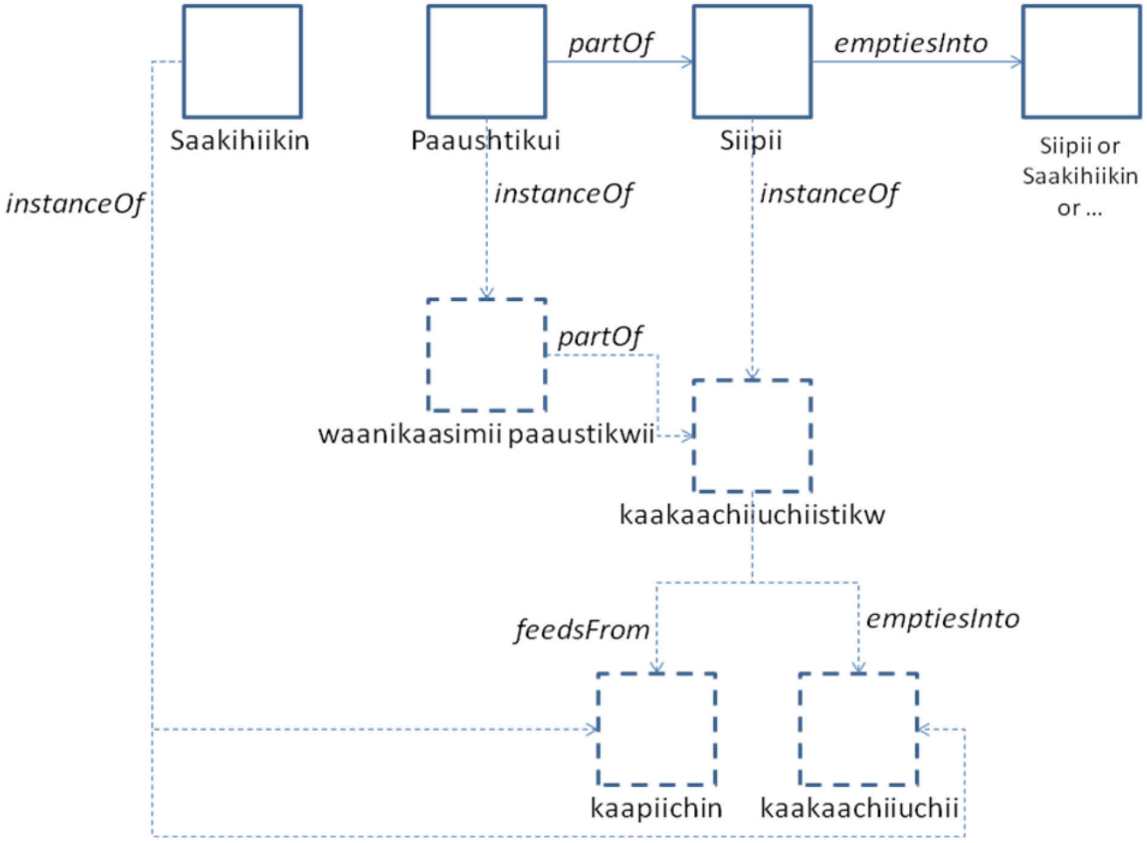
Participant's signature_____ Date _____

B. Interview Guide

Interview material:

- Paper maps of the area (approximately 1:50,000 scale maps showing the entire trapline)
- Google Earth (already used in other community mapping projects)
- Blank paper and pens if interviewee needs it
- Schema of ontology of hydrography (Wellen, 2008)

This is to show to the interview what a resulting 'schema' could look like:



Source: Wellen, 2008, p. 30

Read script for ethics approval. Oral or written consent.

Description of project:

Wachiya!

My name is Genevieve Reid and I'm a student in Geography at McGill University. I work with Colin Scott and Rodney Mark on the Network of protected areas covering the entire Cree territory. I also work here, in Wemindji, with Rod on his maps, and I work with Sammy Blackned on the Wemindji mapping project that includes place names, and the history of traplines.

So this interview now is for my own research for my studies in geography at McGill. I'm conducting interviews with people about the mine and about Muusuuchii. The purpose of this work is to describe Cree ways of seeing and thinking about the land. I think that there are differences between how people from the south and people from Wemindji think about a mountain and a mine for example.

Description of interview
So I know that you were probably interviewed before about Muusuuchii/the mine. However, my questions might be different. The purpose of this interview is to help me to understand what the Cree people think and feel about their land. The results of my research will be shared with the people of Wemindji, the Band Office, and with the Regional government. By working together with the Cree people, I will build a schema that represents and describe a Cree way of seeing the land. I hope that this description and representation could be used in situations such as when people make maps of Wemindji territory, when Wemindji people negotiate with outsiders, or when they talk about what they want for the future. So I'm trying to understand and find a way to describe how you, the Cree, think about your environment and how you see it.

So I want to show you an example of what the schema or diagram that I want to draw could look like. This is an example of a schema that was done by another student at McGill, Christopher Wellen. It's about water bodies, for example rivers, lakes, on Wemindji territory.

Show illustration of Christopher Wellen's ontology hydrography (Annexe B).

This illustration shows a river entity for example, with a description of what the parts are like rapids, and portages for example.

So I suggest starting with a presentation of you. After that, I will ask you questions about what you think about Muusuuchii/the mine. We can use the paper maps here, and/or the maps on the computer if you wish (Google Earth). At the end we could evaluate the interview, and you could say what you think and how you feel about this interview.

Presentation of the participant and expectations in participating
Name, activities, role in the community, area where the participant has lived and lives now.
What are your expectations in participating in this interview? Why do you want to participate?
i.e., So to start the conversation, could you present yourself?
can you talk a little bit about your life path?
how old are you?
Could you talk about the members of your family?
One which trapline did you grow up?

Interview questions for geographic features (i.e., Mountain)

Typically, people from the south, would use words/terms like this to describe a mountain:

A natural feature, an inanimate physical or material object with an elevation, and area with boundaries. Often, on a map a point will be marked to represent the peak of the mountain.

Is there another way or a more complete way to think about a mountain?

Is there a Cree way to explain what a mountain is or what Muusuuchii Mountain is?

Are their any stories and/or life experiences attached to Muusuuchii Mountain?

How do you feel about this mountain? How does this mountain make you feel when you think about it or imagine it?

What role has this mountain played in your life?

What role did this mountain play for the Iyiyuu people in history?

What are some of the values and beliefs (as many as you can think of) that you or other local people hold toward this mountain?

How have you used it? When?

How have you managed its resources or how have people from Wemindji managed its resources?

What are the customary hunting laws for using this site?

What rules apply when on the mountain or around it

What are the boundaries for where those rules apply?

How, why, and when is the mountain used?

What is a hunting sanctuary? Please describe?

What are the roles, purposes, and rules of hunting sanctuaries in general?

What does Muusuuchii Mountain include? Where do its boundaries begin? If we want to protect this mountain, where do boundaries need to be laid in relation to the mountain? If we don't want to damage (or further damage) the mountain, where do we start protecting? How are these boundaries identified and why?

Are there any myths or very old stories about the mountain?

Why is it called Muusuuchii?

How did it get its name?

Does the Mountain have properties or abilities that humans have?

Does the Mountain have feelings/emotions?

Can it be wounded or scarred? How? Can you give and example of a situation where this could happen?

Can it hear? In what kind of situation could the mountain hear things?

Can the mountain influence or decide when or not a hunter will find food there?

Can the mountain know if a hunter misbehaves or doesn't show respect to it?

Does the Mountain have, what we would call in English, 'a spirit'? Or is there a spirit linked to the mountain?

Is the Mountain a kind of being (other-than-human being)?

Do all mountains have the same properties or qualities as Muusuuchii?

What is the difference between Muusuuchi and other mountains?

Interview questions for time

How would you like Wemindji to look like in the future?
In 10 years?
In 55 years?
In future generations?

For the community?
For the land?

(possible answers: developed, safe, more houses, more trees, tourists, clean,…)
Sub questions: Where? Why? What do you mean by XX? Where would you like to see more XX? What does XX include?

What are the themes that you think about when you envision how the community would look like?

How can you organize the themes in categories/or classes?
How does the themes and categories relate to one another?

What kind of changes would you like to see? /What kind of things you would like to stay the same?
(possible answers: infrastructure, roads, lights, stores, playgrounds)
Sub questions: Where? Why? What specific XX? Could you define what is XX? What does XX include?

What part of the community would you like to see changed?/ What part of the community would you like to stay the same?
(possible answers: specific area, around XX building, areas around the community, the river shore, forest)
Sub questions: Why? How? Could you define what is XX? What does XX include?

When you think of your grand children, great grandchildren, in what kind of community and what land would you like them to live?

Where would you like them to live?

When you think about the future what does it make you think about?
how do you wish future generations will live? What kind of life style do you wish they will have?

What does time mean when you are in the land?
In the community?
What is the difference between past, present and future?

How does the past present and future are related?

If you would have to choose a symbol for the concept of time, what would it be?

If you would have to put a symbol on what the concept of time is. Then could you draw something?

And if I ask you to represent or draw time.

Do you know any stories, legends, or myths about what will be coming or about forseeing the future?
about events that didn't happen yet?

Examples of stories to start phased assertion discussions and interviews

Someone in the community told me the story of the wolverine and the skunk:
The wolverine was eating other animals in the bush. The animals gathered and the skunk came to help the animals. When the wolverine came around, the skunk sprayed the wolverine in the eyes. The wolverine was in pain and couldn't open his eyes. He was touching the trees to orient himself. Then he touched the kind of trees you find by the coast. He went to wash his eyes in the Bay. This is why the Bay has salt water and the rivers are fresh water.
What do you think of that story?

In Wapmagoostui, during a community consultation meeting, about what part of the territory should be
protected, one elder was explaining that the land is all sacred and should all be protected.
What do you think of that story?

A lot of people had told me about a hill out in the Bay, on the way
back from Old Factory Island by boat. They say we should never point to that mountain.
Why is that so do you think?

Evaluation

Your feedback is really important. I included here questions to talk about how it feels like to be interviewed and to evaluate this interview in particular.

Maybe you have been interviewed before…
What kind of questions do you usually like to answer in interviews?
What kind of questions do you usually dislike to answer in interviews?

What would make you more willing to answer questions from researchers?
What makes you more reluctant to answer questions from researchers?

What do you think of this interview?
Do you want to add anything to the interview?
Is there anything that I could add or change to improve this interview?

Do you have any ideas of how I should include what I haven't?
Do you think that the questions were relevant?
Did you learn anything new?

As I explained, I will gather the information from interviews and create diagrams and share it with the Cree Nation of Wemindji, and with the Regional government. Do you have ideas of how the results could be useful to the community?